SCIENTIFIC PAPERS

SERIES A. AGRONOMY

Volume LVIII, 2015

University of Agronomic Sciences
and Veterinary Medicine of Bucharest
Faculty of Agriculture

SCIENTIFIC PAPERS
SERIES A. AGRONOMY

Volume LVIII

2015
BUCHAREST

PUBLISHER:

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
Faculty of Agriculture, Romania
Address: 59 Mărăști Blvd, District 1, 011464, Bucharest, Romania
Phone/Fax: + 40 213 318-0466; E-mail: journal@agro-bucuresti.ro
Webpage: http://agronomyjournal.usamv.ro

To be cited: Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015

ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

International Database Indexing: CABI, Index Copernicus, Google Scholar, CNCSIS B+, Ulrich's Periodicals Directory, Research Bible, Scipio, Scientific Indexing Service, PBN (Polish Scholarly Bibliography), OCLC (WorldCat)

SUMMARY

SOIL SCIENCES

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SOIL SCIENCES

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INFLUENCE OF LIMING WITH $Ca(OH)_2$ ON THE CALCIUM AND MAGNESIUM CONTENT IN THE GRAPE OF WINE GRAPE VARIETIES

Mladen ALMALIEV, Krasimir TRENDAFILOV, Stefka TODOROVA

Agricultural University, 12 Mendeleev Blvd., 4000 Plovdiv, Bulgaria

Corresponding author email: mladenalmaliev@abv.bg

Abstract

In condition of combined field experiment was studied the influence of liming with $Ca(OH)_2$ at rates of 1.0, 2.5 and 5.0 t/ha on the input of calcium and magnesium in the grapes of fertility vines from varieties Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Merlot planted on Chromic luvisol. Samples were collected in two consecutive years. In the first year of the study was not found statistically proven variation of the Ca content in the composition of the fresh grape mass. The available Ca amount in grapes in ameliorative lime rate of 5.0 t/ha was lower compared to that what was found for the lower ameliorative lime doses. About magnesium was found statistically proven exceed at the variants with liming, compared to the variants without liming. Overall white varieties during the first year assimilated more Ca amount compared to the red varieties. According to Mg this difference was insignificant. The differences between limed varieties and the control variant in the second year of the study according to the Ca content in the grape were statistically proven at level of probability 95%.

***Key words**: liming, calcium, magnesium, wine grape varieties.*

INTRODUCTION

The acidity in the soil usually occurs simultaneously with more or less pronounced deficiency of calcium or magnesium, or both elements in exchangeable form in the soil. Calcium is the main antagonist on the exchangeable forms of aluminium, hydrogen and most of the metal ions in the composition of the soil sorption complex. In strongly acidic and weakly buffered soils, Ca may be in deficit as nutrient element in the plants. So strong calcium deficiency is very rare, but should be considered when interpreting the data for Ca content in the soil. This is determined by the important physiology-biochemical functions of Ca, mainly related with the process of photosynthesis, by regulating the state and the electoral permeability of the plasma membranes with neutralizing and buffering reactions of the cytoplasm (Kadrev and Peev, 1980). For probable deficit of Ca, as the nutrient element was reported in soils, contain exchangeable Ca in concentration less than 2 meq/100 g (Palaveev and Totev, 1970).

In a study of the properties of different pads and their suitability for specific soil conditions, Himelrick (1991) concluded, that independently of the tolerance of the vine to soils with a wide range of pH (4.05-6.05), pronounced acidity depresses the development mainly of the root system. The author was found a high resistance to acid reaction of the hybrids of *V. labrusca* of pads SO_4, 3,309 Couderc of *V. vinifera*, and varieties Riesling and Chardonnay were most intolerant. The lower tolerance of the white varieties to acidic soil reaction, however, was not associated with different rates of absorption elements from theme, including Ca. All this experimental data were insufficient to formulate criteria for degree of injuriousness of the acidity and degree of lime necessity for vineyards, especially taking into account the combination pad - variety directions (white and red wine varieties) - variety - branches direction (Group A, B and C) - a branch of the variety.

There is a tendency, according to which the application of chemical ameliorants in acidic soils often leads to contradictory and sometimes to negative results, contrary to ameliorants expectations, as a result of an imbalance of the nutrient elements in the soils with liming and account of the specific requirements of the meliorated plants.

The planting practice of large part from the modern plantations of vineyards in the country on genetically acid soils, the proven in recent years adverse effects of soil acidity for the quality of wine grapes (Soyer et al., 1995) and higher requirements of the modern and most often introduced clonally-pads combinations to soil quality (Robredo et al., 1991) renewed the topicality of this task, and its technological complexity cause the necessity of testing new chemical liming ameliorants.

The use of hydrated lime and its high solubility is useful, because of the necessity from overcome the position inaccessibility of calcium contained ameliorants in the active root zone. The amelioration of acid soils in terms of existing durable plantations was technologically possible and causes a response in the plant at the implementation of compliance with the special conditions for conduction of chemical amelioration (Valcheva and Trendafilov, 2011).

In this sense, the aim of the current work was to research the influence of the hydrated lime in increasing rates over the acid-alkaline balance of Chromic luvisol and to determine the influence of liming on calcium and magnesium content in the grapes of four major wine varieties - Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Merlot.

MATERIALS AND METHODS

The interpreted results in this study were obtained as a result of field experiment with fertilization and liming of vineyards in fruit-bearing, planted over unsaturated Chromic luvisol in village of Mezek, Svilengrad municipality.

The experiment scheme was over the method of the long plots (Shanin, 1965), as in the allocation of the variants was included control variant without fertilization and liming, variant without liming, but with combined nitrogen, phosphorus and potassium fertilization and three increasing liming rates with hydrated lime – 1.0, 2.5 and 5.0 t/ha. The experiment was displayed for two years period, as until the beginning of the experiment this plantation was not liming and fertilization with mineral fertilizers neither as a stockpiling nor as current fertilization. This gave us reason to apply phosphorus and potassium fertilizers as rate of stockpiling fertilization - respectively 1.0 t/ha and 600 kg/ha active substance and nitrogen annually by 140 kg/ha active substance in the form of ammonium nitrate.

Each of the variants was displayed in three repetitions. The vineyard was planted in intercrop distances 2.20 m and interlinear distance between the vines – 1.10 m. The experiment was set after the end of the third vegetation period. All included varieties in the study were planted on pad Berlandieri X Riparia, selection Openheim 4 (SO_4), in vegetation experiment this pad shown good tolerance to deficit and excess of calcium and magnesium in the nutrient solution (Valcheva and Trendafilov, 2012).

The ameliorants, phosphorus and potassium fertilizers were applied in the period August - September. One month after liming were applied phosphorus and potassium fertilizers in the form respectively of triple superphosphate and potassium sulphate, and nitrogen fertilizer in the form of NH_4NO_3 was applied in February, before the beginning of the next vegetation.

The grapes from the four varieties, was studied immediately after harvest in the technological maturity, together with the massive harvest of each variety in the vineyards, in which was developed field lime experiment.

Harvested grapes, was separated from the stalks and grapes were prepared for analysis and analyzed to determine the content of nitrogen, phosphorus and potassium. The measurements were carried out in two consecutive years, coinciding with the periods of measuring of the indicators in foliage.

The content of calcium and magnesium in the grapes was determinate atomic absorption after dry aching (BDS EN 14082/03).

RESULTS AND DISCUSSIONS

The data for the content of calcium and magnesium in the grapes of the varieties, which were included in the study, were presented graphically in Figure 1 and Figure 2. The amendment of calcium and magnesium content in the fresh mass of the grapes depends on calcium content in the soil and it was a major component, which directly were influenced by liming.

In the first year of the study was not found statistically proven change of Ca content in the composition of fresh grape mass. The average Ca content in the variants without liming was 60 mg/kg - value, which was considered as low. In some of the variants and especially in those which were used lime rates of 1.0 and 2.5 t/ha hydrated lime was observed increase compared to the control variant, but under high variation in the repeats, and hence a high level of error.

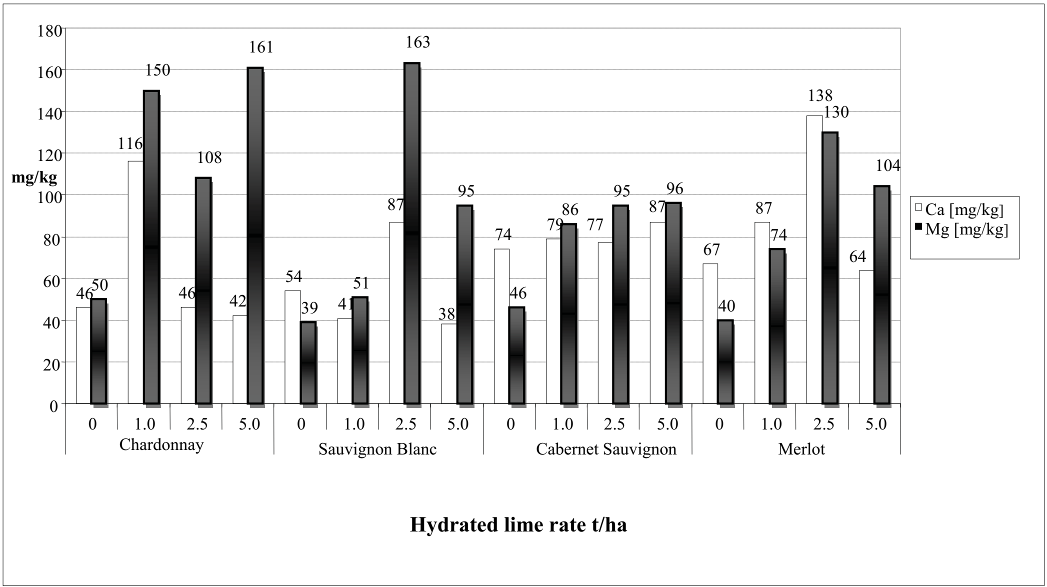

Figure 1. Contents of Ca and Mg in the grapes from varieties Chardonnay, Sauvignon Blanc, Merlot and Cabernet Sauvignon - first year of field experiment with lime

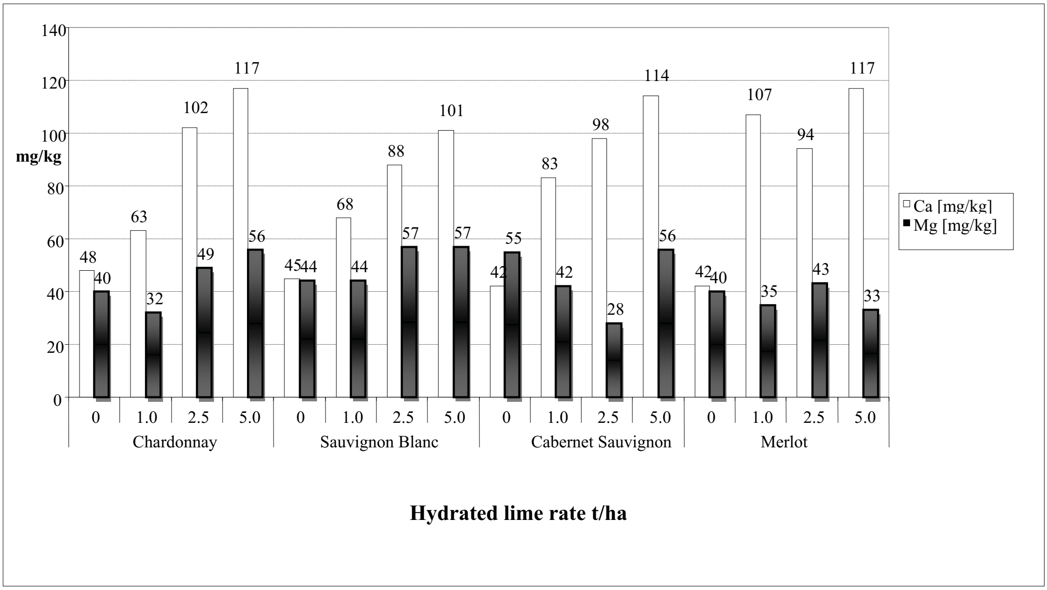

Figure 2. Contents of Ca and Mg in the grapes from varieties Chardonnay, Sauvignon Blanc, Merlot and Cabernet Sauvignon - second year of field experiment with lime

In the variants, in which were used rate of 5.0 t/ha lime material in some cases - for example, in Cabernet Sauvignon, Chardonnay and Merlot the available Ca amount in the grapes at ameliorative lime rate of 5.0 t/ha was lower compared to which was found for the lower ameliorative lime rates.

About magnesium was found statistically proven exceed at the variants with liming, compared to the variants without liming, but also at high level of dispersion of the values for the obtained results. Proven varietal differences in the content of Ca and Mg also were not found. The white varieties generally during the first year absorbed a larger amount of Ca, compared to the red varieties. About Mg this difference was insignificant.

During the second year of the conducted measurements the average Ca content in the control variants without liming was 44.6 mg/kg and probably the difference between the Ca content in the two consecutive years reflects the natural variation of the content of this element in unsaturated soils and without ameliorative interventions. It is clear therefore that the factor "liming" is superimposed on this variability, which from one side illustrates and deficit of the element Ca in the system soil-plant in the soil conditions at the lime experiment. In regard to Mg this variability in the two consecutive years of the experiment was not found.

The differences between the variants with liming and the control variant during the second year of the study in regard to the content of Ca in the grapes were statistically proven at a level of probability 95%. The value of Ca in the variants with liming rate of 1.0 t/ha was 37.95±24.12 mg/kg, in the variant with liming rate of 2.50 t/ha was 95.35±24.12 mg/kg and the variants with liming rate of 5.0 t/ha was 112.37±22.26 mg/kg. Independently from the relatively high values of dispersion in the said replications shows, that in condition of deficit of bases in the soil, apply of Ca containing ameliorants in the soil allows the plant to realize its ambition to reach the equilibrium concentrations of Ca in the reproductive parts. Firmly the ascending character of the dependence, reflecting the content of Ca in the grapes, as a function of lime rate shown, that in terms of the requirements of the plant until the second year after the experiment was set this equilibrium concentration has not been reached yet. This was in agreement with the data from the literature sources, according to which the average equilibrium content of Ca was about 20 mg/kg (Simon, 1978).

The liming with calcium containing ameliorants did not have proven effect on Mg content in the grapes, but in some of the varieties (Cabernet Sauvignon) shown tendency for reduction of its average level when liming.

The varietal differences in the content of Ca and Mg in the composition of the grapes were inessential in all varietal samples and in the groups "White" and "Red" wine varieties. This allows us to deduce the hypothesis that the composition of plant biomass on the vine in most was genotypic deterministic and secondly depends on the complex of growing conditions.

The presence of acid and especially acidic and weakly buffer in acidic soils, for which is typical low Ca^{2+} content in the sorption complex determine strong deficit, who compensate by advantage in its partial or full compensation through ameliorative interventions. To achieve it, however it takes time more than one growing vegetation. It is possible only after attainment of equilibrium concentrations of the ions in the plant cell, the plant can stably respond and with a change in its technological characterizations, as they have a lower biological priority.

CONCLUSIONS

The liming in a field experiment affects the composition of the grape production and leads to a positive variation of calcium content in the composition of the grapes. Probably this is not durable tendency, which found most clearly in the period immediately after ameliorative intervention, when plants absorb and redistribute relatively larger amounts of calcium from ameliorant before realized its full interaction with the soil.

The varietal differences on the content of Ca and Mg in the composition of the grapes were inessential, in all varietal sample and in the groups "White" and "Red" wine varieties, which allows us to deduce the hypothesis, that the composition of plant biomass on the vine in most was genotypic deterministic and secondly depends on the complex of growing conditions.

REFERENCES

BDS EN 14082/03 Footstufs – Determination of trace elements – Determination of lead, cadmium, zinc, copper, Iron, and chromium by atomic absorbtion spectrometry (AAS) after dry aching.

Himelrick D.G., 1991. Growth and nutritional responses of nine grape cultivars to lowsoil pH. HortSci.26: 269-271.

Kadrev T., Peev H., 1980. Agrochemical and physiological bases of the quality of the crop production.

Palaeev T., Totev T., 1970. Soil acidity and Agronomy methods for its elimination. Monograph.

Robredo L-M., Junquera B., Gonzales-Sanjose M.L., Barron L.J.R., 1991. Biochemical events during ripening of grape berries, Italian Journal of Food Science, 3(3): 173-180.

Shanin 1965. Methodology of the field experiment. Publishing House of the Bulgarian Academy of Sciences, Sofia.

Simon E.W., 1978. The symptoms of calcium deficiency in plants. New Phytologist; Jan, Vol. 80, Issue 1, p. 1-15.

Soyer J.-P., Molot C., Barbier J.E., 1995. Fertilisation potassique, repartition des cations et des acides dans les compartiments de la baie et acidite du vin. Oenologie 95, 5e Symposium International d'Oenologie, Coordinator Lonvaud-Funel A., Univ. de Bordeaux, TEC-DOC, p. 19-23.

Valcheva V., Trendafilov K., 2011. Influence of liming with hydrated lime on the acid-alkaline balance in the root zone of wine grape varieties. Scientific reports from International Conference 100 years soil science in Bulgaria, first part, 16-20 May, Sofia, p. 474-479.

Valcheva V., Trendafilov K., 2012. Response of vine rootstocks to the content of Ca and Mg in nutrient solutions. Agricultural Science and Technology, vol. 4, no. 4, p. 392-397.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF NUTRITIONAL STATUS ON FRUIT CRACKING OF FIG (*Ficus carica* L. cv. Sarılop) GROWN IN HIGH LEVEL BORON CONTAINED SOILS

Mehmet AYDIN, Mustafa Ali KAPTAN

Adnan Menderes University, Faculty of Agriculture, Plant Nutrition Department, Aydın – 09100, Turkey

Corresponding author email: makaptan@adu.edu.tr

Abstract

Fruit cracking is one of the important quality parameter in dried fig marketing. Two different research have been carried out to determine the effect of nutritional status on fruit cracking of fig (Ficus carica L. cv. Sarilop) grown in high level boron (B) contained soils of Aydın, Turkey. In the first research, fig trees were grouped depending on cracked fruit ratio. Nutrient contents of soil, leaf and fresh fruit taken from each group were evaluated by cracked fruit ratio of fig trees. In the second study, K_2SO4, NH_4NO_3, $CaCl_2$, $MgSO_4$ and H_3BO_4 fertilizers were sprayed to the trees. Comparing with reference values of leaf and fruit, calcium (Ca) content was low but B content was high while other nutrient contents were in normal range in both experiments. Cracked fruit ratio was given positive correlation coefficients by soil B , leaf B and peel B contents; and negative correlation by soil potassium (K), leaf Ca and peel Ca contents, soil Ca/B, leaf Ca/B, soil Ca/(K+Mg+Na) and fruit Ca/(K+Mg+Na) ratios.

Key words: *Fig tree, fruit cracking, calcium, boron.*

INTRODUCTION

More than 50% of world dried fig is produced in Turkey. Especially Sarılop cultivar is very suitable for drying due to high sugar content, thick pulp and thin skin features (Işın et al., 2003). Some of important quality features in dried fig can be enumerated as disease damage, spots due to excessive moisture or radiation, fruit cracking, eaten by bird or insect (Anonymous, 2006).

Fruit cracking may result from the fluctuation of soil moisture and relative humidity, dry wind or heavy irrigation following a dry spell (Aksoy and Akyüz, 1993; Hepaksoy et al., 2007). Plant cell wall thickness and stability were affected by calcium and also nitrogen, potassium, magnesium and fruit size. In general, these elements were deficient in fig plantation of Great Meander Valley (Aksoy and Anaç, 1993; Aşkın et al., 1997).

Cracked fruit ratio in dried fig is reduced with calcium fertilization (Aksoy and Anaç, 1994). Because, calcium stabilizes cell walls, maintains membrane stability and permeability, alleviates damage that is caused by freezing and thawing stress. Calcium also plays an essential role in all of the basic categories of plant defense against diseases; maintenance of membrane integrity; signalling multiple pathways of defense through enzyme activation; release of phytoalexin, an antimicrobial agent; repair and reinforcement of damaged membranes and cell walls; and synthesis of structural barriers (Marschner, 1995; McLaughlin et al., 1999).

Ficus carica is known as a sensitive crop on boron toxicity (Adriano, 1986). In the saturation extracts of soils, 0.7 mg B kg^{-1} was indicated as the approximate safe limit for sensitive crops including fig tree (Anonymous, 2007). One of the most widespread dried fig plantation area in the world is Germencik-Incirliova belt of Aydin in Turkey. However, this area is under the boron toxicity threaten. In the lowland of Germencik, high (2.0-4.99 mg B kg^{-1}) and toxic level boron (>5 mg B kg^{-1}) contained soil ratio was 75% and 25%, respectively. On the other hand ground water boron content ranged from 0.35 mg B L^{-1} to 4.98 mg B L^{-1} with the mean of 3.3 mg B L^{-1}. This water is not suitable for sensitive and moderately sensitive crops. Nevertheless, it was used in agriculture because of scarcity in irrigation water (Aydın and Seferoğlu, 1999).

Biochemical role of boron is implicated in three main processes: keeping cell wall structure, maintaining membrane function, and supporting metabolic activities (Bolanos et al., 2005). Although considerable agronomic importance, our understanding of B toxicity mechanism is still not completely understood, and remains an open question (Ruiz et al., 2003). Boron toxicity may appear in three ways: (1) disruption of cell wall development; (2) metabolic disruption by binding to the ribose moieties of ATP, NADH or NADPH; and (3) disruption of cell division and development by binding to ribose, either as the free sugar or within RNA (Stangoulis and Reid 2002). Under B toxicity, reactive oxygen species formation and antioxidant enzyme activities are not critical factors of the tolerance mechanism (Karabal et al., 2003).

Increasing Ca content or decreasing B content in fruit skin directly depends on mainly available Ca or B content in soil and transpiration rate (Goldberg, 1993; Tadesse et al., 2001).

There is little research on the nutritional status of dried fig. Effect of Ca and other nutrients on cracked fruit formation in soil contained high level boron is not well understood. Interpretations on this subject were explained mainly by some assumption and clear data were not available. The purpose of this research is to explain effect of nutritional status on cracked fruit formation in dried fig tree.

MATERIALS AND METHODS

Soil Conditions and Fruit Cracking Experiment

This research has been carried out at Erbeyli, Incirliova district of Aydın in Turkey in August 2006. Fig plantation (*Ficus carica* L. cv Sarılop) was about 4 ha and 40-45 years old. Cracked fruit was defined as cracking length was higher than 1/3 of fruit dimension (Anonymous, 2006). Fig trees were grouped depending on cracked fruit ratio as <0.2%, 10-12% and >20% with namely low, moderate and high, respectively at the onset of fruit ripening period in August. Six trees from each group were marked.

Samples were taken as soil from 0-30 cm, leaf from third node and fresh fig fruits with six replications. Physical and chemical properties of soil samples were analyzed by Kacar (1972). For nutrient element analyses, leaf and fruit samples were dried in a forced-air oven at 70°C for 72 hours. The dried leaf samples were ground in a stainless steel Wiley mill. The dried leaf samples were dry ashed in a muffle furnace at 500 °C for 6 h for the determination of P, K, Ca, Mg, and B. The concentrations of Ca and Mg were determined by atomic absorption spectrophotometry (Varian SpectrAA 220FS), K and Na by flame photometry (Jenway PFP7) and P by spectrophotometry (Shimadzu UV-160A) (Kacar, 1972). Total N content of dried leaf samples was analyzed by Kjeldahl digestion method (Kacar, 1972). Boron was determined by azomethine-H method (Wolf, 1974).

Some soil characteristics range of the experimental area were as follows: texture loamy, total salt 0.021-0.024%, organic matter 1.19-1.25%, $CaCO_3$ %2.01-2.84 and pH (1:2.5 water) was 7.58-7.71.

Foliar Fertilizer Experiment

Foliar fertilizer application experiment was established at Tekin, Germencik district of Aydın in Turkey. About 1 ha and 25-30 years old fig plantation was chosen. Average cracked fruit ratio was over 20% in the recent years. Some soil characteristics of the experimental area were as follows: texture loamy, $CaCO_3$ 2.55%, pH (1:2.5 water) 7.76, total salt 0.032%, organic matter 1.31%, total N 0.029 mg kg^{-1}. The concentrations of NH_4OAC extractable K, Ca, Mg and Na were as follows (mg kg^{-1}): 334, 3116, 449 and 41.2 respectively. $NaHCO_3$-available P was 7.76 and Azomethine-H extractable B was 3.72 mg kg^{-1} (Kacar, 1972).

Experimental design was completely randomized with four replications. Treatments were control, K_2SO4, NH_4NO_3, $CaCl_2$, $MgSO_4$ and H_3BO_4. Elemental concentrations of N, P, Ca, Mg and B in the solution were arranged as 0.25% (w/v) and added sodium carboxymethyl cellulose (2.5 mL L^{-1}). Applications were done three times with 8-day intervals starting from 28th of June. Leaf and fruit sampling were taken at the onset of fruit ripening period in August 2007 and carried to the laboratory in cool box. Fruits were peeled manually with a knife, paying attention not to include the fruit pulp. Leaf and peel analysis were done same ways as the first experiment.

Statistical analysis

Data collected from soil and plant samples were analysed with a completely randomized treatment structure. The statistical analysis was performed with the JMP statistical software system (JMP 5.0.1a 1989-2002 SAS Institute Inc.). Mean separations were performed by the LSD-test at a significance level of 0.05.

RESULTS AND DISCUSSIONS

Some chemical properties of soil, leaf and fresh fruit depending on cracked fruit ratio of fig trees are given in Table 1. Soil taken from the first experimental area where fig trees having a high cracked fruits ratio had higher ($p<0.05$) B contents while they have lower in K and Ca contents. In terms of N, P, Mg and Na contents there was no difference among the soil groups.

Table 1. Nutrient contents of soil, leaf and fruit depending on cracked fruit ratio of fig trees

Nutrient content		**Cracked fruit ratio**			**Mean**
		Low (>2%)	**Moderate (8-12%)**	**High (>20%)**	
Soil	N, mg kg^{-1}	0.030	0.029	0.033	0.031
	P, mg kg^{-1}	8.35	9.56	8.23	8.71
	K, mg kg^{-1}	151 a	163 a	115 b	143
	Ca, mg kg^{-1}	1902 a	1840 b	1661 b	1801
	Mg, mg kg^{-1}	299	336	345	327
	Na, mg kg^{-1}	13.2	18.3	15.0	15.5
	B, mg kg^{-1}	2.01 c	2.59 b	3.69 a	2.76
Leaf	N, %	1.52	1.58	1.54	1.55
	P, %	0.076	0.081	0.080	0.079
	K, %	1.273 a	1.062 b	1.165 b	1.167
	Ca, %	1.371 a	1.198 b	1.200 b	1.256
	Mg, %	1.110	1.110	1.168	1.129
	Na, %	0.037	0.048	0.051	0.045
	B, mg kg^{-1}	475 c	527 b	563 a	522
Fruit	N, %	0.631	0.653	0.654	0.646
	P, %	0.105	0.112	0.107	0.108
	K, %	0.632	0.601	0.711	0.648
	Ca, %	0,253	0,207	0,269	0.243
	Mg, %	0,196	0,211	0,185	0.197
	Na, %	0,0082	0,0084	0,0078	0.0081
	B, mg kg^{-1}	169 b	206 a	195 a	190

* Different letters in the same row indicate significant differences ($p<0.05$)

In the leaf samples, K and Ca contents having a high cracked fruit ratio were higher ($p<0.05$) while they were lower in B content. There was no difference ($p<0.05$) among the leaf sample groups for Mg and Na contents. On the other hand, in the fresh fruit sample analysis, statistically differences ($p<0.05$) were found among the B content while K, Ca, Mg and Na contents were not found statistically different.

Evaluation of K, Ca, Mg and Na content in plant tissue is required not only for their specific concentrations but also for their ratio. Mean nutritional problems in the experimental area are low calcium content and toxic level of B supply in soil. Correlation coefficients between cracked fruits ratio and measured observations were given in Table 2. Cracked fruit ratio has a positive correlation coefficient with soil and leaf B contents ($p<0.01$); and negative correlation with soil K and leaf Ca contents, soil Ca/B, fruit Ca/(K+Mg+Na) ratio ($p<0.01$), leaf Ca/B and soil Ca/(K+Mg+Na) ratio ($p<0.05$).

Table 2. Correlations between some nutritional status components and cracked fruit ratio of fig trees

Correlations with cracked fruit ratio	Correlation coefficients		
	Soil	Leaf	Fruit
N	0.386	0.012	0.126
P	-0.081	0.076	0.125
K	-0.508*	-0.133	0.279
Ca	-0.751**	-0.596**	0.184
Mg	0.219	0.297	-0.199
Na	0.170	0.218	-0.011
B	0.899**	0.577**	0.145
K/Ca	-0.398	0.102	0.188
K/B	-0.914	-0.451	0.136
Ca/(K+Mg)	-0.206	-0.307	-0.022
Ca/(K+Mg+Na)	-0.536*	-0.389	-0.639**
Ca/B	-0.932**	-0.520*	0.146

* and ** denote significant r values at $p<0.05$ and $p<0.01$ respectively

In the second study, there were some boron toxicity symptoms in leaf blades at the beginning of the experiment. However, foliar fertilizer applications did not result in any extra damage on leaf and fruit in fig trees. The fruit maturity delayed about 4 days in ammonium nitrate applied trees. Effect of foliar fertilizer applications on nutrient content of leaf and fresh fruit peel was shown in Table 3. In generally, N, K, Ca, Mg, B content of leaf and peel increased statistically in respect to relevant nutrient source as ammonium nitrate, potassium sulphate, calcium chloride, magnesium sulphate and boric acid respectively. Only peel Mg concentration was not changed statistically.

Table 3. Effect of foliar fertilizer applications on the leaf and peel nutrient content and cracked fruit ratio of fig trees

Nutrients	Control	NH_4NO_3	K_2SO_4	$CaCl_2$	$MgSO_4$	H_3BO_4
			Leaf nutrient contents			
N, %	1.38 b*	1.54 a	1.36 b	1.30 b	1.33 b	1.32 b
K, %	1.59 b	1.52 b	1.87 a	1.54 b	1.64 b	1.52 b
Ca, %	1.89 b	1.96 b	1.92 b	2.45 a	1.98 b	1.95 b
Mg, %	0.98 b	0.98 b	1.03 b	1.04 b	1.36 a	0.99 b
B, mg kg^{-1}	418 b	382 b	315 b	391 b	412 b	570 a
			Peel nutrient contents			
N, %	0.49 b	0.53 a	0.47 b	0.47 b	0.44 b	0.48 b
K, %	0.99 b	1.16 b	1.23 a	1.09 b	1.19 b	1.18 b
Ca, %	0.63 b	0.63 b	0.67 b	0.80 a	0.67 b	0.61 b
Mg, %	0.11	0.12	0.11	0.11	0.14	0.11
B, mg kg^{-1}	33.1 b	33.2 b	33.0 b	29.7 c	33.0 b	35.7 a
			Cracked fruit ratio			
	33.7 b	29.1 bc	28.6 c	10.0 d	30.0 bc	42.9 a

*Different letters in the same row indicate significant differences ($p<0.05$)

Cracked fruit ratio was affected significantly by foliar fertilization (Table 3). It was lowest (10.0) in $CaCl_2$ and highest (42.9) in H_3BO_4 treatments. The order was $CaCl_2$< K_2SO_4< NH_4NO_3< $MgSO_4$< Control<H_3BO_4 with the values of 10.0, 28.6, 29.1, 30.0, 33.7 and 42.9, respectively. Comparing with the control, cracked fruit ratio was decreased significantly in Ca and K applications. According to Duncan's multiple range test, boric acid placed in the first place followed by control and the last group was formed by ammonium nitrate, potassium sulphate, and magnesium sulphate.

Using the mean values of treatments, cracked fruit ratio was positively correlated by peel B content as Y= 5.530B-153.2 (R^2=0.965), and negatively correlated by peel Ca content as Y=-146.9Ca+127.2 (R^2=0.895). Similar trends were found for leaf Ca and B concentrations. Nevertheless, their determination coefficient values were lower than that of fruit skin's.

The mean values of the experiment were evaluated as similar for N, K and Mg; low for Ca; high for B when they compared with the relevant studies in the region. For example, reference values of mineral elements in dried fig leaf were found for N, P, K, Ca, Mg as 1.695-1.709%, 0.088%, 1.070-1.161%, 3.568-3.614%, 0.658-0.721%, respectively (Aksoy et al., 1987). Calcium concentration in the fig leaf varied 0.68-2.98 % from April to November (Ersoy et al., 2003) and 2.22-5.78% at the fruit maturity (Anaç et al., 1987).

Several researchers showed that cracked fruit ratio in fig was decreased by Ca applications (Aksoy and Anaç, 1994; Hepaksoy et al., 2007). However, calcium movement into the fruit decreases as the season progresses. Mg, K, P, and N increase along with the translocation of photosynthesis. This reduces the ratio of Ca with other elements, particularly Mg and K that it may result in the physiological disorder (Tadesse et al., 2001).

Fig plant is known as sensitive to boron toxicity (Anonymous, 2007). In the experimental area soil boron concentration ranged from 1.60 to 3.94 mg kg^{-1} that is quite high for sensitive crops (Silanapaa, 1990; Anonymous, 2007). Soluble B concentrations play a major role in the occurrence of B toxicity symptoms (Wimmer et al., 2003). The intercellular soluble B concentrations of basal leaf parts of nonsalt-stressed wheat plants closely reflected the external B supply. The slight tendency towards higher intercellular soluble K^+ concentrations might indicate some membrane damage resulting in higher K^+ leakage into the apoplastic space (Wimmer et al., 2003).

Molassiotis et al. (2006) reported that boron toxicity resulted in increasing ROS activities in apple. Excess boron applications enhanced lipoxygenases (LOX) activity, lipid peroxidation (measured as MDA content) and H_2O_2 accumulation and resulted in diminution of the proline (PRO) content. This kind of processes was likely happened in our study. Besides, Ca deficiency in plant tissue decreased cell wall strength. Thus, fruit cracking increased.

In this study, Ca concentrations were about half of the reference values while B concentrations were was about 4/3 of toxic level in the fig leaves (Jones et al., 1991). In terms of cell wall stability, both cases had a negative effect. Thus, Ca and B contents with Ca/B ratio in soil and plant tissue are main factors on fruit cracking. Although available K content of soil range was close to optimum level, it was effective on fruit cracking. In addition, low tissue Ca content resulted in negative significant correlations between Ca/(K+Mg+Na) ratio and fruit cracking. Because there are antagonistic relations between Ca and other alkalines such as K, Mg and Na (Marschner, 1995).

CONCLUSIONS

The result of present study indicates that Ca and B contents with Ca/B ratio in soil and plant tissue are probably main factors on fruit cracking. Increasing B, K, Mg and Na uptake increases severity of Ca deficiency with the result of higher cracked fruit ratio. These parameters with biochemical composition of fruit skin can be further investigated and tested in screening for cracking.

REFERENCES

Adriano D.C., 1986. Trace elements in the terrestrial environment. Springer-Verlag, New York, p. 73-79.

Aksoy U., Akyuz D.D., 1993. Changes in K, Ca and Mg contents in different parts of the fig fruit during development. In: optimizing of Plant Nutrition. Kluwer Academic Publ., p. 305-309.

Aksoy U., Hakerlerler H., Anaç D., Düzbastılar M., 1987. Soil properties and mineral content of Sarılop fig orchards in Germencik and relationship between mineral nutrients and yield and fruit quality parameters (in Turkish). Taris Res. Developing Center, Bornova, p. 34.

Aksoy U., Anaç D., 1993. Determination of optimum soil and plant nutrients for higher yield and quality in fig production. Optimization of plant nutrition, Kluwer publ., p. 309-313.

Aksoy U., Anaç D.D., 1994. The effect of calcium chloride application on fruit quality and mineral content of fig. Acta Horticulturae. 368: 754-762.

Anaç D., Aksoy U., Eryüce N.. 1987. Studies on macro and some of the micro nutrient status of fig trees in the Aegean Region through leaf analysis. 1. The Big Meander Basin (in Turkish). Journal of Aegean University Agricultural Faculty, 24 (1): 75-90.

Anonymous, 2006. Dried Figs. Turkish Standard. TS 541. ICS 67.080.10.

Anonymous, 2007. www\B\US Salinity Laboratory. Crop Selection for saline soils. Web adaptation from Handbook 60 (p. 65-67. Originally published in 1954.

Aşkın A., Ceylan Ş., Yener H., 1997. A study on the nutritional status of fig orchards in Birgirimağzı. In: Proceedings of the First Internatıonal Symposium on Fig. Acta Horticulturae. 480: 239-246.

Aydın G., Seferoglu S., 1999. Investigation of boron concentration of some irrigation waters used in region for plant nutrient and soil pollution. www.toprak.org.tr/ isd/isd_17.htm.

Bolanos L., Lukaszewski K., Bonilla I., Blevins D., 2005. Why boron? Plant Physiol. Biochem., 42(11): 907-12.

Ersoy N., Gozlekci S., Kaynak L., 2003. Studies on changes of carbohydrates in the leaves of fig (*Ficus carica* L. cv.Beyaz). Acta Horticulturae, 605: 263-275.

Goldberg S., 1993. Chemistry and mineralogy of boron in soils. p. 3-44. In Boron and its Role in Crop Production. (Ed. U.C. Gupta). CRC Press, Boca Raton, FL.

Hepaksoy S., Aksoy U., Can H.Z., Ul M.A., 2007. Determination of relationship between fruit cracking and some physiological responses, leaf characteristics and nutritional status of some pomegranate varieties. Chieam, p. 87-92. www: resources.chiam.org.

Işın F.T., Çukur G., Armağan V.E., Çobanoğlu F., 2003. A research on exportation opportities of Turkish dried and fresh figs within the framework of world trade organization agreements and from the viewpoints of free trade agreement and possible full-membership of Turkey to European Union. TUBITAK Project No: TOGTAG/TARP 2574-10. Ankara.

Jones J.B., Wolf B., Mills H.A., 1991. Plant Analysis Handbook, p. 1-213. Micro-Macro Publishing, Inc., USA.

Kacar B., 1972. Toprak ve Bitkinin Kimyasal Analizleri (Chemical Analysis of Plants and Soil), Ankara Üniversity, Ankara, Turkey.

Karabal E., Yücel M., Hüseyin A.Ö., 2003. Antioxidant responses of tolerant and sensitive barley cultivars to boron toxicity. Plant Science, 164: 925–933.

Marschner H., 1995. Mineral Nutrition of Higer Plants, Academic Pres, Second Edition, p. 379-396.

McLaughlin S.B., Wimmer R., 1999. Calcium physiology and terrestrial ecosystem processes. Tansley Review No. 104, New. Phytol., 142: 373–417.

Molassiotis A., Sotiropoulos T., Tanou G., Diamantidis G., Therios I., 2006. Boron-induced oxidative damage and antioxidant and nucleolytic responses in shoot tips culture of the apple rootstock EM 9 (Malus domestica Borkh). Environ Exp. Bot. 56 (1): 54-62.

Ruiz J.M., Rivero R.M., Romero L., 2003. Preliminary studies on the involvement of biosynthesis of cysteine and glutathione concentration in the resistance to B toxicity in sun over plants. Plant Sci., 165: 811-817.

Silanpaa M., 1990. Micronutrient Assessment at the country level: an international study. FAO Soils Bulletin, Rome.

Stangoulis J.C.R., Reid R.J., 2002. Boron toxicity in plants and animals. In Boron in Plant and Animal Nutrition (eds. Goldbach H.E., B. Rerkasem, M.A. Wimmer, P.H. Brown, M. Thellier and R.W Bell), p. 227-240. Kluwer Academic, New York, USA.

Tadesse T., Nichols M.A., Hewett E.W., Fisher K.J., 2001. Relative humidity around the fruit influence the mineral composition and incidence of blossom-end rot in sweet pepper. J. Hort. Sci. Biotech., 76: 9-16.

Wimmer M.A, Mühling K.H., Läuchli A., Brown P.H., Goldbach H.E., 2003. The interaction between salinity and boron toxicity affects the subcellular distribution of ions and proteins in wheat leaves. Plant, Cell and Environment. 26:1267-1274.

Wolf B., 1974. Improvements in the Azomethine-H method for the determination of boron. Comm. in Soil Sci. and Plant Anal., 5(1): 39-44.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE MOVEMENT OF COPPER, ZINC AND MANGANESE IN THE SOIL OF CUT FLOWER PRODUCTION GREENHOUSES AND FIELDS

Levent BAŞAYİĞİT[1], Pelin ALABOZ[1], Onur ÖZÇER[2], A. Ali IŞILDAR[1]

[1]Suleyman Demirel University, Agriculture Faculty, Soil Science and Plant Nutrition Department, Çünür, 32260 Isparta, Turkey
[2]Ankara University, Agriculture Faculty, Soil Science and Plant Nutrition Department, Turkey

Corresponding author email: leventbasayigit@hotmail.com

Abstract

In the study, the vertical movement and accumulation of Cu, Zn and Mn added to the soil for agricultural practices such as the uses of pesticides and fertilizers in the greenhouses of cut flower production were examined and their changes in the soil profile were determined.
For the comparisons, soil samples were taken from greenhouses and fields both before and after harvest at the depths of 0-5, 5-10, 10-20, 20-40, 40-80, 80-100 cm. The extractable Cu, Zn and Mn contents were determined using DTPA method. The Zn and Mn contents were found to be significantly different in terms of depths, sampling areas and seasons while Cu content did not show significant differences among samples
As a result, it was observed that Zn and Mn added to the soil for agricultural practices leached out of the soil, but Cu tended to accumulate in the soil.

Key words: *heavy metal, greenhouse soils, leaching, accumulation.*

INTRODUCTION

Nowadays, while green-house growing develops, in the world cut flower production is also rapidly increased. Production of cut flower areas which is spread 72% Asian, 13% South American, 9% Europe (AIPH, 2013). While the most exporting countries are Netherlands, Colombia, Ecuador, Kenya, Ethiopia, imports is USA, Germany, England, Russia (Anonymous, 2013). Rose, carnations and chrysanthemums are in the first row among the species that are most income.
Cut flower is produced in the field in summer but, cold periods which is usually plastic and glass greenhouse. According to the soil properties special fertilizers and pesticides applied to plants. Before the sowing they should control pesticides especially gerbera, which is very sensitive species. And they should also applied fertilizer until the time of harvest. The species type of pesticides and fertilizers were varying according to the type of plant.
In the cut flower production, pesticides and fertilizer are used more uncontrolled than agricultural products as food. Remaining on the plants of pesticides is 0.015 to 6% and the other parts are spread environment as chemical contaminants (Yıldız et al., 2005). Chemical contaminants are including heavy metals and they have the structure of fertilizers and pesticides. Phosphorus fertilizer manufactured from phosphoric acid that has include Cd, Pb, Ni and As. Di ammonium phosphate, triple super phosphate and compound fertilizer are have quite high Cd content (Köleli and Kantar, 2006).
Plants need a lot of material to perform many physiological events. That is taking nutrients from the soil through the roots right up to human and animal by the food chain (Tok, 1997). Heavy metal uptake changes according to plant species. Caution exchange capacity, the root surface area, soil pH, organic substances, microorganisms can affect heavy metal uptake (Davies, 1995).
A lot of metal are insoluble form in soil. They convert soluble form by the acidification of the plasma membrane proton pump in the root. Dissolve elements transported by diffusion and mass movement from apoplast to endodermis. If the casparin strip in endodermis closed the apoplast, water and nutrient should moved to the endodermis which is plasma membrane to enter the cell through the cell (simplast or

transmembrane path). Nutrients are moved towards the leaves with simplas transport through the xylem tubes. This event, heavy metals are received by plants and they cause toxicity. Slowdown in growth and development, impaired enzyme activity in root damage, deterioration in storage activities, the decline in photosynthetic activity, a reduction in the uptake of other nutrients and productivity slowdown are observed (Yağdı et al., 2000).
It was known that pesticides are cause the rise of heavy metal concentrations in soil and water resources (Doğan, 2003). The source of copper contamination in the soil and water is copper-based fertilizers and fungicides used agricultural (Oliveiro-Filho et al., 2004).
While vegetable greenhouses in the surface soil (0-40 cm) Cu content creates pollution in 15 years, subsurface soil (40-100 cm) Cu and Cd content reach in 20 years (Huang et al., 2011).
In this study, we will be searched for any clues of the dangers of heavy metal pollution cut flower production areas in the soil, depending on the intensive use of fertilizers and pesticides that leached.

MATERIALS AND METHODS

This study was conducted in the Isparta province of Turkey (30°33’ 18°38” D, 37°47’ 47°27” K). The location of the field is given in Figure 1. Cut flowers have been produced in greenhouses in this area for approximately 15 years.
Research was conducted in greenhouses and fields before harvest and after harvest. Six sampling depths were selected. Soil samples were taken at 0-5, 5-10, 10-20, 20-40, 40-80 and 80-100 cm depths.
Texture analysis was performed according to the Bouyoucos hydrometer method (Gee and Bauder, 1986). Soil reaction and electrical conductivity were determined using EC and pH metres (McLean, 1982) with a glass electrode in a 1:2.5 soil water suspension (U.S. Salinity Laboratory Staff, 1954). Available Cu, Zn and Mn content was determined with DTPA and used A.A.S. The data were analysed with analysis of variance techniques using the Minitab software package (Minitab, 2014).

Figure 1. Location of the study area

RESULTS AND DISCUSSIONS

The physical and chemical properties of the soil samples are presented in Table 1. The soil samples from the greenhouses (S1, S2) and the fields (D3, D4) comprised coarse soils. The pH of the greenhouse soil was found to be 4.8-6.1, while the soil samples from the field were between 5.9 and 6.7. The electrical conductivity of the soil was found to be between 74.5 and 194.3 µmhos/cm for the greenhouse samples and between 50.3 and 104.8 µmhos/cm for the field samples.

Table 1. Some properties of soil samples

Depth cm	pH (1:2.5)				EC (1:2.5) µmhos/cm			
	1	2	3	4	1	2	3	4
0-5	5.5	5.7	6.1	6.3	89.0	152.0	91.7	82.7
5-10	5.2	5.5	6.5	6.6	75.4	194.3	87.3	63.1
10-20	5.5	5.5	6.7	5.9	97.0	127.7	104.8	51.2
20-40	5.1	4.8	6.6	6.7	92.6	122.8	90.0	63.2
40-80	5.9	5.5	6.3	6.2	105.0	113.6	68.2	50.8
80-100	6.1	6.1	6.5	6.1	111.9	101.1	87.7	61.0

Depth cm	TEXTURE															
	Clay (%)				Silty (%)				Sand (%)				Texture Class			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
0-5	6.8	10.2	7.1	9.6	11.5	9.2	15.9	21.9	81.3	80.6	77.0	68.4	LS	LS	SL	SL
5-10	8.6	8.8	9.1	11.1	10.5	10.6	12.2	21.6	80.4	80.6	78.7	67.3	LS	LS	SL	SL
10-20	8.1	9.1	6.5	9.1	12.2	11.5	14.9	19.7	79.7	79.4	78.7	71.2	LS	LS	SL	SL
20-40	8.8	9.1	9.09	9.5	13.6	14.1	13.1	22.0	77.6	76.8	77.8	68.5	SL	SL	SL	SL
40-80	10.5	8.8	5.9	10.5	13.6	13.6	12.6	19.0	76.3	77.6	81.5	70.4	SL	SL	LS	SL
80-100	9.1	9.1	9.7	5.7	11.8	15.6	14.5	12.2	79.0	75.2	75.7	77.6	SL	SL	SL	SL

According to Gallbally and Gallbally (1997) carnations grow optimally at pH values ranging 5.5-7.5, and soil saturation extracts with an electrical conductivity ranging 0.7-1.3 mmhos/cm improve production efficiency and quality. Arı (1993) mentioned that soil texture can vary from sandy loam to sandy clay loam.

Conditions with high pH reduce the nutrient uptake of plants, this includes microelements such as iron, zinc, manganese, copper (Kacar and Katkat, 2010). The study area had a pH value that was suitable for plant nutrient uptake.

Soil Mn Content

The Mn content of the soil is given in Table 2. For both samples the Mn content was reduced depending on the depth of the samples. While the Mn content of the greenhouse soils was found to be between 2.5 and 14.4 mg/kg, the Mn content of the field soil samples were found to be between 2.1 and 4.7 mg/kg. In addition, the Mn content of the greenhouse soils was approximately three times higher than the field samples for the 0–40 cm depth. The Mn content of the soil samples showed significant changes depending on the depth, and they were also found to be significantly different between locations ($P < 0.005$). After harvest, the soil Mn content from the greenhouse was found to be between 1.8 and 12.7 mg/kg, while the Mn content in the field soil samples was between 1.4 and 6.4 mg/kg. For both of the samples taken at the greenhouse before and after harvest, there were no statistically significant differences in the Mn content.

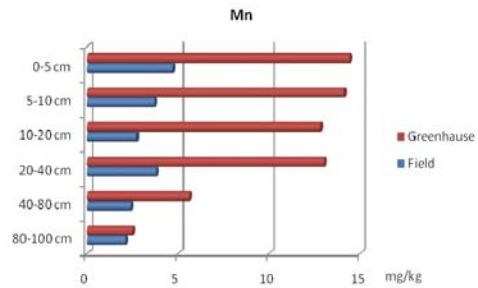

Figure 2. The content of Mn according to depth

According to Lindsay and Norwell (1969) a DTPA extractable Mn content of 14-50 ppm at a depth of 0–10 cm for greenhouse soil was classified as 'adequate'. They also found the extractable Mn to be 4.2 ppm in the field and classified this as 'inadequate' (4-14 ppm).

Alagöz et al. (2006) investigated the properties of soil used to grow carnations in Antalya, Turkey. They found the extractable Mn content for the 0-10 cm and 10-20 cm depths was 2.96-62.16 and 3.49-33.06 ppm, respectively.

Table 2. Soil Mn content (mg/kg)

Place	0-5cm	5-10cm	10-20cm	20-40cm	40-80cm	80-100cm	Mean
Greenhouse	14.4a	14.1ab	12.8abc	13.0abc	5.6abcd	2.5d	10.4
Field	4.7bcd	3.7cd	2.7d	3.8cd	2,4d	2.1d	3.2
Mean	9.6	8.9	8.4	7.7	4	2.3	
Sources of variation	P			F			
Place	0.000			55.44			
Depth	0.005			6.15			
Place*Depth	0.043			3.26			

Soil Zn content

The Zn content of the soil in the greenhouses was found to be between 0.5 and 2.7 mg/kg. In the field samples the Mn content was found to be between 0.3 and 1.8 mg/kg. The Zn content of soil was different between the greenhouse and field samples. Moreover, for both the greenhouse and field soil samples there was a reduction in Zn at lower depths. The Zn content of the greenhouse soil for the 0-40 cm depths was three times higher than for the field soils. The reduction was observed from a depth of 80 cm. These depth-dependent changes in the Zn content were found to be statistically significant. The highest average Zn content was found at the 0-5 cm depth. These data show that agricultural practices increased the soil Zn concentrations for all of the depths examined (0-80 cm). The main cause of this increase is thought to be Zn fertilization in order to improve the quality of cut flower production. Kızılok (2000) stated that higher doses of Zn increased the length of the flower stems and the flowering rate (Figure 3). After harvest the greenhouse soil content was 0.7-4.3 mg/kg in the field, while before harvest it was found to be 0.4–2.3 mg/kg, thus a slight increase was observed.

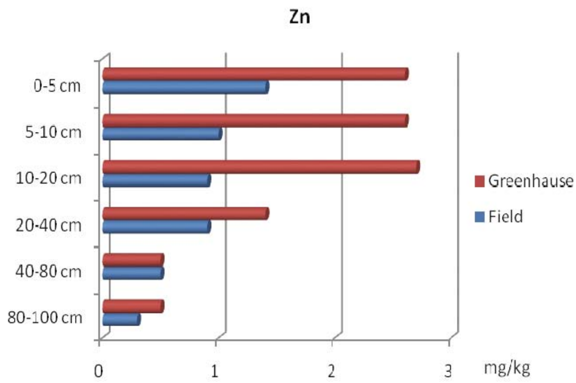

Figure 3. The content of Zn according to depth

Table 3. Soil Zn content (mg/kg)

Place	0-5cm	5-10cm	10-20cm	20-40cm	40-80cm	80-100cm	Mean
Greenhouse	2.6ab	2.6a	2.7a	1.4abc	0.5c	0.5c	1.7
Field	1.4abc	1abc	0.9c	0.9bc	0.5c	0.3c	0.8
Mean	2	1.8	1.8	1.2	0.5	0.4	
Sources of variation	P			F			
Place	0.000			25.25			
Depth	0.001			10.22			
Place*Depth	0.05			3.11			

Soil Cu content

The Cu soil content was found to be 2-2.3 mg/kg for the greenhouse soil samples, and 1.7-2.1 mg/kg for the field samples (Table 4).

The Cu content exhibited a different pattern compared with Mn and Zn: the Cu content did not change according to the soil depth. In addition, the differences between the green-house and field samples were not statistically significant.

The Cu content did not change from the surface to the deeper soil samples due to a lack of activity. Cu according to Zn and Mn still remains by binding strongly to organic

materials of the inorganic exchange in the soil (Kacar and Katkat, 2010). Alagöz et al., (2006) determined that carnations grow in soil with a Cu content of 0.114–5.87 ppm at a depth of 0–10 cm and of 0.142–6.44 ppm at a depth of 10–20 cm.
The content of the soil after harvest was 1.3-2.3 mg/kg for the greenhouse samples and 1.6-2.5 mg/kg for the field samples. Thus, there were no obvious changes observed.

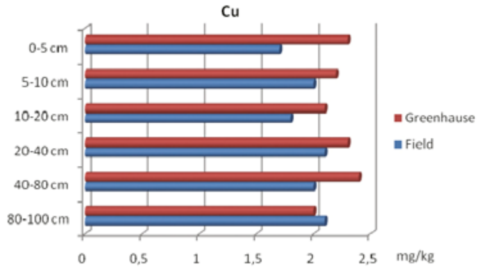

Figure 4. The content of Cu according to depth

Table 4. Soil Cu content (mg/kg)

Place	0-5cm	5-10cm	10-20cm	20-40cm	40-80cm	80-100cm	Mean
Greenhouse	2.3	2.2	2.1	2.3	2.4	2	2.2
Field	1.7	2	1.8	2.1	2	2.1	2
Mean	2	2.1	2	2.2	2.2	2.1	
Sources of variation	P			F			
Place	0.110			2.98			
Depth	0.948			0.22			
Place*Depth	0.889			0.32			

CONCLUSIONS

The results of this study showed that the Mn and Zn content of the soil in cut flower greenhouses significantly increases with depth due to downward washing. However, this was not observed for Cu.
The different Mn, Zn and Cu contents in the soil samples taken from the greenhouses and the fields reflects differences in fertilizer and pesticide application.
In agriculture, many chemicals are used to increase productivity and control pests. The use of chemicals may be uncontrolled, such as in the case of this study. These chemicals are easily washed into the groundwater in sandy soils. To avoid the negative impacts of this process, manufacturer should be informed, and the necessary control procedures should also be applied to non-food agricultural products as well as food products

ACKNOWLEDGEMENTS

This research work was carried out with the support of TUBITAK Project No 2209.

REFERENCES

AIPH (Interrnational, Association of Horticultural Producers), 2013. http:// www. aiph. org/ site/index_en.cfm?act=teksten.tonen&varpag=3954. Access date: 05.01.2015.

Alagöz Z., Öktüren F., Yılmaz E., 2006. Determination of Some Efficiency Properties of Carnation Grown Greenhouse Soil in Antalya Region Akdeniz University Faculty of Agriculture Journal, 19(1): 123-129 (in Turkish).

Anonim, 2013. www.susbitkileriorg.tr/content//docs/
2013 yili-sus-bitkileri-degerlendirme Access Date: 05.01.2015.

Arı N., 1993. Antalya Lier Grown Under Cover in the region and Determination of Nutritional Status of Nathalie carnation varieties. Akdeniz University, Institute of Soil Science Department Master Thesis, Antalya (in Turkish).

Daives B.E., 1995. Lead and Other Heavy Metals in Urban Areas and Consequences for the Health of Their Inhabitants. Environmental Contaminants, Ecosystem and Human Healthy. In: Majumdur, S.K., Millar, E.W., and Branner, F. J., The Pensylvania Academy of Science, Easton P. A., USA., p. 287-307.

Doğan M., 2003. Sanli Urfa Karakoyun onions irrigated with wastewater stream (*Allium cepa* L.) An investigation on the accumulation of toxic elements. Ecology 12, 48 s.1-3 (in Turkish).

Gee G.W., Bauder J.W., 1986. Particle-size Analysis, p. 383-411. In A.L. Page (ed.). Methods of soil analysis, Part1, Physical and mineralogical methods.

Galbally J., Galbally E., 1997. Carnations and Pinks for Garden and Greenhouse. Timber Press, Portland, Oregon. USA, p. 1-310.

Huang X., Li T., Yu H., Zheng Z., X., Huang P., 2011. Notice of Retraction Potential Risks of Heavy Metal Pollution in Greenhouse Soils Cultivated for Different Periods. Bioinformatics and Biomedical Engineering, (iCBBE) 2011 5th International Conference on, p. 1-6.
Kacar B., Katkat V., 2010. Plant Nutrition. Nobel publications, 660, Ankara (in Turkish).
Kızılok S., 2000. Effects on Growth and Flowering of Carnation Zinc Application. E.Ü. Faculty of Horticulture Department of Agriculture, İzmir (in Turkish).
Köleli N., Kantar Ç., 2006. Phosphorus in Manure Heavy Metal Hazard. Journal of Ecology, 9: 1-5 (in Turkish).
Lindsay W.L., Norwell W.A., 1969. Development of a DTPA Micronutrient Soil Test. Soil Sci. Am.Proc. 35: 600-602.
McLean E.O., 1982. Soil pH and lime requirement. In Page A.L., R.H. Miller and D.R. Keeney (eds.) Methods of soil analysis. Part 2 - Chemical and microbiological properties. (2nd Ed.). Agronomy 9: 199-223.
Minitab, 2014. Minitab Statistical Software Release 16.0. http://www.minitab.com/en-us/. Access date: 09.11.2014.
Olivero-Filho E.C., Lopes R.M., Paumgartten F.J.R., 2004. Comperative study on the susceptibility of freshwater species to copper-based pesticides. Chemosphere 56, p. 369-374.
Tok H.H., 1997. Environmental pollution, T.Ü. Faculty of Agriculture, Department of Soil Science, Tekirdağ (in Turkish).
U.S. Salinity Laboratory Staff, 1954. Diagnosis and Improvement of Salina and Alkali Soils. Agricultural Handbook, 60, U.S.D.A.
Yağdı K., Kaçar O., Azkan N., 2000. Effects of Heavy Metal Pollution in Soils and Agricultural. On Dokuz Mayıs University Journal of the Faculty of Agriculture. 15(2): 109-115 (in Turkish).
Yıldız M., Gürkan O., Turgut C., Kaya Ü., Ünal G., 2005. Environmental Problems Caused by the pesticide used in agricultural pesticides VI. Turkey Agricultural Engineering Technical Conference, TMMOB Agricultural Engineers, Ankara, 3-7 Ocak (in Turkish).

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SOILS OF MOLDOVA IN DIFFERENT HISTORICAL PERIODS AND POSSIBILITIES TO RESTORE THEIR QUALITY STATUS

Valerian CERBARI[1], Tamara LEAH[1], Marius ȚĂRANU[2]

[1]Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo", str. Ialoveni, 100, 2070, Chisinau, Moldova, Phone: +37322 284862, E-mail: valerian-cerbari@ramler.ru
[2]Climate Change Office, str. Mitropolit Dosoftei, 156a, of.37, 2004, Chisinau, Moldova, Phone: +37322 232247, E-mail: marius.taranu@clima.md

Corresponding author: e-mail: tamaraleah09@gmail.com

Abstract

The paper aimed to present the historical evolution of quality status of Moldovan soils. Chernozems in Moldova consists about 80% of the total arable land. Food security, environment and health status of the population depends on soil quality. In the last 3-4 decades overexploitation of soil resources led to intensification of land degradation. More than half of agricultural land is affected by erosion, compaction, landslides. Estimates show that in different historical periods, soil resources were affected by various natural disasters, both natural and anthropogenic degradation processes. Anthropogenic degradation of soils manifested in Moldova currently requires to development and implementation the processes and technologies to stop and improve their quality status.

Key words: *chernozem, degradation, remediation, protection, humus.*

INTRODUCTION

Soil cover represents the space involving the whole natural, socio-economic and cultural factors. Soil fertility is the main value of the land. As regards to the intensification of anthropogenic pressure on the environment, the correct distribution of the national economy, management and sustainable land use is one of the main strategic objectives in achieving environmental and economic issues related to climate change, desertification, biodiversity conservation, poverty alleviation. Land resources requires a management motivated and aimed to protect the soils - as natural multifunctional object and important means of agricultural production that cannot be replicated.

MATERIALS AND METHODS

The research methodology was provided under existing standards in the Republic of Moldova. Were used physical and chemical methods, research of soil in the field, systematization, generalization and statistical processing of the obtained information.

RESULTS AND DISCUSSIONS

The use of soil resources in Moldova highlights some important historical period.

The period up to 1812. The small areas of arable soils are used from the surrounding of villages located in forest-steppe zone (Bejan, 2006). This natural conditions ensured a better security and opportunity to population survive. The negative impact of anthropogenic pressure on the soils was comparatively weak in this period and spread only about 10% of the total territory (Table 1).

Table 1. Dynamics of the structure land in Bessarabia and Moldova in the years 1812-2014, thousand ha /%

Years	Total	Arable	Perennial plantation	Other lands
1812	4511 100	516 11.4	46 1.0	3949 87.6
1900	3509 100	2320 66.1	109 3.1	1080 30.8
1950	3296 100	2124 64.4	177 5.4	995 30.2
1990	3376 100	1820 53.9	410 12.2	1146 33.9
2013	3385 100	1816 53.7	295 87	1274 37.6

Sources: Annual Land cadastres

The main factor of land degradation used in agriculture, was linear erosion and landslides - the result of deforestation and land use as arable around the villages. Humus loss, destructuring and secondary compaction of soil arable layer (thickness of which did not exceed 15-20 cm) occurs slowly.

However, as a result of frequent invasions and occupation of the territory by nomadic peoples on the land used as arable produced changes occur in pedogenesis phases and soil quality status was restored. Brown and gray soils of forest-steppe zone, low productive in arable, being abandoned by the natives, gradually evolved into chernozems under the influence of natural steppe vegetation. As a result, in the contemporaneous steppe zone of Moldova formed a polygenetic soil cover.

Second period, the years 1812-1900. Comparatively stable political situation during this period favors the massive increase of population and practical use of arable land suitable for agriculture (Table 1). This fact has led to the intensification of land erosion, primarily, the linear erosion. Nevertheless, due of extensive agriculture, both the surface erosion and other soil degradation processes (humification, destructuring and compaction of arable layer) evolved slowly.

Third period, years 1900-1950 (1965). In these years, as a result of intensification of anthropogenic pressure on arable soils and lack of adequate territorial organization measures, continues to expand the surface of eroded soil and erosion processes in depth. From 1911 to 1965 the number of ravines increased more than 3 times, and in some districts - 5-6 times. As a result of extensive soil tillage farming system, usually with fallow, dehumication, destructuring and secondary compaction of arable layer continued to evolve slowly.

Third period, years 1900-1950 (1965). In these years, as a result of intensification of anthropogenic pressure on arable soils and lack of adequate territorial organization measures, continues to expand the surface of eroded soil and erosion processes in depth. From 1911 to 1965 the number of ravines increased more than 3 times, and in some districts - 5-6 times. As a result of extensive soil tillage farming system, usually with fallow, dehumication, destructuring and secondary compaction of arable layer continued to evolve slowly.

Fourth period, years 1950 (1965) - 1990. This is an implementation period throughout the whole territory of Moldova the intensive agricultural system that included: frequently soil tillage with heavy machinery; performing deep plowing until 35-40 cm; massive use of chemical and organic fertilizers; land planning in large sole that not always meet the requirements of land erosion protection; almost total lack of planning hydrological land organization (Leah, 2012). The activities led to increased surface and depth erosion on the area of arable land. Also in this period greatly increases most dangerous soil degradation processes: loss of humus, destructuring and secondary compaction of arable layer which in previous periods evolved slowly (Figure 1, 2).

Figure 1. Chernozem typical fallow, glomerular - grainy structure of Ah horizon

Figure 2. Chernozem typical arable, with destructuring and strongly compacted arable layer

Increasing land productivity as a result of chemicalization of agriculture towards at the end of this period practically stopped, arable layer of soil lost the natural ability of resistance to compaction.

Fifth period, the years 1991-2014. During this period, land reform is carried out; land fund was divided into 2,5 million individual lots of land without soil planning and organization of antierosion, pedoameliorative necessary measures. Degradation processes of soil cover were extended on about 56 percent of agricultural land: continue to increase erosion processes and surface affected by landslide, the processes of humus loss, deterioration of the structure and soil compaction, alkalization, salinization and swampy; intensified droughts.

Performing the necessary measures in small farms is impossible. Agriculture become again extensive, agricultural production volume has decreased practically 2 times (Cerbari, 2013a).

The existing system of farming the land does not contribute to long-term preservation of the production capacity of soils and requires a radical change. Calculations on the balance of humus and carbon in the soils, showed that the annual irreversibly lost from arable soils consists 1 t/ha/year of humus, which is equivalent to the 0.58 t/ha/year of carbon accumulated historical and atmosphere elimination about 2.13 t/ha/year of CO_2.

Possibility of creating a equilibrated balance of humus in soils and remediation their degraded characteristics are:

Transition from arable land to fallow and gradual restoration of steppe vegetation under the action which formed chernozems. Research conducted on the strip of land with restored steppe vegetation, founded 15 years ago on the Experimental Fields of Research Institute of Field Crops "Selectia", established that in the regime of non utilization of vegetation air mass during 15 years, the organic matter content in arable layer 0-30 cm of soil increased by 0.90% (0.52% of carbon) or 0.06% annually (0.035% of carbon), (Cerbari, Balan, 2010). The balance of carbon in the 0-30 cm soil layer turned positive - +1.3 t/ha/year (0,035 x 1,25 g/cm^3 x 30 cm). This method of restoring the quality status of soils in Moldova cannot be accepted due to the lack of a surplus of arable land.

Use of arable land in rotation with five fields where one field is occupied with a mixture of alfalfa + steppe ryegrass. Experimental data confirmed that over 5 years on the parcel with mixture of perennial herbs, legumes and grasses returned about 25 t/ha (absolutely dry mass) of organic debris and roots of alfalfa and ryegrass (5 t/ha/year), the average nitrogen content 1.9% (Cerbari, 2013b).

Organic matter content in the 0-30 cm layer increased by 0.20% or 0.04% (0.023% of carbon) annually. Annual soil carbon balance turned positive - +0.9 t/ha/year (Leah, Cerbari, 2013a). This accumulation of organic matter in soil over a period of 5 years provides for next 4 years an equilibrated balance of humus for field crops sown after alfalfa + ryegrass. This method for restoring the soil quality status can be accomplished in about 10% of arable land in terms to restoring the livestock sector.

Application in the soil about 10 t/ha/year of manure. Currently, according to statistical data from 2013, in the agricultural soils are introduced about 30 kg/ha/year of manure (that means anything) and about 30-45 kg/ha/year of mineral fertilizer, 75-80% from these are nitrogen fertilizers (Leah, Cerbari, 2013b). That fertilization level cannot ensure profitable agriculture that would lead to the reproduction of soil fertility. In the 1981-1990 period were incorporate into the soil about 6.7 t ha/year of manure, that ensured a weak negative balance of organic matter in the soils.

Currently, the livestock has decreased 6 times. This quantity of cattle ensures the production of about 3 million of manure which is collected from farms, composted and introduction into the soil. This fact, would enable to solve the problem of humus balance in the soil and remediation the soil quality status in about 10% of lands arable. Simultaneously it would solve the problem of sanitary-epidemiological status of the rural environment.

Use as fertilizer the green mass of annual herbs mixture (legumes and grasses), intermediate culture. This process gives the possibility to increase the flow of organic matter in the soil, to create a equilibrated balance of humus and to remediated and maintain for a long-term status of chernozems while reducing CO_2 emissions in the agricultural sector (Table 2 and 3).

The most successful culture used for this purpose is autumn and spring vetch.

Table 2. Harvest of green mass of winter vetch + wheat (20%) and its chemical composition

Harvest	Green mass, t/ha	Humidity, %	Absolutely dry mass, t/ha	Ash	N	P_2O_5	K_2O	C	C:N
				% from dry mass					
Vetch	30.0	81.5	5.6	9.5	4.1	1.1	2.7	39.1	9.5
Roots, total mass in 0-30 cm			2.4	15.2	1.8	0.5	0.5	38.9	21.6
Total mass of organic residues and roots			8.0	11.2	3.4	0.9	2.0	39.0	11.5

Table 3. Status of the arable layer characteristics of chernozem ordinary, until incorporate (numerator) and after incorporation into the soil a crop of green mass of vetch by disking

Horizon and depth (cm)	The bulk density, g/cm^3	Total porosity, % v/v	Sum of favorable aggregates 10-0.25 mm, %	Hydrostability of favorable aggregates, %	Organic matter, % g/g	Mobile forms	
						P_2O_5	K_2O
Ahp1 0-12	1.27 1.08	51.3 58.6	71.2 86.6	30.4 38.6	3.03 3.24	2.3 2.5	24 27
Ahp1 12-20	1.46 1.34	44.3 48.9	55.0 67.2	34.2 37.0	2.92 3.02	2.0 1.9	21 22
Ahp2 20-35	1.50 1.44	42.7 45.0	48.0 53.0	36.4 35.6	2.82 2.83	1.9 1.8	20 20

This culture is characterized by high content of nitrogen in the dry mass up to 5%. The existence of two types of vetch makes possibility to use its green mass in the following cases: i) as intermediate crop sown in autumn and incorporated into the soil in April of the following year, with 4-5 days before sowing the base culture; ii) sown on the field by 2 times, autumn and spring, after incorporation into the soil the green mass of vetch in a rotation with 5 fields.

CONCLUSIONS

Incorporation into the soil of a crop of green mass of vetch roots (8 t/ha of organic debris) will be approximately synthesis 2.0 t/ha of humus in the soil, will be accumulate about 270 kg/ha of biological nitrogen, 50-60% (160 kg/ha) which is the symbiotic nitrogen. Described procedure should be repeated every two years.

On the plot where was incorporated into the soil the vetch green mass, along with remediation of soil characteristics, was registered an increase of corn harvest 1.1 t/ha/year in the first year and 0.4 t/ha of sunflower in the second year (compared to the control plot).

The systematic use of green mass of vetch as organic fertilizer is a chance to save gradually the degraded chernozem, which annually is poorly observed in existing agriculture.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Moldova - Germany bilateral project: *Restoration of structure, remediation the physical properties and carbon conservation of the arable chernozems using green manure in crop rotation* (2013-2015).

REFERENCES

Bejan, Iu., 2006. Dinamica structurii fondului funciar pe teritoriul Republicii Moldova. Rev. Economica, Chisinau, nr. 4, pp. 44-49.

Cerbari V., Balan T., 2010. Cernoziomurile tipice argilo-lutoase din zona călduroasă semiumedă a Moldovei de Nord. În: Monitoringul calității solurilor Republicii Moldova. Ch., Pontos, pp. 96-153.

Cerbari V., et.al., 2013a. Phyto-amelioration of Degraded Chernozem. *Soil as World Heritage.* Ed. D. Dent, Springer Dordrecht Heidelberg New York London, pp. 373-381.

Cerbari, V., et.al., 2013b. Phyto-technology for Remediation of Chernozem in the South of Moldova. *Soil as World Heritage.* Ed. D. Dent, Springer Dordrecht Heidelberg New York London, pp.381-389.

Leah T., 2012. Modificarea structurii fondului funciar în rezultatul reformelor agrare: studiu comparativ. Revista *Agricultura Moldovei*, nr.6-7, 2013, pp. 8-11.

Leah T., Cerbari V., 2013a. Degradation of Ordinary Chernozem in the South of Moldova and phyto-technical measures to remedy of their fertility. *Scientific Papers.* Series A. Agronomy. Vol. LVI, Bucharest, Romania, pp.56-62.

Leah T., Cerbari V., 2013b. Restoration of leached chernozems fertility under the influence of green and organic fertilizers. *Lucrări ştiinţifice*. Seria Horticultură. LVI. Vol.56. nr.2. Ed. „Ion Ionescu de la Brad". Ia i, Romania, pp.413-418.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ANTHROPIC TRANSFORMATION OF CHERNOZEMS FROM BALTI STEPPE OF THE REPUBLIC OF MOLDOVA

Tatiana CIOLACU

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni Str., MD-2070, Chisinau, Republic of Moldova

Corresponding author email: balantatiana@gmail.com

Abstract

Soil degradation represents a global problem because of its influence on quality of human life, environment and biodiversity. Anthropic activity had a great influence on soil quality by onset of degradation processes through agriculture development. Use of soils in agriculture led to the loss of grain structure with high agronomic value. In the arable layer of these soils, predominate fraction of blocks - 40-60%. The former arable layer (25-35 cm) is characterized by nearly monolithic structure. As a consequence the recent arable layer is characterized by medium values of bulk density and the underlying layer is heavily compacted. The total porosity of arable layer is medium and of the former arable layer - small. There is a growth trend of hydrolytic acidity in the superior layers of arable land. Humus content in arable soils decreased by 2.24% in the layer 0-25 cm and by 1.65% in the 0-50 cm layer. Humus losses were respectively 36 and 31 percent of its original amount.

***Key words**: compaction, humus loss, soil degradation, total porosity.*

INTRODUCTION

Soil degradation represents a global problem because of its influence on quality of human life, environment and biodiversity. Anthropic activity had a great influence on soil quality by onset of degradation processes through agriculture development. Researches made by Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" showed that the balance of organic matter in Moldovan soils is negative and makes 0.01% per year (Andries, 2007). All agricultural soils of Moldova are subject to humus loss: initial humus reserves decreased by 40% and annually are lost about 2.4 million tons of humus (Andrie et al., 2012). As consequence soils lost their natural structure and became compacted (Tărâ ă et al., 2010; Ciolacu, 2012.). Given the fact that the soil is not a closed system, but is in close interaction with living organisms that populate it, biodiversity also suffer from soil degradation (Senicovscaia et al., 2010). At the same time, soils of Moldova represent one of the most precious estates indispensable to our country's population. The aim of the present paper is to reveal negative influence of human activity on soils quality state. This can be scientific proved by comparison of arable soils with non-arable fallow soils.

MATERIALS AND METHODS

Investigations were carried out at the experimental fields of Research Institute of Field Crops "Selectia" from Balti, Republic of Moldova. The object of the study was typical clay-loamy arable chernozem from Balti steppe, that was used in agriculture for a very long period of time (Figure 1).

Figure 1. Typical clay-loamy arable chernozem

In order to determine the level of degradation we studied typical chernozems under fallow located in the surrounding forest strip of protection founded 60 years ago (Figure 2), on an area covered with reestablished steppe vegetation (predominantly matgrass).

In both variants, we founded a key set of polygons in the form of a square with sides of 50 m with a main profile in the center and four secondary at the peaks of the square.

Laboratory tests were performed according to the standard methods approved in the Republic of Moldova: soil bulk density was determined by core method, total porosity by calculation. The organic matter content was determined by Tiurin method, total nitrogen content by Kjeldahl method, mobile phosphorus and potassium by Machighin method, soil pH by electrometric method.

Figure 2. Typical chernozem under fallow located in the forest strip founded 60 years ago

RESULTS AND DISCUSSIONS

The next type of soil profile characterizes the investigated typical arable chernozems: Ahp1 – Ahp2 – Ah – Bh1 – Bhk2 – BCk1 – BCk2 – Ck (Figure 3).

Arable layer Ahp1 (0-25 cm) is dark grey almost black. Recent ploughing was performed poorly, that in combination with rough texture and humus loss formed unfavourable for plant growth blocky structure (Figure 1). The former arable layer Ahp2 (25-36 cm) differs from recent arable layer by strong compaction and monolithic or prismatic structure. Structure of Ah horizon (36-49 cm), that never had been ploughed, is glomerular-grained, soil is compact. The lower part of soil profile (100-120 cm) is considerably modified by moles (Figure 3).

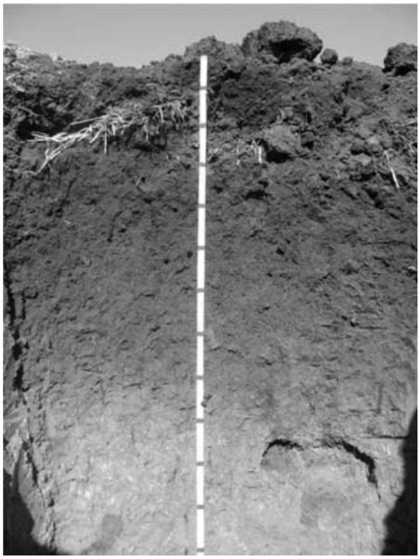

Figure 3. Soil profile of typical clay-loamy arable chernozem

Typical chernozems under fallow have well developed deep soil profile of a type: Ahț1 - Ahț2 - Ah - BH1 - Bhk2 - BCk1 - BCk2 - Ck (Figure 4). Soil colour is dark almost black, which becomes lighter with depth. Soil has a well developed grainy structure almost in the whole humus profile and a slight compaction that increases slowly at lower horizons.

Figure 4. Soil profile of typical chernozem under fallow

Investigated typical chernozems are characterized by comparatively homogeneous texture in the whole profile. On average physical clay content is 62-63%, and the fine clay - 36-38%. The soils are classified as clay loamy. Under the influence of anthropogenic factor (intensive arable work with heavy machinery), these chernozems are predisposed to loss of structure, compaction and crusting.

For soils with clayey or loamy texture, the optimum structural condition is achieved in the presence of 70-80% of agronomical valuable hydro-stable aggregates (of size 0.25-10 mm) (Bondarev, 1994), which is observed in typical chernozems under fallow (Figure 5 and 6). Because of intensive exploitation of arable typical chernozems, they lost their valuable agronomic grainy structure. According to dry sieve analysis, in the arable layer of these soils, predominate fraction of clods - 40-60% (Figure 5).

At the same time, these soils are characterized by practically monolithic structure in the former arable layer 25-35 cm. This layer in the last 15 years was not ploughed and, having a poor structure as a result of intensive work until 1990 year, lost resistance to compaction and become compacted.

Apparently good hydrostability of aggregates is due to strong compaction of structural aggregates formed as a result of soil tillage (Figure 6). However the content of agronomical unfavorable fraction is quite high and constitutes 27-44%.

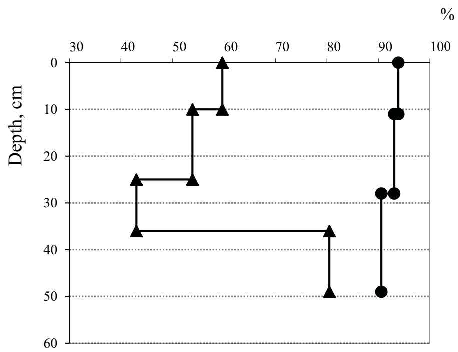

Figure 5. Content of aggregates 10-0.25 mm at sieve dry: ▲ – arable typical chernozem; ● – typical chernozem under fallow

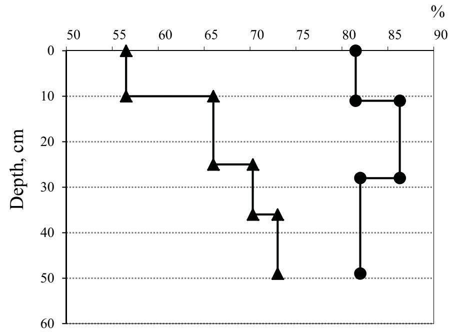

Figure 6. Content of hydrostable aggregates 10-0.25 mm at wet dry: ▲ – arable typical chernozem; ● – typical chernozem under fallow

Investigations of Moldovan soils carried out by Atamaniuk A.K. (Atamaniuk A.K., 1964) established that the optimal values of soil bulk density to retain the maximum amount of moisture are from 1.25 to 1.30 g/cm^3. According to our data, arable layer of investigated soils is characterized by medium values of bulk density (1.34 g/cm^3) while the underlying layer is heavily compacted – 1.46 g/cm^3 (Figure 7).

Bulk density values of Ahț and Ah horizons of fallow soils are optimal for plants growth (1.16-1.29 g/cm^3).

The upper part of the Ahp1 layer (0-10 cm) of arable soil is loose because it is worked during the vegetation period, total porosity is medium – 54.7% (Figure 8).

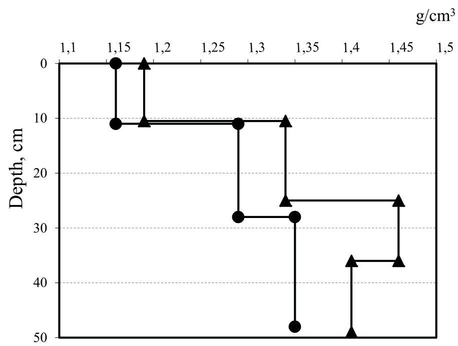

Figure 7. Bulk density of typical chernozems: ▲ – arable typical chernozem; ● – typical chernozem under fallow

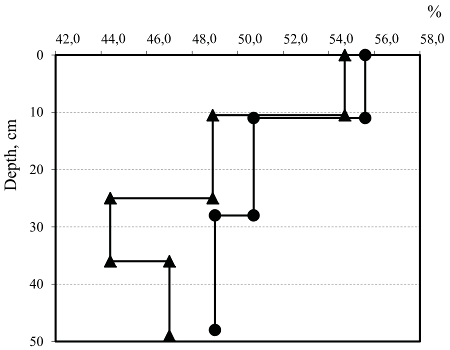

Figure 8. Total porosity of typical chernozems: ▲ – arable typical chernozem; ● – typical chernozem under fallow

The lower part (10-25 cm) is compacted, the total porosity is low – 48.9%. The former arable layer Ahp2 (25-35 cm) is very compacted and as a result its porosity is very small – 44.4%. The optimal values of total porosity vary between 50-60% (Bondarev A.G., 1994), which was found in the case of fallow soil, where total porosity of horizons Ah 1 and Ah 2 is between 55.6 and 50.7%. With depth soil became naturally slightly compacted with total porosity on average 49.0%.

Arable typical chernozems are characterized by weak acid or neutral reaction in upper horizons and slightly alkaline reaction in lower horizons (Table 1).

There is an increase in the acidity of arable land. Hydrolytic acidity of soils is low and very low, but there is a growing trend of hydrolytic acidity in the superior horizons of arable soil.

Dokuceaev (1952) noted the specific feature of our chernozems - large reserves of humus due to the large thickness of the humus profile along with relatively low humus content (in comparison to other chernozems from chernozem belt).

In soils investigated by us, humus is distributed evenly on fallow soil profile and reaches 80-94 cm (that is classified as very deep humus profile). Humus content in arable soils, due to intensive use in agriculture, decreased by 2.24% in the layer 0-25 cm and by 1.65% in the 0-50 cm layer (Table 1). Humus losses were respectively 36 and 31 percent of its original amount (in comparison with typical chernozem under fallow).

Table 1. Characteristics of typical chernozems used in agriculture and under fallow

Horizon/layer and depth, cm		pH	Hydrolytic acidity, me/100 g soil	$CaCO_3$	Total P_2O_5	Humus	Total N	C:N	Mobile forms of, mg/100 g sol	
				%					P_2O_5	K_2O
Arable typical chernozems										
Ahp1	0-25	6.3±0.3	2.4±1.1	0	0.13±0.01	4.03±0.09	0.216±0.021	10.9±1.0	2.0±0.4	32.6±6.3
Ahp2	25-36	6.4±0.4	2.3±1.1	0	0.12±0.01	3.81±0.22	0.205±0.020	10.8±0.9	1.4±0.4	23.1±4.9
Ah	36-49	6.5±0.5	1.7±0.8	0	0.10±0.01	3.01±0.21	0.172±0.023	10.1±1.1	0.9±0.1	17.5±2.2
Bhk1	49-70	7.2	0.9	0	-	2.27	-	-	-	-
Bhk2	70-94	7.5	-	3.3	-	1.31	-	-	-	-
BCk1	94-120	7.8	-	15.1	-	0.93	-	-	-	-
BCk2	120-150	7.9	-	16.7	-	0.77	-	-	-	-
Ck	150-200	8.0	-	17.6	0.08	0.41	-	-	-	-
Typical chernozems under fallow										
Ahţ1	0-11	6.8±0.1	1.8±0.3	0	0.16±0.02	6.70±0.14	0.320±0.02	12.2±0.6	3.0±1.3	60.0±13.7
Ahţ2	11-28	6.7±0.2	1.9±0.4	0	0.13±0.01	5.94±0.07	0.290±0.01	11.9±0.4	2.1±0.8	35.6±13.8
Ah	28-49	6.8±0.3	1.7±0.9	0	0.11±0.01	4.23±0.23	0.220±0.01	11.4±0.3	1.0±0.4	18.8±2.3
Bh1	49-64	7.2	0.3	0	-	2.99	-	-	-	-
Bhk2	64-90	7.9	-	8.4	-	1.70	-	-	-	-
BCk1	90-110	7.9	-	17.6	-	1.00	-	-	-	-
BCk2	130-150	8.0	-	18.8	-	0.72	-	-	-	-
Ck	180-200	8.2	-	22.0	0.06	0.52	-	-	-	-

Total nitrogen content correlates with humus content. The increase of the C:N ratio in fallow soil is explained by a greater flow of carbon in these soils due to rich steppe vegetation.
Investigated typical chernozems are formed on loess poor in phosphorus (0.06-0.08%). It can be noticed that there is a bioaccumulation of phosphorus in the horizon Ahț1 of soil under fallow (0.16±0.02%).
Total phosphorus content in arable soils is smaller and makes 0.13±0.01% in the Ahp1 horizon. Its quantity slightly decreases with depth.
Plant growth is influenced not only by soil physical state. Reserves of such nutritive elements as mobile phosphorus and potassium are important for plant development and yields formation. Intensive use of soils resulted in removal of these elements with yields from the arable layer. So, the reserves of mobile phosphorus and potassium in typical chernozems are lower in comparison with soil under fallow. Mobile phosphorus content is 2.0 mg/100 g soil in the Ahp1 layer and it is decreasing with depth. Mobile potassium content is 32.6 mg/100 g soil in Ahp1 layer, 23.1 mg/100 g soil in Ahp2 and 17.5 mg/100 g soil in Ah layer. It can be concluded that because of long use of land in agriculture the initial reserves of these elements significantly reduced.

CONCLUSIONS

Irrational use of soil resources in agriculture led to deterioration of chernozems natural structure favourable for plant growth, increase of bulk density and soil compaction. The former arable layer (25-35 cm) became compacted because of humus loss and heavy traffic, and formed an impediment for roots growth. Humus losses were about 35 percent of the initial content. Reserves of nutrients in the soil significantly decreased.

REFERENCES

Atamaniuk A.K., 1964. Densitatea aparentă a solului i dezvoltarea plantelor în cazul cernoziomurilor din Moldova Centrală. Autoreferat tezei de doctor în agricultură, Chi inău, 24 p. (rus)

Andries S., 2007. Optimization of nutritional regimes and crop productivity. Pontos, Chisinău.

Andrie S., Cerbari V., Filipciuc V. Calitatea solurilor în Moldova, probleme i solu ii. Academicianul I.A. Krupenikov – 100 ani: Culegere de articole ştiin ifice. „Elan Poligraf" SRL, Chi inău, p. 58-62.

Bondarev A.G., 1994. Bazele teoretice i practice de optimizare a condi iilor fizice a fertilită ii solului. Pedologie, no 11, Moscova, p. 10-15. (rus)

Ciolacu Tatiana., 2012. Problema utilizării durabile şi conservării fertilității cernoziomurilor.Academicianul I.A. Krupenikov-100 ani: Culegere de articole ştiin ifice. „Elan Poligraf" SRL, Chi inău, p. 58-62.

Docuceaev V.V., 1952. Cernoziomul rusesc. Moscova, 636 p. (rus)

Senicovscaia I., Marinescu C., Balan T., 2010. Impactul modului de folosință agricolă a terenurilor asupra biotei cernoziomurilor tipice. Monitoringul calității solurilor Republicii Moldova (baza de date, concluzii, prognoze, recomandări). Chişinău: Pontos, p. 164-171.

Tărâ ă A., Sergentu E., Balan Tatiana, Cerbari V., 2010. Rezerva ii de resurse pedologice protejate de stat. Noosfera, nr. 3, p. 74-86.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

MORPHOLOGICAL COMPOSITION AND PHYSICAL TRAITS OF SOILS WITH DIFFERENT DEGREE OF EROSION IN THE RECEPTION BASIN "NEGREA" AND THEIR INFLUENCE ON THE EROSION PROCESS

Olesea COJOCARU

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni, MD-2049, Chisinau, Republic of Moldova

Corresponding author email: olesea.cojocaru@bk.ru

Abstract

In nature of soil research is done using morphological method was initially used only in botany and geology then was adopted upon row of all other natural sciences. The purpose of the study is to evaluate morphological and physical properties of the soils with different degree of erosion in the reception basin "Negrea" (Republic of Moldova) based on the data obtained from six main soil profiles. We made a morphological description of the profiles and developed a soil map at a scale of 1:5000 showing the spatial distribution of soils with different degree of erosion. The diversity of relief forms, rocks and agricultural land use determine the existence of a variable and complex soil cover consisting mainly of common chernozems (83%). Loam, clay-loam and sandy-dusty soil texture, as well as the unsatisfactory hydrostability of the soil structure are contributory factors for erosion spreading processes on agricultural lands. The soils on slopes are affected by denudation and evolve through a denudation-compensation pedogenesis, it means that there is a certain development of the soil in depth during the relatively long period of slow denudation; thereby pedogenesis compensates, at least partially, the denudation. In the case of the anthropogenically accelerated erosion, resulting from inadequate management practices, great soil losses cannot longer be compensated by pedogenesis. A textural particularity of these rocks is high content of fine-medium sand (20-30%), nonspecific from loesses deposits (5-10%). In the process of performing soil studies it was found that soils on the slopes in the reception basin "Negrea" are affected by denudation and evolves through a denudation-compensation pedogenesis, in the sense that the relatively long period, which is going slow denudation has there is also a certain development of the soil in depth, pedogenesis compensates, at least partially is for thedenudation (Florea et al., 1987). According to the results of the determination and calculation values of water reserves in the layer 0-100 cm of soils at this time are practically equal, which is explained by their texture homogeneity.

Key words*: denudation, eroded soil, physical properties, reception basin, Republic of Moldova.*

INTRODUCTION

According to research conducted it was found that the soil cover of the reception basin "Negrea" is an example of indestructible unit of interaction of soil, vegetation, the environment and a man in a hilly region. The basin is located on the plain Middle Prut within the limits of the estate village Negrea, district of Hancesti, being part of the accumulation basin of rivulet Lapusnita, the left side tributary of the river Prut. The study aimed at the north-east and middle of the agricultural land of the village New Negrea.

Aim of the researches was to highlight genetic peculiarities, negative assessment of changes reception basin characteristics of soils as a result of erosion and the appreciation thereof suitability to different agricultural works. The relief the basin framework consists of two primary surface heights denudation, with altitude 226 - 227 m, who starts from two elongated ridges ending in the valley rivulet Lapusnita. The inclination of relicts of denudation surface is about 1^o (Andries et al., 2003).

The primary surface of denudation is situated flood witnesses - local two heights connected by a saddle from which starts dell of hills. Solification rocks in the reception basin are formed from the mixture loesses deposits of Pleistocene-Holocene with ones alluvial from Pliocene-Pleistocene (Bilinkis 2004; Brindus et al., 1999).

A textural particularity of these rocks is high content of fine-medium sand (20-30%), nonspecific from loesses deposits (5-10%). In the central part of the slope of southwestern exhibition on the field within a crop rotation located above the warehouse from the center dale, solification rocks are weakly skeletal disorders and contain fragments of sandstone, showing the location at shallow depths of compacts rocks. Soil differs from terms of morphology of rock that was formed by a vertically differentiated structure. Solification in the valley rocks are formed from deposits of proluvial pedolit and glacises at the foot of the slopes - from delluvial deposits of pedolit, washed down slopes (Brindus et al., 1999; Florea et al., 1987).

MATERIALS AND METHODS

Reception basin "Negrea" is located in the middle of the hydrographic basin of the rivulet Lapusnita and is typical for the reception basins formed as a result of fragmentation by erosion high terraces of the Prut river and their tributaries left. High terraces of the tributaries of the Prut river and the itself Prut river synchronous were formed in the Pleistocene and represents a unique relief in terms of genesis and lithology rock surface, characteristic of the Middle Prut Plain (Andries et al., 2003).

Description detailed morphological, determination of soils of the reception basin "Negrea" was made based on the data obtained for the six main soil profiles:

Profile № 1. *Ordinary chernozem non eroded*;
Profile №3. *Ordinary chernozem weak eroded*;
Profile №6. *Ordinary chernozem moderately eroded*;
Profile №4. *Ordinary chernozem strong eroded*;
Profile №15. *Chernozem izohumic cumulative*;
Profile №10. *Soil typical cumulative*.

Reception basin "Negrea" is situated in the temperate zone and is characterized by a moderate continental climate, warm, semi-humid. The annual amount of precipitation in the investigated area is equal to 500-550 mm, potential evaporation ranges from 850 mm on the crests and to 900 mm at the foot of the slopes. Coefficient values moisture the territory reception basin, calculated from the formula of Ivanov - Vysockij varies between of 0.6 to 0.65.

RESULTS AND DISCUSSIONS

In the process of performing soil studies it was found that soils on the slopes in this reception basin are affected by denudation and evolves through a denudation – compensation pedogenesis. In the sense that the relatively long period, which is going slow denudation has there is also a certain development of the soil in depth, pedogenesis compensates, at least partially, for thedenudation (Florea et al., 1987).

An exception is the case where there is an accelerated erosion of anthropogenic factors, such as inadequate management situation in which the massive loss of soil through erosion cannot be compensated by the pedogenesis. Both cases are present on the reception basin "Negrea".

First case. Use of land for perennial plantations and unclog of soils led to the output to the surface horizons underlying weak humiferous of soils initially eroded. Also humiferous surface horizons were buried at a depth of 30-50 cm, thus avoiding the possibility of being further destroyed by erosion. Formation of micro terraces between rows in vineyard plantations and orchards, grassing space between trees in orchards led to diminishing of the erosion processes. As a result, intensified processes of accumulation of organic matter in the former underneath horizons, weak humiferous to the surface by unblocking (Cerbari, 2010).

Second case. Vineyards and orchards in the fields of central reception basin were cut by 20 years ago and the lands - in arable included. Under the influence of this action anthropogenic the erosion processes intensified, the losses fertile soil have increased. Therefore, recent grubbing vineyards and orchards old plantations and the passage lands as arable could lead to a suddenly increase of the erosion processes reception basin territory. Ratio between flat and sloping land may serve as an indicator of the degree of manifestation of erosion processes and implicitly of volume of liquid leaks and loss of topsoil and nutrients evacuated from this zone of the river Prut. (Andries et al., 2003; Cerbari, 2010).

Non eroded soils are spread only very weakly inclined surface peaks (approximately inclination 1°). These soils are used as a standard to determination of the degree of soil erosion on slopes, by comparing the total thickness of the humiferous profile of eroded soils with the thickness humiferous profile of soil – non eroded standard.

The spectrum of ordinary chernozems with full profile, of with different degree of erosion, izohumice cumulative and soil typical cumulative sloppy, spread on the territory reception basin "Negrea" (Figures 1.1.-1.6.).

Figure 1.1-1.3. Soil profiles with different degrees of erosion

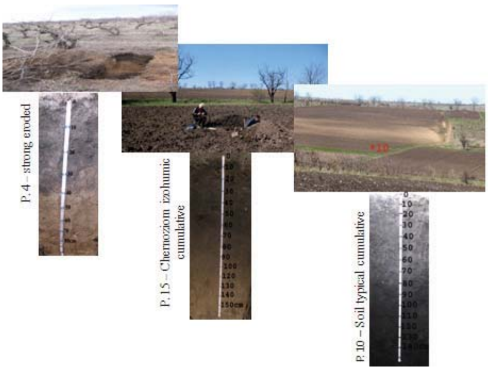

Figure 1.4-1.6. Soil profiles with different degrees of erosion

Profile №1: *Ahp1→ Ahp2 →Ahb→Bh1→ Bh2k→BCk1→BCk2.*
Profile № 3: *Ahp1→Ahp2→Ahb → BCk →Ck.*
Profile №6: *ABhp1→ABhb2 → BCk1→ BCk2.*
Profile № 4: *Bhp1 → Bhb2 → BCk1→ BCk2 → BCk2.*
Profile № 15: *Ahp1 → Ahp2 →Ahb → Bh1 → Bh2k → BCk.*
Profile № 10: *I hp → II h → III h → IV h → Ahb → ABhb→ Bhb1→ Bhb2→ BC.*

After physical clay content on the sector reception basin predominate clayey- loam soils Exceptions are cumulative soils and partly strong and very highly eroded soils horizons or layers above which have the loam texture. Small areas of loam soils are shown on the map of soils in the north-west of the basin atop the near the village (Cerbari, 2010; Canarache, 1990; Puiu, 1980). Information on the particularities of granulometric composition of ordinary chernozems investigated of the territory of reception basin "Negrea" are presented as graphs below (Figure 1.7 (a, b)).

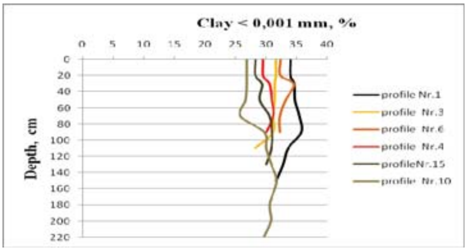

Figure 1.7(a). Clay %, on profile of ordinary chernozems not eroded with different degrees of erosion and cumulative

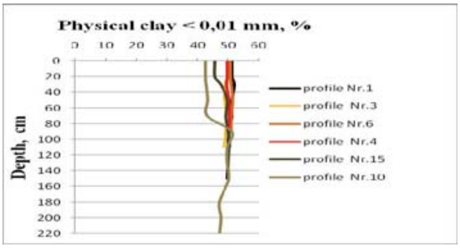

Figure 1.7 (b). Physical clay %, on profile of ordinary chernozems not eroded with different degrees of erosion and cumulative

High total content of medium sand, fine and coarse dust in recent conditions of chernozems arable layer ensures for plain soils of the Middle Prut physical and physical-mechanical properties compared favorable (Krupenikov et al., 1987; Canarache, 1990).

The corresponding humidity physical maturity these soils are working compared easily which ensures the ability to create a favorable germinating bed for crops. Vegetation has a special role in the stabilization the processes of leakage on the slopes. A specific feature of the investigated soils texture is medium and high content of fine sand. This confirms the formation of these rocks parental synchronous from a mixture of loess and alluvial deposits of wind. The highest content of fine and medium sand is characteristic of non eroded ordinary chernozem, located in the upper the basin on the former primary surface denudation of Pliocene age (Bilinkis 2004; Brindus et al., 1999). The high content of fine and medium sand in combination with not too high clay content (mostly 28-31%) ensures cohesion middle between elementary particles of soil that, as a result determines small water stability of the structural elements and a medium resistance of erosion of soils. On the other hand, in terms of texture, these soils are very suitable for vine plantations and orchards what concomitantly with favorable weather conditions led to unclog soils and total land use under the these cultures (Florea et al., 1987; Puiu, 1980; Zaslavskiy, 1966).

Field research was conducted in early spring after rain and soil moisture practically corresponds with researched field water capacity (CC). Aeration porosity values at CC genetic soil horizons in the following is ranked in: arable layers - large aeration porosity; the former arable layers (20-35 cm) - small aeration porosity; underlying layers under the former arable - very low aeration porosity for the strongly eroded soil and low for all other soils (Cerbari, 2010; Canarache, 1990).

In the process researches pedological in the period April 10 to 15 was determined and humidity in the layer 0-100 cm of soil principal profiles. According to the results of the determination and calculation values of water reserves in the layer 0-100 cm of soils at this time are practically equal, this is expluained by their texture homogeneity. Density values with depth increases from 2.63 to 2.64 in the earth's surface horizons up to 2.68-2.72 in the underlying horizons. The bulk density for weak humifiable horizons of reception basin soils varies between 1.40-1.55 g/cm^3, specific values chernozems (Figure 1.8).

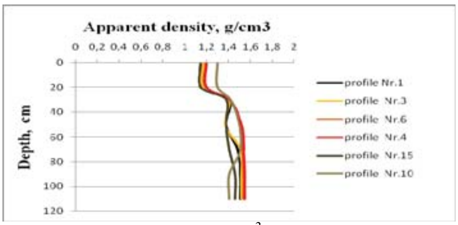

Figure 1.8. Bulk density (g/cm^3), on profile of ordinary chernozems not eroded with different degrees of erosion and cumulative

Database on characteristics of soils investigated will enable to plan and implement the necessary measures for the protection, sustainable use and increasing soil fertility exposed erosion process (Cerbari, 2010).

CONCLUSIONS

The diversity of relief forms, rocks and agricultural use conditional existence on the territory reception basin "Negrea" with complex cover of soils, in which the predominant component ordinary chernozems with varying degrees of erosion (83%).

The texture of loam and clayey-loam, sandy-dusty, unsatisfactory hydro stabilities of the structure are factors that contribute to the spread of the erosion processes of soil on agricultural land of the reception basin.

The soil cover of the reception basin „Negrea" is an exemplification of indestructible unit between the interaction of soil, vegetation (life), environment and human in a hilly region. Soils on the slopes are affected by denudation and evolve through a denudation-compensation of the pedogenesis.

Antierosional works within the reception basin should be made based on a scientific project reasoned that provides a systematic approach to this problem. It is necessary to extend the herbaceous vegetation areas to evacuate rainwater and reduce soil losses as a result of erosion.

REFERENCES

Andrieş S. et al., 2003. Programul de conservare a solului din bazinul hidrografic al râului Lăpuşna pentru reducerea poluării cu nutrienți a resurselor de apă. Chişinău, 60.

Bilinkis G., 2004. Geodinamika krajnego ûgo-zapada Vostočno-Evropejskoj platformy v èpohu morfogeneza. „Biznes-èlita", „Lextoria", Kišinev, 184.

Brânduş C. et al., 1998. Dicționar de termeni fizico-geografici. "Chemarea", Iaşi, 438.

Canarache A., 1990. Fizica solurilor agricole. Ceres, Bucureşti, 268.

Cerbari V., 2010. Monitoringul calității solurilor Republicii Moldova. Pontos, Chişinau, 475.

Florea N. et al., 1987. Metodologia elaborării studiilor pedologice. Partea III-a, Bucureşti, 226.

Krupenikov I., Podymov B., 1987. Klassifikaciâ i sistematiceskij spisok pocv Moldavii. Ştiinca, Kišinev, 157.

Puiu S., 1980. Pedologie. Ceres, Bucureşti, 394.

Zaslavskij M., 1966. Èroziâ pocv I zemledelie na sklonah. Kišinev, 494.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY OF BODY FOR SURFACE TILLAGE IN HEAVY SOILS WITH LOW HUMIDITY

Manol DALLEV, Ivan IVANOV

Agricultural University of Plovdiv, 12 Mendeleev Blvd, 4000, Plovdiv, Bulgaria

Corresponding author email: manol_dallev@abv.bg

Abstract

The article discusses the work of the active disk for the surface tillage of the soil, combining kinematics tiller with horizontal axis of rotation and lateral displacement of soil from disk work body in heavy soil with low humidity.
This paper examines the fragmentation of the soil at a certain speed range of the machine - at a speed 1.9; 4.6 and 7.9 km/h.
The data were processed statistically and are alleging regression equations built and graphics describing fragmentation of the soil.

Key words*: surface tillage, soil, active machine.*

INTRODUCTION

Surface active cultivation machinery soil led to a suitable condition for conducting subsequent operations sowing or planting.
This condition is characterized by the term - garden soil conditions - 70% of the aggregates have a size of 1 to 25 mm.
One of the main objectives of the surface treatment is to create a suitable aggregate composition and structure of the soil meets the requirements for growing the crop.
This study aims to clarify the fragmentation of heavy sandy - loam with low humidity with active disk operating authority for the surface treatment of the soil, combining kinematics surface tillage machine with horizontal axis of rotation and lateral displacement of soil from disk operating authority.

MATERIALS AND METHODS

Fragmentation is determined for each trial in equal distances along the test bed into 5 soil samples as follows: thrust is a metal box without a bottom with dimensions 400 x 300 x 300 mm. The bottom is introduced into it and the box with the soil is removed. The samples taken were left indoors, in which the air dried to a dry state and are separated into fractions by sieves with holes 1 and 25 mm. Fractions are weighed to the nearest 1 g and determine the percentage composition.
The indicator for the erosive dangerous condition of the soil is characterized by size fraction to 1 mm.
Indicator valuable agronomic soil is determined by the fraction size of 1 to 25 mm.

$$P = \frac{G_{ФР}}{G_{П}}.100\%$$

where:

Gfr is the mass of a fraction, g;

Gp - the mass of the entire sample, g (Stanev, 1968).

The moisture content is determined by taking daily samples before and after lunch on the diagonals of the test area at a certain depth the depth of work. Samples taken in airtight cups dried at 105 ° C to constant weight. Measure the weight before and after drying. Soil moisture was determined in the following manner:

$$Wa = \frac{G_B - G_C}{G_C}.100\%$$

where:

GB is the mass of wet soil;

Gc - the mass of the dried soil.

Soil moisture at depth is defined as the average of all samples for a given depth. When choosing a field of performing experiments with the following requirements:
The plot has a slope to the horizon is not more than 2-3°. Surface no bumps, lumps, ridges and

overthrew that provides safe operation of a Size length and width of the test area for an experience are determined by the following considerations:

l = V . t

Length / l / is determined by the maximum forward speed / V / and duration / t /
The width / B / limited working width / Bp / machine.
The dimensions of the whole experimental field are determined taking into account the number of attempts, mode of deployment in length and width. Because of errors some trials may be repeated. Before beginning the test, the test machine is adjusted to operate at the specified depth.
The experimental study was conducted according to a plan of experiments (Mitkov et al., 1993).
Speed is controlled by the transit time through the test section, measured by GPS Garmin 12.
Crop residues and weeds on the surface of the field is not controlled as in the selection of the experimental field has been respected for they are relatively evenly distributed.

RESULTS AND DISCUSSIONS

The studies were conducted in the village Bryagovo, region Plovdiv, in place "Demir Alan " soil representative of heavy sandy - clay machine.
soils with a clay content 56.5%. Soil background - deep plowing.
Energy source is MTZ-82 with speed PTO - 540 min-1 at speeds v1 = 1.89 km/h; v2 = 5.48 km/h; v3 = 7.97 km/h, respectively, of I, III and V gear.
Machine which carry out the surveys (Dallev, 2013) is equipped with a cut discs:

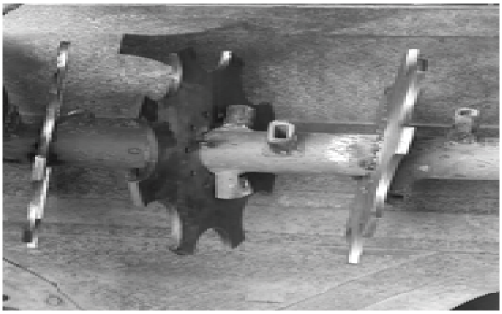

Figure 1. Disk machine

Studies of the aggregate composition of the heavy sandy-loam according to the speed and the humidity was done using a regression analysis on the basis of a passive conducting an experiment at a significance level α = 0.05.
After a data-processing software STATISTICA 7 are derived regression equations describing fragmentation (Z) of the three factions (up to 1 mm; from 1 to 25 mm; over 25 mm) of soil illustrated with regression lines and surfaces at the same level:

Table 1. Plan the experiment

	1 speed, km/h	2 Soil Moisture, %	3 aggregate composition < 1mm,%	4 aggregate composition 1-25mm, %	5 aggregate composition >25mm,%
1	1,89	9,21	10,9	47,3	41,8
2	1,89	9,94	10,4	51,8	37,8
3	1,89	10,26	13,5	54,1	32,4
4	1,89	11,29	9,6	61,7	28,7
5	5,48	9,21	13,4	35,3	51,3
6	5,48	9,94	11,7	38,2	50,1
7	5,48	10,26	7,9	43,7	48,4
8	5,48	11,29	7,7	51,1	41,2
9	7,97	9,21	9	36,4	54,6
10	7,97	9,94	6,4	40,9	52,7
11	7,97	10,26	3,9	44,8	51,3
12	7,97	11,29	1,8	49,3	48,9

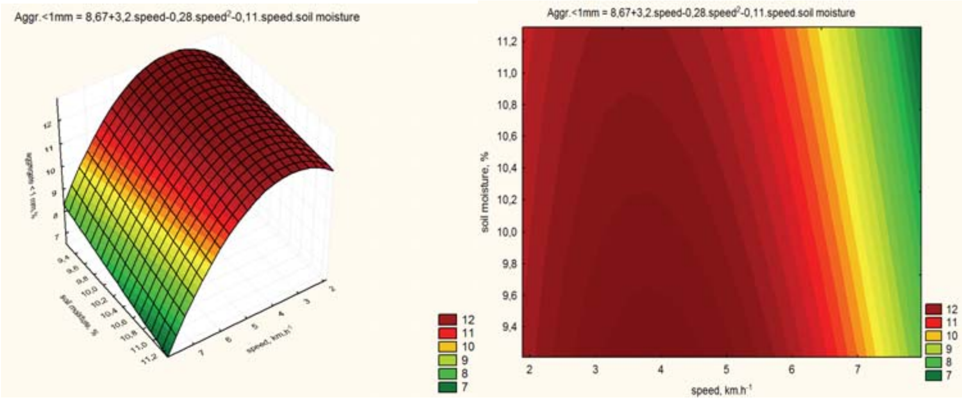

Figure 2. Aggregate composition < 1 mm

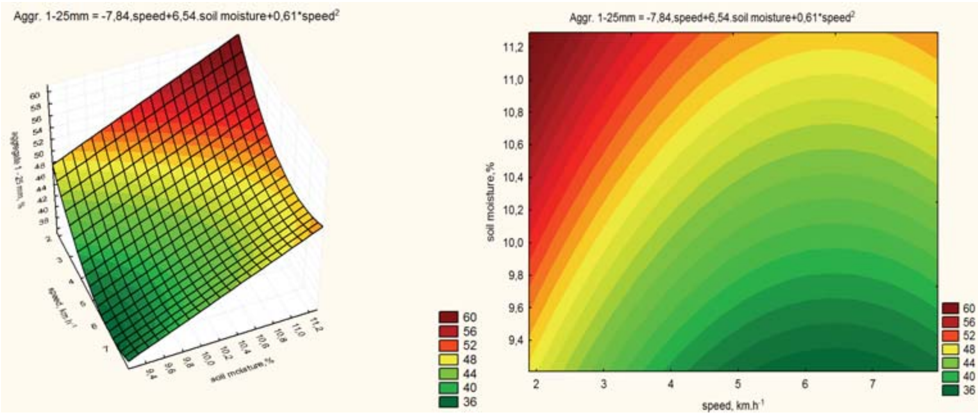

Figure 3. Aggregate composition 1-25 mm

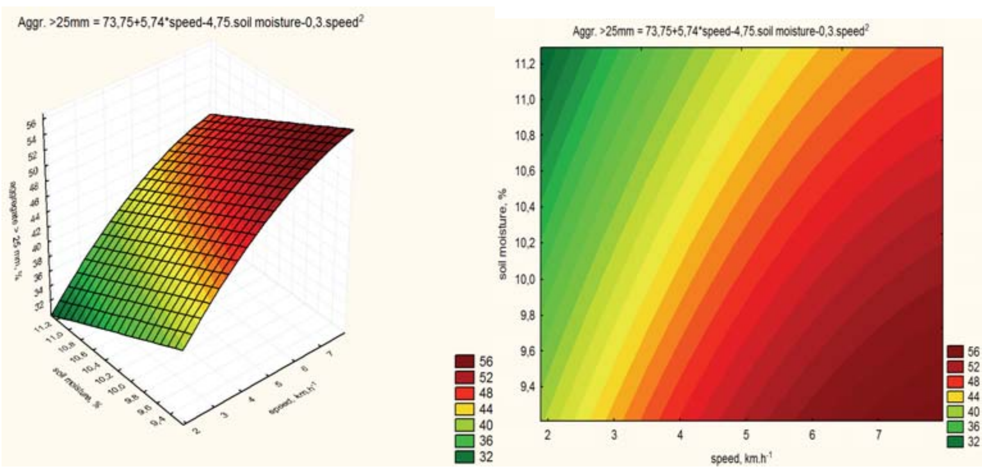

Figure 4. Aggregate composition > 25 mm

CONCLUSIONS

Due to the heterogeneous composition of the plowed field at low soil moisture working body starts hopping and shuffling only lumps of plowing.

In order to observe agrotechnical requirements, units from 1 to 25 mm to be ≥70%, respectively, while those to 1 mm and over 25 mm up to 30%, the measured values of moisture can be seen that it is impossible. Closest values to agrotechnical requirements are obtained at a speed of the unit around 2 km/h and 11% humidity.

During this process, the following will occur aggregate composition:

- 1 mm - 10%
- From 1 to 25 mm - 60%
- Over 25 mm - 30%.

ACKNOWLEDGEMENTS

This research work was carried out with the support of SRC - at the Agricultural University of Plovdiv and also was financed of Project No 03-13/2013.

REFERENCES

Dallev M., 2013. Investigation of a working body surface tillage. Abstract.

Mitkov D. Minkov, 1993. Statistical methods for the study of agricultural machinery part II, S., Zemizdat.

Stanev S. Shishkov, 1968. Machinery for tillage, sowing and cultivation. "Zemizdat", Sofia.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY OF BODY FOR SURFACE TILLAGE IN MEDIUM SANDY - CLAY SOILS WITH LOW HUMIDITY

Ivan IVANOV, Manol DALLEV

Agricultural University of Plovdiv, 12 Mendeleev Blvd, 4000, Plovdiv, Bulgaria

Corresponding author email: manol_dallev@abv.bg

Abstract

The article studied the fragmentation of medium sandy - clay soil with low humidity with active disk operating body for the surface treatment of the soil, combining kinematics tiller with horizontal axis of rotation and lateral displacement of soil from disk work body.
The study was conducted at different forward speed of the unit - 1.9; 4.6 and 7.9 km/h.
The results were processed statistically, are derived regression equations and built graphs describing the fragmentation of soil.

***Key words**: surface tillage, soil, active machine.*

INTRODUCTION

In building technology for growing crops mainly prevail tillage. It is inextricably linked part of any agricultural production. According to the depth of which is carried tillage is - basic and surface tillage (additional). One of the main objectives of the surface treatment is to create a suitable aggregate composition and structure of the soil meets the requirements for growing the crop. This study aims to clarify the fragmentation of medium sandy - loam with low humidity with active disk authority for the surface treatment of the soil, combining kinematics tillage machine with horizontal axis of rotation and lateral displacement of soil from disk working authority.

MATERIALS AND METHODS

Fragmentation is determined for each trial in equal distances along the test bed into 5 soil samples as follows: thrust is a metal box without a bottom with dimensions 400 x 300 x 300 mm. The bottom is introduced into it and the box with the soil is removed. The samples taken were left indoors, in which the air dried to a dry state and are separated into fractions by sieves with holes 1 and 25 mm. Fractions are weighed to the nearest 1 g and determine the percentage composition.

The indicator for the erosive dangerous condition of the soil is characterized by size fraction to 1 mm.

Indicator valuable agronomic soil is determined by the fraction size of 1 to 25mm.

$$P = \frac{G_{ФР}}{G_{П}}.100\%$$

where:

Gfr is the mass of a fraction, g;

Gp - the mass of the entire sample, g (Stanev, 1968).

The moisture content is determined by taking daily samples before and after lunch on the diagonals of the test area at a certain depth the depth of work. Samples taken in airtight cups dried at 105°C to constant weight. Measure the weight before and after drying. Soil moisture was determined in the following manner:

$$Wa = \frac{G_B - G_C}{G_C}.100\%$$

where:

GB is the mass of wet soil;

Gc - the mass of the dried soil.

Soil moisture at depth is defined as the average of all samples for a given depth. When choosing a field of performing experiments with the following requirements:

The plot has a slope to the horizon is not more than 2-3°. Surface no bumps, lumps, ridges and overthrew that provides safe operation of a machine.

Size length and width of the test area for an experience are determined by the following considerations:

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Length / l / is determined by the maximum forward speed / V / and duration / t /
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The dimensions of the whole experimental field are determined taking into account the number of attempts, mode of deployment in length and width. Because of errors some trials may be repeated. Before beginning the test, the test machine is adjusted to operate at the specified depth.
The experimental study was conducted according to a plan of experiments (Mitkov et al., 1993).
Speed is controlled by the transit time through the test section, measured by GPS Garmin 12.
Crop residues and weeds on the surface of the field is not controlled as in the selection of the experimental field has been respected for they are relatively evenly distributed.

RESULTS AND DISCUSSIONS

The studies were conducted in the village Bryagovo, region Plovdiv, in the "old a cemetery" of soil representative of an average sandy - clay soils with a clay content 42.9%. Soil background - stubble. Energy source is MTZ-82 with speed PTO - 540 min-1 at speeds v1 = 1.89 km/h; v2 = 5.48 km/h; v3 = 7.97 km/h, respectively, of I, III and V gear.
Machine with which carry out the surveys (Dallev, 2013) is equipped with a cut discs:

Figure 1. Half disk

Studies of the aggregate composition of the medium sandy loam according to the speed and the humidity was done using a regression analysis on the basis of a passive conducting an experiment at a significance level α = 0.05.
After a data-processing software STATISTICA 7 are derived regression equations describing fragmentation (Z) of the three factions (up to 1 mm; from 1 to 25 mm; over 25 mm) of soil illustrated with regression lines and surfaces at the same level:

Table 1. Plan the experiment

	1 speed, km/h	2 Soil Moisture, %	3 aggregate composition < 1mm,%	4 aggregate composition 1-25mm, %	5 aggregate composition >25mm,%
1	1,89	10,46	21,7	70,3	8
2	1,89	11,49	19,4	73,5	7,1
3	1,89	12,69	21,3	70,9	7,8
4	1,89	18,25	19,1	72,2	8,7
5	5,48	10,46	11,7	65,1	23,2
6	5,48	11,49	9,8	68,2	22
7	5,48	12,69	11,4	65,4	23,2
8	5,48	18,25	10,2	67,9	21,9
9	7,97	10,46	5,2	52,6	42,2
10	7,97	11,49	7,4	57,5	36,1
11	7,97	12,69	5,7	59,1	33,5
12	7,97	18,25	6,4	53,1	41,2

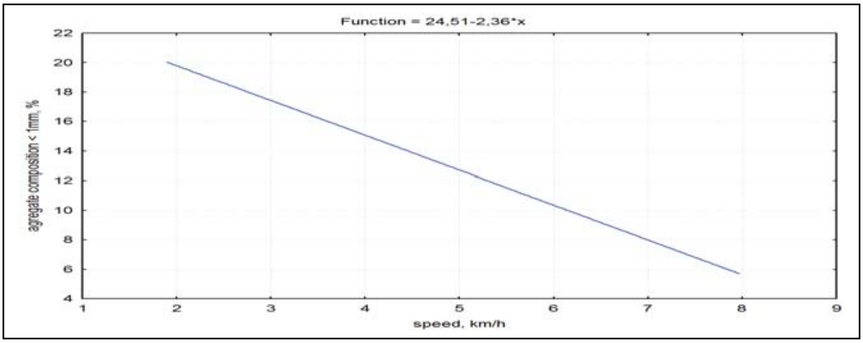


Figure 2. Aggregate composition < 1 mm

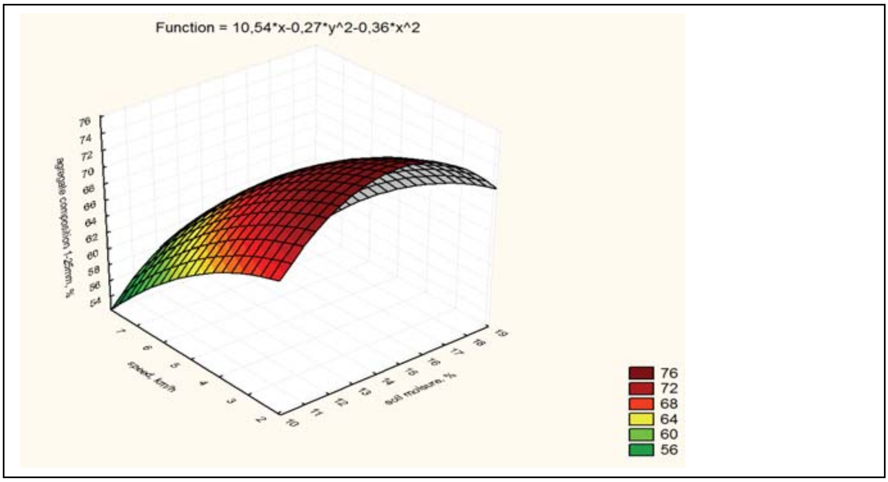


Figure 3. Aggregate composition 1-25 mm

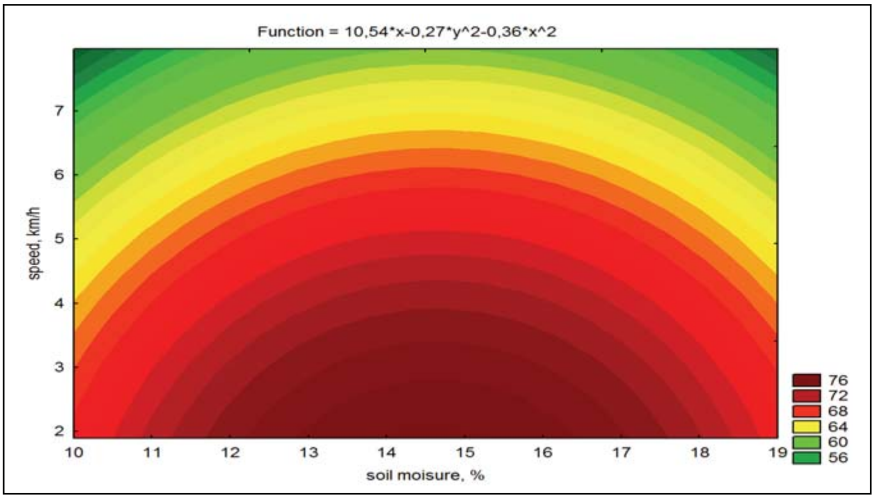


Figure 4. Aggregate composition 1-25 mm

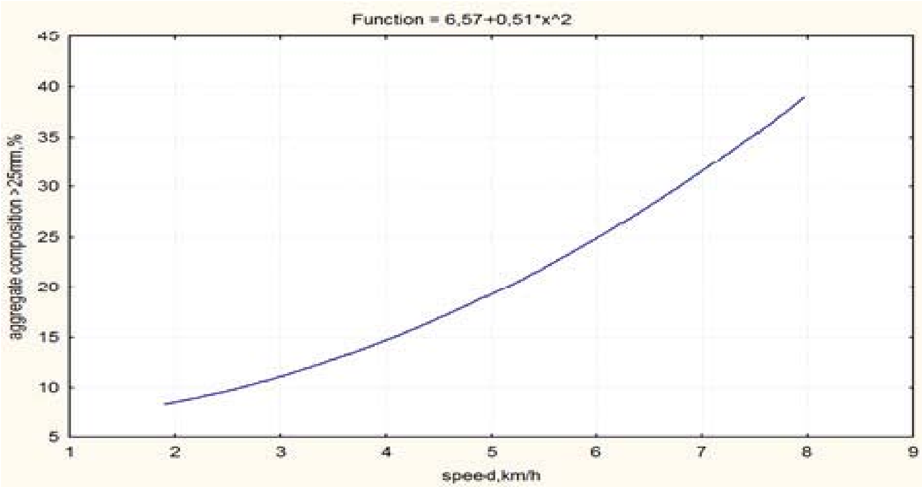


Figure 5. Aggregate composition > 25 mm

CONCLUSIONS

From the resulting regression lines and surfaces of the same response can draw some conclusions:

1. Fragmentation of soil aggregates to 1 mm becomes linear law, humidity (in the studied range) does not have significant effects, but only forward speed of the machine.
2. With increasing forward speed is increased the aggregates with a size above 25 mm, but these reduce to 1 mm. This is due to the fact that with increasing forward speed at a constant speed of the rotor to the tool body is reduced interaction with the soil disc.
3. In the studied range of work of the working body is established that an average sandy loam soils with low humidity recommended speed of the unit with the corresponding cut disk is about 3-3.5 km/h, where the aggregates:
   < 1 mm have values - 15%;
   1-25 mm - 71%;
   > 1 mm - 14%.

ACKNOWLEDGEMENTS

This research work was carried out with the support of SRC - at the Agricultural University of Plovdiv and also was financed of Project No 03-13/2013.

REFERENCES

Dallev M., 2013. Investigation of a working body surface tillage. Abstract.

Mitkov D. Minkov, 1993. Statistical methods for the study of agricultural machinery part II, S., Zemizdat.

Stanev S. Shishkov, 1968. Machinery for tillage, sowing and cultivation. "Zemizdat", Sofia.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE BIOPHYSICAL INSURANCE OF A REGIONAL MODEL OF CONSERVATION AGRICULTURE

Gheorghe JIGAU

Moldova State University, 60 A. Mateevici, MD-2009, Chisinau, Republic of Moldova

Corresponding author email: gheorghe.jigau@gmail.com

Abstract

Alternative soil tillage technologies within short crops rotation do not provide process of liquidation of the soil profile stratification and of optimization of physical characteristics and regimes of arable layer. At the same time the intermediare crops also do not provide these effects. Therefore, even after 7 years of practicing agricultural technologies works, biological processes is highly concentrated in the top 15-25 inches from the surface. From this point of view, it is proposed that alternative technologies to be implemented within the framework of a biologization and fiziatization program of chernozems in 3 stages using rotation works.

Key words*: conservative technologies, landscape adaptation, biologization, greening minimization.*

INTRODUCTION

Accelerated degradation of soil resources associated with a number of new challenges of millennium (instability - climate change, rapid reduction in non-renewable energy resources and increasing prices for them, constantly increasing the energy inputs in agriculture and income reduction, reductions in water and their quality, desertification and so on. a.) shows that the concept of green revolution failed, which involved working in agriculture paradigm shift in which emphasis is placed on increasing yields paradigm focused on reproduction enlarged production base. Last materialize the concept of sustainable agriculture, part of a broader concept - sustainable economy.

The concept of sustainable agriculture requires identification of the non-conformities within agricultural system practiced in its efficiency by reducing energy inputs, greening and biologization part of a vaster concept - sustainable economy.

Reducing energy inputs implies, firstly, minimizing works based on scientific arguments regarding the genesis and evolution of soils and their characteristics.

Minimizing the purposes of conservative technology is seen as a measure of the degree of enhancement technologies. As the degree of intensity is greater than the deeper is minimization, including by direct sowing.

Greening and biologization assume reducing chemical inputs in favor of biological crop protection and soil management fertility. In this regard, drawing out that the concept of conservation agriculture is incompatible with the principles of intensive chemicalization of agroecosystems. This implies the need to move from the paradigm intensification of agriculture by chemical treatment to one paradigm based on the principles of bioagriculture new evolutionary-genetic and environmental - genetic interaction living matter (various plants, animals, microorganisms) and abiotic materials (parent rocks) which lead to the formation and development of various soils and fertility (Jigău, 2009). Failure to follow these principles in their practice of conventional and without significant broadening genetic diversity agrocenosi has reduced the role of biological factor and factor geomorphological increase in anthropogenic pedogenesis. Therefore, under the given climate instability increased strength of the various processes of soil degradation and their bioproductivity. At the same time, the new paradigm involves developing a conceptual framework - a methodological approach based on the fair value of the soil-plant relationships in the development and evolution of ecosystems.

MATERIALS AND METHODS

To these research elaboration, started from point that in all agricultural reforms have faced economical and environmental aspects, giving preference always economical ones.

Acumalated experience in Moldova, in this chapter shows that such approach persists in the conservative farming system practiced in the region.

According to recent generalizations practice technologies provide more conservative economic advantages:

- reducing costs per unit of production by 30-45%.
- reduce energy consumption, particularly fuel and lubricant, thus reducing significantly impact the efficiency econmic these prices;
- reducing the technical park and farm units aggregates, respectively, of expenses connected to maintenance;
- reducing the consumption of mineral fertilizers, synthetic, as captivating the dependence of foreign markets where they are imported.

Despite the fact that many farmers insist that the crop is reduced dependence on climatic conditions, in reality there is great variability in yields from year to year, depending on climatic peculiarities of years. Something else, that even in dry years provides not only the size of harvests and income expenses connected refund.

Environmental issues, in particular the development of soil functions within agroecosystems, in most cases, are considered lesser extent.

At the same time, our research shows that during 2007-2014 years soil development involves many questions.

In this respect mention first, mainly in the substitution of the type of organic waste storage site by the type ex site. This leads to the concentration of biochemical processes mainly in the surface layer.

The soil moisture regime also suffer noticeable changes.

RESULTS AND DISCUSSIONS

Systematic inspection of the pilot lands arranged under production conditions indicate a significant increase water reserves at the beginning of the variation in vegetation deep loosening. Values plowing, no-till and loosening surface is characterized by relatively identical reservations. During vegetation, however, water consumption is the most rational variant No-Till. The variants loosening superficial and deep moisture consumption is almost identical (Figures 1-4).

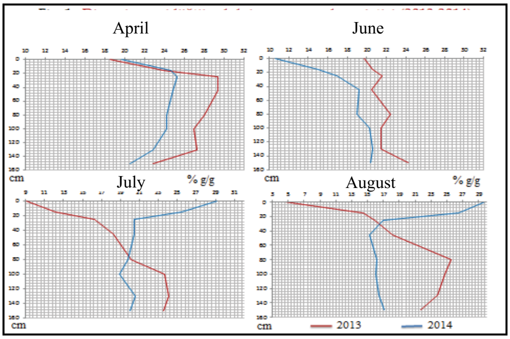


Figure 1. Dynamics of soil moisture under plowing during the vegetation (2013-2014)

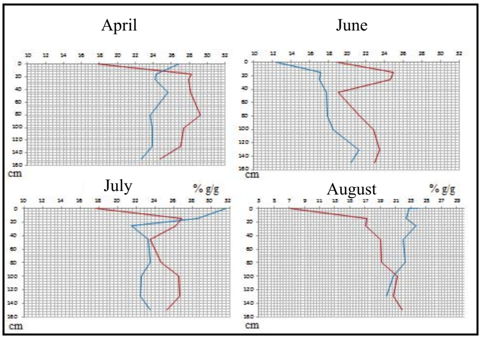


Figure 2. Dynamics of soil moisture under no-till during the vegetation (2013-2014)

Synchronized with moisture dynamics is dynamic apparent density (Figures 5-8).

Monitoring the dynamics of these two parameters show that after 7 years of work practice alternative systems of land within soil profiles clearly emerges arable layers and under arable layer with values close to the critical and even surpassing them. Under these conditions the soil pore space discontinuous gate which cause crop root system remains concentrated in the first 15 to 25 cm from the surface. At the same time, monitoring the dynamics and distribution of humus profile, nitrate nitrogen, phosphorus and potassium exchangeable mobile shows that the processes that determine these parameters are also concentrated in the surface layer (Figures 9-15).

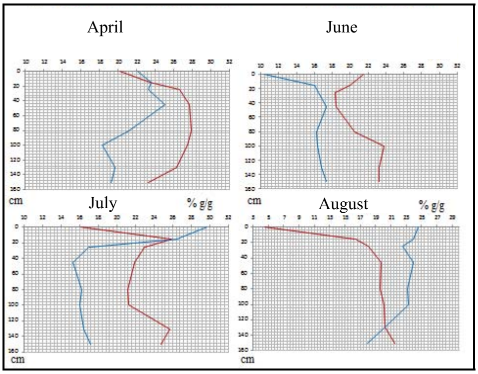


Figure 3. Dynamics of soil moisture under mini-till during the vegetation (2013-2014)

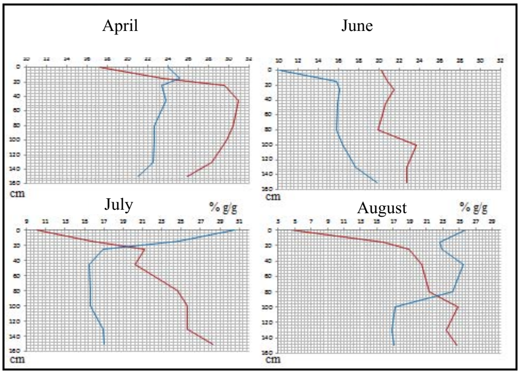


Figure 4. Dynamics of soil moisture under deep refining during the vegetation (2013-2014)

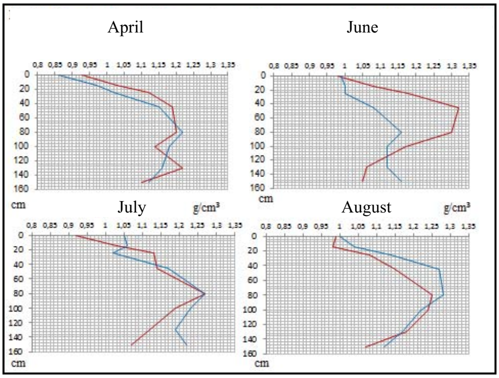


Figure 5. Dynamics of soil apparent density under plowing during the vegetation (2013-2014)

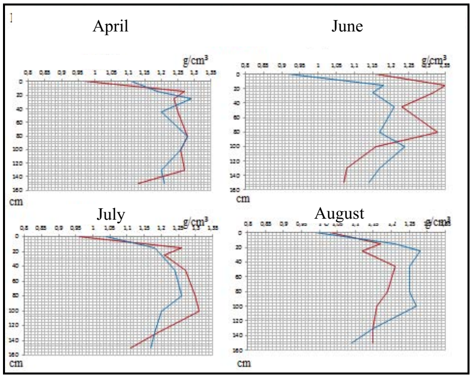


Figure 6. Dynamics of soil apparent density under no-till during the vegetation (2013-2014)

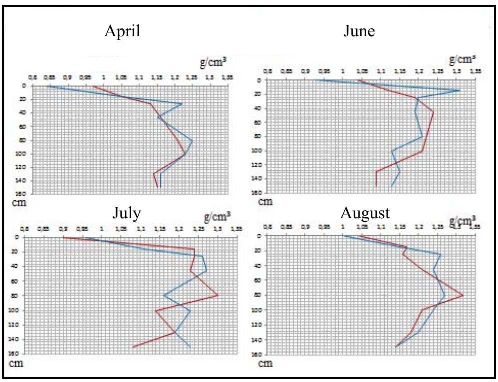


Figure 7. Dynamics of soil apparent density under mini-till during the vegetation (2013-2014)

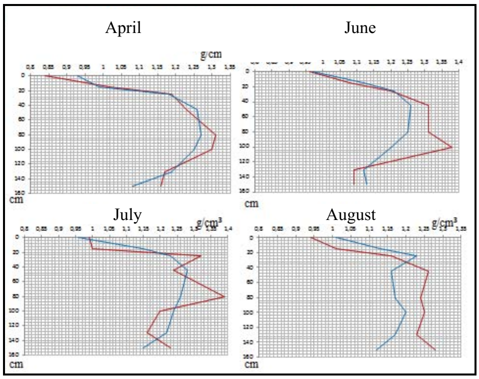


Figure 8. Dynamics of soil apparent density under deep refining during the vegetation (2013-2014)

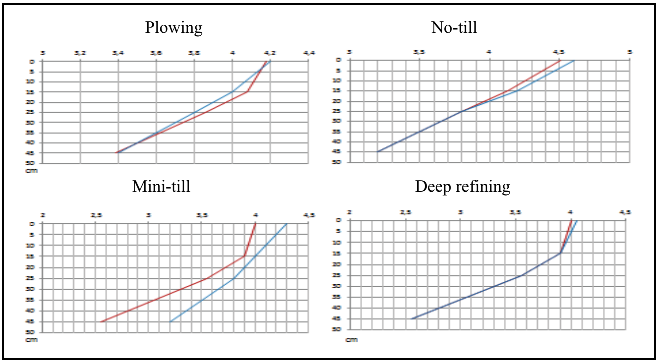


Figure 9. Profile of Humus in different tillage systems

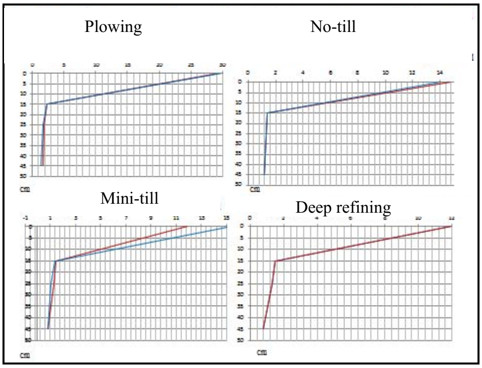


Figure 10. Distribution of nitrogen in the beginning of vegetation on profile in different tillage systems (2013-2014)

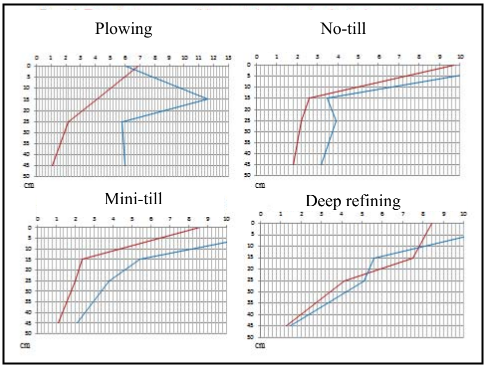


Figure 11. Distribution of nitrogen at the end of of vegetation on profile in different tillage systems (2013-2014)

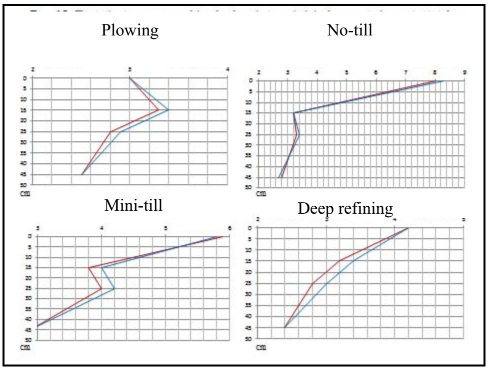


Figure 12. Distribution of mobile phosphorus in the beginning of vegetation on profile in different tillage systems (2013-2014)

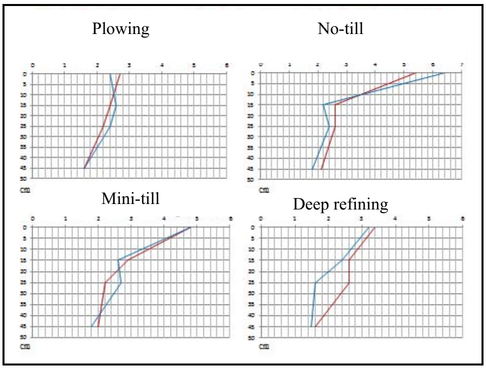


Figure 13. Distribution of mobile phosphorus at the end of vegetation on profile in different tillage systems (2013-2014)

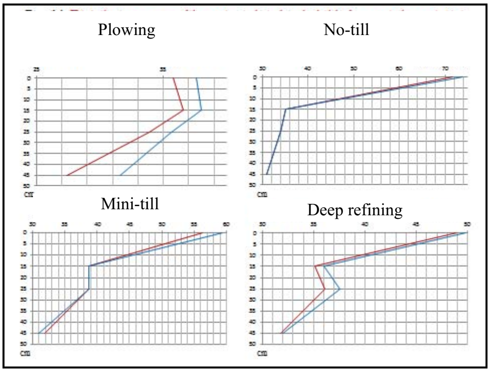


Figure 14. Distribution of potassium in the beginning of vegetation on profile in different tillage systems (2013-2014)

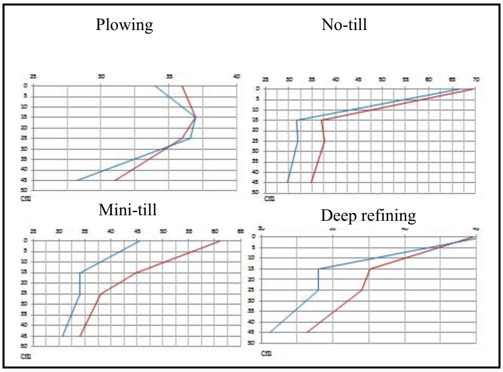


Figure 15. Distribution of potassium at the end of vegetation on profile in different tillage systems (2013-2014)

CONCEPT AND SOLUTIONS

The new paradigm of conservative agriculture is based on optimal combination of plants (crops) capability with adaptability of adaptive potential landscape and requires ecological and evolutionary processes modeled, which is nothing else than unidirectional interactions between different species and variety of living organisms and abiotic material (parent rock) in agrocenosis. By the theory of pedogenesis and soil evolution under only such approach can be ensured fertility increase in agricultural regime (Jigău, 2013). This constitutes the essence of biologization process of agrobiocenosis and creating agrobiogeocenosis. The principles of this process are drawn from nature remains to be done only theoretical interpretation and implementation in production, taking the principles of soil biophysics.

Last is the interface between physics, biology and soil science and study structural and functional organization regularities of soil as biorutinare dynamic systems and phenomena and physical processes taking place in soils involving biological substance.

The core idea of organizing this branch is biogenic soil, reflected in living organisms targeted action on abiotic components (solid, liquid, gas) of soil in order to organize their space and ambiance ambient opimizării initial intrinsic unfavorable for the development and reproduction of living organisms.

Substances, energy and information accumulated in these soils determines actions, in turn, the development of living organisms, achieving response relationships biorutinare systems - the main specific aspect of self-organized structures. Response relationship materializes ecological functions of soil, including the base - fertility. In this respect the development of the main factors of fertility (structure, pore space, water and air capacity reserves of nutrients) are determined by the self-organization of product-oriented optimization biogeocenoze original mother rock characteristics unfavorable for plant growth. Self-organization is achieved through regulatory processes flow rate (intake) and transformation of organic substances in biorutinare systems.

In Agrogen regime, an important factor in dealing with human factor is biorutinare systems that can perform both positive role and negative role degradative creative if his actions are contrary to the laws of natural organization of systems,

Through this prism of ideas biologization agroecosystems is a process of soil fertility management through parental modeling and optimization of substrate development and reproduction of plnatelor himself through crops. In this respect it is known that any work process is used to modeling an ambience ecopedological as optimal for the development and reproduction of plants.

In the role of modeling lies agrobiocenozer is come to plant itself. It is thus achieving a reduction in expenses connected to technological operations (work, fertilization, plant protection).

Achieving this goal is only possible by adapting crops landscape conditions. This implies the need to assess the potential of soils adapriv. In this situation the role of soils death have physical characteristics (size composition, denistatea apparent porosity, aggregate composition, degree of balancing the composition of aggregate and aggregate stability, degree of mobility and accessibility of water in the soil, the degree of aeration). Crop selection to be made taking into account the possibilities mandatory solitary landscapes and cultures. In case of non-simultaneousness capacity of crops adaptability and the potential of the landscape adaptiv, crop plants consume some of the energy necessary to ensure comfort, so they lose bioproductivity.

From those referred consider it necessary a model of conservation farming system corresponding with bioclimatic conditions in the region (Jigău, 2015).

The basic components of the regional model of conservation agriculture are:

- Systemic approach to conservation agriculture.
- Differentiation and adaptation of all components of Landscape agroecosystem (culture, work, fertilization, plant protection).
- Reduce to a minimum of mechanical pressure to modeling soil and increasing the role of biological factor in this process.
- Management of organic substances.
- Practice differentiated crop rotation based on landscape conditions.
- Implementation of a National Programme biologization and fiziatization of agroecosystems in Moldova
- Staggered implementation in stages of components of conservative farming system.

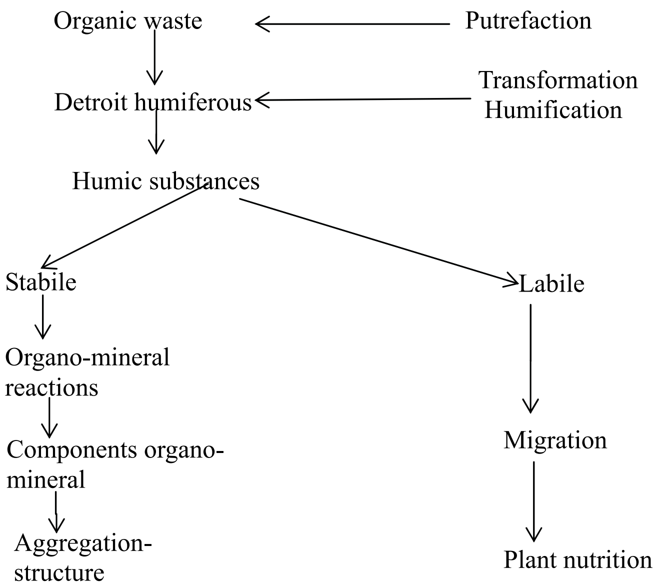
Basic components of the national program and fiziatization of biologization of agroecosystems in Moldova are:

1. The practice of differentiated crop rotation and increasing area occupied by perennial grasses.
2. Systematic practice of sidereal crop, intermediate and interspersed.
3. Incorporate all organic residues in the soil and ensuring biological nitrogen necessary for the decomposition and transformation, their humification.
4. The processing of organic waste in order facilitate the process of animal transportation and soil management.
5. Practicing effective biopreparates as to optimize nitrogen in the soil and transformation framework-humification of organic waste.
6. Minimize chemical inputs from outside and promote biodiversity by increasing biological energy resources.

Its implementation will lead to a number of pedofunctional and landscape effects within biological agroecosystems:

1. System restore of organic substances.
2. Favorisation of modeling biological processes of soil substance in accordance with plant needs:
    - Autorefining and ensuring optimal values of aparent density.
    - Aggregation substance and increasing soil aggregate stability.
    - Ensuring continuous and optimal pore space.
3. Optimizing relationships with water, air, heat, etc.
4. Restoration of soil biota, fewer pests and pathogens.
5. Returnation of the area pedogenetic processes and optimizing soil functions within the landscape.
6. Diminuation of erosion processes.
7. Reduction of energy consumtion.

Functional components of the system of organic substances can be drawn with the following scheme:



In complance with the concept stated above, implementation of regional model of conservation agriculture requires 3 stages as follows:

No.	Phase	Content
1	Transition	System works and arrangements adapted to the characteristics Agrogen layer. Increasing energy resources in the ground. Biologization and optimize physical properties of the layer Agrogen. Effective combination of processes (ie processes) agronomic and biological
2	Elementary pedogenetic processes and landscape restoration	Minimize work. Work systems adapted to the landscape. Differential rotation in accordance with necesitățille adaptive-improvement of the landscape. Practicing field with sidereal. Intermediate crops and intercropping practice tailored to the landscape. Promote biological processes in soil. Moderate fertilization corresponding recovery capacity of the soil.
3	The enlarged production of typogenic processes and working landscapes	Conservative system adapted to the landscape. Crop rotation adapted to the landscape. Structure of crops with high economic efficiency and pedofunctional. Inclusion of perennial grasses in rotation. Placing emphasis on biological resources of the landscape. Promoting biological methods of plant protection.

REFERENCES

Jigau G., 2009. Genesis and soil physics. CEP USM, p. 154

Jigau G., 2013. The role of legumes and ameliorative crops in organic farming. Chisinau, p. 88

Jigau G., 2015. Some results of conservative technologies application in Moldova. Journal LIDER AGRO, No. 1-2, p. 8-13.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

POSTAGROGENIC EVOLUTION OF CHERNOZEMS IN FALLOW CONDITIONS

Gheorghe JIGAU

Moldova State University, 60 A. Mateevici, MD-2009, Chisinau, Republic of Moldova

Corresponding author email: gheorghe.jigau@gmail.com

Abstract

The research in the pilot lands showed a change of chernozems from arable regime to fallow regime involves initiating a new postagrogenic phase of development. The basic components of postagrogenic evolution are restoration system of soil organic substances, porous space recovery, increase capacity for water and water reserves.

Key words: *postagrogenic evolution, humifiable organic matter, labile humic substances, aggregate composition, porous space.*

INTRODUCTION

The periods of crisis in agriculture has always been involving the leave of less productive lands and leave them fallow.

Social and economic changes that took place in between the Prut and Dniester rivers space in the late twentieth century beginning of twentieth first century cited radical changes in the agricultural use of soil resources.

Referred to this chapter is the exclusion of the arable lands from agriculture, and leaveing them fallow.

The investigation of the processes which is realized in soils under fallow conditions presents both, scientifical and practicalal interest, particularly related to forecasting the evolution.

Based on the theory of pedogenesis the transition of arable fallow land involves restoring in time of the place and biological role factor in functioning the soil ecosystem. In this regard, land fallow involves restoring the composition and volume of biological circuit substances and autorehabilitation of feature and and soil regimes:

In Russia, in between the eighteenth and nineteenth centuries was practiced the periodic passage of land fallow to restore the depleted soils. According to V.R.Williams in the first year after fallow maintenance the wheat yields 6-10 t/ha and the content protein substances in grain made up more than 30% (Williams, 1936).

At the same time, P.A.Kostacev, still in the second half of the nineteenth century considered fallow maintenance of soils contribute to amelioration of the restoration of characteristics and soil regimes.

Recent research has shown that in the remaining fallow land the occurs the development of successively several associations of grass plants, including until the rehabilitation of regional plant formation.

According to many authors in soils in the fallow areas it creates a string of restoration and balance directions of the biogeochemical composition circuit of substances and ensure renaturation and enlarged reproduction of the type (subtype) zonal pedogenesis.

The data of Cadastre of the Republic of Moldova for the last 20-25 years shows a significant increase of fallow surfaces, which involves several economic and environmental issues. The purpose of the research involved studying the direction, intensity and dynamics evolution of tipogenetic black soil processes integrated in the process of restoring the fallow landscape.

MATERIALS AND METHODS

The research was conducted in pilot lands in southern (Cantemir) and central (Chisinau) areas of Moldova and included field and laboratory applications.

Field applications included the opening of soil profiles in the width of 8-10 m after morphometric measurements were collected soil samples taking into account the variability in space of morfometrical features. For each profile there were collected 5 sets of individual samples over the entire thickness thereof taking into account the thickness and sequencing of the horizons. Subsequently the samples were mixed in order to obtain a sample with one composition for each depth (horizon).

For laboratory research were used the following methods.

1. Determination of humus - ȚINAO method.
2. Determination of total nitrogen – ȚINAO method.
3. Determination of apparent density - Kacinschi method.
4. Determination of composition aggregation and water stability aggregation - Savinov method.
5. Determination of peptiser clay in water - Gorbunov method.
6. Determination of hydro indices - based on suction curve.

Labile fraction of humic substances extracted using 0.1N NaOH is and subsequent determination of the carbon content was performed by the ȚINAO method.

The total porosity was calculated by applying the formula:

$$Et = \left(I - \frac{Pb}{Ps} \right) x100$$

where,

Et – total porosity, - %;

Pb – bulk density, g/cm^3;

Ps – solid phase density, g/cm^3.

RESULTS AND DISCUSSIONS

Among the first features that react to the chage from chernozems to fallow are morphometric traits. In this context worth to mention that in less than 10 years in the segment of the soil surface the fallow horizon is forming. The horizon color becomes black, the compactness and structure of the high-profile is improving, practically, the agrogenic features disappear completely.

The maintenance of chernozems under fallow regime leads to the restoration and balance the system of organic matter in the soil.

An important index characterizing organic substances system is non-humifiable organic matter content (detrit humus) in the soil.

It is known that placing the chernozems in arable circuit involves the destruction of the humus detrit layer (Jigau, 2009). In addition, the annual plowing of the arable layer leads to an accelerated mineralization of the non-specific organic matter present in soil. The passage of soils from arable under fallow regime is accompanied by a slow increase of non-humifiable organic matter in the soil (Table 1).

Table 1. The dynamics of non-humifiable organic matter in typical chernozem with poor humus in various maintenance regimes (SRL Podgoreni, Cantemir rayon), % (July)

Depth, cm	Soil maintance regime											
	Plow			Mini-Till			Fallow			Forest shelterbelt		
	2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
0-10	0.08	0.08	0.11	0.24	0.41	0.56	1.57	1.77	1.77	1.92	1.93	1.95
10-20	<0.01	0.03	0.02	0.22	0.25	0.28	0.23	0.37	0.41	0.73	0.73	0.79

From the above table we can notice that under typical plowing system of chernozem in southern Moldova that practically the non-humifiable debris are not present. Reducing the cultivation works is increasing the non-humifiable organic matter content in soil.

From the above table we can see that in conditions of Mini-Till System it establishes a stable increase of non-humifiable organic matter content.

The biggest content of non-humifiable organic matter in soils is found in forest shelterbelts.

This content is relatively stable and varies in the range of 1.92-1.93% of 0-10 cm layer. In the 10-20 cm layer the non-humifiable organic matter content decreases abruptly in the range of 0.73-0.79%.
In fallow soils in 0-10 cm layer is establishing a cumulative trend of non-humifiable organic substances. Its content in the layer 10-20 cm indicates a clear cumulative regressive distribution. However, given the fallow age (12 years) we can conclude that the accumulation of non-humifiable soil organic matter results more intensive than in forest shelterbelt (age 53 years). According to the calculations during the 12 years the amount of debris has increased from 3.27 to 11.02 t/ha. The percentage of root residues increased from 11.3 to 43.6%.
The slow restoration of non-humifiable organic matter reserves contributes to unidirectional process of formation and accumulation of humus (Table 2).

Table 2. Indices of restoring the humus profile of typical chernozem poor in humus (SRL Podgoreni, Cantemir) under various conditions of maintenance

Maintainance system	Depth cm	Year								
		2011			2012			2013		
		Total Humus %	Mobile Humus %	% humus mobile from total humus	Total Humus %	Mobile Humus %	% humus mobile from total humus	Total Humus %	Mobile Humus %	% humus mobile from total humus
Plow	0-20	3.6	0.14	3.8	3.6	0.11	3.0	3.6	0.13	3.6
	20-40	3.3	0.06	1.8	3.3	0.06	1.8	3.3	0.04	1.2
	40-60	2.4	0.03	1.2	2.4	<0.03	<1.2	2.4	<0.03	<1.2
Mini-Till	0-20	3.9	0.15	3.8	3.9	0.13	3.3	4.0	0.15	3.8
	20-40	3.3	0.08	2.4	3.3	0.08	2.4	3.5	0.10	3.1
	40-60	2.4	0.04	1.7	2.4	0.04	1.7	2.4	0.04	2.4
Fallow	0-20	4.4	0.32	7.2	4.4	0.28	6.3	4.4	0.36	8.2
	20-40	3.6	0.14	3.8	3.6	0.12	3.3	3.6	0.15	4.1
	40-60	2.8	0.09	3.2	2.8	0.09	3.2	2.8	0.12	4.1
Forest shelterbelt	0-20	4.7	0.38	8.0	4.7	0.33	7.0	4.7	0.39	8.2
	20-40	3.9	0.13	3.3	3.9	0.10	2.5	3.9	0.15	3.9
	40-60	3.3	0.11	3.0	3.3	0.09	2.6	3.3	0.13	3.9

In this regard, it is mentioned that under fallow conditions the formation and accumulation process and helps restore, in particular, the humus profile, and in general the humic substances profile.
From the above table we can see that under fallow conditions increases the humus content not only in the first 0-20 cm but also in deeper layers. The obtained data showes the distribution of humus in the first 0-60 cm the soil within this treatment is significantly different from the plowing treatment approaching to initial version that is typical to forest shelterbelts.
Even more significant changes occurred in the case of labile fraction.
From the presented table can be seen that under fallow conditions significantly increases the processes of decomposition and transformation of debris into stable humus fraction, which helps to restore soil humus reserves and labile fraction of humic substances that contribute to increase the soil fertility.
Also it should be mentioned that the process of humus formation in fallow chernozems is accompanied by enriching the humus with nitrogen.
According to Table 3 it can be found that under arable regime, during the years 1975-2012 –

the total content of carbon was reduced to 0.7-0.8% in arable layer (about 4/3 of the initial content) and total nitrogen content decreased almost twice. In arable layer it decreased from 0.23 to 0.12-0.13%.

Following the C:N ratio it has increased from 11.3-11.8 to 14.6-15.8. This allows us to conclude that dehumification, under arable regime, involves mineralization of fraction of the humic substances rich in nitrogen. At the same time, under pronounced shortage of biological nitrogen the humification process results in the formation of humic substances poor in nitrogen.

The passage of chernozems from arable to fallow regime leads to the restoration process of formation and accumulation of humus. At the same time, there is humus nitrogen enrichment, which allows us to conclude that in terms of postagrogenic conditions of evolution leads to formation of high quality mature humus.

Increasing the humus content in chernozems leads to an improved potential of their's structure.

The data presented in Table 4 is showed that under arable regime, after a period of time the reductions of humus reserves in soil increases in the same time the ratio clay: hummus (A: H), this indicates the capacity reduction of aggregation. This is materializes in increasing the content of fine clay peptised in water and factor of disperssion (Tabel 5). Increasing the content of humus in fallow conditions, on the contrary contribute to reduce the content of fine clay peptised in water, respectively, to reduce the coefficient of dispersion (Table 5).

The increase of the capacity of aggregation leads to intensification of structure process. The data presented in Table 6 shows that from 2003 to 2012 the content of aggregation agronomic valuable has increased on average by 5% in the layer of 0-20 cm and 6-10% in 20-50 cm layer. The coefficient of structure (Ks) in 2012 compared to 2003 increased in average 1.3-1.5 times. At the same time, in soils there is a stable trend of increasing the water stability structure. As a proof, significantly increases the ratio of the total aggregate 10-0.25 mm and content of those water stabile (Table 6).

Significant changes showes the hydrophysical indices (Table 7).

The accumulation of organic matter in the soil leads to the slow change in the solid phase density values. More pronounced is the reduction of these values in the first 0-30 cm from the surface and is well correlating with the evolution in time of organic matter content.

Improving the structural-aggregate situation leads in time to architectural changes of agrogenic layer, combined with reduced soil bulk density. These changes are more pronounced in the 0-50 cm layer which leads to a decrease to the minimum of agrogenic stratification of soil profile. In the latter the bulk density values slightly increases with depth.

Synchronized with the evolution of soil density it is the evolution of spatial porosity.

In Table 7 it is showed that in 2003 the investigated soils had discontinuous porous space, which is determinated by the unsatisfactory values of total porosity of the sub- arable layer (30-40 cm).

Already in 2009 the discontinuity of porous space is reduced to a minimum and by 2012 for the studied chernozems is characteristic a porous profile that is very close to natural state.

Specified changes have a small influence on the hygroscopicity coefficient (CH) and fading coefficient (CO). However, it significantly influence the field capacity to ensure increasing its values and homogenization of hydrophusical profile. As a result it increases the water storage in soil and accesible water reserves (SAD). All these contribute to recover soil functionality, renaturation and enlarged reproduction of the formation of chernozem type soil.

Table 3. Evolution of indices of typical chernozem humus enrichment with nitrogen in various maintenance conditions (release from the archive of Republican Centre of Applied Soils)

Depth, cm	Arable												Fallow								
	1975			1990			2003			2012			2003			2009			2012		
	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N	C	N	C:N
0-10	2.7	0.23	11.8	2.2	0.17	12.9	2.0	0.14	14.3	1.9	0.13	14.6	1.9	0.13	14.6	2.2	0.19	11.6	2.4	0.21	11.4
10-20	2.6	0.23	11.3	2.1	0.16	13.1	1.9	0.13	14.6	1.9	0.12	15.8	1.9	0.12	15.8	2.0	0.17	11.8	2.2	0.19	11.6
20-30	2.3	0.20	11.5	2.0	0.14	14.3	1.6	0.11	14.5	1.7	0.11	15.4	1.7	0.11	15.4	1.7	0.16	10.6	2.0	0.18	11.1
30-40	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.5	0.08	18.8	1.6	0.13	12.3	1.8	0.16	11.3
40-50	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.05	20.0	1.0	0.08	12.5	1.0	0.09	11.1

Table 4. Distribution of clay (A), humus (H) and ratio of clay: humus (A: H) within the typical chernozem profile before and after fallow

Depth, cm	Arable regime												Fallow								
	1975			1990			2003			2012			2003			2009			2012		
	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H	A	H	A:H
0-10	45.8	4.6	10.0	45.2	3.7	12.2	45.2	3.3	13.6	45.1	3.3	13.7	45.1	3.3	13.7	45.8	3.8	12.1	45.8	4.2	10.9
10-20	45.7	4.4	10.4	45.5	3.6	12.6	45.5	3.4	13.4	45.5	3.2	14.2	45.5	3.2	14.2	45.6	3.5	13.0	45.6	3.8	12.0
20-30	48.5	2.6	18.7	48.4	2.7	17.9	48.4	2.7	17.9	48.4	2.8	17.3	48.4	2.8	17.3	48.4	2.8	17.3	48.4	3.1	15.6
30-40	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.8	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.9	48.4	1.8	26.9
40-50	49.6	1.4	35.4	49.7	1.4	35.5	49.7	1.3	38.2	48.7	1.3	37.5	48.7	1.4	37.5	48.7	1.4	34.8	48.7	1.5	32.5
80-90	46.2	1.1	42.0	46.0	1.1	41.8	46.8	1.1	42.5	46.8	1.1	42.5	46.8	1.0	46.8	46.8	1.2	39.0	46.8	1.2	39.0

Table 5. The content of fine clay (<0.001 mm) peptised in water and factor of dispersion of the typical chernozem before and after fallow

Depth, cm	Content of peptised clay, %						Factor of dispersion, %					
	Arable				Fallow		Arable				Fallow	
	1975	1990	2003	2012	2009	2012	1975	1990	2003	2012	2009	2012
0-10	2.9	3.3	3.5	3.6	2.4	2.2	9.7	10.2	12.6	14.9	11.3	9.6
10-20	2.8	3.4	3.4	3.5	2.4	2.3	9.7	10.4	14.4	16.8	12.1	9.5
20-30	2.9	3.3	3.4	3.6	2.6	2.3	9.6	10.8	13.9	16.9	12.4	9.5
30-40	3.1	3.2	3.3	3.5	2.7	2.6	9.9	10.9	12.5	15.3	13.6	9.7
40-50	3.3	3.3	3.2	3.2	3.1	3.0	10.4	10.2	12.3	14.9	13.8	9.9
50-60	3.4	3.4	3.4	3.2	3.1	3.1	11.7	12.2	12.2	13.9	13.9	11.4
70-80	3.1	3.0	3.0	3.0	3.3	3.2	13.8	13.6	13.8	14.0	14.0	13.8

Tabel 6. Evolution of aggregate composition of typical chernozem under fallow regime

Depth, cm	Content of aggre-gation agronomic valuable (10.0-0.25 mm), % (dry fraction)		Coefficient of structure (Ks)		Content of aggre-gation agronomic valuable water stabile, % (humid fraction)		Criterion of water stability, % (Kc)	
	Content	Specifi-cations	Ks	Specifi-cations	Content	Specifi-cations	Ks	Specifi-cations
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2003								
0-10	65.69	good	1.93	good	52.30	good	87	quite good
10-20	59.08	quite good	1.44	good	58.92	good	161	good
20-30	63.78	good	1.76	good	54.76	good	117	good
30-40	64.53	good	1.83	good	54.00	good	114	good
40-50	60.18	good	1.45	good	52.71	good	87.0	quite good
2009								
0-10	67.96	good	2.12	excellent	54.62	good	108	good
10-20	66.60	good	1.80	good	64.41	good	149	good
20-30	67.80	good	2.10	excellent	57.57	good	143	good
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
30-40	67.80	good	2.10	excellent	57.70	good	126	good
40-50	67.25	good	2.05	excellent	56.53	good	133	good
2012								
0-10	70.64	excellent	2.48	excellent	56.93	good	121	good
10-20	74.12	excellent	2.86	excellent	69.90	good	155	good
20-30	71.73	excellent	2.54	excellent	60.38	good	172	good
30-40	70.83	excellent	2.41	excellent	59.37	good	137	good
40-50	71.4	excellent	2.53	excellent	60.00	good	176	good

Tabel 7. Evolution of agro-physical characteristics of typical chernozem under fallow conditions

Depth. cm	Density g/cm^3		Total porosity, %	Moisture during sampling	Agro-physical indices, % g/g			
	Solid phase	Apparent			CH	CO	CC	DAU
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
2003								
0-10	2.55	1.02	60.0	14.55	10.7	13.9	32.6	18.6
10-20	2.57	1.13	56.0	17.75	11.1	14.3	32.2	17.9
20-30	2.59	1.23	52.0	18.96	10.9	14.8	30.3	15.5
30-40	2.60	1.34	48.0	18.38	10.6	14.5	28.5	14.0
40-50	2.62	1.32	50.0	19.96	10.6	14.5	29.8	15.3
50-60	2.63	1.27	52.0	17.31	10.4	14.5	30.5	16.0
60-70	2.65	1.29	51.0	16.98	10.6	14.5	30.8	16.3
70-80	2.67	1.31	51.0	16.94	10.1	13.0	30.1	17.1
80-90	2.67	1.34	50.0	16.92	9.8	13.2	29.4	16.2
90-100	2.69	1.40	46.0	16.92	9.7	13.1	28.1	15.0
2009								
0-10	2.53	1.00	60.0	18.65	10.5	13.4	35.3	21.9
10-20	2.54	1.05	59.0	20.68	10.9	14.0	36.9	22.9
20-30	2.56	1.19	54.0	21.87	11.2	14.3	34.4	20.1
30-40	2.58	1.27	51.0	24.32	10.7	14.8	32.5	17.7
40-50	2.59	1.30	50.0	23.59	10.6	14.6	33.1	18.5
50-60	2.60	1.28	51.0	24.78	10.6	14.5	31.2	16.7
60-70	2.63	1.29	54.0	22.81	10.4	14.5	30.6	16.1
70-80	2.66	1.31	51.0	19.63	10.4	13.0	30.3	20.3
80-90	2.67	1.34	50.0	18.29	10.1	13.0	29.5	16.5
90-100	2.69	1.39	48.0	18.37	9.9	12.9	28.7	15.8
2012								
0-10	2.50	0.93	63.0	23.87	10.4	13.4	36.3	22.9
10-20	2.52	1.02	60.0	25.48	10.9	13.9	38.1	24.2
20-30	2.53	1.11	56.0	25.90	11.3	14.0	34.9	20.9
30-40	2.57	1.18	54.0	25.96	10.9	14.4	33.8	19.4
40-50	2.59	1.27	51.0	26.14	10.7	14.6	33.4	18.8
50-60	2.60	1.28	51.0	25.91	10.6	14.8	32.9	18.1
60-70	2.63	1.29	51.0	23.78	10.6	14.5	30.6	16.1
70-80	2.66	1.31	51.0	20.93	10.4	13.9	30.3	16.4
80-90	2.67	1.34	50.0	20.89	10.1	13.3	29.5	16.2
90-100	2.69	1.39	46.0	20.37	10.1	12.9	28.7	15.8

CONCLUSIONS

By the theory of pedogenesis the transition of chernozems from the fallow to arable regime involves over a spcifica amount of time, restoring the place and role of biological factor in soil ecosystem in order to function and initiate the evolution of postagrogenic soil ecosystem.

Basic components of postagrogenic evolution are:

a) restoring the organic matter in the soil system

b) formation and accumulation of humus

c) structuring and aggregating the soil substance

d) recovery the porous space, increasing the capacity for water and acccesible water reserves in soil.

REFERENCES

Jigau G., 2009. Genesis and soil physics. CEP USM, p.154.

Jigau G., 2013. The role of legumes and ameliorative crops in organic farming. Chisinau, p. 88.

Jigau G., 2015. Some results of conservative technologies application in Moldova. Journal LIDER AGRO, No. 1-2, p. 8-13.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECTS OF BORON AND HUMIC SUBSTANCE TREATMENTS ON THE AVAILABLE BORON DISTRIBUTION IN THE SOIL PROFILE

Mustafa Ali KAPTAN, Mehmet AYDIN, Seçil KÜÇÜK

Adnan Menderes University, Faculty of Agriculture, Plant Nutrition Department, Aydın – 09100, Turkey

Corresponding author email: makaptan@adu.edu.tr

Abstract

Boron (B) toxicity is a significant soil pollution in arid and semi-arid climate regions in the world. The management of boron nutrient in the soil is difficult because of the narrow range between its deficiency and toxicity levels which cause significant reduction in the plant yield. Humic substances are major components of organic matter in soil and have an important role improving soil fertility, increasing uptake of nutrients, cation exchange capacity, water-holding capacity and decreasing the negative effects of chemical fertilizers. In this study, we determined the distribution of B in soil profile of a field which had been provided with different concentrations of humic substances (HS) and different levels of B contained water for two consecutive years. These treatments were performed in cotton (Gossypium hirsutum L. Carmen) crop where four B contained irrigation water (0.6–1.8–5.4–16.2 mg B l^{-1}) and three humic substances (0–200–400 kg ha^{-1}) were applied in field in 2011 and repeated in 2012. The total amount of applied water by drip irrigation was 1039.9 mm. The current study was started after the second season of the cotton harvest. The soil samples were taken at 10 cm equal intervals up to 1 m soil depth. The different B treatments with irrigation increased the available B content in soil and showed an accumulation in the upper part of the soil profile. On the other hand, B leaching was dramatically decreased after plow layer. The humic substance treatments increased the available B contents particularly in the upper part of the soil profile in 5.4–16.2 mg B l^{-1} treatments. The result of our study implied that humic substances do not play a role in the remediation of soil B toxicity.

Key words: *boron toxicity, humic substances, remediation, accumulation, leaching.*

INTRODUCTION

Boron (B) is an essential micronutrient for plant growth. The management of B in soil is difficult because of the narrow range between its deficiency and toxicity levels which cause significant reduction in the plant yield. B toxicity is a significant soil pollution in arid and semi-arid climate regions in the world. In arid and semi-arid regions, B toxicity could be derived from both high soil B contents and irrigation water with high B concentrations (Cartwright et al., 1984; Nable et al., 1997). Turkey is a rich country in terms of geothermal energy reserves but unfortunately, the high B contained geothermal wastewaters are discharged and drained to the Menderes River (Koç, 2011). The addition of B rich waste water to ground water increases the pollution of the water sources for agricultural purposes (Aydın and Seferoğlu, 1999). Boron has been accumulated in the plant over the requirement in the area (Koç, 2007). Aydın et al. (2010) determined that soil available B contents were changed between 0.43 to 2.34 mg B kg^{-1} in the Aydın conditions.

Remediation of soils contaminated with boron was more difficult than the remediation of soil salinity. The leaching was a primary method of controlling salinity and B toxicity of soil by irrigation water. However, boron leaches more slowly than the salt and requires more irrigation water (Anapalı and Gemalmaz, 1992). The leaching of B from soil uses two or three times more water than saline soil (Çiftçi et al., 2004). In addition, the limited boron-free irrigation or ground water, more water usage and lack of drainage were limiting factors to the success of B remediation. The other conventional B remediation technique is liming, but this technique is insufficient process under the alkaline soil conditions. Due to the limitation on the conventional B remediation technique, new methods for B remediation are needed. Humic substances (HS) are major components of the natural organic matter in the soil. These may consist of physically and chemically heterogeneous mixtures of materials. HS affect physical and chemical properties of soil and improve soil fertility (Stevenson, 1994). HS positively affect the water-holding capacity, cation exchange capacity, fertilizer retention and microbial activity of the soil (Lobartini et al., 1997). Moreover, HS increase root vitality and nutrient uptake and contribute to improvement of yields. HS creates soluble or insoluble organic complexes with organic compounds, metals and minerals. Angin et al. (2008) reported that humic acid additions can be an effective way to remediation of B, but their optimum performance depends on degree of soil B contents. Santos and Rodella (2007) stated that humic substances can decrease contents of Zn, Cu, Pb, B, but cannot prevent toxicity in the soil conditions. Effect of humic substances on the soil B content is not well known and there is little research on the B remediation with humic substances.

The purpose of this research was to observe boron accumulation in soil profile due to different levels boron contained irrigation water and effect of humic substances on B leaching

MATERIALS AND METHODS

The Previous Experiment

This research was carried out at Adnan Menderes University Agricultural Faculty, Soil Science and Plant Nutrition Department, in 2011-2012. This experiment was designed in a split plot with three replications. Cotton (*Gossypium hirsutum* L. cv. Carmen) was used as test species in this experiment. The main plots had different levels of boron (B) contained irrigation water as B1: 0.6 (control)– B2: 1.8– B3: 5.4 –B4: 16.2 mg B l^{-1} and the sub plots were humic substance (HS) treatments as HS1: 0 (control) – HS2: 200– HS3: 400 kg ha^{-1}. Second year experiment was designed over the same coordinates as of first year. Etidot67 (Sodium octaborate, 20.8% Soluble B) and Agrolig (65% total humic+fulvic acid) were used as sources of boron and Humic substances, respectively. During the two years' experiment, the total amount of applied water by drip irrigation was 1039.9 mm. Table 1 shows the amount of B by irrigation water into the soil during two years experiment. The total amount of B by irrigation water given into the soil were 6.3, 18.7, 56.1, 168.5 kg B ha^{-1} for B1, B2, B3 and B4 respectively, as the total of two years.

Table 1. The amount of B by irrigation water into the soil during two years experiment (kg B ha^{-1})

Boron levels	2011	2012	Total
B1	3.0	3.3	6.3
B2	8.7	10	18.7
B3	26.3	29.8	56.1
B4	79	89.5	168.5

B1: 0.6 mg B l^{-1}; B2 1.8 mg B l^{-1}; B3: 5.4 mg B l^{-1}; B4: 16.2 mg B l^{-1}

The Current Experiment

This study was started after the second season of cotton harvest. The soil samples were taken at 10 cm equal intervals up to 1 m soil depth by using stainless steel rings (100 cm^3) with three replications in each plots (Figure 1). Air-dried and sieved soil samples were used to measure selected physico-chemical properties. Soil pH was alkaline as measured by distilled water (Kacar, 2008). Soil texture was found sandy loam as analyzed by Bouyoucos (1951). The soil available boron content was determined colorimetrically (420 nm) by the Azomethine-H method (Wolf, 1971).

Data collected from soil samples were analyzed with a completely randomized treatment structure. The statistical analysis was performed with the SPSS statistical software system (PASW Statistics, Ver.: 18.0). Mean separations were performed by the LSD-test at a significance level of 0.05.

Figure 1. Sampling points throughout the soil profile

RESULTS AND DISCUSSIONS

The results indicated that the different levels of boron applications through irrigation water, humic substances treatments and soil depth had a statistically significant impact on the soil available boron contents (Table 2). B×HS, Bxdepth, HS×depth and B×HS×depth interaction was also found statistically significant (Table 2).

Table 2. The result of variance analysis for available B content of soil

Variance Source	DF	Soil available B content
B	3	**
HS	2	*
D	9	**
B x HS	6	**
B x D	27	**
HS x D	18	*
B x HS x D	54	**
Error	232	
$LSD_{0.05\ B}$		0.52
$LSD_{0.05\ HS}$		0.37
$LSD_{0.05\ D}$		0.83
$LSD_{0.05\ BxHS}$		0.91
$LSD_{0.05\ BxD}$		1.65
$LSD_{0.05\ HSxD}$		1.43
$LSD_{0.05\ BxHSxD}$		2.86

* P<0.05, ** P<0.01, DF: degree of freedom, B: Boron application, HS: Humic substances application, D: Soil Depth.

Table 3 shows that effects of different levels of boron contained irrigation water and humic substances on available B contents in 0-100 cm soil depth with 10 cm increments. In terms of B application, the B3 and B4 treatments caused the available boron contents of soil reaching to the toxic level in the upper part of soil profile. The highest available boron content was recorded from the B4 application as 16.99 mg B kg^{-1} in the 10-20 cm soil depth. Comparing with the control (B1), the available B content of soil increased at the high level B application (B4) by 1380 % in the 0-10 cm soil depth. On the contrary, in the control treatment, the maximum B content was obtained in the 90-100 cm soil depth.

The HS treatments increased the available B contents particularly in the upper part of the soil profile. The highest available B content was obtained from HS3 application as 8.01 mg B kg^{-1} in the 10-20 cm soil depth. HS treatments significantly increased soil available B content by 77.75 % in the 0-10 cm soil depth in comparison with control. The lowest B content was recorded from the HS3 treatments in the 90-100 cm soil depth (Table 3).

BxHS interactions were more prominent in B3 and B4 treatments. It was determined that the highest difference occurred between 10-20 cm and 20-30 cm soil depth in the B3 and B4 levels. The highest available boron content was obtained from B4HS3 applications as 23.59 mg B kg^{-1} in 10-20 cm soil depth. The second highest available boron content was recorded from same application but in the 0-10 cm soil depth (Table 3).

Table 3. Effects of different levels of boron contained irrigation water and humic substances on available B contents in different soil depths (mg B kg^{-1})

Applications	Depth (cm)	B1	B2	B3	B4	means
HS1	0-10	0.96	2.97	3.05	10.10	4.27
	10-20	1.32	1.53	7.62	11.16	5.41
	20-30	1.11	1.42	2.33	4.08	2.23
	30-40	1.02	1.16	1.52	3.12	1.71
	40-50	1.13	1.06	0.49	2.66	1.33
	50-60	1.25	1.17	0.34	2.19	1.24
	60-70	1.38	1.01	0.33	2.25	1.24
	70-80	1.25	0.80	0.18	2.12	1.09
	80-90	1.35	0.71	0.08	1.56	0.92
	90-100	1.70	0.56	0.34	1.50	1.02
Means		1.25	1.24	1.63	4.07	2.05
HS2	0-10	1.00	1.29	7.37	12.25	5.48
	10-20	1.41	1.13	6.98	16.23	6.44
	20-30	0.87	1.20	1.65	5.35	2.27
	30-40	0.83	1.21	1.39	3.24	1.67
	40-50	0.85	0.96	1.51	2.94	1.57
	50-60	1.01	0.86	1.45	1.86	1.29
	60-70	1.05	0.57	1.30	1.47	1.10
	70-80	1.34	0.33	1.01	1.41	1.02
	80-90	1.29	0.32	0.60	0.83	0.76
	90-100	0.95	0.28	0.65	1.19	0.77
Means		1.06	0.81	2.39	4.68	2.24
HS3	0-10	0.94	1.25	7.44	20.73	7.59
	10-20	0.79	1.11	6.56	23.59	8.01
	20-30	0.81	1.08	4.64	12.44	4.74
	30-40	0.51	1.13	1.50	3.16	1.58
	40-50	0.64	1.10	1.50	1.88	1.28
	50-60	0.58	1.14	1.44	1.04	1.05
	60-70	0.57	1.14	0.70	0.55	0.74
	70-80	0.68	1.02	0.51	0.83	0.76
	80-90	0.44	0.98	0.45	0.93	0.70
	90-100	0.59	0.95	0.52	0.34	0.60
Means		0.66	1.09	2.53	6.55	2.71

B: Boron application, HS: Humic substances

Figure 2 depicts the distribution of soil available B content in terms of boron applications with irrigation water in the soil profile. B1 and B2 treatments showed almost no difference throughout soil profile. The soil B contents were followed by a course in straight line under the B1 and B2 applications. However, soil B contents increased slightly in all depth in B1 and B2 treatments.

On the other hand, soil available B contents decreased dramatically by both B3 and B4 treatments from 20 cm soil depth. The highest decrease was observed at B4 treatment.

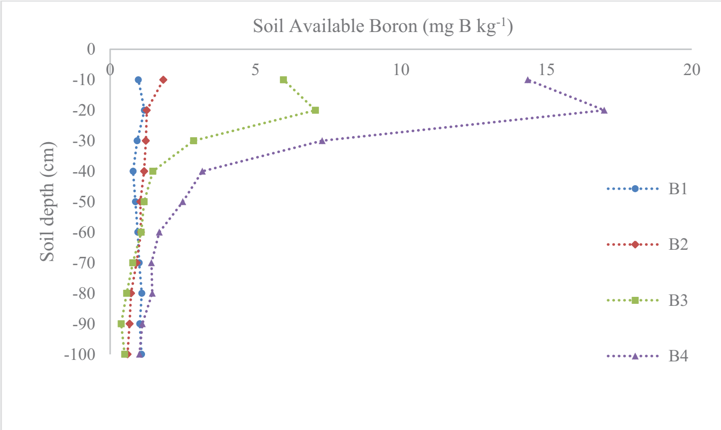


Figure 2. The distribution of soil available B content in terms of boron applications with irrigation water in soil profile

The distribution of soil available B content in terms of humic substances treatments in the soil profile has been given in Figure 3. The soil available B content decreased throughout soil profile by all of HS applications. However, the available B content reduction was apparently different from surface to 40 cm soil depth. The decrease in available B contents was similar in deeper part of soil profile. The highest decrease on the soil available B content was observed in HS3 treatment.

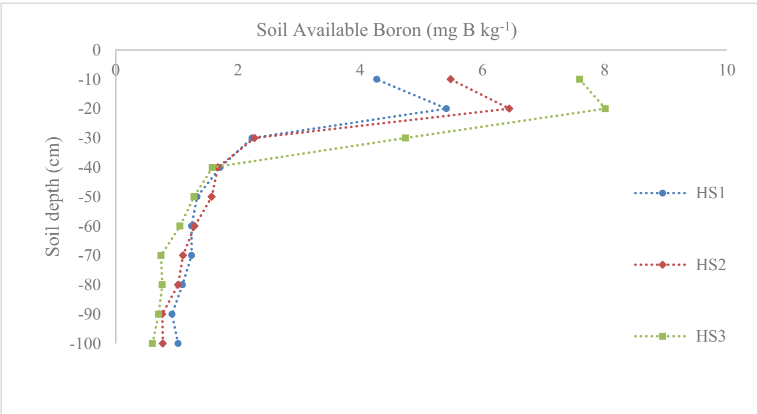


Figure 3. The distribution of soil available B content in terms of humic substances treatments in soil profile

In general assessment, increasing B and HS applications increased soil available B content in the upper part of soil both individually and their interactions. As expected, B addition greatly enhanced available B contents beyond levels in the control soil. Soil available B levels were increased from 0.99 to 16.99 mg B kg^{-1} upon B addition which indicates there B has reached to toxic levels in the soil (Jones, 1999; Choi et al., 2006).

Humic substances are considered to play an important role in B adsorption (Parks and White, 1952; Yermiyahu et al., 1995; Goldberg, 1997). Moreover, humic substances enhanced solubilisation and availability of nutrients in the soils positively. Therefore, they increased B availability in the soils account for its a chelation effects (Milap Chand et al., 1980; Zhang et al., 2003 Turan and Angin, 2004; Sarwar et al., 2012).

High level boron treatments (5.4 and 16.2 mg B l^{-1}) showed a boron accumulation in the upper part of the soil profile. On the other hand, B leaching was dramatically decreased after the plow layer. Effects of humic substances on the soil available B contents were more prominent at the B3 and B4 levels in the plow layer. When humic substances use efficiency on the B remediation in the soils were considering that HS treatments cannot remediate soil B content contrarily showed enhancing effect on the soil B content. The findings are consistent with Kaptan (2013), however, these are in conflict with Turan and Angin (2004); Angin et al. (2008).

CONCLUSIONS

Boron is an essential micronutrient for plant growth. But the excessive accumulation of B in the soils leads to toxicity for plants. This study showed that B application by irrigation water and humic substances addition can increase soil available B content. Humic substances enhanced the retention and availability of B in the soil, hence, their application for B toxicity remediation seems a false practise. The current B levels in the soil and the amount of HS can impact the remediation process. Further research is needed to investigate B toxicity remediation with substances other than HS on different soil types.

REFERENCES

Anapalı Ö., Gemalmaz E. 1992. Tuzlu sodyumlu toprakların ıslahında kademeli ıslah yaklaşımı. IV. Ulusal Kültürteknik Kongresi, Erzurum.

Angin I., Turan M., Ketterings Q.M., Çakıcı A., 2008. Humic acid addition enhances B and Pb phytoextraction by vetiver grass (*Vetiveria zizanioides* (L.) Nash). Water Air Soil Pollution, 188: 335-343.

Aydın G., Seferoğlu S., 1999. Aydın Yöresinde Kullanılan Bazı Sulama Sularının Bor konsantrasyonunun Bitki Beslenmesi ve Toprak Kirliliği Açısından İncelenmesi. Proje No: TOGTAG-1767, Aydın.

Aydın M., Kaptan M.A., Dalkılıç Z., 2010. Relationship between fruit cracking and nutritional status of fig (*Ficus carica* L. cv. sarilop) plantations in the lowland of Aydın, Turkey. International Soil Fertility Congress, Germany.

Bouyoucos G.J., 1951. A Recalibration of hydrometer for marking mechanical analysis of soil. Agronomy Journal, 43: 434-438.

Cartwright B., Zarcinas B.A., Mayfield A.H., 1984. Toxic concentrations of B in a red-brown earth at Gladstone, South Australia. Aust. J. Soil Res, 22: 261-272.

Choi E.Y., McNeill A., Coventry D., Stangoulis J., 2006. Whole plant response of crop and weed species to high subsoil boron. Australian Journal of Agricultural Research, 57: 761-770.

Çiftçi N., Topak R., Yılmaz A.M., Süheri S. 2004. Konya ovası tuzlu-sodyumlu topraklarda jips uygulaması. Sulanan Alanlarda Tuzluluk Yönetimi Sempozyumu, (20-21 Mayıs), Ankara.

Goldberg S., 1997. Reactions of boron with soils. Plant Soil 193:35-48. ISSN: 2251-9343 (Online) 1(4): 11-16.

Jones J.B.Jr., 1999. Soil Analysis Handbook of Reference Methods. CRC Press Reference, 264 p.

Kacar B., 2008. Toprak Analizleri. Nobel Yayın Dağıtım, Ankara.

Koç C., 2007. Effects on environment and agriculture of geothermal wastewater and boron pollution in Great Menderes Basin, Environmental Monitoring and Assessment, 125: 377-388.

Koç C., 2011. Effects of boron pollution in the lower Buyuk Menderes Basin on agricultural areas and crops. Environmental Progress & Sustainable Energy, 30: 347-357.

Lobartini J.C., Orioli G.A., Tan K.H., 1997. Charecteristics of soil humic acid fractions seperated by ultrafiltration. Communications in Soil Science and Plant Analysis, 28: 787-796.

Milap Chand N., Randhawa S., Sinha M.K., 1980. Effect of gypsum, pressmud, fulvic acid and zinc sources on yield and zinc uptake by rice crop in a saline-sodic soil. Plant Soil. 55: 17-24.

Nable R.O., Banuelos G.S., Paull J.G. 1997. Boron toxicity. Plant and Soil, 193: 181-198.

Parks W.L., White J.L., 1952. Boron retention by clay and humus systems saturated with various cations. Soil Sci. Soc. Am. Proc. 16, 298-300.

Santos G.C.G., Rodella A.A. 2007. Effect of sources of organic matter in the alleviation of the toxic effects of B, Zn, Cu, Mn and Pb to Brassica Juncea. Rev. Bras. Cienc. Solo, 31: 793-804.

Sarwar M., Akhtar M.E., Hyder S.I., Khan M.Z., 2012. Effect of Biostimulant (Humic Acid) on Yield, Phosphorus, Potassium and Boron Use Efficiency in Peas. Persian Gulf Crop Protection

Stevenson F.J., 1994. Humus Chemistry, Genesis, Composition, Reactions. Wiley, New York.

Turan M., Angin I., 2004. Organic chelate assisted phytoextraction of B, Cd, Mo and Pb from contaminated soils using two agricultural crop species. Acta Agric. Scand., Sect. B. Soil and Plant Sci., 54: 221-231

Wolf R., 1971. The Determination of boron in soil extracts plant materials compost, manures, waters and nutrient solutions. Soil Science and Plant Analysis, 2: 263-374.

Yermiyahu U., Keren R., Chen Y., 1995. Boron sorption by soil in the presence of composted organic matter. Soil Sci. Soc. Am. J. 59, 405-409.

Zhang X., Ervin E.H., Schmidt R.E., 2003. Plant growth regulators can enhance the recovery of Kentucky bluegrass sod from heat injury. Crop Sci. 43: 952-956.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

COVER CROPS - KEY TO STORING ORGANIC MATTER AND REMEDIATION OF DEGRADED PROPERTIES OF SOILS IN MOLDOVA

Tamara LEAH, Valerian CERBARI

Institute of Soil Science, Agrochemistry and Soil Protection "Nicolae Dimo",
100 Ialoveni str., 2070, Chisinau, Republic of Moldova

Corresponding author email: tamaraleah09@gmail.com

Abstract

The existing system of agriculture in the Republic of Moldova has led to decreasing the humus content, destructuring of arable soil layer and loss of its resistance to compaction. Remediation of degraded chernozem characteristics can be achieved by phytoameliorative methods requiring cultivation of grasses and legumes with fasciculate root system. Given the fact that in the Republic of Moldova is excluded remediation of soil quality status by the method outlined (0.4 ha of arable land per capita) were developed and tested methods for remediation of soil characteristics without interrupting the agricultural production process. As a result of cultivation the mixture of perennial legumes and grasses herbs, the crop which was used as fodder production, it was established that this mixture of herbs over a period of 4-6 years had a positive influence on the quality state of degraded arable layer of chernozems: increased organic matter content, improved structural condition, began forming a fallow layer of 4-5 cm. Restoring characteristics of arable layer of chernozems by tested technology can be achieved in a period of 15 - 20 years. Implementation of this method to remedy the quality state of chernozems is only possible when restoring the livestock sector and allocation under perennial grasses at least 15 percent of agricultural land.

***Key words**: cover crops, organic matter, remediation, soil degradation, Moldova.*

INTRODUCTION

Previous researches regarding to intensive agriculture in Moldova were focused on the cultivation of alfalfa in crop rotations, which were developed intensive technologies effective in favorable conditions of moisture.

The intensification of droughts and land degradation processes in recent decades requires searching for new technologies to combat soil degradation and plant varieties resistant to drought conditions. Degradation processes manifested by loss of organic matter, secondary compaction and damage structure of arable layer (0-35 cm) of soils adversely affecting the quality and capacity of their production (Cerbari et al., 2013a).

Investigations on soil quality monitoring showed that alfalfa in a vegetation period of five years contribute to the stabilization of a equilibrated balance of humus in the soil, but does not lead to improving the structure and reducing the compaction of arable layer. Chernozems, being 15 years in a fallow system of non-used the aerial herb mass, have achieved about 70 percent of humus content and the features of the natural non-degraded soils. (Cerbari and Balan, 2010).

The mixture of perennial grasses and legumes, having as main ecotypes of spontaneous genetic resources, have been shown to be resistant to frost, drought, disease and pests, with a high production of grasses for grazing and mowing (Cerbari and Ciolacu, 2013; Dragan et al., 2009; Moga, 1993). In recent years has been undertaken research aimed at establishing the phytotechnological measures to limit the negative effects of the phenomenon of arable soil compaction by using mixtures of forage grasses (Cerbari et al., 2012; Leah and Cerbari, 2013, 2013a).

Currently in Moldova are difficulties with the production of fodder plant seed, a problem that needs to be solved in the future, with the expansion of sown pastures and establishment of specialized farms in seed production of perennial grasses and legumes. Solving this problem would contribute to the improvement of soil fertility by increasing organic matter and restore degraded structure by compaction.

MATERIALS AND METHODS

The purpose of research was the development and testing the technological procedures and maintaining long-term remediation of quality status of arable chernozems. The object of the research was Chernozem Cambic (Leachate) of Central Moldova (Ivancea, Orhei district).

Field experiments were built up of strips (width 7-10 m, length 500-700 m) with the variants: *Control (arable); Ryegrass + Lucerne* (band founded in 2007); *Ryegrass + Sainfoin* (band founded in 2010). To assess the initial state of degraded soil characteristics were placed one soil profile on each strip. Researches regarding the morphological, physical and chemical properties of soils were carried out according to conventional methods approved for pedological researches in the field and laboratory.

Chernozem Cambic. The soil horizon Ah as a result of dehumification and damage of structure was compacted and characterized by unfavorable physical properties. Profile of humus (Ah + Bh) horizons and sometimes the top of horizon (BC) was leached of carbonates. The Bh horizon was characterized by reddish-brown hue, in the result of alteration "*in situ*" of the minerals.

Chernozem Cambic was characterized by loam-clay texture poorly differentiated in the profile, middle quality of structural composition, moderate compaction of arable layer and strong compaction of Bh horizon.

The humus content of Chernozem Cambic constituted: 3.2-3.5%. Investigated soil was moderately provided with mobile forms of phosphorus and potassium. Hydrolytic acidity - from 1.7 to 2.5 *me*, the content and composition of exchangeable cations on the adsorption complex were typical for chernozems of Moldova. The amount of cation exchange capacity ranging from 31 *me* in the Ahp1 horizon to 22 *me/100 g* in Ck horizon of soil.

The main factors of soil degradation in the Central zone of Moldova are dehumification, distructuration, secondary compaction of arable layer, decreasing reserves of nutrients, strong compaction of postarable layer of soil.

RESULTS AND DISCUSSIONS

Herb mixture (Ryegrass+Lucerne) cultivated 6 years. More than six years after the establishment of the herbal strip was made a general assessment of soil characteristics changes under the influence of root system and organic debris remaining on the soil surface after mowing of perennial grasses (about 25% of the crop harvest). Total harvest of green mass of herbs on the strip (*ryegrass+lucerne*) was 187 t/ha (or 31 t/ha per year). The total mass of organic residues accumulated in the soil during 6 years (2008-2013) on the experimental strip was 33.6 t/ha of absolutely dry mass (Table 1).

Table 1. Total harvest of perennial grasses *(ryegrass+alfalfa)* over a period of 6 years

Harvest	Green mass, t/ha, humidity 75%	Dry mass, t/ha	Grain units, t/ha	N, %	P_2O_5, %	K_2O, %
Total	187	46.7	29.9	2.48	0.57	1.90
Annual	31	7.8	5.0			
Mass of plant debris and roots left in the soil						
Total	-	28.8	-	1.91	0.35	0.91
Annual	-	4.8	-			

As a result of research, it was shown that in the soil layer (0-35 cm) of the strip with perennial grasses (*ryegrass+alfalfa*) in a period of 6 years in soil returned about 30 t/ha of organic debris and roots, in absolute mass dry (or 5 t/ha per year), the average nitrogen content 1.9%. In the period of 6 years, under the influence of the mixture of perennial herbs, grasses and legumes, organic matter reserves in the 0-12 cm layer of leached chernozem increased by 6.3 t/ha. Organic matter content in the 0-12 cm disking soil layer increased by 0.43%, in the 12-20 cm layer - 0.11%, in the 20-35 cm - 0.06% (Figure 1).

Intensification of the organic matter flow in the soil layer (0-12 cm) led to a partial remediation of soil structure, increase the hydrostability of favorable agronomic aggregates, decrease the bulk density (Table 2). As a result of utilization of alfalfa and ryegrass mixture for six years the quality state of 0-12 cm soil layer formed by disking has been positively modified: enriched with organic debris; improved structural status; began forming the follow layer about 4 cm thickness. But the problem that needs solving is the full restoration of quality status of compacted 0-35 cm arable layer.

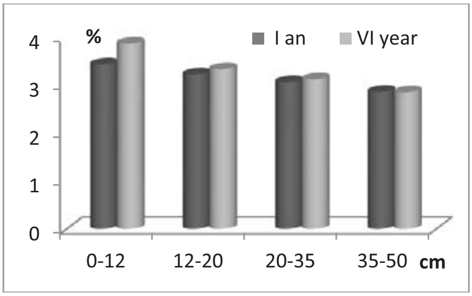


Figure 1. The content of humus in the soil of strip *(ryegrass + alfalfa)*

Table 2. Modification of Cambic Chernozem properties under the influence of *Ryegrass+Alfalfa* in a period of 6 years *(*- initial parameters, **- modified parameters)*

Horizon, depth, cm	Bulk density, g/m³	Total porosity, %	Favorable aggregates sum (10-0,25 mm), %	Hydro-stability of favorable aggregates, %
Ahp1 0-12	1.29* 1.22**	50.8 53.4	66.5 69.0	65.3 73.0
Ahp1 12-20	1.41 1.38	46.4 47.5	51.5 54.7	68.7 75.4
Ahp2 20-35	1.48 1.44	44.5 45.9	50.8 52.7	73.3 78.2
Ah 35-40	1.43 1.41	46.5 47.4	79.3 77.6	75.7 75.4

Herb mixture (Ryegrass + Sainfoin) - 4 years. Research conducted on the strip of grasses (*ryegrass+sainfoin*) demonstrated that in a period of 4 years have seen positive changes in the soil layer 0-12 cm: improved structural status, began the process of fallow layer, reaching a thickness 3 cm.

According to the results, in the soil of strip (*ryegrass + sainfoin*) in four years was return about 17.8 t/ha of organic debris (annual 4.5 t/ha) with average nitrogen content 2.1%. Organic matter content in the 0-12 cm disking soil layer increased by 0.37%, in the 12-20 cm layer - 0.11%, in the 20-35 cm layer - not increased, 0.02% (Figure 2).

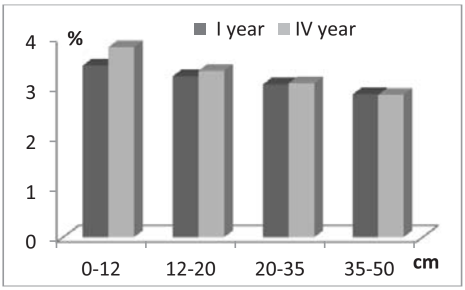


Figure 2. The content of humus in the soil of strip (*ryegrass + sainfoin*)

Intensification of the organic matter flow in the soil layer (0-12 cm) led to a partial remediation of structure, increase hydrostability of favorable agronomic aggregates, decrease bulk density (Table 3).

Table 3. Modification of Cambic Chernozem properties under the influence of *Ryegrass + Sainfoin* in a period of 4 years *(* - initial parameters, ** - changed parameters)*

Horizon, depth, cm	Bulk density, g/m³	Total porosity, %	Favorable aggregates sum (10-0,25 mm), %	Hydro-stability of favorable aggregates, %
Ahp1 0-12	1.29* 1.21**	50.8 53.8	66.5 71.6	65.3 70.9
Ahp1 12-20	1.41 1.35	46.4 48.7	51.5 55.4	68.7 72.4
Ahp2 20-35	1.48 1.48	44.5 44.5	50.8 51.3	73.3 74.2
Ah 35-40	1.43 1.41	46.5 47.4	79.3 78.5	75.7 75.4

The harvest of sainfoin and ryegrass mixture on the strip was very low in the first year (the biology growth particularities of this culture in the first year), lower - in the second year (severe drought), high - in the third and fourth year.

The mixture of herbs was in good condition and provided a great harvest in the fifth year. A negative part of the process of restoring soil quality status by sowing the mixture of sainfoin and steppe ryegrass is that after the third year the sainfoin completely overshadows the ryegrass and as a result, in the fourth year this plant practically disappears, that do not happens when was growing alfalfa and steppe ryegrass mixture.

Introduction into a five fields rotation the field sown with alfalfa and ryegrass or sainfoin and ryegrass is an effective method of restoring quality state of physical, chemical and biological properties of degraded arable layer of soils, and maintaining in this layer a balanced or slightly positive balance of carbon and humus. The problem is to restore the livestock sector, to have consumers of perennial grasses if the area occupied by these crops will be increased.

The total and stable remediation of degraded properties of Cambic Chernozem in the Central part of Moldova by using herbal mixtures can be achieved in a more long period - 15 to 20 years. Technology remediation of quality status of chernozems is required to be implemented at present on about 250,000 ha (13-15% of the territory). It is mandatory for growing perennial grasses surface fodder needed to restore the livestock sector and creation the conservation agriculture system in Moldova.

In the Central Moldova the cultivation of sainfoin and steppe ryegrass mixture as a measure to remediation the quality status of chernozems is necessary to implement simultaneously with the cultivation of alfalfa and steppe ryegrass mixture. Direct economic efficiency of perennial grasses growing is ensured to feed production at least 4 t/ha/year of unit grain. Annual net income is about 5000 LMD/ha (or 250 Euro/ha).

Expanding the culture of drought-resistant species have a positive economic impact on farmers, which can provide necessary of feed in this way with reduced inputs. In addition to obtain high yields of feed mixtures should be noted that sainfoin as a perennial legume has an important role on the soil amelioration, do not require nitrogenous fertilizer, issue nitrogen into the soil for next plant, uses nitrogen leached into the soil at greater depths. These are good reasons of perennial grasses which fits perfectly into the modern concepts of conservative and organic farming in Moldova.

The ecological effectiveness of technologies is manifested by: formation of preconditions for implementation of sustainable agriculture that protects the soil, concomitantly with achieving the high and quality fodder production; ensuring a equilibrated or slightly positive balance of organic matter in the soil; gradual restoration of physical, chemical and biological status of soil.

CONCLUSIONS

Mixtures of grasses *alfalfa + steppe ryegrass* and *sainfoin + steppe ryegrass* ensures high production of fodder - 4 ton of dry matter per hectare in Central part of Moldova.

Increasing the organic matter flow in soil cultivated with perennial grasses mixture (*alfalfa + ryegrass)* and (*sainfoin + ryegrass)* - 4-6 years, led to positive changes in organic matter content, favorable modification in physical and chemical properties.

Cultivation of fodder mixtures (the suitable concept of organic farming) is achieved with low consumption of fertilizer and without herbicides, have a positive economic impact on the farmers.

The experimental results justify the extension of alfalfa, sainfoin and steppe ryegrass mixtures as ameliorative crops of degraded properties of arable soil layer, as fodder species with superior behavior during drought conditions.

REFERENCES

Cerbari V., Balan T., 2010. Cernoziomurile tipice din zona călduroasă semiumedă a Moldovei de Nord. În: Monitoringul calității solurilor Republicii Moldova, Ch.: Pontos, p. 98-163.

Cerbari V., Ciolacu T., 2013. Phytoamelioration of Degraded Chernozem. Soil as World Heritage. Ed. D. Dent. Springer Dordrecht Heidelberg New York London, p. 373-381.

Cerbari V., Scorpan V., Ţăranu M., 2013. Restabilirea stării de calitate a stratului arabil al cernoziomurilor cambice sub influența amestecului de ierburi perene graminee şi leguminoase. În: Cernoziomurile Moldovei – evoluția, protecția şi reatabilirea fertilității lor. Ch.: Lexon Prim, 2013, p. 123-126.

Cerbari V., Scorpan V., Ţăranu M., Bacean I., 2013a. Phytotechnology for Remediation of Chernozem in the South of Moldova. Soil as World Heritage. Ed. D. DENT, Springer Dordrecht Heidelberg New York London, p. 381-389.

Drăgan L. et al., 2009. Cercetări privind cultura în amestec a unor specii de plante furajere rezistente la secetă. Agrotehnica culturilor. AN.IN.C.D.A. Fundulea, Vol. LXXVII, p. 159-169.

Leah T., Cerbari V., 2013. Degradation of Ordinary Chernozem in the south of Moldova and phytotechnical measures to remedy of their fertility. Scientific Papers. Series A. Agronomy, Volume LVI, Bucharest, p. 56-62.

Leah T., Cerbari V., 2013a. Restoration of leached chernozems fertility under the influence of green and organic fertilizers. Lucrări ştiințifice. Seria Horticultura. Ed. „Ion Ionescu de la Brad". Vol. 56/2, Iaşi, p. 413-418.

Moga I., 1993. Cultura leguminoaselor perene. Editura Ceres, Bucureşti, 104 p.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EVOLUTION OF GRAY FOREST SOILS UNDER ARABLE USE IN THE CENTRAL PART OF REPUBLIC OF MOLDOVA

Marina LUNGU

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni Street, MD- 2070, Chişinău, Republic of Moldova

Corresponding author email: marinalungu7@gmail.com

Abstract

The paper aimed to present the evolution of gray forest soils used as arable land after forest deforestation in the Central part of Moldova named Codri area. Was used the comparison method between gray soil (grayzems) under the forest, gray arable soil used in agriculture around 100 years and gray arable soil that had a long period of development under steppe before was used in agriculture. As a result of use in agriculture first three horizons of forest soils (AEhț, AEh and BEhtw) was mixed in one. Framing in agricultural use also led to the decreasing humus content, decreasing of the iluvial-eluvial and cambic processes intensity, soil acidity reducing, soil compaction and worsening of soil structural condition. As a conclusion, arable gray soils need soil-improvement techniques targeted to increase soil organic matter content and improving their physical properties in plowed layer to make them more suitable for plant grow.

***Key words**: soil evolution, forest, Moldova, grayzems.*

INTRODUCTION

The grayzems (gray soils) in Moldova was formed under the forest vegetation during the end of Pleistocene and early Holocene when the climate was colder and more humid that favored forest vegetation growth (Adamenco et al, 1996). But now they are evolving in semiarid climatic conditions corresponding to the chernozems area. Due to their specific peculiarities in this area grey soils from Republic of Moldova are one particularly interesting research object on the one hand in point of view of their development under the forest and on the other hand as a farmland.

Thus now in the forests continues to evolve gray forest soils due to the biological factor, but under the climate regime typical for chernozem area. It gives them some characteristics that distinguish them from other regions (Grati, 1977). In addition during the subatlantic period at the end of Holocene, when soils have reached maturity, anthropogenic factor started his influence on this area, influencing this territory during more than 3000 years, and led to massive clearing of forests to get wood or to use released land for crops grow (Adamenco et al., 1996). Once forest were cleared, there is established steppe vegetation, because are no longer the conditions to return the forest. And the gray forest soils little by little started to get some chernozems features (Cendeev, 2005). But it is interesting that is happen and how is preceding their further development if the cleared land was introduced, immediately or after one period of evolution under the steppe, in the agricultural use. In this context, the paper presents an analysis of the evolution of gray forest soil from Moldova under the climatic conditions characteristic for cernozem formation and agricultural use.

MATERIALS AND METHODS

In order to characterize the evolution of the greyzems in Moldova as the object of study were selected gray soils from the forest and those which were employed in agricultural use on the village Ivancea, Orhei district, in the Central part of Codri area from Moldova that are evolved on clayey-loamy loess deposits placed on the the pliocene alluvial deposits. The central part of Codri area in Moldova is located on the height between the 150-250 m, in the warm and semihumid climatic area.

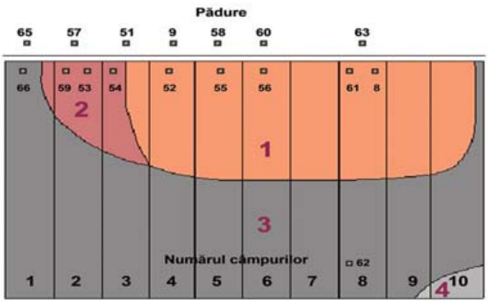


Figure 1. Sole distribution scheme of investigated areas in the experimental field

Legend:
1 –gray arable soil semimoderately humiferous with semiprofound humus profile (used as arable land about 100 years);
2 - gray arable soil semimoderately humiferous with moderately profound humus profile
3 - cambic arable chernozem moderately humiferous with deep profound humus profile
4 –eroded arable leached chernozem with moderately profound humus profile

For research and comparison have been chosen three groups of the soil profile:

- gray soils from primary forest;
- gray arable soil with semiprofound humus profile (used as arable land about 100 years after the deforestation);
- gray arable soil with moderately profound humus profile (free from the forest vegetation much more than 100 years).

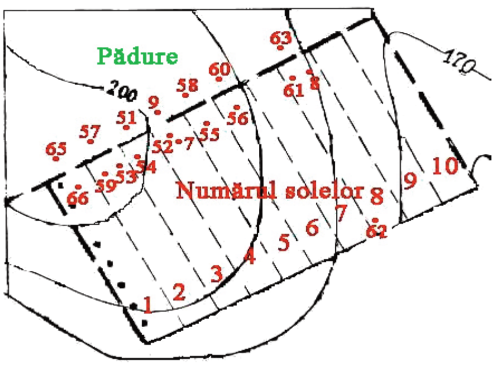


Figure 2. Topographic map of the soil profiles location to study the evolution of gray soil as the result of human impact in central part of Moldova

RESULTS AND DISCUSSIONS

Conducted research (Grati, 1977; Lungu, 2010) has shown that gray soil from the forest is characterized by a clear differentiation of the profile. During the depth 0-31 cm is outlined three genetic horizons: AEhţ, AEh and Behtw with medium texture and low compaction, under which is located iluvial very compacted horizon. It was established that the loss of clay (90 t/ha) from eluvials horizons (AEhţ, AEh, BEh) of gray forest soil are about nine times smaller than its accumulation in iluvial horizons (835 t/ha), what confirm the leading role of alteration “in situ" processes in the textural profile differentiation of these soils in conditions of Moldova. Forest soils are characterized by good structural state and hidrostability of soil aggregates in 0-20 cm layer. Humus profile of forest soils is characterized by thin fallow horizon on surface (8±2 cm) with 8.52±0.56% average humus content. With the deep humus content decreases sudden and is equal to 2.93±0.20% in AEh horizon. Average value of hydrolytic acidity for 0-34 cm layer of gray forest soil is 6.9±2.9 me/100g.

A common feature for both gray forest soils as well as the arable land is comparatively small depth (about 80 cm from surface) of occurrence of iluvial carbonate horizon extremely highlighted; the maximum carbonate content varies within 20-28%. Carbonates are shaped in massive accumulation of carbonate veined concretions. This is a consequence of contrast warmly hydrothermal regime under which influence soils were formed. It should be noted that in forest soils carbonate accumulations are more expressed than in arable soils. A hydrothermal change to a more humid on arable gray soils has led to a more homogeneous distribution of carbonates in the all parental rock.

Arable layer of the gray soil permanently used in agriculture around 100 years consists from mixture of genetic material from three forest soil surface horizons AEhţ, AEh şi BEhtw. This layer has lost initial favorable structure and became rough and highly compact, texture has changed from the middle to middle-fine and the color from gray to reddish brown. Arable and postarable layer (0-30 cm) practically lost its ability to keep the loose state after basic processing. Balanced bulk density (Figure 3) of the arable layer at 10-30 cm depth (below the periodic tillage layer) to mid-summer reach values equal to 1.50 to 1.55 g/cm³, and the degree of compaction - 17 - 18%. As a result, the state of physical quality of this layer becomes unfavorable for crop plants growth.

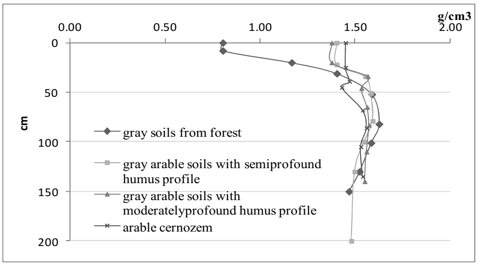


Figure 3. Values of soil bulk density of forest and arable gray soils (average data)

Under arable layer is placed iluvial horizon highly compacted identical to the the same horizon of the forest soil.

As a result of use in agriculture the hydrolytic acidity (Figure 4) in arable soils decreased with more than 2 times (from high to low), which in contrast with hydrothermical regime conditions stopped the eluvial-iluvial processes.

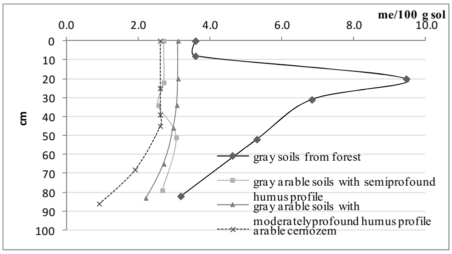


Figure 4. Hydrolytic acidity values of researched soils (average data)

As a result of use in agriculture humus content (Figure 5) in arable land has decreased in the profile section 0-34 cm on average by 1.43% or about 38% (about 70.5 t / ha) of initial humus content in this section of forest soil, having values of 2.33±0.07%. Humifer profile thickness increase is not accompanied by changes in humus quality.

The weighted average content of humus in the arable and postarable layer (0-34 cm) of gray arable soil with moderately profound humus profile is 2.61±0.09%. In the profile of these soils humus content decreases with depth more slowly than the other two.

Arable gray soils with moderately profound humus profile are very similar to those with semiprofound humus profile but differ from them by: thicker and darker humus profile and the presence of more structured and less compact AB horizon.

Because as we found what gray forest soils employed in agricultural production shall be subject to dehumification, and in the forest soils humus is concentrated in the first 0-8 cm and became easily mineralized after grubbing, we consider that gray arable soil with moderately profound humus profile have passed a long stage of development under steppe in its development.

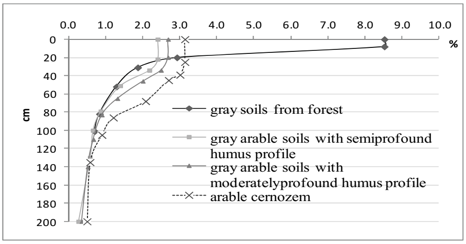


Figure 5. Humus content of researched soils (average data)

Gray arable soils throughout the profile are low in total phosphorus content, unlike the gray forest soils which is characterized by high content of total phosphorus in AEhț horizon as a result of biological accumulation of this element from litter and other organic debris.

But also all this three type of gray soils is characterized by common features as the proof of their common past such as:

- comparatively small depth of carbonates leaching (80-90 cm from ground surface) followed by formation of a highlighted iluvial carbonate horizon very compact when is dry;
- strong argilization in the middle part of the profile;
- the similar way of the clay distribution on the profile;
- existence of the special formation inherited from pedogenesis stage in forest vegetation (holes of the former roots of trees, Fe_2O_3 and MnO_2 cutan on the walls of these holes).

Gray soils of primary forest.

Gray arable soil with semiprofound humus profile (used as arable land about 100 years).

Gray arable soil with moderately profound humus profile (free from the forest vegetation more than 100 years).

Figure 6. Soil profiles of forest and arable grazems

CONCLUSIONS

Gray soils used in agriculture are characterized by following changes in morphological characters and properties:

- formation of the arable layer with average thickness 34 cm from the genetic material of the former three horizons of gray forest soil (AEhț + AEh + BEhtw);
- increasing in arable layer by about 6.0% of clay content compared with the analog section of the forest soil as a result of increasing "in situ" weathering process that led to the mitigation of the textural differentiation on the profile;
- decreasing of humus content in arable layer 0-34 cm on average by 1.74% (43 percent of initial content) compared to the humus content in the same section of the forest soil;
- losing the resistance to compaction of arable layer, balanced bulk density achieve values to the 1.55 - 1.57 g/cm^3 (strong compaction) and poor physical condition as the result of dehumification and weaker structure;
- 2 or 3-fold reducing of hydrolytic acidity values in arable layer and stopping the eluvial-iluvial processes and textural differentiation of the profile (positive change).

The remediation of the properties of these soils should be directed towards increasing the content of organic matter in arable layer and improving the unfavorable structural condition in plowed layer.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Institute of Pedology, Agrochemistry and Soil Protection “Nicolae Dimo”.

REFERENCES

Adamenko O.M. et al., 1996. Quaternary paleogeography of the ecosystem of the lower and middle Dniester. Kiev, 100 p.

Cendeev I.G., 2005. Natural and anthropogenic evolution of forest-steppe soils in Central Russian Upland in the Holocene. PhD thesis in geogr., Moscow, 303 p.

Grati V.P., 1977. Forest soils of Moldova and their rational use. Chişinău: Ştiinţa, 136 p.

Grati V.P., 1975. The nature of the texture differentiation on profile of the forest soils in Moldova. In: Soil Science, no 8, p. 15-19.

Lungu Marina, 2010. Evolution of gray arable soils in Central part of Moldova and measures to improve the negative properties. PhD thesis in biol., IPAPS ”N. Dimo”, Chişinău, 193 p.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

FERTILIZERS FORMULAS WITH EXTRAROOT APPLICATION - PHYSICO-CHEMICAL AND AGROCHEMICAL CHARACTERISTICS

Daniela MIHALACHE, Carmen SÎRBU, Traian Mihai CIOROIANU, Olga GAȚE

National Research and Development Institute for Soil Science, Agrochemistry and Environmental Protection - ICPA Bucharest, 61 Mărăşti Blvd., District 1, 011464, Bucharest, Romania, Phone: +40213184349, Fax: + 40213184348, Email: office@icpa.ro

Corresponding author email: ddobrinescu@yahoo.com

Abstract

Development of new formulas of extra-radicular fertilizers applied by irrigation, drip irrigation or by soil incorporation is a priority both for manufacturers and for users in agriculture.
At worldwide level it was observed a major development of the fertilizers which consist of natural organic substances or synthetic integrated in NPK type structures with/without trace and meso elements, products which can be applied conventional of extra-radicular type. Adding of the organic substances have the role to stimulate the absortion of the nutrients and to provide a balaneced nutrition. The most commonly used organic substances are protein hydrolysates of vegetal or animal origin and various aminoacids.
In order to obtain a new range of fertilizers it was defined the composition of a type NPK with mezo and micronutrients, such as Fe, Cu, Zn, Mn, Mg, S, Co, Mo, and in which protein hydrolysate of vegetal or animal origin were introduced.
The experimental fertilizers were characterized from physico-chemical and agrochemical point of view within the National Network for Fertilizers Testing for authorization for agricultural use.
This paper presents the obtained experimental fertilizers and the results of the agrochemical tests carried out by the National Network for Fertilizers Testing, fertilizers which were applied to maize, sugar beet, eggplant and tomatoes crops. These extra-radicular fertilizers represent modern technologies of fertilization and have quantitative and qualitative significant effects, but also with a positive impact on the economy and environment.

***Key words**: extra-radicular fertilizers, organic substances, protein hydrolysate.*

INTRODUCTION

The analysis of the data existing in the specialized literature regarding the conventional fertilizers of extra-radicular type or those with substances having a stimulating effect of growth indicates the fact that the exclusive use of certain substances in the category of bio-stimulators for the treatment of agricultural crops often does not lease to obtaining significant effects (Cioroianu et al., 2011). In such cases the “explosive” vegetative development of the plant is not supported by an additional contribution, fast, of macro and micro-elements necessary for the nutrition (Iovi et al., 2000). This phenomenon strongly occurs in case of a poor basic fertilization, on degraded soils, as well as in case of unbalanced macronutrient fertilization.
In practice, it is known a wide range of liquid fertilizers, complex solutions with extra-radicular application, having as nutrients nitrogen, phosphorus, potassium, meso and micro-elements that may also contain synthetic organic substances, humic substances, fulvic substances, plant extracts, peptides or protein hydrolysates of animal origin or glycoproteins of plant origin, naphthenates, introduced in order to stimulate the metabolization of nutrients, or to facilitate the absorption of ionic species or molecules (Mihalache et al., 2014).
It is well known that the use of microelements like iron, copper, zinc, calcium, magnesium and manganese chelated with natural organic substances are more easily absorbed by plants, and their presence may destroy or reduce bacteria, viruses, fungi or other pathogens when applied as fertilizing substances to plants.
In the field of agriculture it is recommended the use of extra-radicular fertilizers not only in treating certain nutrition diseases of plants, but also to prevent them, for increased yields, for increased quality of products and to reduce the negative impact on the environment of conventional fertilizers (Dorneanu et al., 2003).
Also, the plants treated with fertilizers

containing natural organic substances with chelating role are more resistant to frost, drought, to biotic and abiotic stress factors (Sîrbu et al., 2010; Trandafir et al., 2007)

MATERIALS AND METHODS

The experiments carried out for obtaining of extra-radicular fertilizers aimed at:

- defining the compositional structure of the fertilizers and establishing of the raw materials;
- establishing the experimental design at laboratory level and of the operating paramenters;
- establishing of the control at different phases and at the final phase;
- verifying of technologies at the laboratory phase;
- sample preparation for physico-chemical characterisation and for agrochemical testing.

The extra-radicular fertilizers experimentally obtained, for physico-chemical characterisation and agrochemical testing, were:

- of NPK type with trace and meso elements and organic substances of animal nature (collagen hydrolyzate), ***VFHA*** variant;
- of N type with trace and meso elements and organic substances of plant nature, ***VFHV*** variant.

In Table 1 the characteristics of experimental fertilizers are presented.

Table 1. Characteristics of experimental fertilizers applied in Network

Estimated composition, g/l	VFHA	VFHV
total N	120	215
P_2O_5	70	-
K_2O	60	-
B	0.3	0.15
Co	0.01	0.005
Cu	0.2	0.15
Fe	0.5	0.3
Mg	0.35	0.25
Mn	0.3	0.2
Mo	0.01	0.005
SO_3	2	1.1
Zn	0.15	0.1
Hydrolyzate of animal nature	14	-
Hydrolyzate of plant nature	-	30

The agrochemical study was conducted within some single-factorial experiences with extra-radicular fertilizers (and compared with a control variant - unfertilized), arranged in randomized experimental variants and in four replicates.

All the researches concerning the extra-radicular fertilizers efficiency and role which are pending for approval, were conducted based on chemical unfertilized variant.

The experiments were placed on the following soil types:

- cambic chernozem (haplic chernozem) located at Ezăreni-Miroslava-Iaşi farm field and at V. Adamachi Iaşi horticultural farm;
- hortic antrosol (hortic anthrosol) in greenhouses, orchards and vineyards.

Energy efficiency (Mcal/ha), as indicator of production intensification, was calculated according to the specified methodology (Teşu and Baghinschi, 1984).

The main quality and fertility characteristics of the soils are given in Table 2.

Table 2. Main physical, chemical and biological properties of the soil resources

Property	Depth (cm)	Field farm Ezăreni *cambic chernozem*	Greenhouse *hortic anthrosol*
Soil texture (% colloidal clay)	0-20	35.7	35.6
	20-40	37.9	36.8
	40-60	39.8	38.9
Seazonal consistence	0-20	moderately cohesive	moderately cohesive
	20-40	hard	hard
	40-60	very hard	very hard
Aeration porosity (PA%)	0-20	18	15
	20-40	11	10
	40-60	9	7
Soil reaction (pH_{H2O})	0-20	6.83	7.11
	20-40	6.61	7.25
	40-60	6.58	7.41
Humus (%)	0-20	3.386	3.664
	20-40	1.924	2.613
	40-60	1.202	1.342
Total content of nitrogen Nt (%)	0-20	0.192	0.253
	20-40	0.163	0.172
	40-60	0.118	0.112
Mobile phosphorus content (ppm)	0-20	71	78
	20-40	62	81
	40-60	54	88
Mobile potassium content (ppm)	0-20	257	277
	20-40	213	245
	40-60	183	239
Degree of base saturation V (%)	0-20	92	94
	20-40	90	92
	40-60	88	87
Soil respiration (mg CO_2)	0-20	28.32	28.62
	20-40	17.32	14.56
	40-60	6.65	5.87
Dehydrogenase (mg TPF)	0-20	19.45	18.23
	20-40	9.34	8.89
	40-60	4.45	5.21

RESULTS AND DISCUSSIONS

The use of organic substances which contain protein and free aminoacids bonded in a complex matrix with chelated macro and trace elements lead to obtaining of physico-chemical stable fertilizers solutions. Besides the chelating properties, the used protein hydrolyzate acts as a protective colloid which helps to maintain the stability of the applied fertilizer by its components having a molecular weight smaller than 10000 Da that forms films at the surface of plant tissue.

These films have the ability to gradually release in time of chelated trace elements on the collagen polypeptides, acting both as hydrophilic protection to environment factors and as well as biostimulator.

Agrochemical testing of the experimental fertilizers was done at the Biological Research Institute from Iasi (experimental field of USAMV Iasi). The extra-radicular fertilizers were applied at crops, such as maize, sugar beet, eggplants and tomatoes, and in three treatments in concentration of 0.5%.

The agrochemical tests results are presented in Tables 3-6.

Table 3. Productive and energetic efficiency of extra-radicular fertilization at the maize crop (Hybrid DK 4685) *Single factor experiment placed in* storeyed blocks *and with randomized experimental variants*

Nr. crt.	Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency - Mcal/ha					
			Dif. kg/ha	%	sm.	Output	Input	Balance	Dif.	%	sm
1	*Control NoPoKo* sprinkled with water (500 l/ha)	*5023*	-	*100*	-	*19690*	*6891*	*12798*	-	*100*	-
2	VFHV - 0.5%	6825	1802	135.88	xxx	26754	10702	16052	3254	125.43	xxx
3	VFHA - 0.5%	6716	1693	133.71	xxx	26327	10531	15796	2998	123.42	xxx

DL 5% - 654 kg/ha
DL 1% - 817 kg/ha
DL 0.1% - 1265 kg/ha

DL 5% - 1261 Mcal/ha
DL 1% - 1733 Mcal/ha
DL 0.1% - 2315 Mcal/ha

Table 4. Productive and energetic efficiency of extraroot and soil fertilization, at the sugar beet crop (Diamant variety). *Single factor experiment placed in storeyed blocks and with randomized experimental variants*

Nr. crt.	Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency - Mcal/ha					
			Dif. kg/ha	%	sm.	Output	Input	Balance	Dif.	%	sm
1	*Control NoPoKo* sprinkled with water (500 l/ha)	*22413*	-	*100*	-	*22413*	*7845*	*14568*	-	*100*	-
2	VFMV - 0.5%	31031	8618	138.45	xxx	31031	12412	18619	4051	127.81	xxx
3	VFHA - 0.5%	30887	8474	137.81	xxx	30887	12355	18532	3964	127.21	xxx

DL 5% - 2718 kg/ha
DL 1% - 3851 kg/ha
DL 0.1% - 5824 kg/ha

DL 5% - 1328 Mcal/ha
DL 1% - 1956 Mcal/ha
DL 0.1% - 2711 Mcal/ha

Table 5. Productive and energetic efficiency of extraroot fertilization at the eggplants crop cultivated in greenhous (Pana Corbului variety), first cycle, drip irrigation. *Single factor experiment placed in storeyed blocks and with randomized experimental variants*

Nr. crt.	Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency - Mcal/ha					
			Dif. kg/ha	%	sm.	Output	Input	Balance	Dif.	%	sm
1	*Control NoPoKo* sprinkled with water (500 l/ha)	*34524*	-	*100*	-	*7940*	*2779*	*5161*	-	*100*	-
2	VFMV - 0.5%	46752	12228	135.42	xxx	10752	4300	6452	1291	125.01	xxx
3	VFHA - 0.5%	47549	13025	137.73	xxx	10936	4374	6562	1401	127.14	xxx

DL 5% - 3628 kg/ha
DL 1% - 5144 kg/ha
DL 0.1% - 7813 kg/ha

DL 5% - 311 Mcal/ha
DL 1% - 464 Mcal/ha
DL 0.1% - 526 Mcal/ha

Table 6. Productive and energetic efficiency of extraroot fertilization at tomatoes first crop cultivated in greenhouse (Precos cultivar), drip irrigation. *Single factor experiment placed in storeyed blocks and with randomized experimental variants*

Nr. crt.	Experimental variants	Average production (kg/ha)	Productive efficiency			Energetic efficiency - Mcal/ha					
			Dif. kg/ha	%	sm.	Output	Input	Balance	Dif.	%	sm
1	*Control NoPoKo* sprinkled with water (500 l/ha)	*30123*	-	*100*	-	*8133*	*2847*	*5286*	-	*100*	-
2	VFHV - 0.5%	41102	10979	136.45	xxx	11097	4438	6659	1373	125.97	xxx
3	VFHA - 0.5%	41455	11332	137.62	xxx	11192	4476	6716	1430	127.05	xxx

DL 5% - 3544 kg/ha
DL 1% - 5412 kg/ha
DL 0.1% - 6106 kg/ha

DL 5% - 354 Mcal/ha
DL 1% - 487 Mcal/ha
DL 0.1% - 566 Mcal/ha

CONCLUSIONS

Within this research study there were obtained and physico-chemically characterized two fertilizers which are extra-radicular fertilizers applied, and they are distinguished by a complex composition in which the NPK or N type matrix are associated with trace elements (e.g. Fe, Cu, Zn, Mn, Mg) as well as with protein hydrolysates which have the role of chelating and biostimulation.

Application in agrochemical testing of some fertilizers which contain hydrolyzed structures of animal or plant nature led to increasing production yileds ranging from 133.71% at maize crop to 138.45% at sugar beet crop, when were applied solutions of 0.5% concentration.

In all crops analyzed the outcom energy indicators (OUTPUT and energy balance) have higher values than those allocated to factors (INPUT). This resulted in very significant energy increases of agricultural products as a result of extra-radicular fertilizers application. The energy production (OUTPUT), the energy consumption (INPUT) are considered the most important indicators for intensification of agricultural production.

REFERENCES

Cioroianu T., Sîrbu C., 2011. Caracterizarea şi testarea agrochimică a unor fertilizanţi extraradiculari cu substanţe proteice. Sitech Publishing House, p. 92-93.

Cioroianu T., Sîrbu C., Oprica I., Grigore A., Mihalache D., Dumitrascu M., Anton I., Soare M., 2011. Fertilizers with protein substances, technology, agro-chemical and physical charcacteristics. International Scientific Symposium, Sustainable Rural Development, Timişoara, Lucrări Ştiinţifice ale Simpozionului, Seria I, Vol. XIII, p. 449-454.

Cioroianu T., Dumitru M., Sîrbu C., 2012, Fertilizant cu hidrolizate proteice cu aplicare extraradiculară, procedeu de obţinere şi metodă de aplicare. Brevet RO 126939/2012.

Mihalache D., Sîrbu C., Grigore A., Cioroianu T., 2014. Protein hydrolysates and amino-acids fertilizers - physicochemical characteristics. Lucrări Ştiinţifice, seria Agronomie, Iaşi, Vol. 57(2), p. 47.

Sîrbu C., Cioroianu T., Dumitru M., Dorneanu A., Negrila M., Mihalache D., Angelescu L., 2008. New structures of biofertilizers with chelate proteinic substances with role of biostimulator and protection for sustainable agriculture. Lucrari Stiintifice USAMV, Seria Agronomie, Iasi, Vol. 51(2), p. 189-194.

Sîrbu C., Cioroianu T., Cojocaru I., Trandafir V., Albu M.G., 2009. The fertilizers with the protein chelated structures with the biostimulator role. Revista de chimie, Vol. 60, nr. 11.

Sîrbu C., Cioroianu T., Dumitru M., 2012. Fertilizanţi cu substante proteice. Sitech Publishing House, p. 211-212.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE CHARACTERISTICS OF THE SOILS IN THE DOMNESTI AREA AND THEIR POTENTIAL FERTILITY FOR HORTICULTURAL USE

Marian MUŞAT[1], Alexandra RADU[1], Anca-Luiza STĂNILĂ[2], Mihaela GEORGESCU[1]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania
[2]National Research Institute for Soil Science, Agrochemistry and Environment Bucharest,
61 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: dr_marianmusat@yahoo.com

Abstract

Domnesti Village is located in the west of Bucharest, on the county road DJ 602. The village is made up of two places: Domneș ti where the administrative center and village Teghes. It is bordered to the north-west of the village Ciorogarla southwest of Giurgiu County is Clinceni southeast and northeast Bragadiru City and Bucharest. A big advantage is the proximity of the village shopping area in west Bucharest, about 2-3 km away.
In this area of pedological study was conducted in order to identify morphological, physical and chemical properties of soil area. The area studied, 16.9 hectares private property, is divided into two bodies: the first S1 S2 10.9 hectares and 6.0 hectares second. The purpose of the studies conducted in the area was establishing productive potential of soils and their suitability for different crops, especially vegetables.

Key words*: aluviosol, suitability, potential.*

INTRODUCTION

The above mentioned locality was conducted a study on the identification pedological soil type, morphological properties and physico-chemical properties. Domnesti the adjacent city, offers the possibility of recovery and fresh horticultural products, due to advantages on regional soil suitability, ensuring smooth and fast transport and the possibility of irrigation of crops because the area is located on the interfluve Argeş – Sabar.
The area studied is approximately 17 hectares, privately owned, divided into two bodies, the aim of the study was to determine the productive potential of soils and their suitability for various uses, especially horticulture (vegetables).
The studied, has a morphologically uniform energy relief, slope degree of fragmentation and reduced the overall appearance of large meadow.
The foundation area consists of Proterozoic crystalline formations. Quaternary surface deposits belonging, being composed of alternating sands with clays, gravels, sands, marl complex near surface covered with loess. In the afore mentioned meadow alternations are more pronounced, forming fluvial deposits without loess blanket.
In terms of basin study area lies in the meadow Arges-Sabar widths from 4-7 km. Note that the Arges River is regulated, the closest retention hydrotechnical work is the accumulation of Mihăileşti, one source of water supply to the city.
Hydrological problems posed Sabar, causing major floods and eroding banks of the river bed. Ground waters are weakly mineralized located at a depth between 2-5 m. The mineralization is of type bicarbonates, bicarbonato-chloride or calc-magnesian, with predominance of calcium and secondary salinisation possibility for irrigation.
As Bucharest, Domnesti has a temperate continental climate with average annual temperatures of 10-11^{o}C and average annual rainfall of 500-600 mm. A feature of the area is torrential rains and local high flow producing Sabar overflow.
The natural vegetation in soils that have evolved in the area is steppe. In the meadow vegetation is mixed, predominantly the forest, near the village Royal Tegheş giving special beauty landscape.

Meadow soils were formed on medium texture fine fluvial deposits. Intense alteration and weathering processes of loamy deposits, mainly led to the formation of clays. The soil profile is found fine clay fractions and fragments of sand visible.

In these conditions have evolved fluvisols (aluviosols) with different subtypes according to local environmental conditions. These soils provide optimal culture vegetables and fodder plants, meadow Argeş-Sabar with tradition in supplying the capital with food and agriculture.

Figure 1. Location territory studied

MATERIALS AND METHODS

In the village Royal district Teghes, pedological study was lead in order to identify morphological, physical and chemical properties of soil area. The area studied is 16.9 hectares, divided into two bodies: the first is 10.9 hectares and the second is 6.0 hectares. The second area is located a greenhouse (Figure 2).

In each surface was established two main points of control, where soil samples were collected at two depths (0-20 and 20-40) in S1 points P2 and P3, and P1, P4 in S2. Each profile was morphologically described the samples were then performed physical and chemical analysis. Interpretation of results was done according to the "Methodology developing soil studies" ICPA Bucharest, 1987.

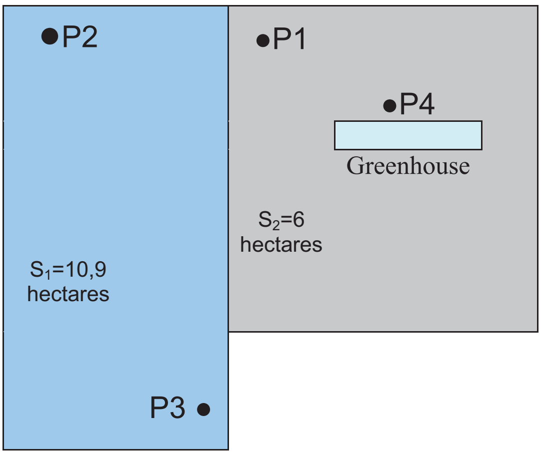


Figure 2. Plan of the area with location of profiles

The analytical methods used for determination of physical, hydro and chemical

Determination of particle size fractions:

- pipette method fraction ≤ 0. 002 mm;
- wet sieving method for fractions 0.002 to 0.2 mm and dried fractions > 0.2 mm. The results are expressed as a percentage of the remaining material after the pretreatment.

The bulk density (DA): the method of the metal cylinder of known volume (100 cm^3) in soil temporary humidity (g/cm^3).

The total porosity (PT) by calculation: PT= (1-DA/D)*100 (% by volume).

The porosity of aeration (PA) by calculation: PA= PT - CC*DA (% by volume).

Degree of compaction (GT) by calculation: GT = [(PM - PT) / PMN] x 100 (% by volume), where: PMN - minimum required total porosity, varied depending on the clay content of the sample, is calculated by formula PMN = 45 + 0.163 A (% by volume); PT = total porosity (% v/v); A - the clay content (% g/g).

The coefficient hygroscopicity (CH): drying at 105^oC of a sample of soil moistened in advance in equilibrium with an atmosphere saturated with water vapor (in the presence of a solution of H_2SO_4-10%) - % by weight (% g /g).

Withering coefficient (CO): by calculation, by multiplication with 1.5 coefficient hygroscopicity, determined by the method of modified Mitscherlich - % by weight (% g/g).

Initial soil moisture (wi): by drying soil sample in an oven at a temperature of 105 ^0C (% by weight of dry soil at 105 ^0C).

pH: potențiometric, determined the combined glass electrode and a calomel, in aqueous Field water capacity (CC): by estimate based on texture and apparent density, according to the "Methodology developing soil studies", ICPA, 1987, vol. I, p. 101 (% by weight).

Total water capacity (CT): by calculation from the formula CT= PT/DA, % by weight.

Useful water capacity (CU) by calculation: CU= CC - CO;% by weight.

The physical and hydrophysical, were calculated according to the methodology-ICPA, 1987.

Organic matter (humus) determined by volumetric method Walkley - Black wet oxidation after the change Gogoaşă - STAS 7184 / 21-82.

$CaCO_3$ (carbonates): the method gasometric using calcimetrul Scheibler, after SR ISO 10693: 1998 (per cent).

Total Nitrogen (N): Kjeldahl method disintegration H_2SO_4 at 350^oC, a catalyst of potassium sulfate and copper sulfate - SR ISO 11261: 2000.

Phosphorus accessible (P mobile): method-Riehm-Domingo and dosed with colorimetric molybdenum blue method after Murphy-Riley (reduction with ascorbic acid).

Potassium (K mobile) accessible: after extraction method Egner-Riehm-Domingo and determination by flame photometry.

pH: potențiometric, determined the combined glass electrode and a calomel, in aqueous suspension the soil/water ratio of 1/2, 5 SR-7184/13-2001.

Interpretation of the results has been submitted in accordance with “Methodology developing soil studies”, ICPA Bucharest, 1987, provided for in current legislation on the subject.

RESULTS AND DISCUSSIONS

Profile 1 presents a material brittle at harvest moisture. Features numerous biogenic neoformations in the first 10 cm (roots, the bunks of larvae, coprolite). Glomerular structure partially degradated (agricultural work carried out). Visible grains of sand in 20 cm deep, fine texture, moderately plastic and sticky. Color 10 YR 2/2 wet.

Profile 2, like the previous one, has felt the roots in the top 20 cm, common biogenic neoformations (traces of roots), sand grains visible. Polyhedral structure converted by subsidence. Vertical cracks of 2-5 cm. Fine texture, moderately plastic and sticky. Color 10YR3/2 wet.

Profile 3 horizontal and oblique fine cracks, many biogenic neoformations, polyhedral structure formed by compaction, very few grains of sand 20 cm down weakly cohesive. Color 10YR 2/2 wet.

Profile 4 is wet at the time of harvesting, the compact environment of 20 cm below the surface and brittle. Several biogenic neoformations, common root for the entire depth of the harvest. Texture fine, grains of sand from 20 cm down moderately plastic and sticky medium-well developed glomerular structure (low degree of compaction).

The sections examined were determined: texture (the percentage of particle size fractions (sand, dust, clay), apparent density (DA g/cm^3), total porosity (PT%) and the degree of compaction (GT).

Soil texture is medium dusty clay loam in all profiles. The fine fraction (less than 0.002 mm clay) is between 39% and 44%, powder fraction between 32% and 36%, and the sand is between 20% and 28%. Figure 3 presents the variation of depth texture collection.

It can be seen that the percentage of clay decreases profile, more pronounced in the profiles P2 and P3. Higher percentages of the sand are 20 cm below the profile is correlated with morphological appearance, the grains of sand are visible to the naked eye at that depth.

Bulk density is medium, with values ranging from 1.17 g/cm^3 and 1.34 g/cm^3. The total porosity is medium varying between 51.6% and 49% (Table 1). The ratio between the total porosity and bulk density expresses the degree of compaction of the soil. Values of two determinations carried out on properties obtained samples of the four profiles, expresses a poor compaction of soil (degree of compaction values fall between 1 and 10).

From this point of view stands profile P4, the degree of compaction is the lowest (2.6), the structure less degraded by agricultural work (see morphological description). The highest values of the degree of compaction is at P3 (8.6), only the profile of the modified structure is cohesive and horizontal and oblique cracks.

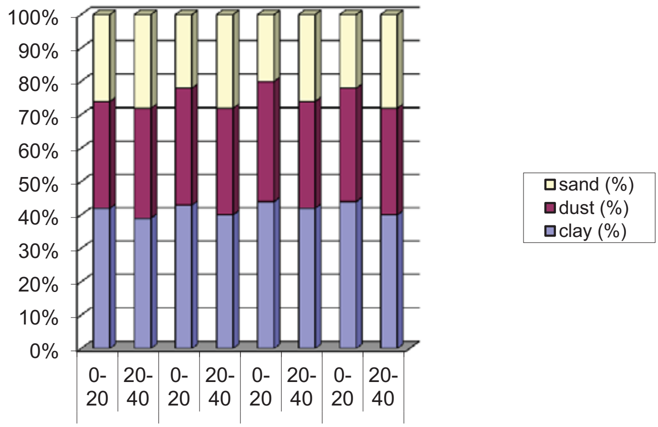


Figure 3. Granulometric composition, depth 0-20 cm and 20-40 cm profiles analyzed

Table1. The values of apparent density, total porosity and the degree of compaction in the analyzed profiles

No. profile	Depth (cm)	Bulk density (DA)	Total porosity (PT)	Degree of compaction (GT)
P1	0-20	1.32	49.8	4.2
	20-40	1.33	49.6	2.4
P2	0-20	1.34	49.0	5.7
	20-40	1.33	49.1	5.7
P3	0-20	1.25	47.5	8.6
	20-40	1.26	47.2	8.6
P4	0-20	1.17	51.6	2.6
	20-40	1.17	51.6	2.6

Of the four profiles samples were taken to determine the soil moisture at two depths of 0-20 cm and 20-40 cm. The method used for the determination is based on measuring the amount of water of the soil sample by successive weighings and drying in an oven to constant weight.

Hydro indices were calculated (CO-wilting coefficient, CH-coefficient hygroscopicity, CC-Field water capacity and CT - total capacity of

the soil water) based on clay content. Useful water capacity was calculated using the formula CU= CC - CO (Table 2).
Wilting coefficient is high, varying between 13.7% and 15.1%, the lowest at 20-40 cm depth P1. Field capacity is medium, values close to 24 %. The total capacity of the soil water is high, with values above 37%. Useful water capacity is low at between 9.1% and 10%.
Soil water availability for plants is not equal throughout the range of useful water capacity (CU). The soil moisture values approaching water field capacity (CC) will be greater water availability. The values of soil moisture at harvest time almost on CC.

Table 2. Humidity values and hydrophysical indices the analyzed profiles

No. profie	Depth (cm)	Humidity (%)	Coefficient hygroscopicity (CH)	Wilting coefficient (CO)	Field water capacity (CC)	Total capacity (CT)	Useful water capacity (CU)
P1	0-20	19.2	9.3	14.8	24.1	37.7	9.3
	20-40	20.3	9.1	13.7	23.2	37.3	9.5
P2	0-20	18.8	10.1	15.1	24.5	36.6	9.4
	20-40	17.4	9.4	14.1	24.1	36.9	10
P3	0-20	18.4	10.3	15.5	24.6	38.0	9.1
	20-40	18.4	9.9	14.8	24.3	37.5	9.5
P4	0-20	22.9	10.3	15.5	24.6	44.1	9.1
	20-40	21.0	9.4	14.1	24.1	44.1	10

Consequently, the soil temporary supply state is expressed by the water supply, which is calculated from the instantaneous moisture. In Table 3 are shown the values determined in the water supplies 4 profiles in the depth of 0-40 cm (Ru, m^3/hectare), the date of collection, the average value for the whole area is 994 m^3/hectare.
Soil water supply is fundamental to agricultural production activities, particularly horticultural plants. Yields obtained depends on soil water reserves, supplemented by deficit irrigation periods.

Table 3. Water reserves in the soil momentary 0-40 cm, the analyzed profiles

No. profil	Humidity (%)	Ru (m^3/ha)
P1	19.8	1053
P2	18.1	970
P3	18.4	927
P4	21.9	1025
The average value of the Ru momentary		**994**

During the growing season soil water consumption is intense, may be associated with prolonged drought, when temporary humidity can reach the wilting coefficient value or less. There is a shortfall of moisture needed by irrigation.
The amount of water that must be administered to compensate for the shortage of moisture, is called the optimal watering time is calculated: m = H Da (CC-PM), H - depth of soil to be watered; DA - apparent density; CC- field water capacity; PM - minimum threshold.
Values frequent watering rules aluviosol fine texture that consideration, are in the range 150-600 (m^3/hectare) and the minimum threshold in the range 18-24%. The data in Table 4 fall within these ranges, the average standard watering studied area is 154 m^3/hectare (Table 4). It is recommended to calculate the actual watering norm, mr = H Da (CC-u), where u - temporary humidity determined at regular intervals of time (example on days 1 and 15 of each month).
Chemical analyzes performed on soil samples collected from four profiles, and interpretation of results was done according to the

"Methodology for developing soil studies" ICPA, 1987.
Soil reaction is slightly acidic (pH is between 6.2 and 6.8) at sections P2, P3 and P4 and P1 in the depth of 20-40 cm. In the first 20 cm of the profile one is neutral reaction (Table 5).

Table 4. Minimum threshold and optimal watering norm 0-40 cm depth

No. profil	Minimum threshold PM (%)	Norm optimal watering M (m3/hectare)
P1	21.0	133.0
P2	21.1	171.5
P3	21.3	161.3
P4	21.2	150.0
Media	**21.15**	**154.0**

Table 5. Chemical characteristics of soil depth 0-20 cm and 20-40 cm

No.profile	Depth (cm)	pH (H_2O)	Humus content (%)	Degree of base saturation V (%)	Humus reserve Rh (t/hectare)
P1	0-20	7.2	6.0	90	158.4
	20-40	6.8	4.3	88	114.4
P2	0-20	6.6	7.8	86	209.1
	20-40	6.6	7.0	86	186.2
P3	0-20	6.4	8.6	84	215.0
	20-40	6.6	5.2	86	131.1
P4	0-20	6.2	8.6	79	201.2
	20-40	6.2	6.0	79	140.4

The soil is analyzed eubazic all over the degree of base saturation (V%) is between 79-90%.
Humus content has higher values in the first 20 cm of the profile analysis. The analysis of data presented in Table 5 shows that the soil has medium containing organic matter (humus). Humus reserve (Rh t/hectare) is large and very large, with lower values P1 profile. We can say that the surface S1, P2 and P3 reserves of humus, the 40 cm depth, is Rh = 185.4 t/hectare, and the surface S2 with P1 and P4, Rh = 153.6 t/hectare to 31.8 t/hectare less. High humus content in soil fertility analysis expressed its good.
Approximately 95% of the nitrogen is nitrogen linked to soil organic matter, nutrients are mostly used by plants during all phases of vegetation. In cultivated soils derived nitrogen and organic fertilizers and minerals applied at the end of the growing season may be negative balance. When nitrogen plant nutrition is poor, they have poor stamina, reduced growth, less branched slender stems, leaves and small fruits. Soil nitrogen balance is influenced by the humid during the growing season.
Total nitrogen content (Nt) is analyzed middle ground between 0.20 to 0.27 % values (Table 6). Nitrogen indicator is determined by calculation based on the content of humus and helps to establish the required dosage of organic fertilizer of the soil. Thus, S1 optimal dose is 22.7 t/ hectare, and for surface S2 is 23.5 t/hectare to 0.75 t/ha higher.

Table 6. The total nitrogen content, nitrogen and optimal dosages index organic fertilizer, the analyzed profiles, the depth of 40 cm

No. profile	Total nitrogen (%)	Nitrogen indicator IN	Organic mater t/hectare
P1	0.20	5.3	23.5
P2	0.27	6.4	22.8
P3	0.23	5.8	23.6
P4	0.24	6.0	23.2

CONCLUSIONS

Ameliorative measures recommended farmland studied are:

- compensation moisture deficit irrigation, watering rate is calculated based on temporary humidity;
- organic fertilization with manure or incorpore lush growing species (white lupine, mash, rape, etc.);
- -correct and timely execution of mechanical works, so as to avoid soil compaction that can damage soil structure studied is susceptible to compaction;
- morphological and physico-chemical roperties of soils in the study area allow their use for horticulture, especially for gardening.

REFERENCES

Muşat M., Burcea Mariana, Radu Alexandra, 2013. Pedoagrotechnical. Ceres Publishing, Bucharest.

Parichi M., Râşnoveanu I., Jalbă Marcela, Vespremeanu Rodica, Marian Elisabeta, 1986. Characterization of soil resources of Ilfov County. Archive ICPA, Bucharest.

Parichi M., Râşnoveanu I., Râşnoveanu Anişoara, Jalbă Marcela, Marian Elisabeta, Mircea I., 1986. Soil research in Ilfov County. Archive ICPA, Bucharest.

Posea Gr., Ştefănescu Ioana, 1984. Bucharest in Ilfov County. R.P.R Academy Publishing House, Bucharest.

Stănilă Anca-Luiza, Parichi M., 2011. Soil Background of Ilfov County. Scientific Papers, UASVM Bucharest, Series A, Vol. LIV, p. 40-46.

Vlad V., Florea N., Toti M., Mocanu Victoria, 2014. Corelation sistems for soil clasification SRCS and SRTS, Sitech Publishing, Craiova.

***1987. Development methodology soil studies (3 vol.) ICPA, Bucharest.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE ALTERNATION OF VARIOUS TILLAGE METHODS AND MAINTENANCE OF SOIL UNDER ORCHARDS

Tatiana NAGACEVSCHI[1], Sava GRIȚCAN[2]

[1]Moldova State University, 60 A. Mateevici, MD-2009, Chisinau, Republic of Moldova
[2]Scientific and Practical Institute of Horticulture and Food Technology, 59 Vierului, MD-2011, Codru, Chisinau, Republic of Moldova

Corresponding author email: lola8459@mail.ru

Abstract

A special importance in terms of maintaining soil fertility in orchards it has maintenance method. The different methods were investigated in orchards. The experience included 3 variants: 1. Black field between rows (witness); 2. Mulching the soil through coating; 3. Temporary revegetation with perennial grasses. Alternation in time and space of these methods allows to minimize the expenses and environmental protection as well as the premises to recommend the soil maintenance method that lead to the improvement of physical properties and increase organic matter content when the soil is maintained covered by grass and moisture preservation in the case of temporary use of the coating.

Key words: *soil, degradation, apparent density, porosity, structure.*

INTRODUCTION

Soil work in orchards is particularly important as regards to the maintenance of soil fertility, that depends on the type of maintenance use. Aimed to highlight this issue have been studied diffrent methods of soil maintenance in orchards. Soil work for a long time in orchards contribute to the worsening of soil physical proprities as a result that is acting negatively on growth and fruitfulness of fruit trees. Yield losses due to physical degradation of soil proprities, through its compaction is equal to production increases due to irrigation and close to same as those obtained from the use of fertilizers. As a result of preparatory work of the land before planting (subsoiling, compaction, leveling) and taking into account that fruit plants cover the land for 15-20 years, the soil are strongly modified in terms of the reversal horizons and improvement of aerobic regime, thermal and nutritional (The complex program of valorisation of degraded lands and increasing soil fertility, 2004).

MATERIALS AND METHODS

The researches aim to highlight the changes of agrophysical proprieties of the soil in the fruit orchards in long term: control variant for all experiments has served black field maintained free of weeds through mechanical works between rows and manual hoeing in rows. Depending on the conditions of moisture and soil conditions were used disc harrow, cutter or cultivator. There have been carried out 4-5 works during the growing season as required. The experience includes 3 variants: 1. Black field in the intervals between rows (withness); 2. Mulching the soil through coverage layers (pellicle) on the strip along the row width of 1.0 m; 3. Revegetation with perennial grasses on the strip along the row width of 1.0 m (fallow). Alternation in time and space of these methods allows minimizing the expenses and contributing to environmental protection. The research was conducted in plum tree plantations on the typical chernozem weak hummus sloppy loamy, which is located in the pedogeographic district Forest Hills Codrii. To characterize the soil cover on experimental polygons this were arranged in the main profiles and samples were collected from genetic horizons.

RESULTS AND DISCUSSIONS

State of soil settlement is determined in general by the bulk density, substantially influenced by the growth and development of agricultural crops, since they depend on airhydric regimes and various chemical processes and microbiological. The porosity depends on the water retention capacity, permeability and aeration. This in its turn depends on texture, structure and bulk density. In the soils moderately loose, the total porosity component proprieties are favorable, concomitantly providing good conditions for water retention accessible to plants, aeration and rapid circulation of excess water. The compacted soils, except coarse texture, on the contrary the ratio of components in total porosity is often less favorable (Canarache Andrei, 1990). In the orchards space of arable layer and in the layer 20-30 cm occurs a differentiation of the parameters of total porosity according to the increase of apparent density.

Table 1. The bulk density and total porosity

	Black field		Pellicle		Revegetation	
Depth, cm	ad, g/cm^3	T.p. %	ad, g/cm^3	T.p. %	ad, g/cm^3	T.p. %
0-10	0.99	62	1.09	58	1.08	59
10-20	1.26	52	1.16	56	1.03	61
20-30	1.28	52	1.28	52	1.21	57
30-40	1.28	52	1.28	52	1.17	57
40-50	1.24	53	1.25	53	1.18	57
50-60	1.20	56	1.20	56	1.19	57
60-70	1.25	52	1.30	51	1.25	52
70-80	1.30	51	1.30	51	1.30	51

The data obtained (Table 1) shows that the upper layers of soil (0-10 cm) in all three variants of soil maintenance the apparent density parameters are extremely low, these comprising values of 0.99-1.09 g/cm^3 characterizing the soil as loose which demonstrated the total porosity values 58-62%. In the 10-20 cm layer is observed an increase in apparent density in black fields and pellicle variants compared with revegetation that characterize weak compacted soil as 1.26 g/cm^3, moderately compacted loose 1.16 g/cm^3 and very loose 1.03 g/cm^3. The 20-40 cm layer is characterized by higher parameters of apparent density in comparison with 0-20 cm layer as well with the underlying layer or 40-50 cm which corresponds to the lower part of the sloppy layer. At the same time the formation of this layer with higher values of apparent density are evident, in the case of soil maintained as black field and under pellicle where de soil is characterized as weak loose and in the revegetation the soil is moderately loose. This proves that the soil maintenance covered by grass lead to the improvement of physical proprieties namely to decease of apparent density and porosity increase maintaining an optimal airhydric regime compared to black field.

Table 2. Structure

Depth, cm	The diameter of aggregates, mm			k_{st}
	>10	10-0.25	>0.25	
Black field				
0-10	33.20	51.70	84.90	1.07
10-20	41.30	56.60	97.90	1.30
20-30	33.80	61.20	95.00	1.58
30-40	33.80	61.60	95.40	1.61
40-50	30.00	62.30	92.30	1.65
Pellicle				
0-10	21.90	64.60	86.50	2.54
10-20	25.20	70.40	95.60	2.38
20-30	24.20	69.30	93.50	2.26
30-40	26.50	69.50	96.00	2.28
40-50	29.50	68.80	98.30	2.21
Fallow				
0-10	15.10	73.00	88.10	2.70
10-20	23.50	74.50	98.00	2.92
20-30	23.40	72.70	96.10	2.66
30-40	25.00	71.20	96.20	2.52
40-50	25.50	71.50	97.0	2.51

Characterizing the soil structure (Table 2) we observed moderate clods structure in the black field soil and lower in fallow soil and in the pellicle. Fallow soil and under the pellicle has a more stable structure characterized by a Ks in the upper layer 0-20 cm from 2.72-2.92 and from 2.38-2.54 while to black field corresponding 1.07-1.30. In the covered by grass soil as well as the pellicle are not observed degradation of the structure while the degradation of clouds structure in black field layer is present on throughout sloppy layer. Hydrostability aggregates through which is also appreciated the structure is reduced in the case of fallow soil. Hydrostability aggregates amount higher than 0.25 mm constitute only 26-27% and the bottom which proves the depth of subsoiling up to 50 cm where he was returned to the surface layer. In the covered by grass soil is observed a good hydrostability in the entire sloppy layer, where amount of hydrostability aggregates are higher than 25 mm and is 44-62%.

Under anthropic regime the state of aggregate structure is also influenced by the changes in the processes of pedogenesis: changes in the decomposition process and transformation of organic debris under arable regime; changes in the process of humification caused by its realization under airhydric regime respectively, redox displaced; the process under arable regime flows more accelerated up to the final product, which cause deficiency of organic substances participating in the aggregation; changes in the organic substances system in the soil; reducing content of labile organic substances; the drastic reduction of fauna (mesofauna in the soil); the specified factors determined sprying structure (Soil degradation and desertification, 2000).

Determination of the chemical proprieties of typical hummus weak chernozems sloppy demonstrated (Table 3) that is characterized by medium content of humus in the surface horizons (2.50-2.87%) and lower content in the underlying horizons (1.50%). However both humus content and mobile forms of N, P and K were higher even though are not essential parameters in the revegetation and in pellicle variants. These indices are below the statistical mean for typical hummus weak chernozem (3.83%). The decrease of organic matter content is due to daily occurrence through subsoiling of a part of transitional horizon B. Should be noted that the upper soil horizons unsloppy from adjacent land (at a distance of 35-50 m), humus content ranges from 3.29 to 4.20%. Moisture content was largely influenced by rainfalls that have been unsystematic in recent years. The high degree of moisture was maintained at 19.6% in pellicle variant and lowest 16.2% in the black field.

The water reserve in the layer 0-60 cm is determined by roots of the plants and constitute 131.6 mm in the black field, under variants with vegetation as a result of clearing grass on the soil surface layer is formed mulch through which is reduced evaporation and water reserve constitute 156.8 mm and the soil water reserve under covered with pellicle is higher 159.3 mm.

Table 3. Chemical characteristics

Variants	Depth., cm	Moisture, %	Humus, %	NO_3 mg/100g	P_2O_5 mg/100g	K_2O mg/100g
1.	0-20	13.24	2.76	1.74	2.72	24.0
	20-40	15.16	2.83	1.43	1.98	20.0
	40-60	18.86	1.70	1.30	1.60	17.0
2	0-20	19.23	2.50	1.43	2.90	26.0
	20-40	21.18	2.65	1.59	2.40	25.0
	40-60	20.79	1.58	1.30	2.20	18.0
3	0-20	19.05	2.87	1.82	2.75	27.0
	20-40	21.05	2.85	1.70	2.40	24.0
	40-60	19.83	1.78	1.37	1.85	17.0

In conclusion may be added that all the variants in comparision with the control variant have accumulated a larger amount of water in the soil. In terms of physical proprities and chemical, fallow soil variant is most beneficial but with regard to conservation and more reasonable use of soil moisture in maintaining soil the most successful is pellicle.

Table 4. Harvest

Black field		Pellicle		Fallow	
Harvest. tree, kg	Harvest. ha, ton	Harvest. tree, kg	Harvest. ha, ton	Harvest. tree, kg	Harvest. ha, ton
24.4	16.1	28.3	18.7	27.4	18.1

CONCLUSIONS

The work and maintenance of soil in orchards is particularly important in terms of maintaining soil fertility. Based on the research we can say that through grassing maintenance as well soil mulching through the pellicle temporarily lead to the improvement of physical proprieties and increase organic matter content and appropriately to the preservation of moisture. In the case of maintenance as black field the soil is subjected to physical degradation and it also refer to the crop.

REFERENCES

Canarache A., 1990, Physics of agricultural soil. P. 26-66.

***Soil degradation and desertification, 2000, Chisinau, p. 71-81.

***, The complex program of valorisation of degraded lands and increasing soil fertility, 2004, Chisinau, p. 70-71.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

IMPACT OF DIFFERENT SOIL TILLAGE PRACTICES ON BIOTA OF CHERNOZEMS IN THE NORTHERN ZONE OF THE REPUBLIC OF MOLDOVA

Irina SENICOVSCAIA, Vladimir FILIPCHIUK, Alina TSINTSARI

"Nicolae Dimo" Institute of Pedology, Agrochemistry and Soil Protection
Ialoveni str. 100 MD 2070, Kishinev, Republic of Moldova

Corresponding author email: irina_sen@mail.ru

Abstract

The effect of different tillage practices on soil biota' state of chernozems has been investigated. Two experimental sites located in the northern zone of the Republic of Moldova have been tested with application of soil biological indicators in June and October, 2014. Land management practices with application of no-tillage on the leached chernozem (2 years of use) and mini-tillage on the slightly eroded typical chernozem (10 years of use) have been compared with the long-term conventional tillage of 25-27 cm. The application of no-tillage has created conditions for the improvement of the biota's vital activity in the leached chernozem. The effect of no-tillage was manifested in the increase of number and biomass of Lumbricidae family by 4.1 and 14.1 times respectively. Worms were concentrated in the 0-40 cm soil layer. Chernozem with no-tillage application is characterized by greater stability in comparison with the conventional tillage due to higher number of saprophages. No-tillage system has increased the microbial biomass carbon compared to the traditional tillage system. Dehydrogenase and polyphenoloxidase activities were significantly higher in conditions of no-tillage treatment. A positive impact of mini-tillage practice on soil was less pronounced. It was shown that biota's abundance increased and the humus content in the slightly eroded typical chernozem grew by 0.44-0.51%. The application of conservation management practices led to the soil compaction. Bulk density in the 0-40 cm soil layer increased on average from 1.36 to 1.41 g cm^{-3} in the leached chernozem and from 1.15 to 1.30 g cm^{-3} in the slightly eroded typical chernozem.

***Key words**: biota, no-tillage, mini-tillage, conventional tillage, chernozem.*

INTRODUCTION

Soil tillage system is important for the regulation of the formation of humus and nutrients in the root zone, for the soil biota's ensuring access to plant residues in the upper layers of the soil, and the crop yield formation as a whole (Miura et al., 2008; Soane, 2012). As a result of the mixing of soil layers the water-air and thermal regimes have been changed, thus affecting on the composition and activity of soil invertebrates and microorganisms. The periodic tillage favors the air admission into the soil, thereby adjusting the ratio between air and water in it, creates optimal conditions for growth of agricultural plants and multiplication of aerobic microorganisms. The use of different types of tillage can modify the direction and intensity of the processes of humification - mineralization in the soil.

Soil conventional tillage or traditional intensive tillage by plowing besides the positive effects, such as reduction of compaction and increase the water permeability, is the reason of the evolution of soil towards the development of degradation processes in conditions of the Republic of Moldova. This concerns primarily with the intensified mineralization of organic matter, restructuring of the arable layer, its spraying, reducing of the aggregate stability and soil biota's degradation (Andriesh et al., 2004; Senicovscaia, 2012). On the other hand, the usual tillage of land is expensive process and depends on the prices of fuel and lubricants.

The negative effects of conventional tillage have led to necessity of application of alternative soil management practices. These techniques are known as *"conserving/preserving tillage"*. It should be noted that the concept of conservation processing includes many processes from direct seeding and *no-tillage* to the deep cultivation without turning of soil layers. The implementation of soil tillage technologies should be based on the detailed knowledge of characteristics of soil. Necessarily should be taken into account such important factor as soil biological properties in cases when soil conservation tillage is applied.

The importance of monitoring researches of the biota increases in case of the application of soil conservation technologies on degraded soils.

The purpose of research was to determine the impact of conventional and conservation soil tillage technologies on biota of chernozems in the northern zone of the Republic of Moldova.

MATERIALS AND METHODS

Experimental sites and soils. Two experimental sites located in the northern zone of the Republic of Moldova in the forest steppe region of northern upland have been tested in June and October, 2014. Land management practices with application of *mini-tillage* and *no-tillage* have been compared with the long-term conventional tillage on 25-27 cm.

The first site was located in ”Gospodarul Rediu” SRL in the Rediu de Sus village, Falesti region. The experimental site was on the slope with a gradient of 2-3º. Soil conservation technique *mini-tillage* was applied in the area of 60 ha over 10 years. Field with *mini-tillage* was compared with conventional tillage (plowing to a depth of 25-27 cm). The soil of plot is the slightly eroded heavy loamy typical chernozem with humus content of 3.52% and pH = 6.97 in the 0-40 cm layer.

The second site was located on the territory of ”SoroAgro” SRL in the Rediu Mare village, Dondusheni region. Technology of *no-tillage* has been implemented for 2 years at the demonstration plot with the area of 106 ha. The area of control plot with conventional tillage (plowing to a depth of 25-27 cm) consists of 109 ha. The soil was presented by the deep heavy loamy leached chernozem with humus content of 3.71 % and pH = 6.66 in the 0-40 cm layer.

Status of invertebrates. The state of invertebrates was identified from test cuts by manually sampling the soil layers to the depth of soil fauna occurrence. The identification of invertebrate’s diversity at the level of families and their classification according to nutrition were conducted by Gilyarov and Striganova’s method (1987).

Microbiological properties. The microbial biomass C was measured by the rehydratation method based on the difference between C extracted with 0.5 M K_2SO_4 from dried soil at 65-70^oC within 24 h and fresh soil samples with K_c coefficient of 0.25 (Blagodatsky et al., 1987). K_2SO_4 – extractable organic C concentrations in the dried and fresh soil samples were simultaneously measured by dichromate oxidation. The quantity of K_2SO_4 – extractable C was determined at 590 nm with "СФ-103" spectrophotometer. Reserves of MB have been calculated taking into account the carbon content of the microbial cell and the bulk density of soils.

Enzymatic activity. The (potential) dehydrogenase activity was determined by the colorimetric technique on the basis of triphenylformazan (TPF) presence from TTC (2, 3, 5-triphenyltetrazolium chloride) added to air-dry basis of soil (Haziev, 2005). The (potential) polyphenoloxidase activity was determined by the colorimetric technique with the use of hydroquinone as a substrate (Karyagina and Mikhailovskaya, 1986).

RESULTS AND DISCUSSIONS

Invertebrates. Conservation tillage has an ambiguous effect on the biota of investigated chernozems. Number of invertebrates and *Lumbricidae* family under the soil conservation tillage technology *mini-tillage* is characterized by slightly increase compared to indicators in soil in the plot with conventional tillage to a depth of 25-27 cm. Number of invertebrates in the slightly eroded typical chernozem under *mini-tillage* increases from 50.7 to 86.7 ex m^{-2} and earthworms – from 41.4 to 78.7 ex m^{-2} (Table 1). The biomass of invertebrates and *Lumbricidae* family contrary reduces from 12.3 to 5.6 g m^{-2} and from 6.7 to 5.3 g m^{-2} in the initial sampling period. On the whole the number of invertebrates in the plot with *mini-tillage* on average is higher by 1.7 times than in the plot with plowing of 25-27 cm but the total biomass is lower by 1.2 times.

The application of *no-tillage* technology has a positive effect on the biota in the leached chernozem. The rise of the total number of invertebrates and earthworms from 33.3 to 136.0 ex m^{-2} and their biomass from 1.7 to 23.9 g m^{-2} in conditions of *no-tillage* has been observed.

The dominant position in the composition of soil fauna occupies *Lumbricidae* family in all technologies of tillage. Their share in the total number of invertebrates increases from 84.9% in the plot with conventional tillage to 90.8% under *mini-tillage* and 92.2% in conditions of *no-tillage* technology. A similar tendency has been established in the indicators of biomass. Their share in the total biomass of invertebrates rises from 71.8% in the plot with plowing to 74.3% under *mini-tillage* and 93.3% in conditions of *no-tillage* technology.

Table 1. Number and biomass of invertebrates and *Lumbricidae* family in chernozems under different soil tillage (average values, n = 6, P ≤ 0.05)

Soil	Soil tillage	Number, ex m^{-2}		Biomass, g m^{-2}	
		total	*Lumbricidae* family	total	*Lumbricidae* family
Slightly eroded typical chernozem	Arable 25-27 cm	50.7	41.4	8.5	5.2
	Mini-tillage	86.7	78.7	7.0	5.2
Leached chernozem	Arable 25-27 cm	33.3	29.3	1.7	1.4
	No-tillage	136.0	125.4	23.9	22.3

In the slightly eroded typical chernozem under arable the base mass of invertebrates (72.3 - 75.1%) and *Lumbricidae* family (66.8-68.9%) is concentrated in the 0-30 cm layer, while in the soil under *mini-tillage* the most animals (76.3-92.6%) and earthworms (79.4-92.0%) are accumulated in the layer of 10-40 cm. Chernozem in conditions of *mini-tillage* techniques is characterized by a thick active layer of soil.

In the leached chernozem in conditions of conventional tillage earthworms are concentrated in the layer of 30-50 cm. On the contrary in the soil under *no-tillage* a major amount of invertebrates (92.6-100.0%) is located in the layer of 0-40 cm. The number of *Lumbricidae* family decreases gradually in the soil profile to a depth of 50 cm.

Slightly eroded typical chernozem under arable is characterized by a high diversity of invertebrates in comparison with the soil in conditions of *mini-tillage* technique (Table 2).

Table 2. Diversity of soil invertebrates (on the family's level) in the slightly eroded typical chernozem under different soil tillage, ex m^{-2}

No	Family	Arable 25-27 cm	Mini-tillage
17-18.06.2014			
1	*Lumbricidae*	42.7	66.6
2	*Glomeridae*	0	2.7
3	*Scarabaeidae (larva)*	2.7	0
4	*Gryllidae*	2.6	0
5	*Geophilidae (larva)*	0	2.7
6	*Pyralidae (larva)*	2.7	0
7	*Carabidae*	2.6	0
8	*Formicidae*	+	0
Total		**53.3**	**72.0**
13-14.10.2014			
1	*Lumbricidae*	40.0	90.7
2	*Scarabaeidae*	0	2.7
3	*Geophilidae*	2.7	0
4	*Carabidae*	2.7	5.3
5	*Lucanidae*	0	2.6
6	*Tenebrionidae*	2.6	0
Total		**48.0**	**101.3**

This soil contains 4-6 families of invertebrates, whereas under *mini-tillage* conditions only 3-4 families. In addition to *Lumbricidae* family, other species of the *Formicidae, Scarabaeidae, Gryllidae, Pyralidae, Geophilidae, Tenebrionidae* and *Carabidae* families in faunal samples have been identified. *Lumbricidae* family is prevalent in soils with both types of tillage. Species of *Glomeridae, Scarabaeidae, Lucanidae, Carabidae and Geophilidae* families have been reported in the chernozem under soil conservation tillage.

In the fauna of the leached chernozem *Lumbricidae* family occupies a dominant position also, their numbers amounts to 85.0-100.0% (Table 3). The average weight of *Lumbricidae* family's representatives increased from 0.05 g on the plot with arable to 0.18 g on the plot with *no-tillage*. *Lumbricus terrestris* is the most typical specie of earthworms in the leached chernozem. *Allolobophora rosea* has been encountered in single copies.

Besides *Lumbricidae* family, species of invertebrates from ants which are spread in enormous quantities have been identified in faunal samples. *Lasius niger* was a typical representative of *Formicidae* family.

Soil fauna was represented by only two families in summer, the plot with conventional tillage contained 4 families, and plot with *no-tillage* – 6 families in autumn.

Table 3. Diversity of soil invertebrates (on the family's level) in the leached chernozem under different soil tillage, ex m^{-2}

No	Family	Arable 25-27 cm	No-tillage
19.06.2014			
1	*Lumbricidae*	13,3	72,0
2	*Formicidae*	++	++++
Total		**13,3**	**72,0**
15-16.10.2014			
1	*Lumbricidae*	45,3	178,7
2	*Glomeridae*	0	8,0
3	*Geophilidae*	0	5,3
4	*Araneidae*	2,7	2,7
5	*Elateridae*	2,6	0
6	*Tenebrionidae*	2,7	2,6
7	*Pieridae*	0	2,7
Total		**53,3**	**200,0**

Saprophages predominated in both methods of tillage in investigated chernozems.

The share of saprophages in the complex of soil fauna in the slightly eroded typical chernozem under arable is 80.1-83.3%, under *mini-tillage*–89.5-92.4% (Figure 1). The contribution of phytophages in the total number of invertebrates is significantly lower and has been reduced to zero in the plot with *mini-tillage*. The content of invertebrates with mixed type of nutrition amounts to 2.7-9.8% in the arable chernozem and 0-3.8% with *mini-tillage*. Zoophages constitute 0-2.7% in the arable soil and 3.8-5.3% in the soil with *mini-tillage*. Ecological pyramids in the chernozem with *mini-tillage* application are characterized by higher stability compared to the application of the conventional tillage on 25-27 cm depth. Necrophages have been found only in the arable soil and constitute 2.6%.

The contribution of saprophages to the total number of invertebrates in the leached chernozem is significant and constitutes 85.0-100.0% for both types of soil tillage. Invertebrates with mixed type of nutrition (*Formicidae* family) are significant in the plot with *no-tillage*. Ecological pyramids are incomplete, but the soil under *no-tillage* is characterized by greater stability compared to the conventional tillage due to larger number of saprophages.

Microorganisms. The application of *mini-tillage* and *no-tillage* technologies stimulates the restoration of microorganisms in investigated chernozems in the demonstration sites.

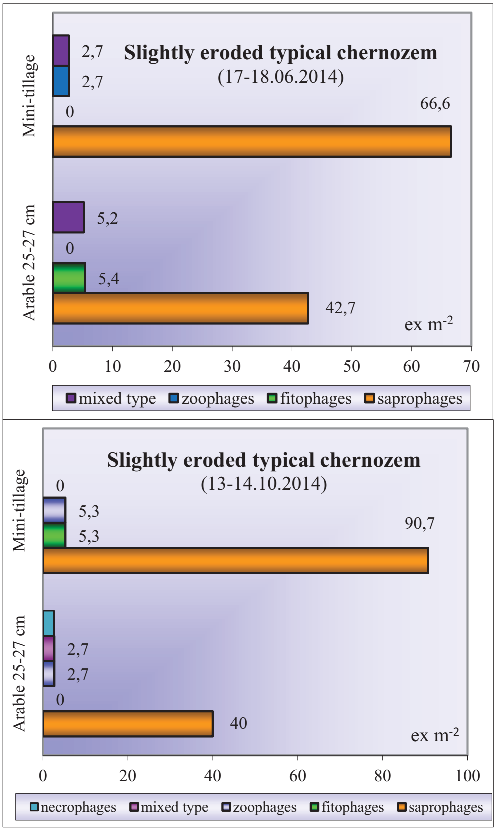


Figure 1. The composition of invertebrates depending on the mode of nutrition in the slightly eroded typical chernozem in conditions of the different tillage methods application (average, without *Formicidae* family in the arable plot)

The microbial biomass in the slightly eroded typical chernozem increases in average from 283.2-514.7 to 398.5-524.0 µg C g^{-1} soil in the 0-20 cm layer and from 227.2-440.9 to 469.0-588.0 µg C g^{-1} soil in the 20-40 cm layer (Table 4). The share in the total microbial carbon in the 0-40 cm layer in the plot under arable is 1.24-2.37% and in the plot with *mini-tillage* – 1.87-2.40%. The application of *mini-tillage* contributes to the increase of microbial biomass stocks by 1.3-1.9 times in the 0-40 cm layer.

Enzymatic activity. The tendency to activate the polyphenoloxidase in conditions of *mini-tillage* in the slightly eroded typical chernozem in autumn has been registered (Table 6). Dehydrogenase activity has not changed statistically significant with the exception of the layer of 20-40 cm.

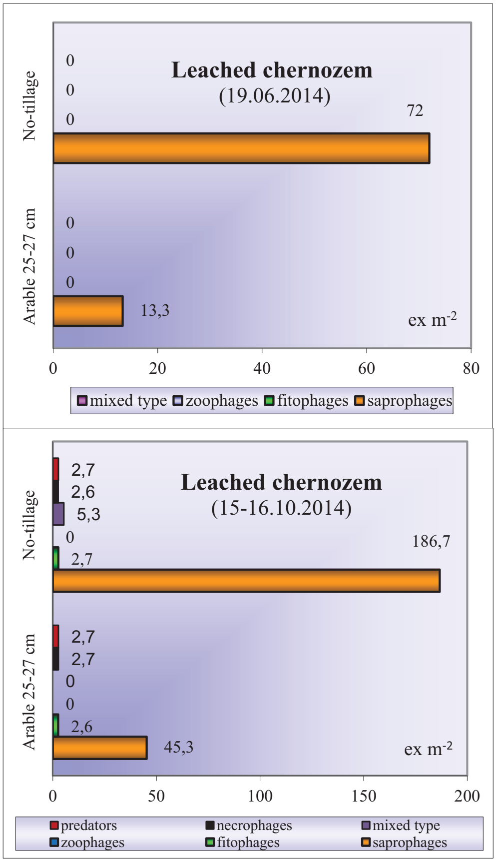


Figure 2. The composition of invertebrates depending on the mode of nutrition in the leached chernozem in conditions of the different tillage methods application (average, without *Formicidae* family)

Table 4. Microbial biomass content and reserves in the slightly eroded typical chernozem in conditions of different tillage systems

Soil tillage	Depth, cm	MB, µg C g^{-1} soil	C_{MB}/C_{org}, %	Reserves of MB, kg ha^{-1}	
				in layers	in 0-40 cm layer
17-18.06.2014					
Arable 25-27 cm	0-20	283.2	1.34	1246.1	2300.3
	20-40	227.2	1.14	1054.2	
Mini-tillage	0-20	398.5	1.73	2131.9	4383.1
	20-40	469.0	2.00	2251.2	
LSD 5%		98.5			
13-14.10.2014					
Arable 25-27 cm	0-20	514.7	2.43	2285.3	4436.9
	20-40	440.9	2.30	2151.6	
Mini-tillage	0-20	524.0	2.30	2661.9	5884.1
	20-40	588.0	2.50	3222.2	
LSD 5%		67.6			

MB – microbial biomass; C_{org} – organic C

The humus content in the slightly eroded typical chernozem grew from 3.48-3.56% in arable soil to 3.99-4.00% in the 0-40 cm layer of soil under *mini-tillage*.

The increasing trend of microbial carbon content and the ratio between microbial and total carbon content have been recorded in the leached chernozem in conditions of *no-tillage* technology. There has also been indicated the increase of microbial biomass reserves under the application of *no-tillage* (Table 5). Reserves of microorganisms' biomass in the 0-40 cm layer are 4796.6-6449.9 kg ha^{-1} in the plot with plowing and 5649.4-6563.9 kg ha^{-1} in the plot with *no-tillage*.

Favorable conditions for the functioning of enzymes in soil under conditions of *no-tillage* have been found (Table 7). The most powerful impact of the conservation technology on soil enzymes was recorded in the 20-40 cm layer.

Table 5. Microbial biomass content and reserves in the leached chernozem in conditions of different tillage systems

Soil tillage	Depth, cm	MB, µg C g^{-1} soil	C_{MB}/C_{org}, %	Reserves of MB, kg ha^{-1}	
				in layers	in layers
19.06.2014					
Arable 25-27 cm	0-20	403.3	1.90	2097.2	4796.6
	20-40	485.5	2.26	2699.4	
No-tillage	0-20	441.6	2.02	2773.3	5649.4
	20-40	528.7	2.37	2876.1	
LSD 5%		48.9			
15-16.10.2014					
Arable 25-27 cm	0-20	597.1	2.76	3319.9	6449.9
	20-40	592.8	2.71	3130.9	
No-tillage	0-20	469.2	2.13	2665.1	6563.9
	20-40	667.6	2.95	3898.8	
LSD 5%		72.5			

MB – microbial biomass; C_{org} – organic C

Table 6. Influence of different tillage systems on the enzymatic activity of the slightly eroded typical chernozem

Soil tillage	Depth, cm	Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}
17-18.06.2014			
Arable 25-27 cm	0-20	2.58	64
	20-40	1.10	6.5
Mini-tillage	0-20	2.54	9.0
	20-40	2.54	7.3
LSD 5%		0.60	1.0
13-14.10.2014			
Arable 25-27 cm	0-20	3.90	6.5
	20-40	0.13	5.8
Mini-tillage	0-20	1.65	4.0
	20-40	1.58	5.0
LSD 5%		1.27	1.0

Table 7. Influence of different tillage systems on the enzymatic activity of the leached chernozem

Soil tillage	Depth, cm	Dehydrogenase, mg TPF $10g^{-1}$ soil $24h^{-1}$	Polyphenoloxidase, mg 1,4-p-benzoquinone 10 g^{-1} soil 30 min^{-1}
19.06.2014			
Arable 25-27 cm	0-20	2.65	6.5
	20-40	0.79	3,3
No-tillage	0-20	3.29	10.0
	20-40	2.04	10.3
LSD 5%		0.88	2.7
15-16.10.2014			
Arable 25-27 cm	0-20	2.50	6.8
	20-40	0.13	4.5
No-tillage	0-20	2.73	10.5
	20-40	1.33	9.8
LSD 5%		0.97	2.7

The application of conservation management practices led to the soil compaction. Bulk density in the 0-20 cm soil layer increased from 1.11 under arable to 1.31 g cm^{-3} under *mini-tillage* in the slightly eroded typical chernozem and from 1.35 in the plot with arable to 1.40 g cm^{-3} in conditions of *no-tillage* in the leached chernozem. A similar regularity has also been observed in the 20-40 cm soil layer. Bulk density increased from 1.19 to 1.29 g cm^{-3} in the slightly eroded typical chernozem and from 1.36 to 1.41 g cm^{-3} in the leached chernozem respectively.

CONCLUSIONS

The application of conservation tillage practices in conditions of the northern zone of the Republic of Moldova has different effects on soil biota. The common characteristic of *mini-tillage* and *no-tillage* is the growth of the number of invertebrates, reserves of microbial biomass, the multiplication and development of the *Lumbricidae* family, increase enzymatic activity.

The effect of *mini-tillage* on the soil biota manifests by the increase of the total number of invertebrates by 1.7 times, *Lumbricidae* family – by 1.9 times, growth of the microbial biomass and reserves. The slightly eroded typical chernozem at the plot with *mini-tillage* is characterized by the lower diversity of invertebrates compared to arable chernozem. Ecological pyramids in conditions of *mini-tillage* application are characterized by the greater stability compared to the arable soil by the reason of increasing numbers of saprophages and the lack of phytophages.

More pronounced effect is the use of *no-tillage* technology though this method has been used for 2 years. The number of *Lumbricidae* family in the leached chernozem in average was 4.1 times higher compared with the arable plot, the biomass – 14.1 times respectively. The weight of one exemplar of earthworms in chernozems was 3.6 times higher and constituted 0.18 g. The characteristic feature of the chernozem with *no-tillage* application is concentration of earthworms in the layer of 0-40 cm and the higher share of saprophages in the total population of soil invertebrates.

Negative consequences of the conservation practices application are soil compaction.

ACKNOWLEDGEMENTS

This research work was carried out in the framework of the project "Determination of soil physical, chemical and biological properties of demonstration plots in the implementation of conservative agriculture" No BES-036/14 RFSADP with the support of Consolidated Unit of Programmes Implementation IFAD.

REFERENCES

Andriesh S. (Ed.) et al., 2004. The complex program of recovery of degraded lands and increase of soil fertility. Part I. Pontos, Kishinev.

Blagodatsky S.A., Blagodatskaya E.V., Gorbenko A.J., Panikov N.S., 1987. Rehydration method for the determining of the microbial biomass in the soil. Pochvovedenie, Moscow, 4: 64-71.

Gilyarov M.S., Striganova B.R. (Ed.), 1987. Quantitative Methods in Soil Zoology. Nauka, Moscow.

Haziev F.H., 2005. Methods of soil enzymology. Russian Academy of Sciences, Ufa.

Karyagina L.A., Mikhailovskaya N.A., 1986, Determination of polyphenoloxidase and peroxidase activities in the soil, Journal of the Academy of Sciences of BSSR, 2: 40-41.

Miura F., Nakamoto T., Kaneda S., Okano S., Nakajima M., Murakami T., 2008. Dynamics of soil biota at different depths under two contrasting tillage practices. Soil Biology and Biochemistry, 40(2): 406-414.

Senicovscaia Irina, 2012. Biota of degraded soils and methods for its restoration. AGROLIFE Scientific journal, Bucharest, 1: 78-83.

Soane B.D., Ball B.C., Arvidsson J., Basch G., Moreno F., Roger-Estrade J., 2012. No-till in northern, western and south-western Europe: A review of problems and opportunities for crop production and the environment. Soil and Tillage Research, 118: 66-87.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON EXPLOITATION OF WASTES FROM THE PRODUCTION OF ALCOHOLIC BEVERAGES AS FERTILIZER

Andrei SIURIS, Vasile PLAMADEALA

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo", 100 Ialoveni Str., MD-2070, Chisinau, Republic of Moldova

Corresponding author email: siurisandrei@mail.ru

Abstract

Are examined several waste products, unexplored until now, that are discharged from the units producing alcoholic beverages: wine yeast, vinasse and grain mash. The last one has the origin from agriculture, so all the elements contained in it were taken from the soil. Equitable to the soil is that they would return to the soil through fertilization. Continuous accumulation and discharge without any norm cause environmental pollution, having main impact on soil and surface waters. Researches regarding their exploitation in agriculture are missing in the Republic of Moldova. In this context, we could solve waste problem by exploiting them as fertilizer.

***Key words**: soil fertility, grain mash, vinasse, waste products, wine yeasts.*

INTRODUCTION

With annual crops from soil are removed considerable amounts of nutrients. For the reason of high prices for processing and handling fertilizers practically are not applied.
Simultaneously soil remains poor in nutrients, humus and with unfavourable physical properties. As a source of partial compensation of organic matter and biofile elements can serve wastes from the production of alcoholic beverages (wine yeasts, vinasse, grain mash). Currently the wineries and sections for obtaining alcohol from Moldova annually accumulates about 100 thousand tons of waste material (Statistical Year Book, 2013).
Accumulation and spilling without any legal norms of wastes causes a serious pollutant impact on the environment, but primarily on soil and surface water (Duca, 2011; Ruggieai et al., 2009).
However, the aforementioned wastes contain a major amount of nutrients for plants need: 28 thousand tons of organic matter, 180 tons of nitrogen, 82 tons of phosphorus and 257 tonnes of potassium. International research in terms of characteristics and use in agriculture of wastes from the production of alcoholic beverages are very few (Gemtos et al., 1999; Tejada et al., 2009), and in the Republic of Moldova are absent. In this context, we must solve the problem of waste through its application in agriculture as fertilizer.
The research aim is to highlight the potential of wastes from the production of alcoholic beverages as fertilizer, their influence on soil fertility and crop productivity.

MATERIALS AND METHODS

As objects of research served soil, vineyards, field grown plants and waste from the production of alcoholic beverages (wine yeast vinasse, grain mash) applied in two long-term field experiments at the Technological-Experimental Station "Codru" situated in the village Codru, municipality Chisinau, founded in 2011 on cambic chernozem.
Chemical and physic-chemical analysis of solid wine yeast, soil, grapes and wines were made by the standards adopted or approved in the Republic of Moldova, Statistical analysis was performed using the method of dispersion and correlation using MS Excel program.

RESULTS AND DISCUSSIONS

The research has established that the solid wine yeast is characterized by an acidic environment. The average pH value is 3.5 (Table 1).

Table 1. Chemical composition of solid wine yeast from wineries based on the weight with natural moisture

Index and measure unit	x	min	max	S	V, %
pH	3.5	3.2	3.7	0.1	3.5
Moisture content, %	48.0	42.0	58.9	9.6	20.0
Organic matter content, %	46.8	38.3	50.3	9.5	20.3
Ash, %	5.3	2.8	8.8	3.1	55.0
Carbon, %	23.4	19.2	25.5	1.2	5.2
Total nitrogen, %	1.5	0.77	1.81	0.6	40.0
$N-NO_3$, mg/100 g	1.6	0.71	2.80	0.7	42.5
$N-NH_4$, mg/100 g	32.9	26.9	51.7	2.4	7.3
Total phosphorus, %	0.7	0.60	0.79	0.1	18.5
Total potassium, %	2.5	2.3	2.7	0.3	10.2

Humidity ranges from 42.0 to 58.9% and constituted 48.0% on average. Chemical composition shows that yeast solid are an important source of soil organic matter and nutrients for agricultural crops. Calculated from mass with natural moisture, organic matter content is on average 46.8%. The standard deviation of the mean (S) in absolute size is 9, and the coefficient of variation (V) 20.3%. Among the total primary elements potassium prevails with average content 2.5%, followed by total nitrogen and total phosphorus 1.5% 0.70%. Compared with conventional manure, solid wine yeast contains 2.7 times more nitrogen, 1.6 times more phosphorus, 2.4 times more potassium and 2.7 times more organic matter. On average 1 ton of solid wine yeast with natural moisture contains 47 kg NPK. So, we can state that solid wine yeast is a concentrated fertilizer that can economically justify its transportation to long distances over 10 km from the wineries.

Vinasse presents the liquid remaining after the distillation of alcohol from wine. The liquid is cloudy or slightly cloudy, with a golden-reddish color, with a distinct odor of heat treatment and a sour taste. Vinasse is characterized by an acidic environment. The average pH value was 3.4 units (Table 2).

Table 2. Chemical composition of vinasse from wineries

Index and measure unit	x	min	max	S	V, %
pH	3.4	3.0	3.7	0.26	7.8
Dry residue, g/l	15.2	7.5	24.7	7.3	47.8
Fixed residue, g/l	1.9	1.2	2.9	1.2	65.0
Organic matter content, %	13.3	6.3	21.7	10.7	80.3
Total nitrogen, %	0.02	0.007	0.05	0.02	82.5
Total phosphorus, %	0.02	0.006	0.039	0.02	82.5
Total potassium, %	0.12	0.048	0.157	0.04	37.0
$N-NH_4$, mg/100 g	67	52	86	25.4	37.7
$N-NO_3$, mg/100 g	9.3	0.31	23.8	6.4	68.6
Ca^{2+}, mg/l	106	72	120	20	19
Mg^{2+}, mg/l	84	49	146	36	43
Na^{+}, mg/l	172	125	210	44	25
K^{+}, mg/l	579	335	1127	333	61
Cl^{-}, mg/l	90	69	122	24	26
SO_4^{-2}, mg/l	155	79	280	75	48

Dry residue ranges from 7.5 to 24.7 g/l forming an average (X) 15.2 g/l. The content of organic matter makes up an average of 13.3%, with a variance (V) from 3.6% to 21.7%. Mineral compounds are an average of 0.12%. Total nitrogen and phosphorus content makes up 0.02% on average.

Of the total nitrogen content, the ammonia constitutes about 34%. In the aqueous extract predominate potassium (579 mg/l) and sodium (172 mg/l) monovalent cations. The concentration of bivalent cations of calcium and magnesium constitutes on average 106 mg/l and 84 mg/l. Among the anions sulfate is predominant. Their concentration is from 79 mg/l to 280 mg/l with an average of 155 mg/l. Chlorine content ranges from 69 to 122 mg/l, accounting for an average of 90 mg/l.

Manufacture of spirits from cereals (wheat, barley, maize) has always been a problem with unfavorable environmental consequences. The cause is grain mash, a product highly polluting the environment. Until land reform grain mash was used as animal feed. With the dissolution of large livestock complexes that possibility has disappeared and spirits producers face serious problems in relation to environmental legislation, since most wastes are thrown into the environment.

Grain mash is characterized by a content of 93.4% of water and 6.63% of dry matter (Table 3). The average pH value is 3.7 units. From the primary elements in the composition of grain mash, prevail nitrogen content with an average of 0.28%. The average content of total phosphorous and potassium is respectively 0.12 and 0.11%, and the content of organic substances is 54.4 g/l. Among monovalent cations predominates potassium (783 mg/l) and sodium (450 mg/l). The concentration of bivalent cations of calcium and magnesium is on average 97 mg/l and 234 mg/l.

Among the anions are primarily sulfates. Their concentration is from 188 mg/l to 533 mg/l with an average of 367 mg/l. Chlorine content ranges from 202 mg/l to 397 mg/l, forming on average 299 mg/l.

Table 3. Chemical composition of the grain mash from the ethyl alcohol producing industry

Index and measure unit	x	min	max	S	V, %
pH	3.7	3.4	4.2	0.33	8.9
Moisture content, %	93.4	92.1	97.0	1.3	1.4
Dry residue, g/l	66.3	40.5	72.0	4.9	7.4
Fixed residue, g/l	14.9	9.3	21.4	1.3	8.7
Organic matter content, %	51.4	16.2	62.1	4.8	9.3
Total nitrogen, %	0.28	0.21	0.33	0.04	12.6
Total phosphorus, %	0.12	0.06	0.19	0.08	23.5
Total potassium, %	0.11	0.09	0.13	0.24	22.3
$N\text{-}NH_4$, mg/100 g	143	71	224	63.1	44.2
$N\text{-}NO_3$, mg/100 g	5.8	2.9	11.0	3.7	69.3
Ca^{2+}, mg/l	97	60	100	26.6	27.5
Mg^{2+}, mg/l	234	183	244	86.2	36.8
Na^{+}, mg/l	450	185	550	19.4	43
K^{+}, mg/l	783	649	850	166	21.2
Cl^{-}, mg/l	299	138	321	98.4	32.9
SO_4^{-2}, mg/l	357	188	533	140	39.1

Table 4 presents the data that show the influence of wastes from the production of alcoholic beverages on the content of organic matter, available phosphorus and potassium in the arable layer of cambic chernozem. Average data for 4 years demonstrated that doses of wine yeast (13 and 26 t/ha), (equivalent to 100 and 200 kg N/ha per year) led to a significant increase of organic matter content, respectively by 0.23 and 0.39% (6120 and 10400 kg/ha). The application of vinasse doses of 300 (K_{450}) and 600 m^3/ha (K_{900}) leads to significant increases in organic matter content values in average over four years by 0.22 and 0.34% (5850 and 9040 kg/ha). At fertilization with grain mash the growth of organic matter content in three experimental years was in average 0.15 and 0.25% (3780 to 6300 kg/ha).

Fertilization with wine yeast resulted in statistically significant increase of available phosphorus content for four years on average from 0.47 to 0.64 mg/100 g (from 10.6 to 14.5 kg/ha) compared to the control. The application of vinasse showed an increase of available phosphorus by 0.36 and 0.20 mg/100 g (4.5 and 8.1 kg/ha) compared to the reference variance. Statistically significant values of the content of available phosphorus were identified in the management of grain mash. The difference of the average over four years compared to the control was 0.21 and 0.46 mg/100 g (4.7 to 10.4 kg/ha). Regarding available potassium content, statistically ensured increases compared to the control were recorded in the application of vinasse in the dose of 300 and 600 m^3/ha and grain mash in the dose of 94 m^3/ha.

The results of research conducted over four years showed that applying of studied wastes to grapevine culture had a beneficial effect on plant productivity (Table 5).

Table 4. Influence of waste from the production of alcoholic beverages on the main agrochemical indicators of cambic chernozem (arable layer)

Variant of the experiment	Organic matter			P_2O_5, mg/100 g			K_2O, mg/100 g		
	Mean	Increase compared to the control		Mean	Increase compared to the control		Mean	Increase compared to the control	
		%	kg/ha		%	kg/ha		%	kg/ha
Cambic chernozem, Experimental Station "Codru", village Codru, municipality Chisinau (2011-2014)									
1.Witness	4.05	-	-	2.25	-	-	29	-	-
2.Wine yeast, 13 t/ha per year	4.28	0.23	6120	2.72	0.47	10.6	36	7	160
3.Wine yeast, 26 t/ha per year	4.44	0.39	10400	2.89	0.64	14.5	38	9	206
4.Vinasse, 300 m^3/ha per year	4.27	0.22	5850	2.45	0.20	4.5	40	11	251
5.Vinasse, 600 m^3/ha per year	4.39	0.34	9040	2.61	0.36	8.1	44	15	342
DL 0.5%	0.17	0.17	4520	0.15	0.15	3.4	6.7	6.7	153
Cambic chernozem, Experimental Station "Codru", village Codru, municipality Chisinau (2012-2014)									
1.Witness	2.93	-	-	2.31	-	-	26	-	-
2.Grain mash, 47 t/ha per year	3.08	0.15	3780	2.52	0.21	4.7	29	3	68
3.Grain mash, 94 t/ha per year	3.18	0.25	6300	2.77	0.46	10.4	32	6	136
DL 0.5%	0.12	0.12	2048	0.14	0.14	6.9	2.8	2.8	53

Table 5. Influence of wastes from the production of alcoholic beverages on Sauvignon grape harvest obtained on cambic chernozem, t/ha

Variant of the experiment	Grape harvest on the years				On average		
	2011	2012	2013	2014	Crop, t/ha	Crop increase	
						t	%
1.Witness	9.8	7.6	10.6	9.8	9.5	-	-
2.Wine yeast, 13 t/ha per year	10.8	8.7	11.9	12.0	10.9	1.4	15
3.Wine yeast, 26 t/ha per year	10.9	8.8	14.1	13.9	11.9	2.4	25
4.Vinasse, 300 m^3/ha per year	10.8	8.7	12.0	-	10.5	1.0	11
5.Vinasse, 600 m^3/ha per year	10.6	8.5	12.6	-	10.6	1.7	12
DL 0.5%	0.60	0.64	0.94				

Application of wine yeast at a dose of 13-26 t/ha annually provided a significant increase of the grape harvest averaged over four years from 1.4 to 2.4 t/ha, by 15-25% more compared to unfertilized control (9.5 t/ha). Significant impact on plant productivity of grapevines had vinasse incorporated in dose of 300 and 600 m^3/ha annually. Crop growth rate averaged over three years was 1.0-1.1 t/ha or by 11-12% more compared to the control.

Fertilization with mash grains led to statistically significant increase in productivity of field crops (Table 6).

Table 6. Effects of fertilization with mash grains on field crops productivity, kg/ha

Variant of the experiment	Grape harvest on the years			On average, grain units		
	2012, sunflower	2013, winter wheat	2014, sunflower	Crop	Crop increase compared to witness	
					kg	%
1.Witness	1230	3818	1170	2449	-	-
2.Grain mash, 47 t/ha per year	1840	5673	1790	3670	1221	50
3.Grain mash, 94 t/ha per year	2070	6183	1980	4046	1597	65
DL 0.5%	223	520	172			

Mash grains applied annually at a dose of 47 and 94 m^3/ha (equivalent to N_{120} and N_{240}) resulted in the average yield increase in three years of 1221-1597 kg/ha grain units or 50-65% in comparison with unfertilized variant.

CONCLUSIONS

Wastes from the production of alcoholic beverages, with their varied content of nutrients and immense amount of organic matter, should be included in the agricultural cycle by using them as fertilizer.

Fertilization with wastes from the production of alcoholic beverages resulted in significant increase in organic matter content (0.15-0.39%). There was a significant increase of mobile phosphorus (0.20-0.64 mg/100 g) and exchangeable potassium (6.0-15 mg/100 g).

Application of wine yeast provided a significant increase of grapes harvest (Sauvignon) averaged over four years from 1.4 to 2.4 t/ha. Crop increase at vinasse incorporation was on average for three years 1.0-1.1 t/ha. Applied grain mash determined the average crop production increases over three years of 1200-1600 kg/ha grain units or 50-65% compared to the unfertilized control.

REFERENCES

Duca Gh., 2011. Secondary wine products. Ed. Science L., Chi inău, p. 94-114 (rom).

Gemtos T., Chouliaras N., Marakis St., 1999. Vinasse rate, time of application and compaction effect of soil proprieties and durum wheat crop. Journal of Agriculture Engineering Research, p. 283-296.

Ruggear L., Cadena E., Martinez J., 2009. Recovery of organic wastes in the Spanish wine industry. Technical, economic and environmental analysis of the composting process. Journal of Cleaner Production, 17, p. 830-838.

Tejada M., Garcia-Martinez A., Parrado J., 2009. Effects of the vermicompost composted with beet vinasse of soil proprieties, soil losses and soil restoration. Catena, v. 77, p. 238-247.

***, Statistical Yearbook of the Republic of Moldova, Chi inău, p. 295-302 (rom).

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

CONTRIBUTIONS TO THE KNOWLEDGE OF SOILS FROM THE PITEŞTI PLAIN FOR SUSTAINABLE USE

Anca-Luiza STĂNILĂ[1], Mihail DUMITRU[1], Marian MUŞAT[2]

[1]National Research Institute for Soil Science, Agrochemistry and Environment – ICPA Bucharest, 61 Mărăşti Blvd, District 1, 011464, Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: luizastanila2011@yahoo.com

Abstract

The study is located in the South of the country, in the of Pitesti Plain, a subunit of Teleorman Plain, in turn a subdivision of the Romanian Plain.
In terms of geological composition of the territory studied are prevalent proluvial deposits (upper Pleistocene), followed by gravels, sands and sandy clays (upper and lower Pleistocene).
Under the influence of pedogenetic factors and processes within the Pitesti Plain was formed by a wide range of soils, belonging to the classes: protisols, cambisols, luvisols, vertisols and hidrisols.
Within the territory of Pitesti Plain land suitability is partially limited by certain factors such as compaction, stagnogleyzation, gleyzation, erosion and danger inundability.
Knowing all parameters (morphological, physical and chemical) soils, modern approach to agricultural technologies and empowering all stakeholders have the effect of both correct and sustainable exploitation of the natural resources and preserve and improve the quality of the main means of production feed people.

***Key words**: sustainable use, Pitesti Plain, pedogenetic processes, soils, improvement requirements.*

INTRODUCTION

This paper aims to characterize soils in Pitesti Plain sustainable use. It was developed based on field studies and documentation specialist. To perform the work, really useful we have been given and studies of geology, geomorphology and pedology undertaken territory Gr. Posea, M. Parichi et al., M. Iancu and I. Rădulescu.
The character piedmont, passing gradually into the Câlniştei Plain through the Dâmbovnic Plain. It consists of a series of terraces (7) of Argeş fan whose development south up to 8-10 km wide (in the locality Broşteni).

MATERIALS AND METHODS

In this case was applied the ICPA methodology which included a rich land (50%) and laboratory (40%), which consisted in exploration the ground cover in large and medium scale, using soil profiles in a network of points with respect to the geological, geomorphologic composition of planning, its hydrography, hydrology and hydrogeology. In the Piteşti Plain were open a huge number of profiles (hundreds or even thousands at the major relief units) who studied the number and the thickness of horizons, color, texture, structure, moisture, consistency, plasticity, compactness, adhesion, porosity, degree of gleyzation or stagnogleyzation, soil storage condition, etc. To characterize the physical, chemical and hydro were collected numerous soil samples unmodified and modified settlement on which were performed the determinations in the laboratory.

RESULTS AND DISCUSSIONS

Being placed in great relief unit of the Romanian Plain, Piedmont Piteşti Plain the same geological character, emphasizing local and specific issues. From the geologic is formed at the surface of deposits belonging almost exclusively Quaternary (Figure 1). Quaternary largely consists of gravels, sands and clays based, the so-called strategy of Frăteşti, over following a marl and clay, then sand (for Mostiştea), gravel (Colentina) and loess-like deposits.

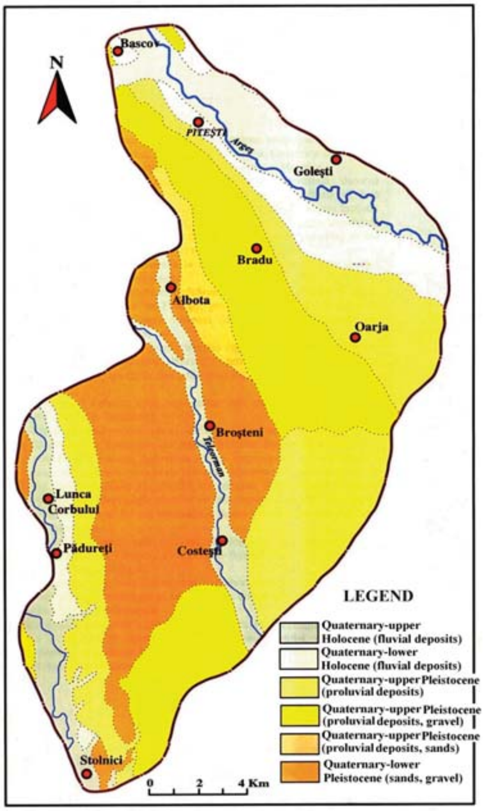


Figure 1. Geological map of the Piteşti Plain (after I.G.)

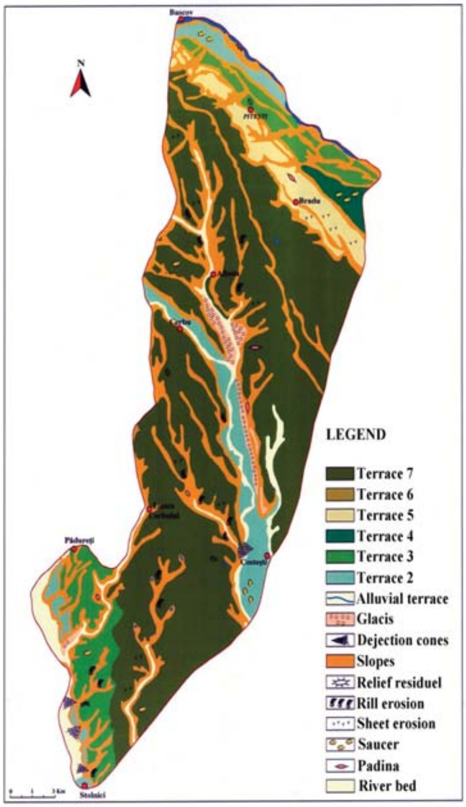


Figure 2. Relief map of the Piteşti Plain

Regarding genetic types of Quaternary deposits have the greatest development deluvial deposits - proluvial covering all fields and terraces. Fluvial deposits are located in the valleys and meadows.

Of the sediments that make up the Holocene and Pleistocene age upper and lower of the Piteşti Plain, important for the genesis and development of soil cover are those of the terraces Argeş. Clays predominate found over a large area in the center of the territory studied.

As apparent from the relief map of Piteşti Plain studied region, presents itself as several easy steps descending, NS direction. The Argeş Valley, from south of the terraces is conducted Bascov fan (Figure 2).

Fragmentation is high relief, Argeş and Teleormanul is currently the only major valleys that cross the plain wording. It would also add Cotmeana River in the S, SV. This emerges clearly meadow and terraces Argeş and Teleorman Valley. As microrelief elements can river bed, glacis, dejection cones, slopes, relief residuel, rill erosion, sheet erosion, saucers and padina.

Argeşul which originally flowed from North to South, about the current route of the river Vedea went first Câlniştei route and in an earlier stage Neajlov route, reaching only later to form the current bed. Reconstitution of this process could be carried out on the basis of the six fan-shaped terraces exist only on the Argeş River right in the area of Piteşti, Argeşul left them behind him, one by one, as the journey to the East (Figure 3).

Figure 3. Cheer terrace IV of Argeş River South of Piteşti

Teleormanul is a river that has its origin in Piedmont Cotmeana, which headed south, deep into powerful only a few kilometers from the springs. Throughout the piedmont present only on the left side terraces and the entry into plain on both sides (Figure 4).

Figure 4. Shore erosion Teleormanului Valley

The complexity of the interaction factors (physical geography), as well and pedogenetic processes is reflected in the diversity of soil cover sensitive. As pedogenetic processes that contributed to the formation and development are mentioned: clay migration, argillisation, gleyzation, stagnogleyzation, processes vertices and erosion (Figure 5).
Clay migration, stagnogleyzation we encounter almost everywhere in the study, with the formation of a wide range of soils, from luvisols and ending with vertisols.

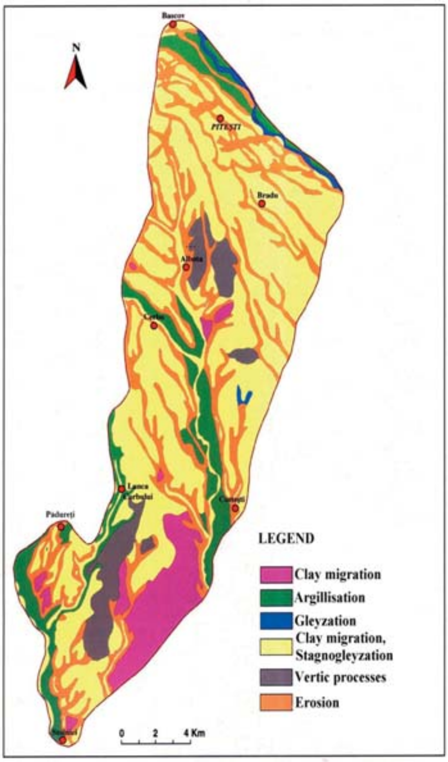


Figure 5. Piteşti Plain. Map of pedogenetic processes

Pedogenetic process argillisation is present in all soils formation of the territory, the characteristic alluviosols.
Gleyzation permanently or periodically due to excess water in the soil, met at gleiosols.
Processes vertices are characteristic clay rich soils, which are able to swell.
Erosion although not yet pedogenetic process interrupts soil formation or favors.
Under the influence of pedogenetic factors and processes within the territory of Pitesti Plain formed a wide range of soils from classes: protisols, cambisols, luvisols, vertisols and hidrisols.
Protisols have the diagnostic horizon A, followed by material or parent rock. They consist of the following types: regosols and aluviosols (Figure 6).
Regosols. Soils having a horizon A has developed on parental material unconsolidated or poorly consolidated, kept close to the surface by erosion geological difficulties. They met in Argeş and Bascov.

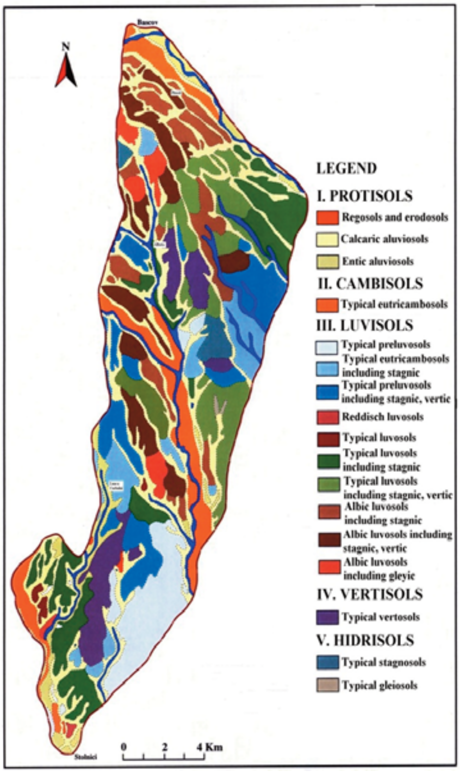


Figure 6. Soils map of the Piteşti Plain (after I.C.P.A)

Presents a profile of the type *Ao - AC - C.* Among soils with low natural fertility due to low content of humus and nutrients poverty.

Alluviosols are young soils related forms of relief, such as meadows. They were formed on account of the most recent deposits of water courses. Average thickness of these materials varies from 1-2 m 5-10 m. We meet on the Argeş Valley and Teleormanului being represented by enthice and calcarice subtypes.

It is characterized by a poorly differentiated profile of type *Ao - AC - C*. They range in texture from sandy to clay, sometimes contrasting (the middle coarse, fine on rough, etc.). Humus content rarely exceeds 1.5% in Ao horizon and decreases sharply at the horizon C. The degree of base saturation shows high values (95-99%).

The supply of nutrients is poor nitrogen (0.069 to 0.090), medium phosphorus (13.5 to 20.0) and total potassium poor (45-80 ppm).

Cambisols

Group soils that essential diagnostic element is the presence profile cambic B horizon (Bv), represented by typical eutricambosols. These soils we encounter on the terrace of the valleys I Argeş and Teleorman. Parent material consists of clay loams and sandy gravel frequently. *Typical eutricambosols* presents a profile of the type *Ao - AB - Bv - C*, moderately deep. They contain about 35-40% clay in the upper horizon and not more than 45% in Bv horizon. The reaction of these soils is moderately weak acid, humus content ranging from 2 to 4%. From a biological active and relatively well supplied with nutrients.

Luvisols

Luvisols class includes those soils which have diagnostic argic B horizon (Bt) enriched in clay migrated, morphologically recognizable by the presence of clay particles coating the surface structural elements. They may or may not eluvial horizon (El or Ea). They are represented by preluvosols and luvosols.

Preluvosols are represented by the typical and stagnice subtypes.

Typical preluvosols appear in the Pitesti Plain on the terraces VI and VII. Parent material consists of clays, clay loams and loams. Typical preluvosols are characterized by a profile type: *Ao – Bt - C* or *Cca.* The surface texture is loamy (30-31% clay under 0,002 mm) and clayish on profile (33-42%). Contain humus in small amounts, and the degree of base saturation (75-80%) fall into the category of eubasic these soils.

In terms of supply of nutrients and microbiological activity, typical preluvosols has a relatively good situation.

Luvosols occur in the studied in a variety of subtypes: typical, reddish, stagnated, albic and gley. *Typical luvosols* have found a large area of terraces of II, III, IV, V, VI and VII (Figure 7). Parental material is represented by loams or clay loams with more coarse material - quartz sand and gravel small.

It has the following sequence of horizons: *Ao - El - EB - Bt - C.* Have a differentiated texture profile from sandy loamy to clay loamy. The reaction of these soils is generally acid, higher values occur in Ao (5.8 to 6.2), which fall in the horizon El (5.4 to 5.7). The degree of base saturation of 60-78% of these soils is in the category of mesobasic.

The supply of nutrients and microbiological activity is generally unsatisfactory.

Figure 7. Typical luvosols on the terrace IV of the Argeş

<u>Albic luvosols</u> are found in central and northern Piteşti Plain terraces II, III, IV, V, VI and VII. Parental material is clay loam the contents terraces. Albic luvosols has the following sequence of horizons: *Ao - Ea - EB - Bt-C*. Compared to the typical luvosols, shows a more pronounced textural differentiation, thus the content of clay in the Bt horizon (52.7%) doubling the face of Ao (28.1%).

These soils are categorized soils with low fertility, and this because of physical, chemical and trophic less favorable. They have a less good structure, low humus and nutrient supply inadequate.

Vertisols is represented in the territory covered by *typical vertosols*. Appear spread out to the south of the Lunca Corbului locality and near Albota locality, on the terrace of VII.

Parent material consists of fine textures sediments containing at least 50% clay under 0.002 mm. The morphology typical vertosols type *Az - Bzy - Cz or C*. The texture is clay content is relatively uniform throughout the entire depth of the soil profile (72-74%). Have low permeability to air and water and a water reservoir sometimes very high, but that is inaccessible to plants.

Hidrisols

In this class were included soils were formed and evolve under conditions of excess moisture, periodic or permanent water comes from groundwater, precipitation, leaked on the slopes, streams and coastal horizon as a diagnostic character Gr or W.

In Piteşti Plain are represented by typical stagnosols and typical gleiosols.

Typical stagnosols occupy small areas north of localities Broşteni and Albota. Parent material consists of fine sediment texture, permeable hard proluvial home, usually free of carbonates (clays, clay loams, loess-like deposits).

It is characterized by a profile type *Aow - AoW - BW - C*. It has a texture clay loam-clay containing up to 53% clay in the Bt horizon. Humus content is low, ranging from 1.8 to 2.3% in the upper horizon.

Natural fertility stagnosols is generally low.

Typical gleiosols have a very small spread in the territory north of Costesti. Parent material consists of various sediments of alluvial-proluvial nature, alluvial and deluvial generally poor or no carbonate.

Presents a profile of type *Ao - AGox-Gr*. Soil reaction can vary from weak to strong acid (pH 5.0 to 6.5) and humus content is relatively low (2.0 to 3.0% in Ao). Are poorly biologically active due to excess moisture.

Within the territory of Piteşti Plain land pretability is partially limited by factors such as compaction, gleyzation, stagnogleyzation, erosion and danger inundation. Given the nature and intensity of restrictive factors have particularly following categories of land (Figure 8):

Class I. Lands with very good pretability for of field crops without any restriction we encounter on the terrace I of the Teleorman and Argeş River.

Class II. Lands with good pretability reduced limitations due to compaction, stagnogleyzation and danger inundation have a spreading in large territory especially on the terrace VII.

Class III. Lands pretability middle with moderate limitations that reduce soil acidity range of crops due, stagnogleyzation and low nutrient supply has a relatively large spread from terrace II and ending with terrace VII.

Class IV. Lands with poor pretability severe limitations that determine appreciable reduction in yields due stagnogleyzation field crops and erosion, they encounter very little territory south of the Bradu locality and close to the Smeura locality.

Knowing in detail the potential of the natural environment factors regarded separately and integrated complementarismul man can consciously intervene in recouping pretability native land and its optimization by means of modern farming.

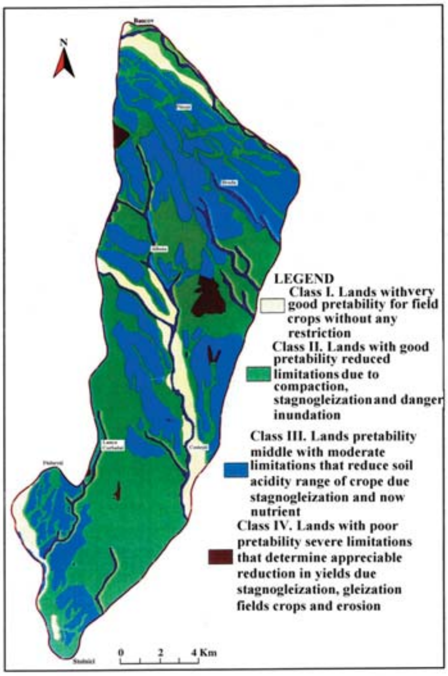


Figure 8. Piteşti Plain. Grouping map arable land after pretability

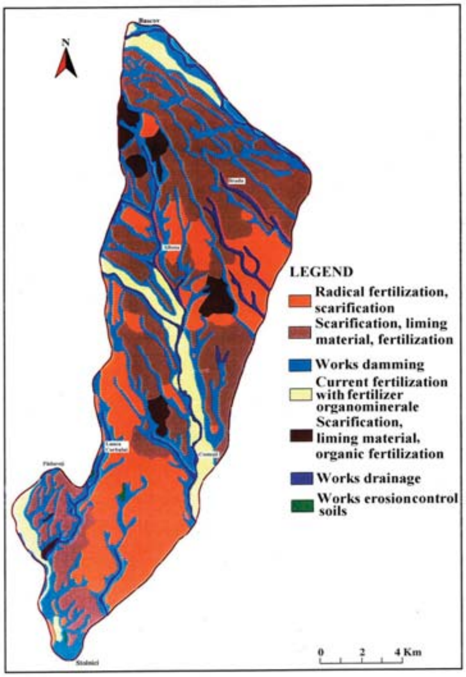


Figure 9. Piteşti Plain. Agropedoameliorative map requirements

As is natural limiting factors of agricultural production shall be lodged in natural elements of the sub-frame, namely the conditions of relief and stagnation of soil erosion and the danger of flooding.

To all these human activity embodied in applying an poor agrotechnical (mechanical work performed on soils with high humidity, chemical fertilizer mainly acidic differentiated fertilization, organic fertilization absence.

In order to eliminate the negative effects of limiting factors of agricultural production and thereby improve the productive potential of land belonging Piteşti Plain are necessary (Figure 9):

- in the south and center on the terrace VII in right localities Costeşti, Lunca Corbului, Albota on luvisols and vertisols are necessary radical fertilization and scarification;
- the right localities Cerbu, Pădureți and Piteşti on typical luvosols and albic luvosols are necessary scarification, liming material and fertilization radical;
- on aluviosols are necessary damming in works and current fertilization with fertilizer organominerale, on the terrace I of Argeş and Teleormanului;
- near the Smeura locality and east of the Cerbu locality, left Teleormanului on stagnosols and luvosols albic is necessary scarification, liming material and organic fertilization;
- on gleiosols in east part of the territory studied is necessary lowering the groundwater below 2 m and work drainage;
- to the north Stolnici and to the south Lunca Corbului on a small surface is necessary to work erosion control soils.

The territory we occupied the predominant Piteşti Plain pastures (Figure 10). Cultivated land they'll meet near localities Stolnici, Pădureți, Lunca Corbului, Costeşti, Albota, Bradu and Piteşti, being represented by cereal crops (wheat, maize) (Figure 11, 12), technical plant (rape) (Figure 13), etc.

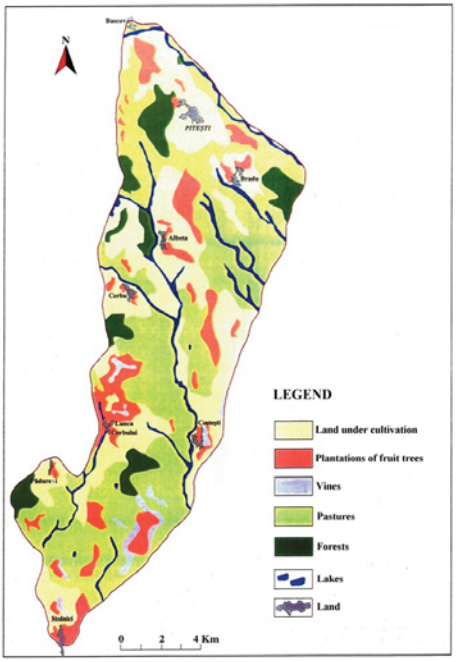


Figure 10. Piteşti Plain. Land use map

Figure 11. Culture of maize on the terrace Argeş

Figure 12. Culture of wheat on the terrace Argeş

Figure 13. Culture of rape to the north Costeşti

In this area may meet many plantations of fruit trees (especially plum) at Stolnici, Lunca Corbului, Albota, Bradu, near Bascov.
Also within the territory studied appear small areas of land planted with vines more south near Lunca Corbului.
Local forests occur in the west and north of the territory. They consist of *Ouercus robur*, *Q.frainetto*, *Fagus sylvatica* mixed with *Quercus frainetto*.

CONCLUSIONS

The studied the Piteşti Plain is located in the south, south-east of Romania, in its plain of the same name. Piteşti Plain geological composition is closely related to that of the Romanian Plain east of the stages of its evolution.
From a geomorphological differ interterritorial, terraces, floodplains, and the microrelief elements can river bed, glacis, dejection cones, slopes, relief residuel, rill erosion and sheet erosion.
From a climate perspective studied area is located within the continental temperate climate zone belonging subhumid moderate heat (subareas 1-4), characterized by annual average temperatures 8.5-10.5 ^{0}C and rainfall of 450-700 mm (1) and 700-800 mm (4).
Under the continuing influence of pedogenetic factors and associated mentioned in Piteşti Plain formed and evolved a wide range of soils, belonging to several classes, namely: protisols, cambisols, luvisols, vertisols and hidrisols.

Based on detailed knowledge of the potential of the natural environment factors, considered separately and in their complementarismul integrated in Piteşti Plain were distinguished four categories of land: the land without restrictions or impaired (class I) to those with severe limitations (class IV).

Eliminate the negative effects of factors involves the application of several measures and works pedoameliorative and hydroameliorative. They may be made single and combined with each other.

Very important are the work of loosening or amending soil tillage depth as organic fertilizer and chemical fertilizer supplemented.

REFERENCES

Borlan Z., Răuță C., 1981. Agrochemical soil analysis methodology in order to establish the necessary amendments and fertilizers. ICPA, Bucharest.

Coteț P., 1976. Romanian Plain. Geomorphology study integrated. Ceres Publishing House, Bucharest.

Florea N., Dumitru M., 2002. Soil Science in Romania in the early twentieth century, Book For All Publishing House, Bucharest, 416 p.

Florea N., Munteanu, I., Rusu C., Dumitru M., Ianoş Gh., Răducu Daniela, Rogobete Gh., Țărău D., 2012. Romanian System of Soil Taxonomy. Sitech Publishing House, Bucharest.

Parichi M., Vartolomei Fl., Stănilă Anca-Luiza, 2006. A map of the soils in the Romanian System of Taxonomy - 2003. Annals of the Spiru Haret University, Geography Series, No. 9, Romania for Tomorrow Publishing House, Bucharest, p. 121-124.

Parichi M., Stănilă Anca-Luiza, Cruceru N., 2006. The main soils of the Romania relief units. Romania for Tomorrow Publishing House, Bucharest, 179 p.

Posea Gr., 1984. Aspects of the evolution of Danube and Romanian Plain. Terra no. 1, Bucharest, p. 3-10.

Posea Gr., Cruceru N., 2005. Geomorphology Romania. Romania for Tomorrow Publishing House, Bucharest, 443 p.

Stănilă Anca-Luiza, Parichi M., 2001. Mapping soils. Romania for Tomorrow Publishing House, Bucharest, 160 p.

Răuță C., Canarache A., Nițu I., 1985. Tickler works on agropedoameliorative. ICPA, Bucharest.

Stănilă Anca-Luiza, Parichi M., 2003. Soils Romania. Romania for Tomorrow Publishing House, Bucharest, 191 p.

Stănilă Anca-Luiza, Parichi M., Vartolomei Fl., 2011. Pedologycal resources of Romania. Scientific Papers UASVM Bucharest, Series A, Vol. LIV, p. 47-53.

Stănilă Anca-Luiza, Parichi M., 2012. What you need to know about the soil they work. Romania for Tomorrow Publishing House, Bucharest, 72 p.

Stoica Elena, Răuță C., Florea N., 1986. Methods for chemical analysis of soil. ICPA, Bucharest.

Vâlsan G., 1915. Romanian Plain. B.S.R.G., Vol. XXXVI, Bucharest.

***, 1987. Development methodology soil studies (3 vol.). ICPA, Bucharest.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

INFLUENCE OF LIMING WITH $Ca(OH)_2$ AND STOCKPILING FERTILIZATION ON THE NITROGEN, PHOSPHORUS AND POTASSIUM CONTENT IN THE GRAPE OF WINE GRAPE VARIETIES

Krasimir TRENDAFILOV, Mladen ALMALIEV

Agricultural University, 12 Mendeleev Blvd, 4000, Plovdiv, Bulgaria

Corresponding author email: mladenalmaliev@abv.bg

Abstract

In condition of combined field experiment was studied the influence of liming with $Ca(OH)_2$ at rates of 1.0, 2.5 and 5.0 t/ha on the input of nitrogen, phosphorus and potassium in the grapes of fertility vines from varieties Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Merlot planted on Chromic luvisol. Samples were collected in two consecutive years. At the variants with liming rates of 2.5 and 5.0 t/ha hydrated lime was found the average higher nitrogen content compared to the control variant, but the excess was more significant only at the rate of 2.5 t/ha, average for all participating varieties. Highest nitrogen content was found in the grapes of the varieties Chardonnay and Merlot, and the lowest - in Cabernet Sauvignon. Differences between the varieties for red and white wines were statistically proven regarding to the nitrogen content in the grapes. In the red wine varieties was found average about 70% of the nitrogen content in the white varieties. Liming with rates of 1.0 and 2.5 t/ha leads to logical and proven toward variation in the repeats increase in the concentration of potassium in the foliage - respectively to 0.238% average for the rate of 1.0 t/ha and 0.275% for the rate of 2.5 t/ha. When applied the rate of 5.0 t/ha lime material was found reduction of the potassium content and below the level of the control variant - up to 0.200%. The grapes in the white varieties contain proven more potassium compared to the red varieties, as the highest was average amount of potassium in the grapes of variety Sauvignon Blanc.

Key words*: liming, nitrogen, phosphorus, potassium, wine grape varieties.*

INTRODUCTION

The variety of soil conditions in Bulgaria is large and in terms of opportunities for wine viticulture in recent years was formed specific areas for production of quality wines, which according to the methodology for determination of areas for their production (Mihalev Trendafilov, 2005) should cover certain requirements regarding to the location of vineyards. In this sense, the location determines the specificity, and the specificity is due to the advantages and disadvantages of the region, including its soils. In this terms of ameliorative influences on the soil conditions could be accepted insofar as no change the specific and proven for some wine region advantages of the landscape.
The influence of soil acidity on the varieties of V.vivnfera, in the cultivation technology of grafted and rooted vines differentiated once by interactions between the root of the pad and the soil and the second time - the interaction between the pad and cultural vine (Kaserer et al., 1996).
Sanjun Gu (2010) summarizes 19 general types interactions between these general three elements of the system soil-pad-vine, which influence on the quantity and quality of the final product and it should be in mind, that each of them is a complex indicator and depends on the specific environmental conditions. This indefiniteness of the system location - wine vineyards was the reason for the emergence and development of a discussion concept for vineyard terroir. Much of the publications on the topic, although detailed to describe the physiographic characteristic on more or less known vine terroirs, they have not indicated interpretation of the link between the quality of the terroir and the quality of grapes from wine vineyards of the respective area, and did not answer the question of with which own qualities the terroir gives specifics of wine vineyards, cultivated there and why is that.
In this context, we believe that the liming of acidic soils in the vineyard areas should be

limited to detoxify of harmful in acidic soils concentrations of easily mobile exchangeable aluminium, hydrogen and manganese, but should not be allowed to completely change soil-chemical environment.

The aim of this study was to research the influence of liming with $Ca(OH)_2$ on the content of nitrogen, phosphorus and potassium in the grapes of fertility vines from varieties Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and Merlot planted on Chromic luvisol.

MATERIALS AND METHODS

The experiment was performed for two years period in already existing vineyards, planted on acidic soils, which were not liming before planting.

Each of the variants was displayed in three repetitions. The distribution of the variants of the experiment has shown in Table 1. The vineyard was planted in intercrop distances 2.20 m and interlinear distance between the vines – 1.10 m. The experiment was set after the end of the third vegetation period. All included varieties in the study were planted on pad Berlandieri X Riparia, selection Oppenheim 4 (SO_4). The ameliorant, phosphorus and potassium fertilizers were applied in the period August - September. One month after liming were applied phosphorus and potassium fertilizers in the form respectively of triple superphosphate and potassium sulphate and nitrogen fertilizer in the form of NH_4NO_3 was applied in February, before the beginning of the next vegetation period.

The grapes from the four varieties, was studied immediately after harvest in the technological maturity, together with the massive harvest of each variety in the vineyards, which developed field lime experiment.

Harvested grapes, was separated from the stalks and grapes were prepared for analysis and analyzed to determine the content of nitrogen, phosphorus and potassium. The measurements were carried out in two consecutive years coincide with the periods of measuring of indicators in foliage.

The samples of plant material were analyzed after wet burn by Keldal method. Nitrogen was determined by distillation on apparatus of Parnas-Vagner, phosphorus - colorimetrically on molybdate-vanadate method, potassium - by flame photometer (BDS 11374/86).

Table 1. Applied amounts of chemical ameliorants and fertilizers in the variants on the field experiment

Variant	Variety	Rate hydrated lime t/ha	Rate N kg/ha	Rate P_2O_5 t/ha	Rate K_2O kg/ha
Control variant	Chardonnay	0	0	0	0
	Sauvignon Blanc	0	0	0	0
	Merlot	0	0	0	0
	Cabernet Sauvignon	0	0	0	0
Fertilization - N,P,K	Chardonnay	0	140	1	600
	Sauvignon Blanc	0	140	1	600
	Merlot	0	140	1	600
	Cabernet Sauvignon	0	140	1	600
Hydrated lime	Chardonnay	1	140	1	600
		2.5	140	1	600
		5.0	140	1	600
	Sauvignon Blanc	1	140	1	600
		2.5	140	1	600
		5.0	140	1	600
	Merlot	1	140	1	600
		2.5	140	1	600
		5.0	140	1	600
	Cabernet Sauvignon	1	140	1	600
		2.5	140	1	600
		5.0	140	1	600

RESULTS AND DISCUSSIONS

The experiment was performed in already existing vineyards, planted on acidic soils, which were not liming before planting. The main aim of the study was to research the influence of liming in increasing doses and the mineral fertilization on the content of main nutrient macro elements - nitrogen, phosphorus and potassium in the grapes of four wine varieties vines - Chardonnay, Sauvignon Blanc, Merlot and Cabernet Sauvignon.

Table 2 shown the contents of nitrogen, phosphorus and potassium in the grapes of the four varieties, depends on the rate of liming with hydrated lime.

In the variants with liming rates of 2.5 and 5.0 t/ha hydrated lime was found average higher nitrogen content compared to the control variant, but the excess was significant only at the rate of 2.5 t/ha, average for all participating varieties. The ameliorant even in relatively lower rates had amelioration effects by neutralizing easily mobile exchangeable positions and less by modifying of exchangeable reserve of the bases. The positional inaccessibility and spatial heterogeneity of the ameliorant was sufficiently overcome for a period of about two years, from the date of liming and simultaneously with this starts fast process of leaching of the ameliorant in deeper layers. From a technological view point it can be assumed, that depth of layer, for which should count the rates for chemical-amelioration effect under the described conditions for chemical amelioration of acidic soils under existing plantations was 50 cm from the soil surface (Valcheva and Trendafilov, 2011). The stockpiling fertilization with phosphorus and potassium had weak effect on the neutralization of soil acidity, as caused weak neutralization of soil sorption positions occupied by exchange hydrogen.

The neutralization effect was manifested in weakly buffered soils or in less buffer zone of the profile of acid and unsaturated differentiated soils. In the presence of relatively weak buffering of the sorption complex, the buffering potential, associated with the transformation of the phosphate and the activity of potassium from the fertilizers causes a reduction in the equilibrium concentrations of hydrogen in exchangeable form. The mineral fertilization with the main nutrient elements caused an increase in nitrogen content in the grapes which occurs independently from the variety and the direction of cultivation (Valcheva et al., 2012). Highest nitrogen content was found in the grapes of Sauvignon Blanc, Chardonnay and Merlot and lowest in Cabernet Sauvignon.

The differences between the varieties for red and white wines were statistically proven as regards of the nitrogen content of the grapes. In the red wine varieties was found average about 70% lower nitrogen content compared to the white wine varieties. It is quite possible this difference to be due to the late harvest of the red wine varieties, when the active metabolism of the cells in the tissue of the grape mass had completely finished, while the white wine varieties harvest in phase of still active vegetation.

Table 2. Content of nitrogen, phosphorus and potassium [%] in grape from varieties Chardonnay, Sauvignon Blanc, Merlot and Cabernet Sauvignon, depends on the liming rate with hydrated lime

Year	Direction of cultivation	Variety	Rate hydrated lime t/ha	N (%)	P (%)	K (%)
1	2	3	4	5	6	7
1	White	Chardonnay		0.17	0.013	0.27
			1	0.10	0.020	0.22
			2.5	0.20	0.010	0.23
			5.0	0.20	0.010	0.22
		Sauvignon Blanc		0.20	0.013	0.27
			1	0.20	0.010	0.24
			2.5	0.50	0.020	0.24
			5.0	0.20	0.010	0.22
	Red	Cabernet Sauvignon		0.13	0.010	0.22
			1	0.10	0.010	0.22
			2.5	0.10	0.010	0.22
			5.0	0.10	0.010	0.23
		Merlot		0.17	0.010	0.17
			1	0.20	0.010	0.22
			2.5	0.20	0.010	0.22
			5.0	0.20	0.010	0.21
2	White	Chardonnay		0.17	0.013	0.23
			1	0.10	0.020	0.22
			2.5	0.20	0.010	0.23
			5.0	0.20	0.010	0.22
		Sauvignon Blanc		0.20	0.013	0.27
			1	0.20	0.010	0.23
			2.5	0.50	0.020	0.24
			5.0	0.20	0.010	0.22
	Red	Cabernet Sauvignon		0.13	0.010	0.22
			1	0.10	0.010	0.22
			2.5	0.10	0.010	0.22
			5.0	0.10	0.010	0.23
		Merlot		0.17	0.010	0.17
			1	0.20	0.010	0.22
			2.5	0.20	0.010	0.22
			5.0	0.20	0.010	0.21

Weak and unproven statistical tendency for excess of phosphorus content, compared to the control variant was observed in variants, with applied lime rates of 1.0 and 2.5 t/ha lime material, while the phosphorus content in the variant with the highest applied rate was lower compared to the control variant.

The varietal differences manifested and with regard to the phosphorus content in the grapes. The white varieties contain average with 30% higher amount of phosphorus in the grapes, compared to the red varieties, and this tendency was proven in the volume of the entire sample characterized the average of the two experimental years.

The differences between the amount of contained phosphorus in the grapes in the two consecutive years of measurement was not found.

Potassium content in the grapes, average for the entire sample of all varieties and variants of liming was 0.229%. The liming with rates of 1.0 and 2.50 t/ha leads to logical and proven, compared to variation in the repeats increase in the concentration of potassium in the fresh mass of the grapes, respectively to 0.238% average for the rate of 1.0 t/ha and to 0.275% for the rate of 2.50 t/ha. When applied the rate of 5.0 t/ha lime material was found decrease of the potassium content and below the level of the control variant to 0.200%. A similar tendency was found and in regard to the assimilation of phosphorus, however, here it was more pronounced and statistically proven.

The grapes in the white varieties contain proven more potassium compared to the red varieties, as highest was average amount of potassium in the grapes of the variety Sauvignon Blanc. Proven difference between the potassium content of the grapes in the two consecutive years of measurement of the composition of the grape mass was not found.

CONCLUSIONS

As a result of the study was found highest nitrogen content in the grapes of varieties Sauvignon Blanc, Chardonnay and Merlot, and the lowest in Cabernet Sauvignon.

The white varieties contain with 30% higher amount of phosphorus in the grapes compared to the red varieties, as this tendency was proven in the volume of the entire sample. The grapes in the white varieties contain proven more potassium compared to the red varieties, as highest was the average amount of potassium in the grapes of the variety Sauvignon Blanc.

REFERENCES

Kaserer H., Blahous D., Brandes W., 1996. Optimizing wine grape quality by considering rootstock-scion interaction. acta hort. (ishs) 427: 267-276.

Mihalev D., Trendafilov K., Methodology for determination of areas for production of quality wines. http://www.eavw.com/bg/zak_drugi/metodologia.htm

Sanjun Gu., 2010. Effect of Rootstocks on Grapevines. http:// www. pawpaw. kysu. edu/viticulture/ Information/ Rootstock.

Valcheva V., Trendafilov K., 2011. Influence of liming with hydrated lime on the acid-alkaline balance in the root zone of wine grape varieties. Scientific reports from International Conference 100 years soil science in Bulgaria, first part, 16-20 May, Sofia, p. 474-479.

Valcheva V., Trendafilov K., Todorova S., 2012. Influence of mineral fertilization on the harmful soil acidity and chemical composition of wine grape varieties -Agricultural Science and Technology, vol. 4, no 3, p. 260-264.

***, BDS11374/86, 2009. Compound feed, protein concentrates and raw materials for them. Rules for sampling and testing methods, Sofia (Bg).

CROP SCIENCES

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCHES ON THE IMPACT OF FERTILIZATION ON FUSARIOTOXINE (DEOXYNIVALENOL, DON) PRODUCTION IN WHEAT GRAINS

Roxana ANDRONE, Mihai GIDEA, Ioan ROSCA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: ioanrosca_usamv@yahoo.com

Abstract

Fusarium is a major disease in most wheat growing areas around the world, including Romania. Five species of the genus Fusarium can cause this to wheat, Gibberella zeae Schwain (Petch.) (with anamorphous Fusarium graminearum Schwabe) is the predominant pathogen in many parts of the world. This disease not only causes crop losses, but also contamination of wheat with fusariotoxine (especially deoxynivalenol, DON) which, due to cytotoxic and immunosuppressive properties, are harmful to humans and animals. DON content was analyzed in samples of wheat harvest 2012 and 2013, taken from field plots (mixture from 5 repetition for each variant) The maximum Fusariotoxine limit allowable for cereals, regulated by Commission Regulation (EC) No. 1126/2007 of 28 September 2007 (amending Regulation (EC) No. 1881/2006), is 1.25 mg / kg (ppm). The protection of crops against mycotoxin contamination using fungicides is not always productive; the application of bio stimulant seems to be promising in this respect. At some specific stages of wheat (Triticum aestivum L.) growth, commercially available organic growth stimulants (bio stimulants) were tested from 2012 and 2013 in experimental field. The purpose of our work was to evaluate the effect of bio stimulants treatment on mycotoxin content in grain harvest. The application of bio stimulants in recommended dosages, depending of the year (connected with climatic conditions) and variant, has been found that could reduce the content of DON till 0.5405 and 0.781 mg/kg (ppm), in 2012 and 2013 respectively.

Key words: *bio stimulant, wheat, evolution of deoxynivalenol (DON).*

INTRODUCTION

Fusarium head blight (FHB), also known as scab, is a fungal disease of small grain cereals that has become of increasing international importance in recent years. FHB is caused by several species of the fungal pathogen, Fusarium. The most important species is *Fusarium graminearum*, since it can result in the most yield loss and is responsible for the production of toxin in the grain (http://www.agriculture.gov.sk.ca/fusarium-head-blight). Fusarium is one of the most widespread and damaging diseases in cereals in favorable areas causing losses of 10-20% of production. Although epidemics of Fusarium in wheat, in Romania, are not common, the disease is important, during a certain period of time, attack recorded in five from nine localities, but in one third of the locations, the incidence was negligible, although the disease is considered as the most important wheat disease in Romania. The disease occurs with greater intensity in Romania representing a particular problem in the production of healthy seed (Saulescu, 1993). Outbreaks of this disease were recorded in 1970 and 1975, many areas of common wheat crop attack rises to 65-80%, followed by a strong shriveled grains. The disease was recorded most frequently under hot, wet climatic conditions where significant yield losses and mycotoxin accumulation in grain were reported (Parry et al., 1995). In the UK, warming is considered as the main factor involved in frequency increasing of fusarium diseases (Gosman et al., 2007). Mycotoxins are toxic, secondary metabolites produced during the fungal infection process. Deoxynivalenol or DON is the most common mycotoxin associated with FHB and is produced in high amounts by *F. graminearum*. Compared to other mycotoxins, DON is one of the least toxic but can still result in reduced feed consumption or feed refusal, especially when fed to non-ruminants (http://www.agriculture.gov.sk.ca/fusarium-head-blight). There is some evidence that FHB can be affected by fertilizer regimes. Martin et al. (1991) and Lemmens et al. (2004) observed that increasing the amount of nitrogen applied to cereals resulted in increased incidence of FHB or *Fusarium*-infected grain, however Lori et al. (Lori et al., 2009) reported that favourable weather conditions are a more important factor for FHB infection than tillage practice and fertilizer treatments. Plant biostimulants are diverse substances and microorganisms used to enhance plant growth. The global market for biostimulants is projected to increase 12% per year and reach over $2,200 million by 2018. Despite the growing use of biostimulants in agriculture, many in the scientific community consider biostimulants to be lacking peer-reviewed scientific evaluation (Calvo et al., 2014; Anonymous, 2013). According to the same study, the largest market for biostimulants in 2012 was Europe. The European biostimulants industry council (EBIC) reported that in 2012 over 6.2 million hectares were treated with biostimulants in Europe (defined as the European Economic Area) (European Biostimulants Industry Council, 2013).

High fertilizer rates significantly increased spring wheat grain infection with *Fusarium* spp. tillage systems had no significant influence on *Fusarium* infection level; however, they had indirect effect on mycotoxin content in separate years (Supronienė et al., 2012).

MATERIALS AND METHODS

Experimental trials were done at Moara Domneasca (experimental farm belonging to University, near Bucharest), variants and moment of treatments are presented in table 1. In 2012 were 3 experimental variants, in 5 replicates, plot area 13 x 8=104 m^2. Sowing data October 25, 2011 after sunflower (hybrid Expres), cultivar: Dropia, sowing rate 250 kg/ha. Basic fertilization (N60/P60), before sowing under ploughing; herbicide applying on May 10 with Granstar (tribenuron methyl), 40g/ha. In 2013 were 4 experimental variants in 4 replicates, plot area 13.5 x 7.5 = 101.25 m^2). Sowing data October 17, 2012 after sunflower (hybrid Favorit), cultivar Dropia, sowing rate 250 kg/ha, basic fertilization (N60/P60), before sowing under ploughing. At growth stage BBCH 31-33 was applied herbicide Pelican Delta 606 WG (diflufenican 60% + metsulfuron metil 6%), at growth stage BBCH 61 was applied fungicide Acanto Plus (picoxistrobin 200 g/l + ciproconazol 80 g/l).

Table 1. Variants and moment of treatments

Year	Product	Rate (l/ha)	No. applications	Growth Stage
2012	**Megafol**	2 + 2	1 1	BBCH 31-33 BBCH 61
	Megafol	3	1	BBCH 31-33
	Megafol	3	1	BBCH 61
	Check	-	-	-
2013	**Megafol**	2	1	BBCH 31-33
	Megafol	3	1	BBCH 61
	Cropmax	2	1	BBCH 31-33
	Cropmax	3	1	BBCH 61
	Check	-	-	-

DON content was analyzed in samples of wheat harvest 2012 and 2013, taken from field plots (mixture from repetitions for each variant). It was used a kit DON Fast Ridascreen from R-Biopharm (Figure 1) and read absorbance reader Stat Fax 2100 (Figure 2). DON concentration in mg/kg corresponding to each sample absorbance it was red using the calibration curve. To express qantitative immunoenzymatic reaction of Ridascreen kit it was used special software, RIDA® SOFT Win.

Figure 1. Reagent kit Ridascreen fast DON

Figure 2. Read absorbance reader Stat Fax 2100

RESULTS AND DISCUSSIONS

Fusarium disease not only causes crop losses, but also contamination of wheat with fusariotoxine (especially deoxynivalenol, DON) which, due to cytotoxic and immunosuppressive properties, are harmful to humans and animals. DON content was analyzed in samples of wheat harvest 2012 and 2013, taken from field plots (mixture from 5 repetition for each variant). The maximum Fusariotoxine limit allowable for cereals, regulated by Commission Regulation (EC) No. 1126/2007 of 28 September 2007 (amending Regulation (EC) No. 1881/2006), is 1.25 mg/kg (ppm). In 2012 taking into consideration that the maximum Fusariotoxine limit allowable for cereals, regulated by Commission Regulation (EC), is 1.25 mg / kg (ppm), so only at check is exceeded this limit 1.963 (ppm). Less DON content was registered at variant Megafol, 2 applications at rate l/ha, the variant has a DON content (0.5405 mg/kg (ppm). The variant Megafol, 1 application at rate l/ha: 3 l/ha (at growth stage BBCH 31-33), has a DON content [0.9765 mg/kg (ppm)], close to maximum Fusariotoxine limit allowable for cereals [1.25 mg/kg (ppm)]. The variant Megafol, 1 application at rate l/ha: 3 l/ha (at growth stage BBCH 61), has a DON content [1.2 mg/kg (ppm)], close to maximum Fusariotoxine limit allowable for cereals [1.25 mg/kg (ppm)]. In 2013 as in previous year, only at check is exceeded this limit 1.942 (ppm). Less DON content was registered at variant Megafol, applications at rate 2 l/ha at Growth Stage BBCH 31-33 [0.519 mg/kg (ppm)], also under the level of Cropmax applications at rate 2 l/ha at Growth Stage BBCH 31-33 [0.781 mg/kg (ppm)]. The variant Megafol, application at rate 3 l/ha (at growth stage BBCH 61), has a DON content [0.99 mg/kg (ppm)], under to maximum Fusariotoxine limit allowable for cereals (1.25 mg/kg (ppm), also under the level of Cropmax 3 l/ha (at growth stage BBCH 61), has a DON content [1.21 mg/kg (ppm)].

Table 2. Variants and moment of treatments

Year	Product	Rate (l/ha)	No. applications	DON content ppm (mg/kg)
2012	**Megafol**	2 + 2	1 1	**0.5405**
	Megafol	3	1	**0.9765**
	Megafol	3	1	**1.2**
	Check	-	-	***1.963***
2013	**Megafol**	2	1	**0.519**
	Megafol	3	1	**0.99**
	Cropmax	2	1	**0.781**
	Cropmax	3	1	**1.21**
	Check	-	-	***1.942***

CONCLUSIONS

- Our experiment prove that application of biostimulants reduce quantity of DON under The maximum Fusariotoxine limit allowable for cereals, regulated by Commission Regulation (EC) No. 1126/2007 of 28 September 2007 (amending Regulation (EC) No. 1881/2006), is 1.25 mg / kg (ppm).
- In 2012 as in 2013, only at check is exceeded this limit [1.963, in 2012 and 1.942, in 2013 mg/kg (ppm)].
- Less DON content was registered at variants, applications at rate 2 l/ha at Growth Stage BBCH 31-33 than at the variants, application at rate 3 l/ha (at growth stage BBCH 61).

REFERENCES

Anonymous, 2013. Biostimulants market-By Active Ingredients, Applications, Crop Types & Geography-Global Trends & Forecasts to 2018. http://www.marketsandmarkets.com/Market-Reports/biostimulant market -1081.

Calvo P. et al., 2014. Agricultural uses of plant biostimulants. Plant and Soil. An International Journal on Plant-Soil Relationships 383: 3-41.

Gosman N. et al., 2007. Evaluation and characterization of resistance to fusarium head blight caused by *Fusarium culmorum* in UK winter wheat cultivars. Plant Pathology, 56: 264-276.

Lemmens M. et al., 2004. The effect of nitrogen fertilization on *Fusarium* head blight development and deoxynivalenol contamination in wheat. Journal of Phytopathology, vol. 152, p. 1-8.

Lori G.A. et al., 2009. Fusarium head blight in wheat: impact of tillage and other agronomic practices under natural infection. Crop Protection, vol. 28, p. 495-502.

Martin R.A. et al., 1991. Influences of production inputs on incidence of infection by Fusarium species on cereal seed. Plant Disease, vol. 75, p. 784-788.

Parry D.W. et al., 1995. Fusarium ear blight (scab) in small grain cereals - a review. Plant Pathology, Vol. 44, Issue 2, p. 207–238.

Saulescu N.N., 1993. An evaluation of present wheat breeding priorities for Romania. Lucrari Stiintifice U.S.A.B. 24 (1): 25-36.

Supronienė S. et al., 2012. The impact of tillage and fertilization on Fusarium infection and mycotoxin production in wheat grains. Žemdirbystė (Agriculture) 99.3: 265-272.

***, European Biostimulants Industry Council, 2013. Economic overview of the biostimulants sector in Europe, 17 April 2013. http://www. biostimulants.eu/…./Biostimulant_economics_17April2013.pdf).

***, http://www.agriculture.gov.sk.ca/fusarium-head-blight.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DIVERSIFICATION OF SUNFLOWER GERMPLASM FOR DIFFERENT ECONOMICALLY IMPORTANT CHARACTERISTICS

Gabriel Florin ANTON[1,2], Maria JOIȚA-PĂCUREANU[2], Aliona CUCEREAVII[3]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Biotechnologies, 59 Mărăşti Blvd, 011464 Bucharest, Romania
[2]National Agricultural Research and Development Institute Fundulea
N. Titulescu street, no. 1, 915200, Fundulea, Romania
[3]Research Institute for Genetics and Physiology, Chişinău, Moldova

Corresponding author email: gabi22mai@yahoo.com

Abstract

Sunflower is a very important crop in the world agriculture. Taking into consideration the high seed yield and oil yield, thanks to the extension of sunflower cultivated varieties and hybrids having a high oil content, this crop has a good place in the hierarchy of dominant crops over the world. Genetic resources may be used as initial germplasm for obtaining new sunflower inbred lines or as genes donor sources for the value increasing of some lines.
Sunflower wild species are the most rich and varied source of favorable genes for the important characteristics of cultivated species. Sunflower interspecific hybrids are very important in breeding, thanks to a very good genetic variability. As the result of our research work, we have obtained many interspecific populations, after crossing sunflower wild species Helianthus argophyllus with Helianthus annuus cultivated variety Record. There have been studied different characteristics, in two years of experiments for the wild species, for the cultivated variety and for the interspecific populations. Observations regarding flowering duration and vegetation period were recorded. There have been analyzed different morphological characteristics (plant height, number of leaves, petiole length, head diameter, seed wide, seed length, and number of branch) as well as other characteristics, including the seed oil content. Regarding the resistance of the hybrid populations and of the parental lines to the pathogen Phomopsis helianthi and the parasite Orobanche cumana, it was found that, after 5 generations of selfpollination, some hybrid populations presented good resistance to the tested pathogens and parasites.
The data obtained during the experiments has shown that in the most cases, the differences referring to the cultivated sunflower are statistically significant. Similar results were obtained with the hybrid populations for all analyzed characteristics.

Key words: *sunflower, genetic resources, wild species, analyzed characteristics, bromrape.*

INTRODUCTION

Sunflower crop has an important place in the word agriculture, due to many advantages, as the capacity to release high seed yield and good oil content.
Sunflower kernels are used in industry for obtaining good oil for human food as well as, the secondary matter used in animal food.
Sunflower oil has a very good quality, with high percent of the unsaturated acids and capacity to maintain stability and long time conservation.
After being obtained first sunflower hybrids with high oil content (Vrânceanu, 2000), area cultivated with sunflower crop has increased over the world, including our country, Romania. There have been obtained and sunflower hybrids with low oil content and high protein content, these being used as confectionary sunflower.
Sunflower crop is important as well as, for agriculture technology purpose, in doing a good crop rotation (Sin, 2002).
For obtaining good commercial sunflower hybrids, the breeding work must to be accelerated. In the breeding work, the genetic variability in sunflower germplasm is of a great importance.
Taking into consideration the climate changes in the last years, in all breeding programs from research institutes or private companies there is interest in obtaining sunflower hybrids with a good resistance to dry conditions (Belhassen et al., 1996; Singh, 2000).
The pathogen *Phomopsis helianthi* which produce brown spot and parasite *Orobanche cumana* are producing losses in sunflower seed

yield, breeding for resistance being very important for this crop (Vrânceanu, 2000).

To assure the variability in sunflower germplasm, there are used different genetic resources, as: sunflower old cultivars with low oil content, varieties with high oil content, hybrids and inbred lines, synthetic populations, induced mutations and sunflower wild species, which are the most important genes donor for many important characteristics for cultivated sunflower (Vrânceanu, 2000; Skoric et al., 2012).

In this paper there are presented some results of our work for genes transferring from wild species into cultivated sunflower.

MATERIALS AND METHODS

There have been used some wild species (*Helianthus argophyllus* and *Helianthus maximiliani*) and Record variety belonging to cultivated sunflower. The purpose was to transfer genes for resistance to drought as well as for resistance to the pathogen *Phomopsis helianthi*, from *H. argophyllus* and genes for resistance to the parasite *Orobanche cumana* (broomrape), from *H. maximiliani*.

It has been done the measurement of different morphological characteristics of the obtained interspecific hybrids as well as the vegetation period, flowering duration, one thousand seeds weight and the oil content.

For the interspecific hybrids with resistance to the pathogen *Phomopsis helianthi*, as well as to the parasite *Orobanche cumana*, there have been done the tests of resistance in natural infection/infestation conditions, as well as in the artificial infestation for broomrape parasite.

For testing sunflower resistance to broomrape resistance in the artificial infestation, we used the Pancenko method (Păcureanu-Joița et al., 1998), by planting sunflower genotypes in pots of 5 litters capacity with a soil mixture and sand, including 2 grams of broomrape seeds, in each of them. The broomrape attack could be seen on sunflower roots after 35 days from planting time.

RESULTS AND DISCUSSIONS

The interspecific hybrids in sunflower breeding have an important role because of a large genetic variability, which assure a base for success in this field.

Due to our research work there have been obtained some interspecific populations which help us to create restorer inbred lines (from crossing wild sunflower *Helianthus argophylluys* with cultivated variety Record). The obtained populations have been studied for different characteristics important for cultivated sunflower.

The data presented in table 1 are showing that the flowering time for the wild specie is closely populations HI 398 and HI 363. The vegetation period for the hybrid populations was between 93 and 104 days.

Table 1. Phenological data for some interspecific hybrids obtained by crossing cultivated sunflower *H. annuus* (Record variety) with *H. argophyllus* (2012- 2013)

Genotype	Beginning of flowering (days from emergence)	Flowering time (days from emergence)	Duration of central head flowering (days)	Vegetation period (days)
Cultivated sunflower				
Record	54	54	5	108
Wild specie				
H. argophyllus	108	115	6	142
Interspecific hybrids				
HI 321	51	53	4	95
HI 398	51	52	6	93
HI 363	52	53	6	104

The morphological characteristics of the interspecific populations are presented in tables 2, 3 and 4.

There are presented the average values of the most important characteristics, frequently analyzed in the breeding programs. The data are showing that in most of cases, the difference regarding the cultivated genotype is statistically important. A positive significance it has been determined for the characteristics as: number of branches, the branches head diameter (HI 321 and HI 398). These characteristics are very important in sunflower breeding work, for the restorer inbred lines. Due to these data we can to say that the hybrid populations are closely the parent belonging to the cultivated sunflower, regarding all analyzed characteristics, after 5 generations of self-pollination.

Table 2. Different characteristics for some interspecific hybrids obtained by crossing cultivated sunflower *H. annuus* (Record variety) with *H. argophyllus* (average 2011-2013)

Genotype	Plant height (cm)	No. of leaves	Leave wide (cm)	Leave length (cm	Petiol length (cm)
Cultivated sunflower					
Record	177.2	32.0	21.1	22.0	16.2
Wild specie					
H. argophyllus	236.5	261.0	0.6	20.7	0
Interspecific hybrids					
HI 321	121.6***	28.0***	16.7***	17.5***	14.4***
HI 398	129.4***	32.0	15.1***	16.0***	14.2***
HI 363	90.3***	20.0***	16.7***	17.2***	10.2***

DL: 0.1%; 1%; 5%

Table 3. Different characteristics for some some interspecific hybrids obtained by crossing cultivated sunflower *H. annuus* (Record variety) with *H. argophyllus* (average 2011-2013)

Genotype	Distance between knots (cm)	Stem diameter (mm)	Head diameter (cm)	Number of branchs (n)	Length of branchs (cm)	Number of flowers ranges (n)
Cultivated sunflower						
Record	5.8	29.4	23.0	0	0	51.0
Wild specie						
H. argophyllus	15.6	12.1	1.2	14.0	12.8	16.0
Interspecific hybrids						
HI 321	5.8	22.0***	13.2***	25.0***	28.4***	50.0
HI 398	5.5	25.0***	12.6***	24.0***	21.2***	53.0
HI 363	4.7***	21.0***	15.0***	0	0	46.0***

DL: 0.1%; 1%; 5%

Table 4. Different characteristics for some some interspecific hybrids obtained by crossing cultivated sunflower *H. annuus* (Record variety) with *H. argophyllus* (average 2011-2013)

Genotype	Lateral heads diameter (cm)	Kernel wide (mm)	Kernel length (mm)	Kernel diameter (mm)	Oil content (%)	TKW (g)
Cultivated sunflower						
Record	0	5.9	11.2	3.9	48.0	78.3
Wild specie						
H. argophyllus	1.1	2.2	5.0	1.3	28.4	5.8
Interspecific hybrids						
HI 321	7.1***	5.0***	11.0	3.5*	45.4**	35.4***
HI 398	8.6***	5.3**	11.5	3.6*	45.0**	37.3***
HI 363	0	5.0***	8.8***	3.5*	44.1***	40.3***

DL: 0.1%; 1%; 5%

Crossing the wild sunflower *Helianthus maximiliani* with cultivated sunflower (Record variety) we obtained different hybrid populations which can to help us in obtaining some lines with good resistance to the most virulent populations of the parasite broomrape.

In figures 1, 2 and 3 there are presented the results obtained by testing different populations among some differentials for broomrape races, in 3 locations situated in areas infested with populations of the parasite which have different virulence. In figure 1, the test made in Tulcea area, has showed that the attack degree of the parasite was higher in 2013 year and the best populations regarding the resistance are IS 604 and IS 581. In Ialomita area, the broomrape populations are less virulent and the resistance are very good for most of hybrid populations, excepting IS 557 (Figure 2).

In Constanta area, the broomrape virulence is high and the sunflower interspecific hybrid populations are less resistant, but, the populations IS 604 and IS 581 have a good resistance (Figure 3).

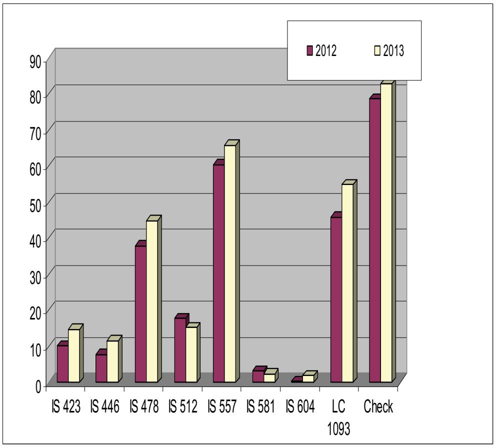


Figure 1. The attack degree of broomrape parasite on interspecific sunflower hybrids in Tulcea area (2012-2013)

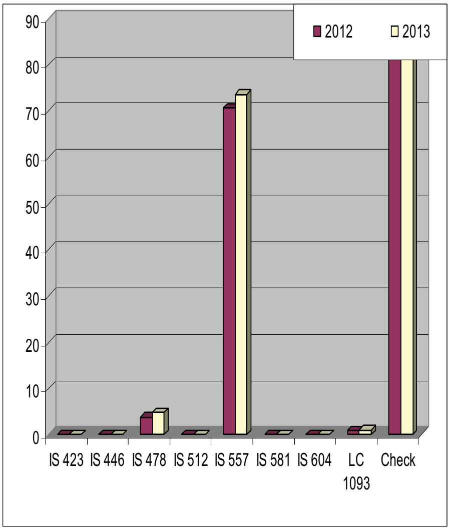


Figure 2. The attack degree of broomrape parasite on interspecific sunflower hybrids in Ialomița area (2012-2013)

These interspecific populations have been studied for resistance to broomrape in the artificial infestation conditions, too, with four populations of the parasite (Table 5). The results are showing that the same populations which have presented a good resistance in tests made in natural infestation conditions have a good resistance in the artificial conditions testing. The broomrape attack degree is a little higher, comparing with test in natural conditions.

The pathogen *Phomopsis helianthi* is un important risk factor for sunflower crop, so, it is necessary to find sources of resistance. In figure 4 there are presented results of testing for some sunflower interspecific populations (*H. argophyllus* x Record variety). The results are showing that some populations have a very good resistance (HI 321 and HI 398). The attack was higher in 2013 year.

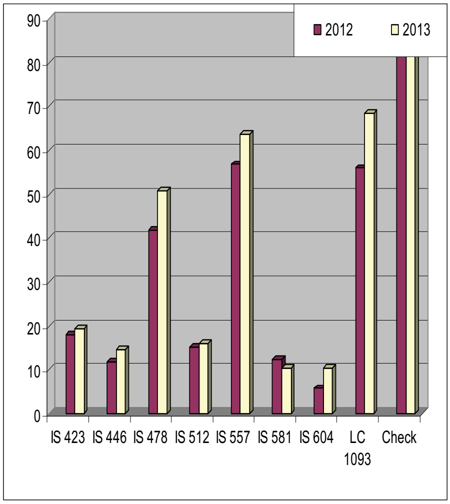


Figure 3. The attack degree of broomrape parasite on interspecific sunflower hybrids in Constanța area (2012-2013)

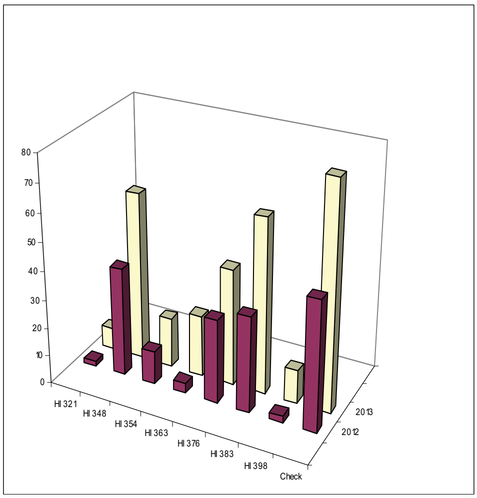


Figure 4. The attack degree of pathogen *Phomopsis helianthi*, in natural infection conditions (2012-2013)

Table 5. Broomrape attack degree in the artificial infestation condition

Sunflower Genotype	Attack degree (%)			
	Broomrape 1	Broomrape 2	Broomrape 3	Broomrape 4
IS 446	0.56	11.4	18.5	3.8
IS 478	11.42	48.6	61.2	19.5
IS 512	0.23	21.9	25.4	15.2
IS 557	51.7	77.8	61.4	55.6
IS 581	0.0	10.4	7.9	7.8
IS 604	0.34	9.3	8.5	6.9
LC 1023	1.87	19.6	21.7	16.3
LC 1044	0.0	8.7	8.4	5.5
LC 1112	2.67	17.8	15.6	14.6
LC 1145	1.98	21.8	25.9	18.3
LC 1093	0.45	55.4	31.4	34.8
LC 1003	56.7	71.6	67.8	62.4
LG 1	0.0	0.0	0.0	0.0
LG 2	0.0	6.9	7.5	4.2
Check	72.6	80.4	82.3	75.5

CONCLUSIONS

Sunflower wild species are very good sources of genes for important characteristics which must to increase the value of cultivated sunflower.

The interspecific populations obtained by crossing the wild sunflower *Helianthus argophyllus* with cultivated variety Record, have showed significant values for important characteristics. Some of these populations have a good resistance to the pathogen *Phomopsis helianthi.*

Some of hybrid populations obtained by crossing the wild sunflower *Helianthus maximiliani* with cultivated variety Record have a good resistance to the parasite *Orobanche cumana*.

REFERENCES

Belhassen E., Castiglioni V.P.R., Chimenti C., Griveau Y., Jamaux Y., Steinmetz A., 1996. Looking for physiological and molecular markers of leaf cuticular transpiration using interspecific croses between *Helianthus argophyllus* and *Helianthus annuus*. In: Drought Tolerance in Sunflower, Symp. II, Beijing, China, p. 39-44.

Păcureanu-Joița M., Vrânceanu A.V., Marinescu G. A., Sandu I., 1998. The evaluation of the parasite-host interaction in the system *Helianthus annuus* L.-*Orobanche cumana* Wallr. In Romania. Proc. Second Balkan Symp. On Field Crops, Novi Sad, Yugoslavia, 16-20 June, 1998, Vol. I: 153-155.

Sin G., 2002. Tehnologii moderne pentru cultura plantelor de câmp. Ed. Ceres, Bucureşti.

Singh B.D., 2000. Plant Breeding-Principies and Methods. Kalyani Publishers, Ludhiana, New Delhi, Noida, India, p. 1-896.

Skoric D., Seiler G.J., Liu Z., Jan C.C., Miller J.F., Charlet L.D., 2012. Sunflower genetics and breeding. Serbian Academy of Sciences and Arts, Novi Sad, Serbia.

Vrânceanu A.V., 2000. Floarea-soarelui hibridă. Ed. Ceres, Bucureşti.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SOME IMPORTANT PLANTS USED AGAINST DIABETES IN FOLKLORIC MEDICINE IN SAVUR (MARDIN/TURKEY) AREA AND THEIR APPLICATION AREAS

Sukru ARASAN[1], Ilhan KAYA[2]

[1]Ministry of Agriculture, Rural Affairs of Aliaga, 35800, Izmir, Turkey
[2]Yuzuncu Yil University, Agriculture Faculty, Plant Protection Department, Van, Turkey

Corresponding author email: ilhankaya71@hotmail.com

Abstract

In this study; it is aimed to determine the purpose and the mode of use of some important plants used against diabetes in folk medicine in Savur (Mardin). Surveys were carried out in Savur Town Centre, and in some towns and villages of Savur district, during the years of 2012-2013. A total of 207 resource persons were interviewed. As a result of the study, 10 species from different families were determined which have been used for against diabetes. The plants determined in research area were: Bryonia multiflora Boiss. & Heldr. (Ulüngür), Cerasus mahaleb (L.) Miller var. mahaleb (L.) Miller (Mahlep), Hypericum triquetrifolium Turra (Pırpırotu), Malva neglecta Wallr. (Çobançöreği), Olea europaea L. (Zeytin), Punica granatum L. (Nar), Teucrium polium L. (Acıyavşan), Thymbra sintenisii Bornm & Aznav subsp. sintenisii (Akzahter), Quercus brantii Lindl. (Karameşe), Cyclotrichium leucotrichum (Stapf ex Rech. Fil.) Leb. (Karaçekme). Local names and the mode of use and necessary doses of therapeutic plants were documented.

Key words: *medicinal plants, folkloric medicine, diabetes, Savur, Mardin.*

INTRODUCTION

Mardin has a limit and this region, the Southeastern Anatolia Region of Turkey, Iran and Turan includes endemic flora characters. The people in our region has a rich flora have benefited from herbs from the past to the present (Akgul, 2008; Ozgokce and Ozcelik, 2004).

Mardin is one of the oldest settled areas of many civilizations. At the same time, it is one of the rare cities living in harmony of the people from different faiths for centuries in the world. Historically and culturally, it is one of the richest cities of Turkey (Anonim, 2013). Therefore it posesses important ethnobotanical data.

The aim of the study, was to determine plants used in folk medicine in Mardin (Savur) and is to provide information regarding their applicability.

MATERIALS AND METHODS

Surveys were carried out in the central Savur Town, and in some towns and villages of Savur, during the years of 2012-2013. A total of 207 resource persons were interviewed.

In the diagnosis of the collected samples, as the primary source "Flora of Turkey and the East Aegean Islands" (Davis, 1965-1985; Guner et al., 2000) were used.

RESULTS AND DISCUSSIONS

As a result of the study, 10 species belonging to different families were determined which have been used for therapeutic purposes. The plants determined in research area were:

1. *Bryonia multiflora* Boiss. & Heldr. (Ulüngür)
Familia: Cucurbitaceae.
Local Name of Plant: Amızğa, Ğerzikrêvi, Lığbê, Rezıkrêvi, Rızıkrêvi.
Collection Period: May–July.
Location: C8, Mardin; Savur, Serenli Köyü, Dengiza Çavê Amero Mevkii, 37º 33' 02.4" N, 40º 50' 20.2" E, 830 m, 06.05.2013, Ş.Arasan.
Plant Part: Root (Figure 1).

Recommendation for use: The of plant roots are consumed in the half rate of chickpea seed against diabetes daily. (Hıdır Öncül).

Figure 1. *Bryonia multiflora* Boiss. & Heldr.

2. *Cerasus mahaleb (*L.) Miller var.*mahaleb* (L.) Miller (Mahlep)
Familia: Rosaceae.
Local Name of Plant: Kenêr, Mehleb, Mahleb.
Collection Period: May.
Location: C8, Mardin; Savur, Serenli Köyü, Köy İçi, 37º 33’ 51.9’’ N, 40º 49’ 21.5’’ E, 958 m, 18.04.2013, Ş.Arasan.
Plant Part: Fruit (Figure 2).

Figure 2. *Cerasus mahaleb (*L.) Miller var. *mahaleb* (L.) Miller

Recommendation for use: The mature fruit of the plant are consumed against diabet (Nuriye Öncü, Gülnaz Saçan).

3. *Hypericum triquetrifolium* Turra (Pırpırotu)
Familia: Guttiferae.
Local Name of Plant: Aran, Botav, Batof, Batov, Bahtof.
Collection Period: July.
Location: C8, Mardin; Savur, Bengisu Köyü, Köy İçi, 37º 30' 18.9" N, 41º 06' 28.2" E, 1054 m, 15.07.2013, Ş.Arasan.
Plant Part: Above-ground parts (Figure 3).

Figure 3. *Hypericum triquetrifolium* Turra

Recommendation for use: Above ground portion of the plant boiled in water and is drunk (Sultani Aksoy, İbrahim, Baki İpek, Gurbet Aytar).

4. *Malva neglecta* Wallr. (Çobançöreği)
Familia: Malvaceae
Local Name of Plant: Tolık, Tolkê, Ğıbbes, Ğıbbez.
Collection Period: March-May.
Location: C8, Mardin; Savur, Beşevler Mevkii, 37º 32' 42" N, 40º 50' 42.9" E, 839 m, 25.05.2013, Ş.Arasan.
Plant Parts: Leave, Stem, Root (Figure 4).

Figure 4. *Malva neglecta* Wallr.

Recommendation for use: The plant is consumed against diabetes as raw (Zübeyde Alökmen, M.Said Demir).

5. *Olea europaea* L.(Zeytin)
Familia: Oleaceae.
Local Name of Plant: Zeytin, Zeytun.
Collection Period: October-November.
Location: C8, Mardin; Savur, Merkez, 37º 32' 38.4" N, 40º 44' 16.7" E, 868 m, 30.09.2013, Ş. Arasan.
Plant Part: Fruit, Leave, Stem (Figure5).

Figure 5. *Olea europaea* L.

Recommendation for use: The plant's leaves are boiled in water and are drunk a day twice against diabetes (Saruhan Filiz).

6. *Punica granatum* L.(Nar)
Familia: Lythraceae.
Local Name of Plant: Hınnar, Hınar, Henar, Hennar, Remuno, Rımman.
Collection Period: June-November.
Location: C8, Mardin; Savur, Koşuyolu Köyü, Köy İçi, 37º 29' 25.5" N, 41º 01' 36.3" E, 1088 m, 25.05.2013, Ş.Arasan.
Plant Part: Fruit, Flower (Figure 6).

Figure 6. *Punica granatum* L.(Nar)

Recommendation for use: Pomegranate juice is drunk against diabetes (Cemil Aslaner).

7. *Teucrium polium* L. (Acıyavşan)
Familia: Lamiaceae.
Local Name of Plant: Bojna, Bojnak, Bojank, Cadê, Cedê, Gihabibo, Gihabo, Gihagevrık, Giyabojna, Mervent.
Collection Period: April-May.
Location: C8, Mardin; Savur, Dereiçi, Köy İçi, 37º 32' 54.2" N, 40º 57' 36.2" E, 931 m, 15.05.2013, Ş.Arasan.
Plant Parts: Above-ground parts (Figure 7).

Figure 7. *Teucrium polium* L.

Recommendation for use: *T. polium* is one of the most widely used plants in traditional folk medicine. The plant is eaten against diabetes as raw or it infused in hot water and is drunk (Şerif Bozkurt; Nuray Bozkurt, Şeyhmus Yıldız).

8. *Thymbra sintenisii* Bornm & Aznav subsp. ***sintenisii*** (Akzahter)
Familia: Lamiaceae.
Local Name of Plant: Cehter, Cehteri, Zahter, Zehter.
Collection Period: July-Agust.
Location: C8, Mardin; Savur, Yaylayanı Köyü, Köy Çevresi, 37º 35' 55.9" N, 40º 59' 26.6" E, 1118 m, 15.07.2013, Ş.Arasan.
Plant Part: Above-ground parts (Figure 8).

Figure 8. *Thymbra sintenisii* Bornm & Aznav subsp. *sintenisii*

Recommendation for use: *T. sintenisii* infused in hot water and is drunk two cups a day against diabetes (Koçere Demirtaş).

9. *Quercus brantii* Lindl. (Karameşe)
Familia: Fagaceae.
Local Name of Plant: Ballot, Balutê, Beru, Bellot, Çılo.
Collection Period: September-October.

Location: C8, Mardin; Savur, Bağyaka Köyü, Diyarbakır - Savur Yolu, 37º 33' 39.5" N, 42º 47' 49.4" E, 997 m, 02.09.2013, Ş.Arasan.
Plant Part: Fruit-Coat (Figure 9).

Figure 9. *Quercus brantii* Lindl.

Recommendation for use: Acorn fruit is eaten one or two in day against diabetes (Murat Yılmaz, Yamane Acar, Cengiz Çelebi, Emine Yılmaz).

10. *Cyclotrichium leucotrichum* (Stapf ex Rech.f.) Leb. (Karaçekme)
Familia: Lamiaceae.
Local Name of Plant: Rihana tehtan.
Collection Period: June.
Location: C8, Mardin; Savur, Yenilmez Köyü, 37º 30' 28.3" N, 40º 59' 48.8" E, 1133 m, 05.06.2013, Ş.Arasan.
Plant Part: Above-ground parts (Figure 10).

Figure 10. *Cyclotrichium leucotrichum* (Stapf ex Rech.f.) Leb.

Recommendation for use: A few branches of this plant boiled in water and is drunk (Abdülhamit Erkek).

CONCLUSIONS

In this study, a total of 207 resource persons were interviewed. As a result, 10 species from different families were determined which have been used against diabetes for therapeutic purposes. Plant species were grouped with local and common names. Therapeutic application, dosage, mode of use and mode of treatment were documented. Thus, it has been tried to be transmitted to generation to the next of experience and knowledge accumulated of thousands of years of local people from past to present.

ACKONOWLEDGEMENTS

This research was financially supported by a grant from Office of Scientific Research Projects Yuzuncu Yil University (2013-FBE-YL032).

REFERENCES

Akgul A., 2008. Ethnobotany in Midyat (Mardin). E.Ü. Institute of Science and Technology,Department of Biology, Graduate Thesis, İzmir, 176 p.
Anonim, 2013. http://www.mardin.gov.tr (Date of access: 15.11. 2013).
Davis PH., 1965-85. Flora of Turkey and East Aegean Islands. Vol. 1-9. Edinburgh University. Pres. Edinburgh.
Guner A., Ozhatay N., Ekim T., Baser H.C., 2000. Flora of Turkey and the East Aegean Islands, Vol.11. Edinburgh Univ. Pres. Edinburgh.
Ozgokce F., Ozcelik H., 2004. Ethnobotanical aspects of some taxa in East Anatolia (Turkey). Economic Botany. 58 (4): 697-704.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DETERMINATITION THE PROPER PLANTING DATE FOR COLD TOLERANT SPRING-TYPE CULTIVARS OF RAPESEED IN MILD COLD CLIMATIC CONDITIONS OF MASHHAD-IRAN

Mehdi AZIZI

Khorasan Razavi Agriculture & Natural Resources Research Center, SPII Department, POBox: 91735-488, Mashhad, Iran

Corresponding author email: meh_azizi2003@yahoo.com

Abstract

In order to determining the proper planting date for cold tolerant spring type cultivars of rapeseed, a two years experiment was done in Agriculture and Natural Resources Research Center of Khorasan-Razavi, Toroq Station in Mashhad , at North-east of Iran during 2006-2008 growing season. In this experiment seven planting dates with one month intervals from 23 Sept. to 23 March, were studied. Two cultivars namely, Hyola401 (Hybrid) and RGS003 (Standard Open Pollinated) were set as main plots and planting dates as sub plots in a split plot design, with four replications. Seed yield and yield components, i.e. number of branches per plant, number of pod per plant, was determined. Plant height at maturity stage also measured. Results showed, Hyola401 had greater yield especially in 23 Sept. and 23 Oct. planting dates. Planting of this cultivar on 23 Feb., as spring cultivation, produced a proper seed yield. This hybrid regardless of its shorter height, had very optimum branch number and also pods per plant and these tends it to achieve higher seed yield .For escaping from chilling stress in fields that is probable at the presence of reproductive stages at the end of fall, it is recommended , the farmers cultivate the Hyola401 on 23 October.

Key words: *B. napus, seed yield, delayed planting, Hyola401, RGS003.*

INTRODUCTION

Agricultural scientists know about the effect of interaction between genotype × environment for their breeding programs (Seyis et al., 2006). Amongst environmental factors, planting date has a key role for determining the time of plant phenological coincidence with external factors for yield increasing purpose. So some of spring rapeseed cultivars, because of their high tolerance to cold conditions, have possibility to sowing in autumn (Ghanizadeh, 2008).
Proper planting date can protect plant against freezing injuries (Rife and Zeinali, 2003), but in cold tolerant spring type rapeseed cultivars stem elongation is significantly related to planting date specially in moderate climatic conditions (Ghanizadeh, 2008).
Between vast range of spring cultivars of rapeseeds there is some cold tolerant ones can endure cold winters as well as winter types and obtain high potential photosynthetic capacity after wintering (Rapacz, 2002; Rapacz et al., 2001; Rife and Zeinali, 2003).
In this context, I have tried to show the effect of different planting date from Sept. to March on agronomic responses of two spring type of rapeseed cultivars that originally had cold tolerance capability and recently use by Iranian farmers in mild cold areas as a winter crop.

MATERIALS AND METHODS

In order to characterize the evolution of yield, yield components and plant height at maturity stage of two spring type of rapeseed to different planting dates a two years experiment was conducted. The site of experiment was Agriculture and Natural Resources Research Center of Khorasan-Razavi, Toroq Station in North-east of Iran. In this experiment seven planting dates with one month intervals from 23 Sept. to 23 March, were studied. Two cultivars namely, Hyola401 (Hybrid) and RGS003 (Standard OP) were set as main plots and planting dates as sub plots in a split plot design, with four replications.
The period analysed in this study was 2006-2008. In 2006-2007, the date 23 Jan. was omitted from analysis because we couldn't plant it for occurrence of heavy snow at that time.

The data, collected from the field was analysed statistically and mean comparisons was done based on Duncan's multiple range test.

RESULTS AND DISCUSSIONS

Seed yield

Results of interaction effects for means of cultivar × planting date in selected variables have shown in tables 1 and 2 for each year of experiment separately. The hybrid cultivar, Hyola401, had the more seed yield in all planting dates compared to RGS003 in two years. But the highest yield was obtained in the first and second planting dates i.e. 23 Sept. and 23 Oct. Apart from the nature of these cultivars, being spring, the highest seed yield was obtained in early fall planting dates. This confirms Rapacz (2002) suggestion about such cultivars.

As a spring crop, the best planting date in end of winter for rapeseed is around 23 Feb. Results for this date were different for two cultivars in two years. At first year the highest seed yield i.e. 1971 $kg.ha^{-1}$ was belonged to Hayola401, and in the second year 1856 $kg.ha^{-1}$ to RGS003, it shows that selecting a proper cultivar for sowing rapeseed in end of winter is slightly difficult and perhaps we need to select between cultivars with narrower differences and stable seed yields.

Different planting dates have distinct effects on seed yield, growth traits and morphology of rapeseed and yield is decreased in late plantings because of shortening the vegetative stage (Thurling, 1991; Kimber and McGregor, 1995).

Branch number/plant

The most branch numbers was established in 23 Nov. for two cultivars in both years. Because in this planting date we had much more chilling effect on plants, and this stimulated the re-growth of plant crown buds and more branching out. The second rank for this trait was belonged to 23 Sept., the first planting date. Mendham et al., (1981) showed in early plantings, rapeseed produce more branches. In both years the branching pattern for both cultivars was uniform but in Hyola401 was more stable. It seems hybrid cultivars have high potential for controlling their yield component in a steady state plateau for yield offset.

Pod number/plant

Pod setting pattern was different for cultivars in both years. The most pods per plant were produced by Hyola401 on 2006-2007 and by RGS003 on 2007-2008 growing season. The highest pod per plant was obtained in treatment 23 Nov. These advantages does not lead to higher seed yield, that in the previous section I explained My reasons for it.

As I mentioned previously the highest seed yields was achieved in planting dates 23 Sept. and 23 Oct., in which pod numbers per plant were 80-180. In connection with this trait, heritability has less controlling effect in comparison with environmental factors (Diepenbrock, 2000; Taylor and Smith, 1992).

More delay in planting date can reduce pod number per plant, because the pollination of rapeseed flowers coincides to the warmer parts of the season, then a lot of pollen abortion is occurred (Diepenbrock, 2000; McGregor, 1987).

Plant height

Totally the hybrid cultivar Hyola401, had the lowest height for sum of interaction effects in both years. Differences for this trait between cultivars can be due to the variation of days to maturity (Ozer, 2003).

The highest plant height was obtained in earliest planting dates i.e. 23 Sept. and 23 Oct. for Both cultivars, but the RGS003 was superior for this trait in both years. Delayed sowing reduced plant height up to 25 percent.

With delay in planting, availability of plant for growth resources such as light, water and nutrients is reduced, resulting in shortening its height (Sharief and Keshta, 2002). This is not necessarily an indication that shorter cultivars have lower seed yield (Rapacz, 2002).

Table 1.Mean comparison for cultivar × planting date effects in spring type rapeseed (Mashhad 2006-2007)

Source of Variation		Seed Yield (kg/ha)	Branch/plant	Pod/plant	Height (cm)
Hyola401	23Sept.	4444^{a}	3.5^{bc}	100^{c}	115^{abc}
	23 Oct.	3460^{b}	2.8^{c}	80.5^{c}	120^{a}
	23 Nov.	2604^{d}	5.3^{ab}	159^{b}	90^{e}
	23 Dec.	2100^{ef}	3.3^{bc}	78^{c}	98.7^{de}
	23 Feb.	1971^{ef}	3.3^{bc}	81.2^{c}	102^{cde}
	23March	977^{g}	4^{bc}	90^{c}	93.7^{de}
RGS003	23Sept.	3137^{bc}	3.5^{bc}	83.2^{c}	125^{a}
	23 Oct.	2694^{cd}	3.3^{bc}	82^{c}	128^{a}
	23 Nov.	1779^{f}	7^{a}	224^{c}	105^{bcd}
	23 Dec.	2408^{de}	3^{c}	65.8^{c}	117^{ab}
	23 Feb.	1609^{f}	3^{c}	57.5^{c}	103^{cde}
	23March	588^{g}	3.3^{bc}	61^{c}	92.5^{de}

Letters in each columns show significant differences based on Duncan's Test.

Table 2. Mean comparison for cultivar × planting date effects in spring type rapeseed (Mashhad 2007-2008)

Source of Variation		Seed Yield (kg/ha)	Branch/plant	Pod/plant	Height (cm)
Hyola401	23Sept.	4302^{a}	5.3^{c}	145.3^{cd}	118.8^{abc}
	23 Oct.	4523^{a}	5.3^{c}	105.5^{dc}	122.5^{ab}
	23 Nov.	1443^{fg}	13.7^{a}	289^{ab}	92.5^{ef}
	23 Dec.	2917^{b}	4.5^{c}	102.5^{de}	101.2^{def}
	23 Jan.	2580^{bcde}	4^{c}	104^{de}	110^{bcd}
	23 Feb.	1322^{fg}	6^{c}	109.8^{de}	105^{cdef}
	23March	602^{g}	4.2^{c}	39.7^{e}	91.2^{f}
RGS003	23Sept.	2841^{bc}	7.5^{bc}	215.5^{bc}	127.5^{a}
	23 Oct.	4303^{a}	4^{c}	90.7^{de}	130^{a}
	23 Nov.	1792^{def}	11.2^{ab}	339.5^{a}	106.3^{cde}
	23 Dec.	2773^{cd}	4.5^{c}	152^{cd}	118.8^{abc}
	23 Jan.	1765^{ef}	5^{c}	123^{de}	116.3^{abc}
	23 Feb.	1856^{cdef}	4.2^{c}	107^{de}	106.3^{abc}
	23March	996^{fg}	3^{c}	44.2^{e}	93.7^{ef}

Letters in each columns show significant differences based on Duncan's Test.

CONCLUSIONS

The hybrid cultivar, Hyola401, had distinct superiority in seed yield for both years. The best planting dates based on yield were 23 Sept. and 23Oct. In these sowing dates, Hyola401 showed high potential for compensation of environmental damages specially caused by cold conditions. It seems that despite 20 percent reduction in seed yield, the second planting date can be more safer and recommendable to mild cold regions. Planting on 23 Oct., prolongs the rosette stage of spring type rapeseed and the stem elongation of plant is coincide to early March. So, rapeseeds that have grown with these conditions, remain protected against damage of cold, because their reproductive growth do not start at the end of autumn, and their buds remain off until March due to cold temperatures.

The best planting date for those farmers who wants to sow rapeseed on end of winter, is 23 Feb., and the best cultivar for this purpose is Hyola401 too. This cultivar has a potential for producing 1900 $kg.ha^{-1}$ seed yield with complimentary irrigation.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Khorasan Razavi Agriculture and Natural Resources Research Center, Seed and Plant Improvement Institute, Mashhad, Iran.

REFERENCES

Diepenbrock W., 2000. Yield analysis of winter oilseed rape (*Brassica napus L.*): A review. Field Crops Research, 67: 35-49.

Ghanizadeh S., 2008. Evaluation of cold tolerant spring cultivars of rapeseed at different winter planting date. MSc. Thesis, Islamic Azad University of Mashhad.

Kimber D., McGregor D.I., 1995. Brassica oilseeds, production and utilization. CAB International Publication Co.UK.

McGregor D.I., 1987. Effect of plant density on development and yield of rapeseed and its significance to recovery from hail injury. Canadian Journal of Plant Science, 67: 43-51.

Mendham N.J., Shipway P.A., Scott R.K., 1981. The effect of delayed sowing and weather on growth, development and yield of winter oilseed rape (*Brassica napus L.*). Journal of Agricultural Science Camb, 96: 389-416.

Ozer H., 2003. Sowing date and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. European Journal of Agronomy 19: 453-463.

Raif C L., Zeinali H., 2003. Cold tolerance in oilseed rape over varying acclimation duration. Crop Science 43: 96-100.

Rapacz M., 2002. Cold-deacclimation of oilseed rape (*Brassica napus var. oleifera*), in response to fluctuating temperatures and photoperiod. Annals of Botany, 89: 543-549.

Rapacz M., Tokarz K., Janowiak F., 2001. The initiation of elongation growth during long term low temperature of spring-type oilseed rape may trigger loss of frost resistance and changes in photosynthetic apparatus. Plant Science, 161: 221-230.

Seyis F., Friedt W., Luhs W., 2006. Yield of *Brassica napus L.* hybrids developed using re-synthesized rapeseed material sown at different locations. Field Crops Research, 96: 176-180.

Sharief A.E., Keshta M.M., 2002. Influence of sowing dates and plant density on growth and yield of canola (*Brassica napus L.*) under salt affecting soils in Egypt. Scientific Journal of King Faisal University Basic and Applied Sciences, 31: 65-78.

Taylor A.J., Smith C.J., 1992. Effect of sowing date and seeding rate on yield and yield componenets of irrigated canola (*Brassica napus L.*) grown on a red-brown earth in south-eastern Australia. Australian Journal of Agricultural Research, 43: 1629-1641.

Thurling N., 1991. Application of the ideotype concept in breeding for higher yield in the oilseed *Brassicas*. Field Crops Research, 26: 201-219.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE EFFECT OF HIGH NPK LEVELS ON POTATO YIELD SIZE STRUCTURE AND TUBERS STARCH CONTENT

Nina BĂRĂSCU[1], Maria IANOŞI[1], Marcel M. DUDA[2], Victor DONESCU[1]

[1]National Institute of Research and Development for Potato and Sugar Beet Braşov, Street Fundăturii no 2, Postal code 500470, Brasov, Romania
[2]University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Calea Mănăştur 3-5, Postal code 400372, Cluj-Napoca, Romania

Corresponding author email: nina.barascu@gmail.com

Abstract

The aim of this study was to highlight yield quantitative and qualitative changes of two mid-early potato varieties Christian and Roclas, as a result of base fertilization with different doses and NPK (nitrogen, phosphorus, potasium) reports. The experiment was done between 2013-2014, on a cernoziomoid soil, non-irrigated crop. Nitrogen fertilization levels applied, 100 and 200 kg N/ha, lies on the lower and upper boundary OSPA Braşov recommendations for autumn potato crops. The variants were realized with two complex fertilizers administered before planting: C15-15-15, for NPK report 1:1:1 and C5:10:22 supplemented with ammonium nitrate through which was achieved the NPK report of 1:0.9: 2.
On average, in those two years, NPK report, with higher potassium level did not influenced significantly the total yield of Christian and Roclas varieties. Were found weak growths of tubers yield with diameters bigger than 60 mm on behalf of productions of tuber fraction 35-60 mm. On both varieties fertilization with NPK report 1:0.9:2 resulted in significant declines of tubers starch content compared with NPK report 1:1:1. Increasing nitrogen levels from 100 to 200 kg N/ha had similar effects on yield and starch content of the tubers.
*For the studied period, correlation of total yield, commercial yield, yield from fraction bigger than 60 mm and fraction smaller than 35 mm with tubers starch content, was significant on Christian variety (r = -0.638***, -0.630***, -0.722***, -0,559***). On Roclas variety, only correlation between large tuber yield and starch concentration was significant (r = -0,433*).*

Key words: *fertilization, potato, starch, yield.*

INTRODUCTION

Potato is a plant that consumes large quantities of nutrients and capitalizes better mineral and organic fertilizers applied rationally. Potato yield is influenced by both quantitatively and qualitatively. Rational fertilization aims at balancing the amount of nutrients through fertilizers, taking into account the contribution of soil (Ianoşi et al., 2002).
Excessive application rates of nitrogen and potassium, along with excessive soil levels of eithers nutrient, may reduce tuber solids (Carrie Laboski and Kelling, 2007). Potato crop has strict requirement for a balanced fertilization management, without which yield and quality of tubers are diminished. Potassium improves yields and some of the tuber quality parameters as tuber size, percentage of dry matter, starch content are affected by potassium nutrition (Patricia Imas and Bansal, 1999).
K fertilization generally reduces specific gravity (Locascio et al., 1992, cited by Kelling et al., 2002) if applied in excess of rates (Lisińska and Leszczyński, 1989; Davenport, 2000). Based on a research on the influence of potassium fertilisation on yield and dry matter content for the cultivar Asterisc and Fontane, Demeulemeester and Bries (2011) reported that potassium fertilization resulted only in a small yield increase, which could be correlated with the moderated to high K content of the soil. Potassium deficiencies reduce the yield, size and quality oft he potato crop (Mikkelsen, 2006).
Nitrogen is the one most often limiting for potato growth; application of fertilizer N is necessary to ensure profitable potato production and, in general, N application increases the proportion of larger-sized tubers (Zebarth and Rosen, 2007). Proper N management influences almost all of the

important properties related to tuber yield and quality (Mikkelsen, 2006).
Nitrate fertilization determine yield increase and although have an influence on potato chemical composition and tuber quality. Too much available N can have negative effects on tuber yield and quality; excess N at or before tuberization can reduce yield and specific gravity (Atkinson et al., 2003).
In a field experiment, Eleiwa (2012) reported that increasing the NPK levels significantly increased yield parameters. The highest values of the yield parameters were obtained by using the highest NPK (120:80:100) as compared with other two NPK levels (102:68:85 and 90:60:75). According to Cucci and Lacolla (2007) trials conducted on potato fertilization at different rates of nitrogen, phosphorus and potassium have shown that the tubers with the highest specific gravity and starch content values are obtained when applying respectively 200 and 50 kg/ha of nitrogen and phosphorus.
Fertilization with large quantities of nitrogen is ageing the tubers, dry matter content being reduced and increases the content of nitrates in the tubers. The dry matter content can fall so much that the tubers will no longer be able to be used for industrial processing (www.potato.nl).
In this experiment, our objectives were to study the effect of base fertilization with different doses and NPK (nitrogen, phosphorus, potassium) reports on yield and tuber quality of two mid-early potato varieties Christian and Roclas.

MATERIALS AND METHODS

The experiment was done between 2013-2014, on a cernoziomoid soil, non-irrigated crop. The experience was of poli-factorial type, with plots subdivided, into who have been studied quantitative and qualitative changes of the yield of two mid-early potato varieties, Christian and Roclas, as a result of the basic fertilization with dosages and different NPK ratios. Nitrogen fertilization levels applied, 100 and 200 kg N/ha, lies on the lower and upper boundary OSPA Braşov recommendations for autumn potato crops. The variants were realized with two complex fertilizers administered before planting: C15-15-15, for NPK report 1:1:1 and C5:10:22 supplemented with ammonium nitrate through which was achieved the NPK report of 1:0.9:2.
The researches were conducted in two years with very different growth conditions from the climatic point of view. From October 2012, to March 2013, prior to the potato crop, the average temperature was 0.9°C higher (Table 1), face of Multi-annual Average (MMA).
Rainfall amount achieved was practically equal with the value characteristic for this area.
In 2014, preliminary period to potato crop was characterized by a fall-winter particularly mild with 2.5°C higher than the average. The amount of rainfall in winter has been closely to MMA for Braşov area, ensuring a good supply of water into the soil.

Table 1. Average temperatures and the amount of rainfall, 2012-2013 and 2013-2014 (Braşov)

Year	Average temperature °C			The amount of rainfall mm		
	MMA	Achieved	Deviation	MMA	Achieved	Deviation
Winter period (October – March)						
2012-2013	0.7	1.6	+0.9	177.0	174.9	-2.1
2013-2014		3.2	+2.5		172.6	-4.4
Vegetation period (April – September)						
2013	14.6	16.0	+1.4	457.4	422.2	-35.2
2014		15.3	+0.6		505.1	+47.7

In 2013, vegetation period was characterized by higher temperatures than normal, the average exceeding with 1.4°C the MMA value. In 2014, between April-September, monthly average temperatures were close to normal.
With all that in 2013 the amount of rainfall was approaching fallen (92.3%) of the value of a multi-annual, the level of rainfall was very low since the second decade of July until mid-August (Figure 1).

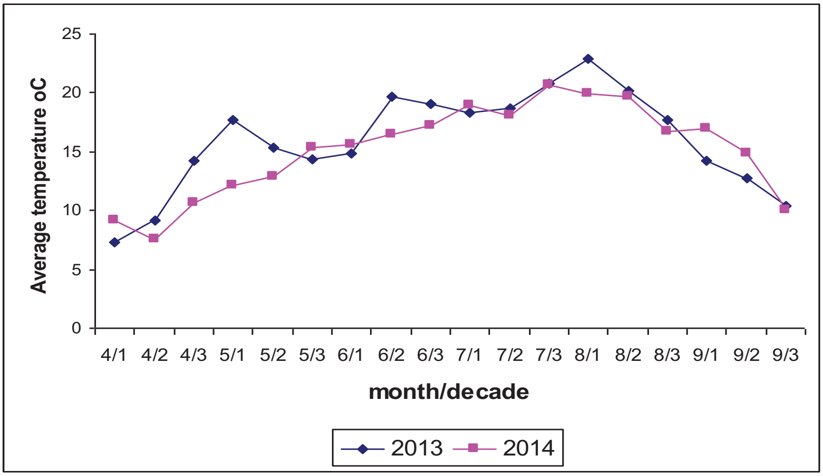


Figure 1. Average temperatures (monthly decade) during the growing season Braşov 2013-2014

In 2014, by the end of July, the thermo-hydrate conditions were very favorable for potato plants growth. High temperatures and low rainfall in August led to the maturation of the plant and end of vegetation in case of Christian and Roclas varieties (Figure 2).

In the years 2013-2014, soil samples were pick up and analyzed at University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Soil-Plant Laboratory, in accordance with the methodology recommended by the I.C.P.A. Bucharest. In the two years, 2013-2014, analyzed soil had a ph=5.3 respectively 8.3, good supply of organic matter 3.6-4.8%, poor in phosphorus supply 62-21 ppm P-AL, good in potassium supply 260-400 ppm K-AL and a good in nitrogen supply $I_{N=}2.3$ respectively 4.6.

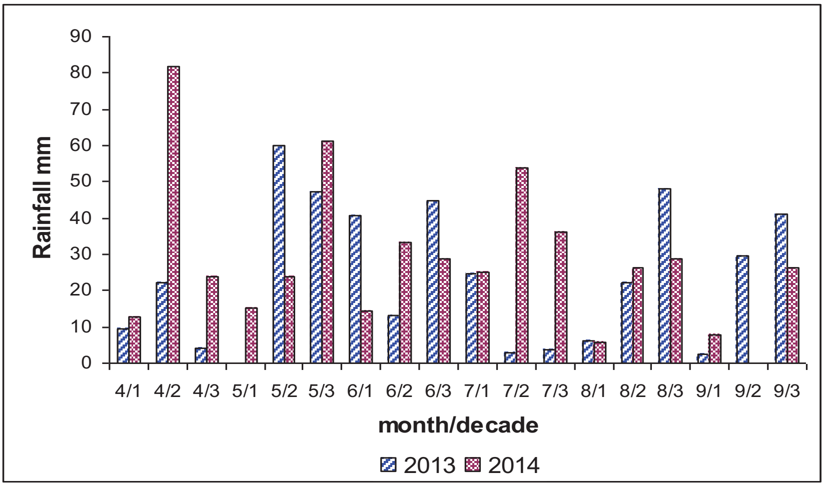


Figure 2. The amount of rainfall during vegetation period (monthly decade), Braşov 2013-2014

RESULTS AND DISCUSSIONS

Very different growing conditions in those two years are led to large differences in yield from one year to the next, for all the research factors and interactions (Table 2). On average, in 2013, on the trial was realized a yield of 26.9 t/ha, while in 2014, the experimental yield was 47 t/ha.

Table 2. Effects of different fertilization with NPK dozes and reports on the total yield of tuber - Christian and Roclas varieties (Braşov 2013-2014)

Variety	Report NPK	Dozes N Kg/ha	Total yield t/ha		
			2013	2014	Average
Christian	1:1:1	100	26.3 fg	44.3 cde	**35.3 abc**
		200	24.6 fg	45.3 bcd	**35.0 bc**
	1:0,9:2	100	29.2 fg	43.7 de	**36.4 abc**
		200	26.4 fg	38.4 e	**32.4 c**
Roclas	1:1:1	100	29.4 f	50.5 bc	**39.9 a**
		200	27.3 fg	51,0 b	**39.2 ab**
	1:0.9:2	100	30.2 f	45.6 bcd	**37.9 ab**
		200	22.4 g	57.4 a	**39.9 a**
Average report NPK	**1:1:1**		**26.9 b**	**47.8 a**	**37.3**
	1:0,9:2		**27.1 b**	**46.2 a**	**36,6**
Average dozes N kg/ha	**100**		**28.8 b**	**46.0 a**	**37.4**
	200		**25.2 c**	**48.0 a**	**36.6**
Average varieties	**Christian**		**26.6 c**	**42.9 b**	**34.8 -**
	Roclas		**27.3 c**	**51.1 a**	**39.2 ***
Average years			**26.9**	**47.0 ***	

DL (year) 5% = 6.2 t/ha LDS (year*variety) 5% = 5.1 t/ha
DL (variety) 5% = 3.6 t/ha LDS (year*rep) 5% =3.0 t/ha
DL (report) 5% = 2.1 t/ha LDS (year*dozes) 5% = 3.0 t/ha
DL (dozes N) 5% = 2.1 t/ha LDS (year*variety*rep*dozes) 5% = 6.0 t/ha

The potato varieties have differed significantly from each other, the yield of Roclas variety averaging 39.2 t/ha higher than 34.8 t/ha of Christian variety.

On average, in those two years, NPK report, with higher potassium level did not influenced significantly the total yield of Christian and Roclas varieties. Were found weak growths of tubers yield with diameters bigger than 60 mm on behalf of productions of tuber fraction 35-60 mm.

The only significant effects of increasing nitrogen dose of 100 to 200 kg/ha have been recorded at the ratio 1:0.9:2 which in 2013 determined the decrease of the total yield from 30.2 t/ha to 22.4 t/ha. In 2014, by increasing the level of nitrogen the total yield of tubers has grown from 45.6 t/ha to 57.4 t/ha.

In 2013, due to scarcity of rainfall during yield accumulation, at high doses of nitrogen was observed light yield declines of all fertilization variants and on both potato cultivars. In the year with favourable thermo-hydrate conditions for potato (2014), with the exception of high potassium report on Christian variety, the trends of yield increases were statistically insignificant. The response to N fertilization varies greatly with sites and climatic conditions and that field specific recommendations are required for the optimum management of N (Belanger, 2000).

In 2013 have not become manifested significant structural changes due to fertilization on studied potato varieties. The yield structure of both varieties was significantly amended by increasing the tuber yield in a favourable year, 2014 (figure 3 and 4). In this year on Roclas variety it appears that to the increased yield has contributed 35-60 mm fraction also. In 2013 and 2014, NPK ratio and dosage levels of nitrogen have not influenced the yield of small tubers.

The starch content of the tubers was significantly influenced by the growth conditions. In both potato varieties, the accumulation of tuber starch was significantly lower in 2014 face to 2013 (table 3). Higher ratio of NPK and nitrogen dose of 200 kg/ha resulted in decreasing of starch content in those two years, on average with 0.9-1.2%.

Downs potato starch content of Roclas variety, with the increase of the dose of potassium and nitrogen is more evident and statistically significant in both the years surveyed. The largest starch accumulation was recorded at NPK ratio 1: 1: 1 with nitrogen level of 100 kg/ha.

On Christian variety, it was revealed that the statistical effect of decrease in starch content is very strong at NPK ratio 1: 1: 1, with nitrogen level of 200 kg/ha.

For the studied period, correlation of total yield, commercial yield, yield from fraction bigger than 60 mm and fraction smaller than 35 mm with tubers starch content (table 4), was significant on Christian variety (r = -0.638***, -0.630***, -0.722***, -0.559***). On Roclas variety, only correlation between large tuber yield and starch concentration was significant (r=-0.433*).

Purposes of correlations indicate very significant downs starch content as a result of increases of yields.

In case of Roclas variety only the correlation between the tubers yield and starch concentration was significant (r = -0.433*).

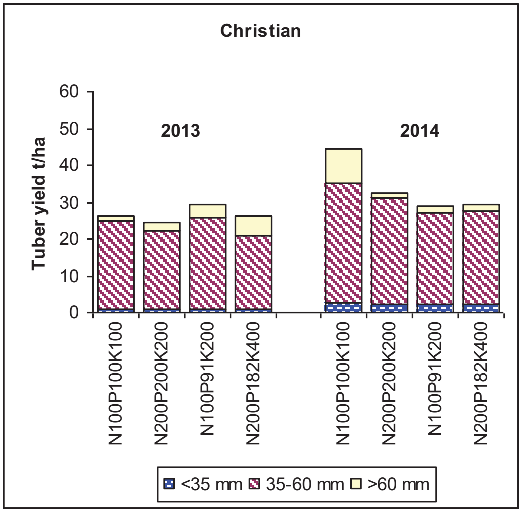


Figure 3. Yield size structure of Christian variety for different variants of fertilization

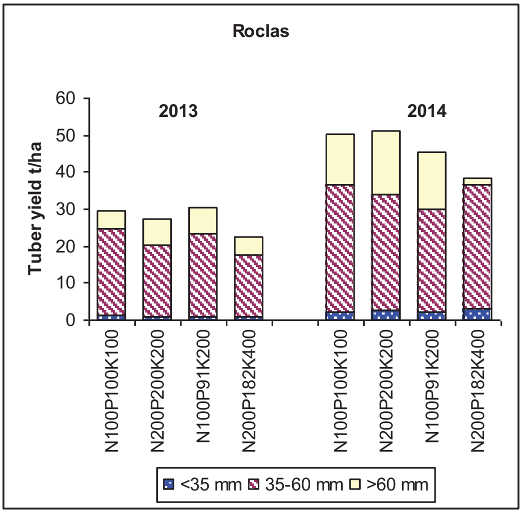


Figure 4. Yield size structure of Roclas variety for different variants of fertilization

Table 3. Effects of different fertilization with NPK dozes and reports on tubers starch content from Christian and Roclas varieties (Braşov 2013-2014)

Variety	Report NPK	Dozes N Kg/ha	Starch content %		
			2013	2014	Average
Christian	1:1:1	100	17.0 b	15.2 ef	**16.1 bc**
		200	16.3 bcd	13.5 g	**14.9 e**
	1:0.9:2	100	16.1 cde	14.4 f	**15.3 de**
		200	15.3 ef	12.5 h	**13.9 f**
Roclas	1:1:1	100	18.1 a	17.2 b	**17.7 a**
		200	16.8 bc	15.7 de	**16.2 bc**
	1:0.9:2	100	16.5 bcd	16.5 bcd	**16.5 b**
		200	16.0 cde	15.3 ef	**15.7 cd**
Average report NPK	**1:1:1**		**17.1 a**	**15.4 c**	**16.2 -**
	1:0.9:2		**16.0 b**	**14.7 d**	**15.3 ^{0}**
Average dozes N kg/ha	**100**		**16.9 a**	**15.8 b**	**16.4 -**
	200		**16.1 b**	**14.3 c**	**15.2 ^{0}**
Average varieties	**Christian**		**16.2 b**	**13.9 c**	**15.0 -**
	Roclas		**16.9 a**	**16.2 b**	**16.5 ***
Average years			**16.5**	**15.0 ^{0}**	

DL (year) 5% = 0.4 % LDS (year*variety) 5% = 0.6 %
DL (variety) 5% = 0.4 % LDS (year*rep) 5% = 0.4 %
DL (report) 5% = 0.3 % LDS (year*doze) 5% = 0.4 %
DL (dozes N) 5% = 0.3 % LDS (year*variety*rep*doze) 5% = 0.8 %

Table 4. Potato yield – starch content simple correlations and regressions

Yield structure mm	Christian				Roclas			
	Average t/ha	a	b	r	Average t/ha	a	b	r
Total	34.8	18.43	-0.098	-0.638***	39.2	17.48	-0.025	-0.316
>35	33.9	18.46	-0.103	-0.630***	37.42	17.49	-0,026	-0.314
> 60	7.9	16.43	-0.176	-0.722***	11.4	17.26	-0,065	-0.433**
35-60	25.2	17.10	-0.082	-0.269	26.1	17.03	-0,020	-0.135
<35	1.68	16.66	-0.965	-0.559***	1.8	17.18	-0.366	-0.304

CONCLUSIONS

In conditions of a non-irrigated crop, in 2013, with a deficit of moisture during the yield accumulation period, production results were not significant at increasing fertilizer NPK ratio 1:1:1 to 1:0.9:2, respectively on doubling the doses of nitrogen from 100 to 200 kg/ha at mid-early varieties Christian and Roclas.

In 2014 more favourable in terms of thermo-hydrate, the increases yields of Christian had not justified the increase in the level of fertilization, while the highest yield of Roclas (57.4 t/ha) was achieved by fertilization with NPK ratio 1:0.9:2 at a dose of 200 kg nitrogen/ha.

The yield structure of both varieties was significantly amended by increasing the yield with big tuber in 2014. In the same year it is found that to the increased yield of Roclas variety has contributed the 35-60 mm fraction also.

The starch content of the tubers was significantly influenced by the growth conditions, in both varieties, the accumulation of starch in tubers was significantly lower in 2014 comparatively with 2013.

Increasing doses of nitrogen on both cultivars in two years, independent of NPK ratio, caused the decrease in starch content.

ACKNOWLEDGEMENTS

This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

REFERENCES

Atkinson D., Geary B., Stark J., Love S., Windes J., 2003. Potato varietal responses to nitrogen rate and timing, Idaho Potato Conference, January 22.

Belanger G., Walsh J.R., Richards J.E., Milburn P.H., Ziadi N., 2000. Yield response of two potato cultivars to supplemental irrigations and N fertilization in New Brunswick. American Journal of Potato Research, 77: 11-21.

Laboski C.A.M., Kelling K., 2007. Influence of fertilizer management and soil fertility on tuber specific gravity: a reviw. American Journal of Potato Research, 84: 283-290.

Demeulemeeser K., Bries J., 2011. Managing processing quality of high yielding potato varieties by potassium. The 18th Triennial Conference of the European Association for Potato Research, July 24-29, Oulu.

Cucci G., Lacolla G., 2007. Effects of different fertilizing formulae on potato. Italian Journal of Agronomy, 3: 275-279.

Ianoşi I.S., Ianoşi Maria Elena, Plămădeală B., Popescu A., 2002. Cultura cartofului pentru consum. Ed. Phoenix 2002.

Davenport J.R., 2000. Potassium and specific gravity of potato tubers. Better Crops, Vol. 84, nr. 4.

Kelling K.A., Panique E., Speth P.E., Stevenson W.R., 2002. Effect of potassium rate, source and application timing on potato yield and quality. Idaho Potato Conference, January 23.

Lisińska G., Leszczyński W., 1989. Potato science and technology. Elsevier Applied Science.

Mikkelsen R., 2006. Best management practices for profitable fertilization of potatoes. Better Crops, vol 90, nr. 2.

Eleiwa M.E., Ibrahim S.A., Mohamed M.F., 2012. Combined effect of NPK levels and foliar nutritional compounds on growth and yield parameters of potato plants (*Solanum tuberosum* L.). African Journal of Microbiology Research, Vol. 6(24), p. 5100-5109.

Imas P., Bansal S.K., 1999. Potassium and integrated nutrient management in potato. Global Conference on Potato, New Delhi, India.

Zebarth B.J., Rosen C.J., 2007. Research perspective on nitrogen BMP development for potato. American Journal of Potato Research, 84: 3-18.

*** www.potato.nl.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESULTS REGARDING THE CORRELATION OF THE YIELD OF GRAINS WITH THE YIELD OF DRY MATTER AT MAIZE CROP

Adrian Gheorghe BĂŞA[1], Viorel ION[1], Marin DUMBRAVĂ[1], Alexandru FÎNTÎNERU[1], Lenuța Iuliana EPURE[1], Georgeta DICU[2], Daniel STATE[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Marasti Blvd, 011464, Bucarest-1, Romania
[2]SC Procera Agrochemicals Romania SRL,
47 Muncii Street, 915200, Fundulea, Calarasi, Romania

Corresponding author email: adibasa@agro-bucuresti.ro

Abstract

Under optimal conditions it is expected that grain yield correlates positively, at least to some point with the biological yield, respectively the yield of above-ground dry biomass. But, the influence of different growing factors affects this correlation. In this respect, the aim of the paper was to present the results we have obtained at maize in South Romania at different hybrids and under different growing conditions (different environmental and technological conditions) regarding the correlation of the yield of grains with the yield of dry matter. In view to achieve this aim, field experiments were performed in 2012 and in 2013 in different locations from South Romania. In 2012, ten maize hybrids were studied in four locations, while in 2013 five maize hybrids were studied in two locations, which represented different soil and climatic conditions. Moreover, in 2013 each studied hybrid was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and three plant densities (60,000, 70,000, and 80,000 plants ha^{-1}). Under climatic conditions of 2012 and in different locations from South Romania, the yield of grains of the studied maize hybrids correlated positively with the yield of dry matter. At different row spacing and plant populations, the yield of grains correlated differently with the yield of dry matter according to growing conditions.

Key words: *maize, yield, grains, dry matter, growing conditions.*

INTRODUCTION

Maize (*Zea mays* L.) is a plant with a high grain yield potential. The yielding capacity of maize plant is determined by the yield components, which are those components that are participating to the yield formation (Ion et al., 2013). The yielding components are supposed to be dependent up to certain level by the biomass of maize plant. At its turn, the biomass of maize plant is depending on a sum of growth factors among which the cultivated hybrid, plant population, row spacing and soil conditions have a significant influence on the accumulation of the above-ground biomass and its repartition between plant components (Ion et al., 2014).

There are authors who found that biological yield is the most influential factor affecting grain yield of maize cultivars, and as a consequence the high yielding cultivars of maize can only be achieved by increasing plant biomass (Ghassemi-Golezani and Tajbakhsh, 2012). Hybrid, population density and row spacing interact to influence whole-plant yield (Baron et al., 2006). Row spacing and plant density were found to have a site specific influence (Baloyi, 2013). Researches on twin rows planting configurations are still new and needs further evaluation (Gozubenli et al., 2004).

Under optimal conditions it is expected that grain yield correlates positively, at least to some point with the biological yield, respectively the yield of above-ground dry biomass. But, the influence of different growing factors affects this correlation.

The aim of the paper was to present the results we have obtained at maize in South Romania at different hybrids and under different growing conditions (different environmental and technological conditions) regarding the correlation of the yield of grains with the yield of dry matter.

MATERIALS AND METHODS

Researches were performed in field experiments in 2012 and in 2013 in different locations from South Romania, which represented different soil and climatic conditions.

In 2012, researches were performed in field experiments with ten maize hybrids, respectively: CERA 270 (FAO group 270), CERA 290 (FAO group 290), CERA 370 (FAO group 370), CERA 390 (FAO group 390), CERA 6 (FAO group 390), CERA 420 (FAO group 420), CERA 2504 (FAO group 440), CERA 4505 (FAO group 450), Baragan 48 (FAO group 480), and CERA 10 (FAO group 540).

The maize hybrids were studied in four locations from South Romania, respectively: Fundulea, Calarasi County; Valcelele, Calarasi County; Visani, Braila County; Posta Calnau, Buzau County.

The year 2012 could be characterized as warm and dry, with temperatures higher than multiannual averages, especially in April and August, and with rainfalls less than multiannual averages in summer months, especially in July (only 2 mm, which means about 70 mm deficit).

The plant density was in average for the ten studied hybrids of 66,000 plants ha^{-1} at Fundulea, 62,600 plants ha^{-1} at Valcelele, 63,400 plants ha^{-1} at Visani, and 62,800 plants ha^{-1} at Posta Calnau.

In each location and for each maize hybrid, two plants in four replications (in total eight plants) were cut at soil level and they were analysed for establishing the yield of grains and the yield of dry matter. The dry matter was determined by oven drying the plants 24 hours at a temperature of 80°C.

In 2013, researches were performed in field experiments with five maize hybrids, respectively: Cera 440 (FAO group 440), Flanker (FAO group 450), ES Feria (FAO group 550), PR35T36 (FAO group 500), and Cera 540 (FAO group 540).

The maize hybrids were studied in two locations, respectively: Fundulea from Calarasi County and Moara Domneasca from Ilfov County.

Each hybrid was studied under three row spacing (75 cm, 50 cm, and twin-rows of 75/45 cm) and three plant densities (60,000, 70,000, and 80,000 plants ha^{-1}).

In each location and from each variant the maize plants from one square meter were cut at soil level and were weighed immediately. The ears were collected and analysed in view to be determined the yield of grains. One maize plant for each variant was taken into the laboratory, where it was determined the dry biomass by oven drying at 80°C for 24 hours, as to be determined the yield of dry matter.

In both experimental years, the determinations were performed at fully ripe stage. The yield of grains was calculated in $kg.ha^{-1}$ at moisture content of 14%. The yield of dry matter was calculated in $kg.ha^{-1}$ and represents in fact the yield of above-ground biomass.

RESULTS AND DISCUSSIONS

Under climatic conditions of 2012, the yield of grains of 10 maize hybrids correlated positively with the yield of dry matter (expressed as above-ground dry biomass) at maize crop in different locations from South Romania (Figure 1). This means the highest yields of grains were registered at the highest yields of dry matter.

Under climatic conditions of 2013 and at 75 cm between rows, the yield of grains did not correlated very well with the yield of dry matter compared to the situation registered in 2012 (Figure 2). Moreover, in Fundulea location characterised by better growing conditions the yield of grains correlated positively with the yield of dry matter, while in Moara Domneasca location characterised by not so good growing conditions and even by drought in 2013, the yield of grains correlated negatively with the yield of dry matter. That means that when the growing conditions are less favourable the plant density should be lower, which means less dry matter yield. Also, under less favourable growing conditions there were register a wider variation of the data.

Under climatic conditions of 2013, as in the case of the row spacing of 75 cm, the yield of grains correlated positively with the dry matter at row spacing of 50 cm (Figure 3.a) and twin-rows of 75/45 cm (Figure 4.a), but only in

Fundulea location characterised by better growing conditions. In exchange, in Moara Domneasca location, respectively under less favourable growing conditions, at 50 cm between rows the yield of grains correlated negatively with the dry matter up to a point and after that the correlation became positive (Figure 3.b). At twin-rows of 75/45 cm and in Moara Domneasca location, on the contrary the yield of grains correlated positively with the dry matter up to a point and after that the correlation became negative (Figure 4.b).

At different plant densities, the yield of grains correlated positively with the dry matter in Fundulea location, the best correlation being registered at plant density of 70,000 plants.ha^{-1} while the worst correlation being registered at plant density of 80,000 plants.ha^{-1} (Figures 5.a, 6.a, 7.a). Also, at plant density of 70,000 plants.ha^{-1} there was registered the smallest dispersion of data.

In Moara Domneasca location, with less favourable growing conditions, the yield of grains correlated negatively with the dry matter at least up a certain point, especially at 50,000 and 80,000 plants.ha^{-1} (Figures 5.b, 6.b, 7.b).

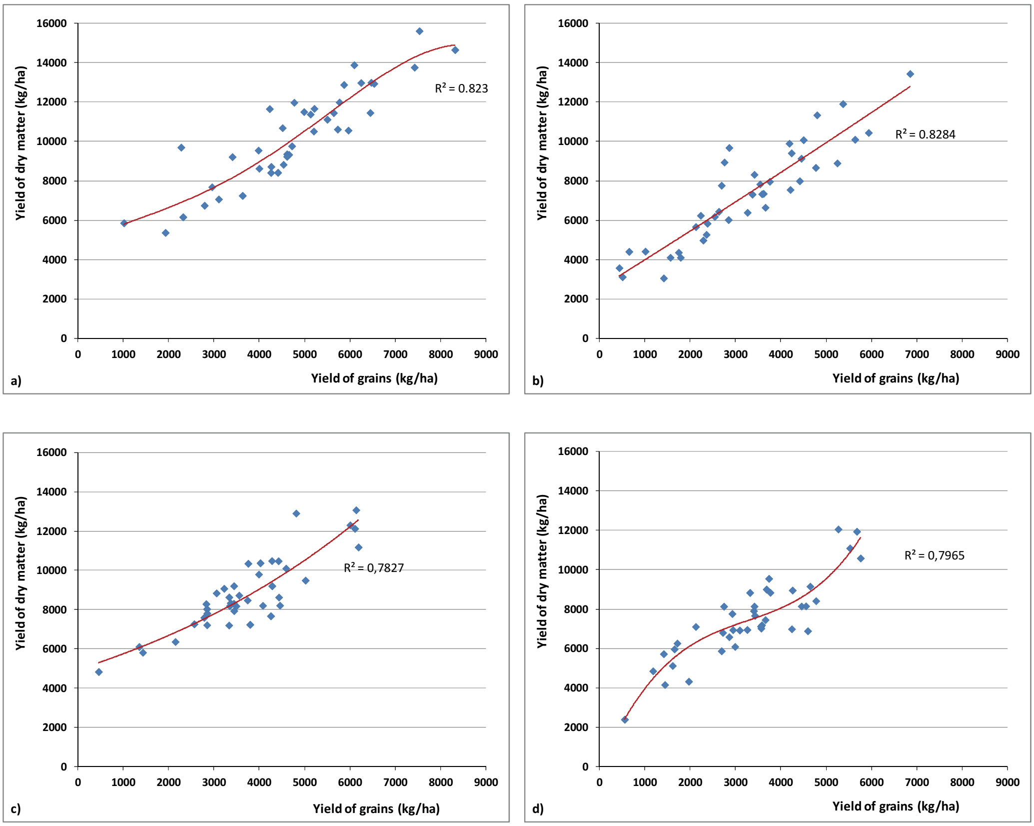


Figure 1. Correlation of the yield of grains with the yield of dry matter at maize crop in different locations from South Romania and under climatic conditions of 2012

(a- Fundulea, Calarasi County; b- Posta Calnau, Buzau County;c- Visani, Braila County; Valcelele, Calarasi County)

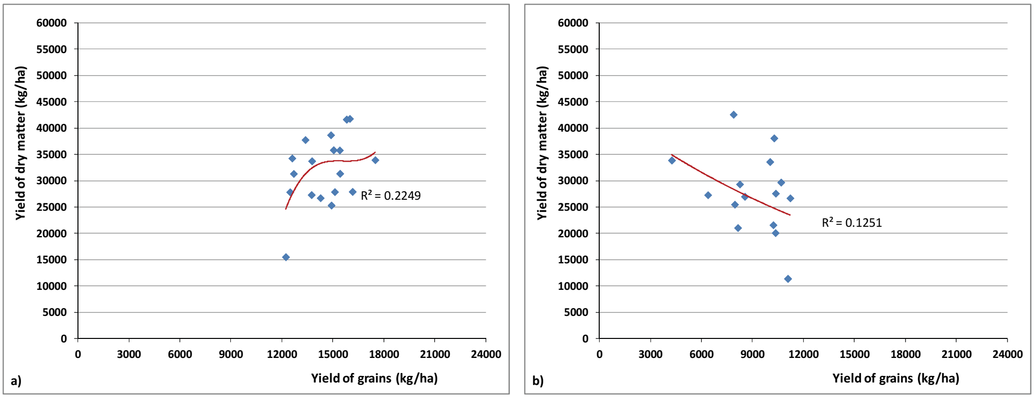


Figure 2. Correlation of the yield of grains with the yield of dry matter at maize crop at row spacing of 75 cm and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

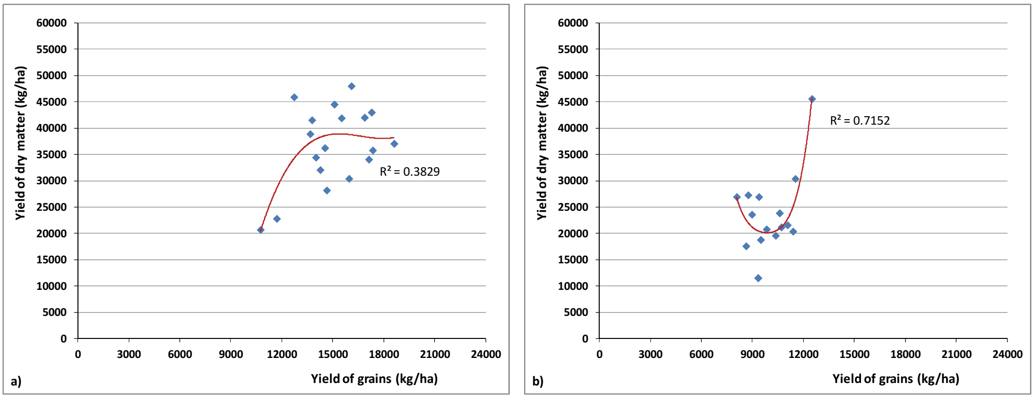


Figure 3. Correlation of the yield of grains with the yield of dry matter at maize crop at row spacing of 50 cm and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

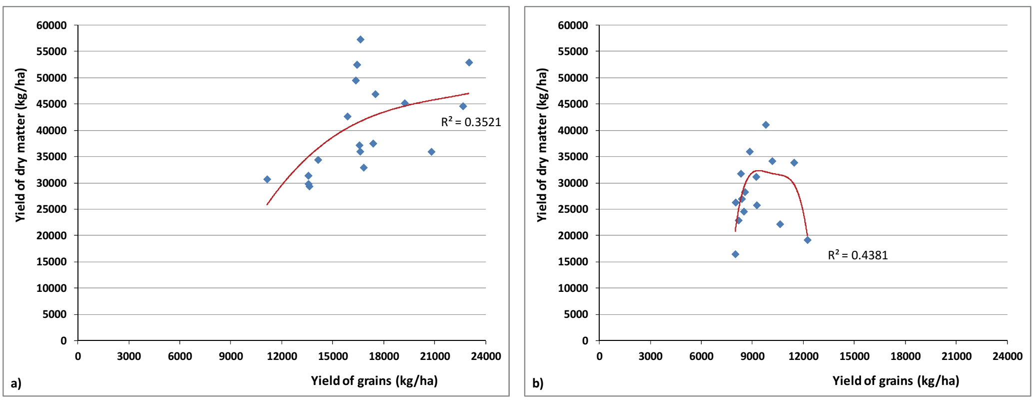


Figure 4. Correlation of the yield of grains with the yield of dry matter at maize crop at twin-rows of 75/45 cm and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

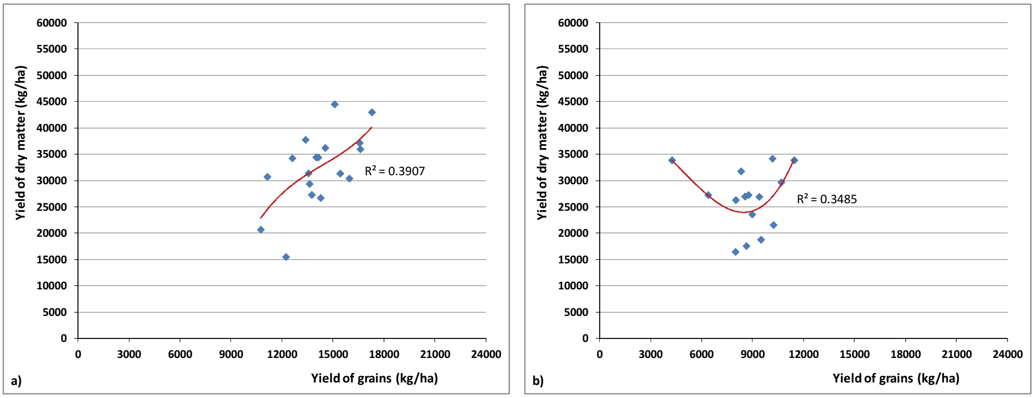


Figure 5. Correlation of the yield of grains with the yield of dry matter at maize crop at plant density of 60,000 plants/ha and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

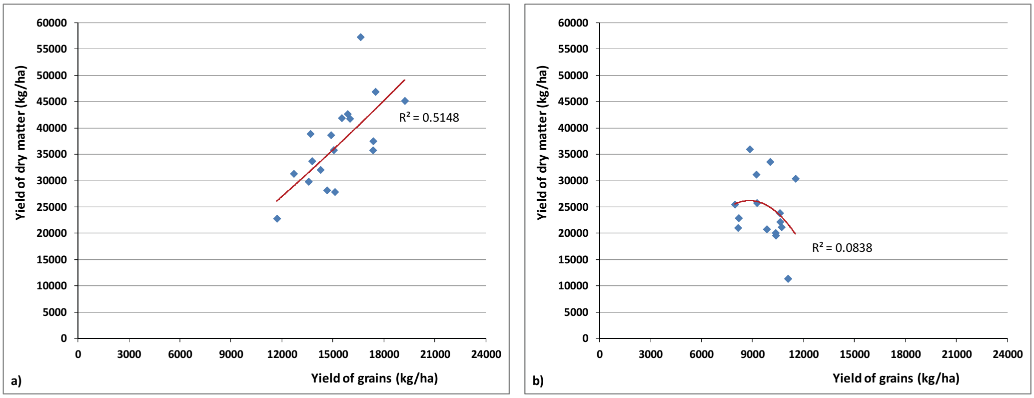


Figure 6. Correlation of the yield of grains with the yield of dry matter at maize crop at plant density of 70,000 plants/ha and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

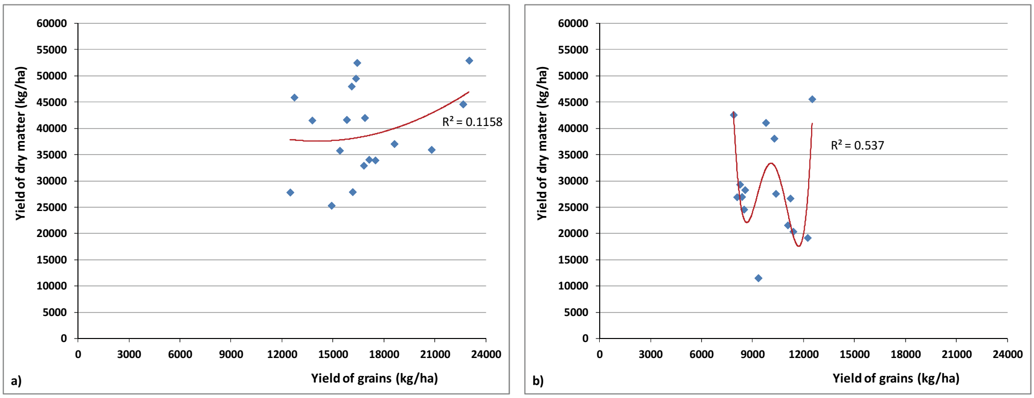


Figure 7. Correlation of the yield of grains with the yield of dry matter at maize crop at plant density of 80,000 plants/ha and under climatic conditions of 2013 (*a- Fundulea, Calarasi County; b- Moara Domneasca, Ilfov County)*

CONCLUSIONS

Under climatic conditions of 2012 and in different locations from South Romania, the yield of grains of the studied maize hybrids correlated positively with the yield of dry matter (above-ground dry matter).

At different row spacing, the yield of grains correlated differently with the yield of dry matter according to growing conditions. Thus, under favourable growing conditions at different row spacing, the yield of grains correlated positively with the yield of dry matter, while under less favourable growing conditions the tendency was the yield of grains to correlate negatively with the yield of dry matter.

Also at different plant densities, the yield of grains correlated differently with the yield of dry matter according to growing conditions. Thus, under favourable growing conditions at different plant densities, the yield of grains correlated positively with the yield of dry matter, while under less favourable growing conditions the tendency was the yield of grains to correlate negatively with the yield of dry matter.

ACKNOWLEDGEMENTS

The researches carried out for the elaboration of the present paper were financed by Romanian Program "Partnerships for Priority Domains", project PN-II-PT-PCCA-2011-3.2-1778 "OPTImization of BIOMass and Approach to Water conservation" (OPTIBIOMA-W), Contract no. 45/2012.

REFERENCES

Baloyi T.C., 2013. Maize grain yield response to variance in plant density under minimal soil disturbance and row spacing. Agricultural Science Research Journals Vol. 3(8): 250-260.

Baron V.S., Najda H.G., Stevenson F.C., 2006. Influence of population density, row spacing and hybrid on forage corn yield and nutritive value in a cool-season environment. Canadian Journal of Plant Science, 86: 1131-1138.

Ghassemi-Golezani K., Tajbakhsh Z., 2012. Relationship of plant biomass and grain filling with grain yield of maize cultivars. International Journal of Agriculture and Crop Sciences, Vol. 4 (20): 1536-1539.

Gozubenli H., Kilink M., Sener O., Konuskan O., 2004. Effects of single and twin row planting on yield and yield components in maize. Asian Journal of Plant Scinces, 3 (2): 203-206.

Ion V., Dicu G., State D., Fintineru G., Epure L.I., Basa A.G., Toader M., 2013. Yield components of different hybrids of maize (*Zea mays* L.) cultivated in South Romania under drought conditions. Scientific Papers. Series A. Agonomy, Vol. LVI, p. 276-283.

Ion V., Băşa A.Gh., Temocico G., Dicu G., Epure L.I., State D., 2014. Maize plant biomass at different hybrids, plant populations, row spacing and soil conditions. Romanian Biotechnological Letters, Vol. 19, No 4, p. 9551-9560.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON *ALTERNARIA* SPECIES PRESENT ON RAPESEED (*Brassica napus*) IN THE SOUTH REGION OF ROMANIA

Lavinia-Mariana BERCA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Marasti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: laviniamariana.berca@gmail.com

Abstract

Alternaria species have a variable affinity for host although they are often found in conjunction. The aim of this study was to compare the distribution of six Alternaria species present in infected seeds samples taken directly from two districts in South Romania. Ten samples of seeds were taken directly from ten different growing fields in Teleorman and Calarasi, in June, just prior to harvest. For each of the ten samples has been performed three replicates, each of five seeds. Overall 150 seeds were placed on Petri dishes (ø 10 cm) on PDA. A semi-permanent slides was performed from each of the colonies formed around the seeds after 10 days of incubation, at 21ºC. These slides were analyzed, field by field, under a microscope (x40), until 50 conidia of Alternaria species were identified. For each replicate an average of 2350 conidia (150-250 conidia/ plate) were identified with certainty on 94% in vitro colonies formed by pathogens around the seeds. Alternaria brassicicola was the most frequent species identified on seeds from growing fields in Calarasi (53.91%) and Teleorman (57.12%). We found that A. brassicicola and A. brassicae were present on all infected seeds whereas A. brassicicola, A. brassicae and A. radicina were detected on 93.62% colonies formed around the seeds. The relative distribution of A. brassicae ($p < 0.0001$), A. brassicicola ($p < 0.0001$), A. radicina ($p = 0.001$) and A. solani ($p = 0.0003$) in samples from Calarasi and A. radicina ($p = 0.004$), A. solani ($p = 0.028$), A. tenuis ($p = 0.0006$) in samples from Teleorman were found be present statistical significant differences. Overall these results indicated that the distribution of Alternaria species can present significant variations even if samples from the same district are investigated.

***Key words**: seeds, rapeseed pathogens, Alternaria, Romania.*

INTRODUCTION

Brassica napus ($2n = 38$) is cultivated in most European countries and performs well in a range of soil conditions, providing adequate moisture and fertility levels. The seeds are rich in proteins and oil (rapeseed contain an average of 40% oil on a dry matter basis) being used for rape oil. This plant is of interest for industry (humans or animals food industry, detergent lubrication oils, soap manufacture, production or erucic acid), medicine and research (Lim, 2013; Alvarez et al., 2001).
The seed yields vary from 900 to 3,000 kg/ha but decreases dramatically after infectious diseases (e.g. produced by fungi, bacteria, mollicutes, viruses,) and environmental damages (e.g. herbicide injury, nutrient deficiencies, postharvest disorders). Thus, diagnose and management of these diseases of *Brassica* species are of interest for farmers, pathologist, industry and seed providers (Rimmer, 2007; Afonin et al., 2008). *Alternaria* species is a diverse group of pathogenic and saprophytic fungi (Gherbawy, 2005) widespread distributed in soil and organic matter (Cristea et al., 2008; Cristea and Berca, 2013; Mardare et al., 2014; Pana et al., 2014; Cristea et al., 2015). Some *Alternaria* species were often found in conjunction in growing fields (Nowicki et al., 2012) and on *Brassica napus* seeds. The species responsible for Alternaria leaf spot disease can affect all stages of plants growth and have a wide range of negative effects on photosynthesis and production in wet seasons (Perelló et al., 2013; Shrestha et al. 2000). It is known that *A. brassicicola* and *A. brassicae* may be detected on surfaces and into the seed tegument and also in organic material (Rangel 1945; Humpherson-Jones, 1989, Humpherson-Jones and Phelps, 1989). The main ways of transport for pathogens are the diseased seed, while tools, animals, water and wind represent ways to disseminate the conidia.

Investigations of the relationship between different environmental factors and distribution of *Alternaria* species contribute to understanding disease epidemiology and measures necessary for prevention or protection of growing fields (Lou et al., 2013).

In Romania, rape area was 46,859 ha in the Calarasi County (2013) and 23,758 ha (2013), in the Teleroman County and represented 53.3% of the country' surfaces, with a production of 187,261 tonnes in 2013 (INSSE – Baze de date statistice). The wind and rainfall from agricultural areas from Teleorman and Calarasi can be permisive for *Alternaria* species development.

The aim of this study was to compare the distribution of six *Alternaria* species present in seed samples taken directly from two districts in South Romania.

MATERIALS AND METHODS

The seed samples were taken directly from ten growing fields with signs of alternariosis from Calarasi (Drajna-3, Roseti-1, Dichiseni-1) and Teleorman county (Draganesti Vlasca-2, Calomfiresti-2, Frasinet-1), in June 2014 (26-29 June), just prior to harvest (Figure 1).

Overall 150 seeds were used to perform three replicates for each of the ten samples. For each replicate five seeds from the same sample were placed on Petri dishes (ø 10 cm) on PDA culture medium (potato- dextrose- agar). The seeds have been not disinfected before this stage because we want to estimate the presence of *Alternaria* on seeds surface not into seeds tissues. The seeds were incubated for 10 days, at 21ºC (Hulea, 1969; Constantinescu, 1974). The in vitro colonies formed by pathogens were inspected and were white-gray and brown to black on the reverse side. The Petri dishes were stored at 5ºC until they were investigated.

A semi-permanent slide was performed for each colony formed around the seeds after 10 days of incubation.

The slides were examined under a microscope (x40), field by field, until 50 *Alternaria* spores were identified (Raicu and Baciu, 1978).

For each replicate an average of 2350 conidia (150-250 conidia/plate) was counted. The number of *Alternaria brassicae, Alternaria brassicicola, Alternaria radicina, Alternaria dauci, Alternaria solani* and *Alternaria tenuis* conidia identified on each slide was recorded.

Figure 1. The map of the South Region of Romania

The tables with distribution of *Alternaria* species was compared with χ^2 or Fisher test (rxc) using StatsDirect software (version 2.8.0). A p values < 0.05 was considered statisticaly significant.

RESULTS AND DISCUSSIONS

Overall, an average of 2350 conidia / replicate (150-250 conidia/plate) has been identified with certainty as *Alternaria* species on *in vitro* colonies formed by pathogens around the 94% of seeds (Figures 2 and 3). In addition the identity of 6.67% *Alternaria* species was not certain and they were excluded from analysis.

Figure 2. The Spores (conidia) of *Alternaria* species (light microscope, 40x)

The average of percentage distribution of the six *Alternaria* species in all colonies formed in *vitro* indicated that the predominant species are *A. brassicicola* (56%), *A. brassicae* (20%) and *A. radicina* (12%) while the other three species are rarer and have a frequency less than 10% (Figure 4).

The main results obtained on samples from each districts are presented in Table 1.

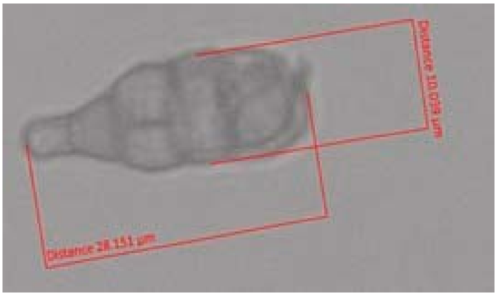


Figure 3. The Spores (conidia) of *Alternaria* species (light microscope, 40x)

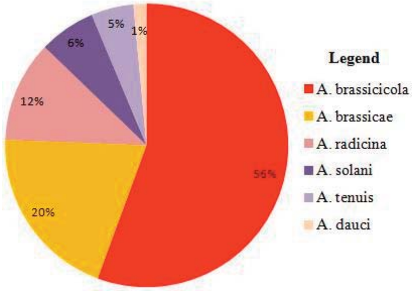


Figure 4. The percentage distribution of *Alternaria* species in 10 growing fields affected by alternaria leaf spot disease in Calarasi and Teleorman

When the relative distributions of the *Alternaria* species were compared in relation to provenience of seeds samples, the relative distribution of the six species was found to be similar and *Alternaria brassicicola* was the most frequent species identified in booth County (Calarasi: 53.91%, Teleorman: 57.12%).

The differences between relative distributions of these species are not significant. When the distribution of each species was analysed the highest differences between districts were identified for *A. brassicae* and *A. tenuis*.

Identification of what *Alternaria* species is more frequent on seeds it is important to establish the phytosanitary state of seed lot.

Next, the relative distributions of *Alternaria* species which are detected on the seeds taken from the same plate were tested.

The results presented significant differences in three samples from Teleorman and two samples from Calarasi (50% of samples). The highest differences ($p < 0.0001$) were recorded for the seeds harvested from Calomfiresti (Teleorman). The last test compared the distribution of each *Alternaria* species present on all seeds taken directly from growing fields from a single district. The results indicated that *A. brassicae* ($p < 0.0001$), *A. brassicicola* ($p < 0.0001$), *A. radicina* ($p = 0.001$) and *A. solani* ($p = 0.0003$) from Calarasi samples and A. *radicina* ($p = 0.004$), *A. solani* ($p = 0.028$), A. *tenuis* ($p = 0.0006$) from Teleorman samples were found to present a different distribution.

The results obtained from the last two tests indicated that the distribution of *Alternaria* species is influenced by different local factors.

Table 1. The percentage distribution of the six *Alternaria* species found on 150 seeds from ten growing fields in Calarasi and Teleorman

District	Parameter	*A. brassicicola*	*A. brassicae*	*A. radicina*	*A. solani*	*A. tenuis*	*A. dauci*
Calarasi	average %	53.91	22.09	11.09	7.45	3.64	1.82
	minimum %/plate	24	2	0	0	0	0
	maximum %/plate	76	46	30	20	10	14
Teleorman	average %	57.12	18.16	12	5.60	5.92	1.20
	minimum %/plate	24	4	0	0	0	0
	maximum %/plate	26	80	30		18	20

CONCLUSIONS

We found that fungus colonies surrounded 94% of the 150 seeds from growing fields affected by alternariosis. *A. brassicicola* (56%), *A. brassicae* (20%) and *A. radicina* (12%) are the most common species of *Alternaria* on these seeds.

Mixed infections with different *Alternaria* species seem to be common in investigated growing fields in Calarasi and Teleorman.

ACKNOWLEDGEMENTS

This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

REFERENCES

Afonin A.N., Greene S L., Dzyubenko N.I., Frolov A.N., 2008. Interactive agricultural ecological atlas of Russia and neighboring countries. Economic plants and their diseases, pests and weeds. (http://www.agroatlas.ru/, accesed in March 2015).

Alvarez M.J., Estrada J.L., Gozalo F., Fernandez-Rojo F., Barber D., 2001. Oilseed rape flour: another allergen causing occupational asthma among farmers. Allergy, vol. 56: 185-188.

Constantinescu O., 1974. Metode şi tehnici în micologie. Ed. Ceres, Bucureşti.

Cristea S., Georgescu M., Patrascu N., Groza O., 2008. Research regarding the pathology and anatomy of the seed-the extension of wheat Karnel. Lucrări Ştiinţifice, seria Agronomie, vol xxx: p. 831-838.

Cristea C.M., Berca M., 2013. Researches concerning the caryopses micoflora of wheat to the varieties grown in Modelu location, Calarasi county. Research Journal of Agricultural Science, vol. 45 (1): 139-143.

Cristea (Manole) M.S., Cristea S., Ză1ă C., 2015. Research on micoflora present in the caryopses of wheat (*Triticum aestivum*) in the S-E of Romania, in terms of 2014. Romanian Biotechnological Letters, vol. 20(1): 10183-10189.

Gherbawy Y., 2005. Genetic variation among isolates of *Alternaria spp*. from select Egyptian crops. Archives of Phytopathology and Plant Protection, 38(2): 77-89.

Hulea, A., 1969. Ghid pentru laboratoarele de micologie şi bacteriologie. Editura Agrosilvica, Bucureşti.

Humpherson-Jones F.M., 1989. Survival of *Alternaria brassicae* and *Alternaria brassicicola* on crop debris of oilseed rape and cabbage. Annals of Applied Biology, vol. 115: 45-50.

Lou J., Fu L., Peng Y., Zhou L., 2013. Metabolites from Alternaria fungi and their bioactivities. Molecules, vol. 18(5): 5891-935.

Humpherson-Jones F.M., Phelps K., 1989. Climatic factors influencing spore produciton in *Alternaria brassicae* and *Alternaria brassicicola*. Annals of Applied Biology, vol. 114: 449-458.

Lim T.K., 2013. *Brassica napus*. Edible Medicinal and non-medicinal plants fruits, vol. 5(Fruits): 72-104.

Mardare E.S., Cristea S., Zala C., 2014. Researches on the micoflora of sunflower's achenes for the hybrids cultivated in Fetesti area, Ialomita county. Lucrări Ştiinţifice, seria Agronomie, vol 57(2): 213-216.

Nowicki M., Nowakowska M., Niezgoda A., Kozik E.U., 2012. *Alternaria* black spot of crucifers: symptoms, importance of disease, and perspectives of resistance breeding. Vegetable crops research bulletin, vol. 76: 5-19.

Pană M., Cristea S., Cernat S., Negrilă E., 2014. The mycoflora of barley - the varieties extension certificated at ARDS – Teleorman. Lucrări Ştiinţifice, seria Agronomie, vol. 57(2): 217-220.

Perelló A.E., Larrán S., 2013. Nature and effect of *Alternaria spp*. complex from wheat grain on germination and disease transmission. Pakistan jopurnal of Botany, vol. 45(5): 1817-1824.

Raicu C., Baciu D., 1978. Patologia semintei. Editura Ceres, Bucuresti.

Rangel J.F., 1945. Two *Alternaria* diseases of cruciferous plants. Phytopathology, vol. 35: 1002-1007.

Rimmer S.R., Schattuck V.I., Buchwaldt L., 2007. Compendium on Brassica crop diseases. American Phytopathological Society. APS Press, p. 1-110.

Shrestha S.K., Mathur S.B., Munk L., 2000. Transmission of *Alternaria brassicae* in seeds of rapeseed and mustard, its location in seeds and control. Seed Science and Technology Journal, vol. 8: 75-84.

http://www.extento.hawaii.edu/kbase/crop/Type/a_bras1.htm (on-line resource, accesed in March 2015).

INSSE - Baze de date statistice (http://statistici.insse.ro/ accesed in March 2015).

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE STUDY OF SOME INBRED LINES OF MAIZE AND HYBRIDS F1 RESULTED FROM THEIR CROSSING

Dorina BONEA[1], Marin SOARE[1], Viorica URECHEAN[2], Rodica SOARE[1]

[1]University of Craiova, Faculty of Agriculture and Horticulture, Libertatii Street, no 19, 200583, Craiova, Dolj, Romania
[2]Agricultural Research and Development Station Simnic, road Balceşti, no. 54, 200721, Craiova, Dolj, Romania

Corresponding author email: dbonea88@gmail.com

Abstract

The genetic diversity is an important source of heterosis, which is more intense when extremes types participate. Also the information on the genetic diversity of inbred lines is fundamental for the germplasm multiplication and conservation. In this paper, the characterization and establishment of the phylogenetic relationships between the Romanian and foreign inbred lines were performed by using the phenotypic differentiation index (PDI total) calculated for 13 characters and the heterosis. The results show that the phenotypic differentiation index (PDI) can be an effective tool in forecasting maize hybrids, but not always the greatest PDI means also the greatest heterosis. F1 hybrids resulting from Romanian crossed inbred lines extracted from the IInd selection cycle from the national germplasm collection, present both a good specific combining ability and a good productivity for the parental forms, being the best from an economic point of view in the given conditions.

***Key words:** germplasm, heterosis, phenotypic differentiation index.*

INTRODUCTION

Maize (*Zea mays* L.) is one of the most valuable crops due to its multiple uses in food industry, animal husbandry and industry. The most important aspect concerning both researchers and farmers is the yielding capacity. The improvement of the yielding capacity begins with the selection of the inbred lines. The selection has to be associated with the testing of the general and specific combining ability as a measuring way of yielding capacity they give to hybrids.

Growing cultivated plant genetic resources, plant breeding and evaluation methods are important topics and they are also much debated. Present breeding programs aimed at searching older local populations valuable genes or other closely related species, including wild plants (Holubec, 2010).

Heterosis is a general biological character, which in the case of maize is both involved in morphological and physiological features. But the most important change in maize due to the heterosis bearing economic effects also that has led to the exploiting of this phenomenon by using hybrids between inbred lines is the reproductive heterosis (Has, 2004).

Today heterosis is considered to be an important means of increasing yield. The presence of enough hybrid strength is an important prerequisite for the successful production of hybrids and the heterotic studies can provide the basis for the exploitation of valuable hybrid combinations in the future breeding programmes (Thirupathi et al., 2012).

Thus, the largest maize growing countries (Romania included) cultivate this species mainly, growing especially simple hybrids (Voica, 2001). In Romania there are 2 721.2 thousand hectares (MADR, 2012) cropped with maize which makes it the first crop in order of cultivated surface.

The genetic diversity is very important when choosing inbred lines for hybridization programs (Banerjee and Kole, 2009).

There are many methods which have been used for the study of genetic diversity. The genetic diversity and its relationship with heterosis was studied by many authors (Hallauer et al., 1988; Smith, 1997; Bonea, 2001; Musat, 2008; Has et al., 2011).

Has et al. (2011) believe that the phenotypic evaluation of inbred lines is important since it prevents even many crosses, leading to a low cost within the breeding program and it also improves the assessment precision.
The estimation of the genetic variability of maize inbred lines based on phenotypic analysis is an important tool in order to carry out their identification and characterization. This type of analysis allows the observation of a species in relation to the plant's build and performances under biotic or a-biotic stress conditions since the environmental effect is always a stressful factor (Wietholter et al., 2008).
In Romania, in addition to the hybrids obtained from the local inbred lines (local populations and maize varieties cropped until the wide cropping of hybrids started to be generalized and used), foreign companies well known for their maize breeding and hybrid seed producing have introduced their own genetic material. This situation made us perform a comparative study of some Romanian and foreign inbred lines knowing that the information on the phenotypical and genetic diversity of inbred lines is fundamental for germplasm multiplication and conservation.

MATERIALS AND METHODS

The studied biological material was represented by ten inbred lines shown in Table 1, as well as six hybrids F1 resulted from crossing these lines.
The experiments took place at ARDS (Agricultural Research and Development Station) Simnic, Romania, in normal field conditions in 2009 and 2010 using the randomized block method with three repetitions. The ARDS is located at 44°19' N, 23°48' E, and 182 m height. The soils are luvosol.
Observations and grades have been made and given on the performance characters (grain yield, 1000 grain weight, grain-to-ear ratio, the note for the shriveled grain), plant's description elements (plant height, ear height, number of ears per plant, number of leaves per plant and foliar surface), ear characters (length, weight, diameter in the middle ear and the grade for the grain consistency).

Table 1. The studied biological material

Inbred lines and hybrids F1 resulted from crossing	The origin of inbred lines
Lc 235, Lc 151, Lc 64	Romanian inbred lines extracted from local populations from Oltenia, (obtained at ARDS Simnic)
Lc 235 x Lc 151	-
Lc 64 x Lc 235	-
Lc 408, Lc 406, Lc 403	Local maize germplasm extracted from the IInd selection cycle from national germplasm collection (obtained at National Agricultural Research and Development Institute -NARDI Fundulea)
Lc 408 x Lc 406	-
Lc 408 x Lc 403	-
Lc 9340, Lc 7445, Lc 4432, Lc 7619	Foreign inbred lines of German origin
Lc 9340 x Lc 7448	-
Lc 4432 x Lc 7619	-

For shrivelled of the grain there were given grades from 1 to 9 (1= very shriveled kernels; 9 = kernels full and well developed) and in the same way was done for the grain's consistency which received grades from 1 to 9 (1= dent, 9 = endured, glassy).
The genetic and phenotypic diversity of these ten inbred lines has been estimated based on:

- the calculation of the phenotypic differentiation index (PDI) using Herbert and Vincourt's formula (1985):

$$PDI = \sqrt{\sum(x_m - x_n)^2}$$

where: *Xm, Xn* – parental line average characters (m and n).

- in order to calculate the heterosis we used the formula proposed by Hallauer and Miranda (1981):

$$H\% = [F1-(P1+P2)/2]/[(P1+P2)/2]x100$$

where:

F1 = the average of the first hybrid generation and *(P1 + P2)/2* = average values for the parental forms P1 and P2.

RESULTS AND DISCUSSIONS

The average calculated values for the analyzed thirteen characters (four performance characters, five plant characters and four ear characters) cover the biometrical measurements on a two year period (2009 and 2010), when the experiments were carried out. These values express the *"per se"* value of a certain character for the inbred studied lines (Table 2). Making a comparison between the yield and its main elements for the studied inbred lines (Table 3) one can notice a superiority of the Romanian inbred lines. Higher grain yield for these Romanian inbred lines (10.0%) is mainly achieved due to ear weight (23.4%) and plants' height (10.4%).

The production capacity of inbred lines is an important aspect for the hybrid seed producer, but the real value of the inbred lines is given by their specific ability to carry through combinations. Therefore, the specific combining ability and the production capacity of Romanian and foreign maize inbred lines grown at ARDS Simnic have been intensively studied by Bonea and Urechean (2003), Bonea (2005), Bonea et al. (2009 a; 2009 b), Ilicevici (1994), Radu et al. (1994).

After the comparing (Table 4) the yield obtained and its main elements for the studied F1 hybrids we noticed a superiority of the foreign hybrids. The greater grain yield for the foreign hybrids (+13.5%) is achieved, especially, due to the higher vegetative strength showed by the foliar surface (+17.2%) and total plant height (+5.7%), but also due to the 1000 grain weight (7.9%).

The risks of vulnerability and the increase of genetic erosion for the *Zea mays* species have made necessary the search for new germplasm sources. As a result, for the breeder it is important to know the genetic differences between the used inbred lines, this being the only way how the crossings based on the heterotic model of the parental sources can be made successfully.

For an easier understanding of the phenotypic diversity of the studied inbred lines the differentiation indexes have been calculated for all the thirteen characters we analyzed (Table 5). Several authors (Herbert and Vincourt, 1985; Calboreanu – Badea, 2007; Musat, 2008; Copandean, 2010, 2011; Copandean and Rotar, 2012) have used phenotypic differentiation index in the study of the diversity of parental lines considering that the high value of this index shows a high degree of genotypic differentiation between the parental lines, while lower values indicate their similarity degree.

Analyzing the interaction between Romanian inbred lines extracted from the local populations one can notice that the lowest value, i.e. PDI = 31 (Lc 235 x Lc 151) and a middle value of PDI = 45 for Lc 64 x Lc 235 (Table 5). This means that between these inbred lines there is a small to medium genetic divergence since they come from a small geographical area.

At the interaction between Romanian inbred lines extracted from national germplasm collection one can notice that high values i.e., PDI = 82 (Lc 408 x Lc 406) and PDI = 88 (Lc 408 x Lc 403) are obtained (Table 5). There is a large genetic difference between these inbred lines meaning that they come from very different sources of germplasm.

Table 2. The performance characters and vegetative characters of the plant and ear for the studied inbred lines (the average at ARDS Simnic)

Characters	Inbred lines									
	Lc 235	Lc151	Lc 64	Lc 408	Lc 406	Lc 403	Lc9340	Lc 7445	Lc4432	Lc 7619
GY (t /ha)	5.70	6.00	6.85	7.02	5.64	5.83	5.76	5.10	5.14	6.21
TGW (g)	285	300	310	411	330	360	343	365	331	338
GER(%)	73	75	80	73	72	75	72	75	72	80
EP	1.14	1.13	1.15	1.14	1.01	1.00	1.00	1.04	0.99	1.15
PH(cm)	210	295	215	220	205	170	205	200	200	170
EH (cm)	70	80	83	80	50	52	60	67	75	60
SG*	8.5	8.0	8.0	8.5	8.0	8.5	7.5	6.5	8.5	8.5
LP^{-1}	12.8	13.0	15.6	13.0	13.1	12.1	16.0	13.7	15.3	13.2
FS (dm^2)	40.1	49.6	59.3	38.2	46.2	32.3	46.2	37.6	45.8	41.9
EL (cm)	16.3	14.9	18.4	18.0	17.4	14.1	16.9	18.0	16.0	17.4
EW (g)	167	190	200	171	167	198	179	138	148	170
ED (cm)	4.20	4.44	3.80	4.07	4.11	4.40	4.20	3.98	4.07	4.40
GC**	*2*	5	4	3	3	3	4	3	3	4

GY - Grain yield; TGW- 1000- grain weight; GER- Grain-to-ear ratio; EP- No. ears/plant; PH - Plant height; EH - Ear height; SG - Shrivelling of the grain; LP - No. leaves/plant; FS- Foliar surface; EL - Ear length; EW- Ear weight; ED - Ear diameter; GC - Grain consistency;
*1= very shriveled kernels; 10 = kernels full and well developed
**1= dent; 9 = endured, glassy

Table 3. The comparison of the yield and its main characters for the Romanian and foreign maize inbred lines

Characters	Romanian inbred lines average (control)	Foreign inbred lines average	Control difference	Control comparison %
GY (t/ha)	6.17	5.55	-0.62	-10.0
GER(%)	76.0	74.0	-2.0	-2.6
TGW (g)	332.6	344.2	+11.6	+3.5
EW (cm)	182.1	158.7	-23.4	-12.8
EP	1.09	1.04	-0.05	-4.5
PH (cm)	204.1	193.7	-10.4	-5.1
FS (dm^2)	44.2	42.8	-1.4	-3.1

GY - Grain yield; GER- Grain-to-ear ratio; TGW- 1000- grain weight ; EW- Ear weight; EP- No. ears/plant; PH - Plant height; FS- Foliar surface

Table 4. The comparison of the yield and its main characters for the Romanian and foreign maize hybrids

Characters	Romanian maize hybrids average (control)	Foreign maize hybrids average	Control difference	Control comparison %
GY (t/ha)	11.29	12.82	+1.53	+13.5
GER(%)	80.2	78.5	-1.7	-2.1
TGW (g)	438.0	473.0	+35.0	+7.9
EW (cm)	313.1	326.1	+13.0	+4.1
EP	1.03	1.05	+0.02	+1.9
PH (cm)	259.0	274.0	+15.0	+5.7
FS (dm^2)	67.8	79.5	+11.7	+17.2

GY - Grain yield; GER- Grain-to-ear ratio; TGW- 1000- grain weight ; EW- Ear weight; EP- No. ears/plant; PH - Plant height; FS- Foliar surface

Table 5. Phenotypic differentiation index of the maize inbred lines for 13 characters

Inbred lines	Inbred lines ♀				
♂	Lc 235	Lc 64	Lc 408	Lc 9340	Lc 4432
Lc 151	31				
Lc 235		45			
Lc 406			88		
Lc 403			82		
Lc 7448				48	
Lc 7619					42

Analyzing the interaction between foreign inbred lines we notice that we have obtained middle values for the PDI, from 43 (Lc 4432 x Lc 7619) to 48 (Lc 9340 x Lc 7448), which means that these lines originate from less genetically different sources.

Therefore, a lower differentiation index indicates a high degree of similarity between inbred lines. Similar results were obtained by Calboreanu - Badea (2007), Copandean and Rotar (2012).

The reproductive heterosis has represented and it still represents the main research goal on the heterosis at maize (Musat, 2008).

While in the first phase of introducing maize hybrids there have been obtained hybrids among varieties that gave a heterosis of 4.4 to 45.4% compared to the average of the parents, together with the resulted hybrids from the inbred lines, the intensity of reproductive heterosis has increased very much, especially due to the low productive capacity of the parental inbred lines (Has, 2004).

Table 6 presents the calculation of the value of the reproductive heterosis at the hybrids obtained from crossings between the studied inbred lines. For a more coherent data interpretation we split the hybrids obtained into three groups:

I. The hybrids obtained from Romanian inbred lines extracted from local populations in Oltenia (Lc 235 x Lc 151 and Lc 64 x Lc 235)

II. The hybrids obtained from Romanian inbred lines extracted from the IInd selection stage from the national germplasm collection (Lc 408 x Lc 406 and Lc 408 x Lc 403)

III. The hybrids obtained from foreign inbred lines (Lc 9340 x Lc 7448 and Lc 4432 x Lc 7619).

The reproductive heterosis obtained by the hybrids we studied, compared to the parents' average has been from 65.9 to 134.2%.

Analyzing comparatively the results on the intensity of heterosis one can notice differences between the three groups. The relative average value of the heterosis in the second and third group is close and for the hybrids in the first group is visibly lower (which can be due to a lower genetic difference between the inbred lines used for crossings, lines that have been obtained from local sources from a geographically small area, i.e. Oltenia).

Economically speaking, the best hybrids are the Romanian hybrids obtained at NARDI Fundulea (Lc 408 x Lc 406 and Lc 408 x Lc 403) whose parental lines have a good productivity.

Comparing the heterosis' intensity to the PDI (Table 5) values obtained by parental types of the hybrids we have studied one can see that the highest PDI does not always stand for the most clearly indicated heterosis. Similar results were obtained by Muşat (2008).

CONCLUSIONS

The phenotypic differentiation index (PDI) can be an effective tool in predicting maize hybrids, but the highest PDI does not always stand for the most clearly indicated heterosis.

The hybrids obtained from Romanian inbred lines extracted from local populations in Oltenia have a limited specific ability to carry through combinations, but they have a good productivity of parental lines.

The hybrids obtained from inbred lines extracted from the IInd selection stage from the national germplasm collection show both a good specific ability to carry through combinations and a good productivity of parental lines, being the most indicated economically speaking.

The foreign hybrids that we have studied have a very good specific ability to carry through combinations but a lower yielding capacity of parental lines under given conditions.

REFERENCES

Banerjee P.P., Kole P.C., 2009. Analysis of genotypic diversity in sesame (*Sesamum indicum* L.) based on some physiological characters. Czech J. Genet. Plant Breed., 45 : 72-78.

Bonea D., 2001. Genotypic and phenotypic variability of some maize inbred lines and hybrids grown at ARDS on drought resistance. PhD thesis Craiova.

Bonea D., Urechean V., 2003. Reciprocal cross effects for grain yield and content of raw protein in the maize grain. Maize Genetics Cooperation, Newsletter 77, Columbia, Missouri, p. 67,

Bonea D., 2005. The results concerning the synchronization of the inbred lines of maize (parental forms of some simple hybrids) at blossoming. Proceeding of the International Conference „Agricultural and Food Sciences, Processes and Technologies", vol. 3: 621-624.

Bonea D., Urechean V., Deaconu D., 2009a. The study of some genes sources from collection A.R.D.S. Simnic. Analele Universității din Craiova, seria Agricultură – Montanologie – Cadastru Vol. XXXIX: 47-50.

Bonea D., Urechean V., Constantinescu E., Deaconu D., 2009b. Aspects regarding the reaction to the drought of some corn inbred lines cultivated in S.C.D.A. Simnic. Bulletin UASVM Agriculture, 66 (1): 262:272.

Calboreanu - Badea C., 2007. Phenotypic and molecular variability of sweet corn inbred lines, component of the most important comercial hybrids created at ARDS Turda, in order to establish the efficiency of marker assisted selection of inbred lines. PhD thesis. Cluj-Napoca.

Copandean A., 2010. Aspects regarding genetic diversity of parental forms in some released maize hybrids. Bulletin UASVM Agriculture, 67: 314-314.

Copandean A., 2011. The relationship between molecular, genetic and phenotypic diversity in some inbred lines of maize. Bulletin UASVM Agriculture, 68(1): 402.

Copandean A., Rotar C., 2012. The diversity of some maize inbred lines. Research Journal of Agriculture Science, 44 (1): 36-43.

Hallauer A.R., Miranda Fihlo J.B., 1981. Quantitative genetics in maize breeding. Iowa State University Press, Ames.

Hallauer A.R., W.A. Russell W.A., Lamkey K.R., 1988. Corn breeding. In: G.F. Sprague and J.W Dudley (Ed.). Corn and corn improvement. 3rd edn. Agron. Monogr 18, ASA and SSSA, Madison, Wisconsin.

Has I., 2004. Heterosis for maize. Monographic study, vol. I, Romanian Academy Publishing House, Bucharest. 119-223.

Has V., Pop R., Haş I., Copandean A., 2011. Genetic variability in a set of early maize inbred lines. Bulletin UASVM Agriculture, 68(1): 155-164.

Herbert Y., Vincourt P., 1985. Mesures de la divergence genetique. Distance calculees sur des criteres biometriques. Estimation et applications INRA. Station d'Amelioration des Plantes Fourrageres Lusignan.

Holubec V., 2010. The monitoring, collecting and conserving of landraces and wild plant genetic resources, in situ, on-farm. Czech J. Genet. Plant Breed., p. 46 : S1.

Ilicevici S., 1994. Posibilities and limits of local germoplasm utilization for releasing superior maize hybrids. RAR, 2; 1-7.

MADR. 2012. Total area cultivated with maize in Romania. Available at:http://www.madr.ro/ro/culturi-de-camp/cereale/porumb.html (accessed by November 2014).

Musat G., 2008. Contributions on heterosis comparative study for some local and foreign hybrids within ARDS Simnic conditions. PhD thesis. Craiova.

Radu A., Urechean V., Similaru E., Naidin C., Radu A., Paraschivu M., 1994. Use of genetic estimates in breeding maize for resistance to stem breakage. Analele Institutului de Cercetari pentru Cereale si Plante Tehnice, Fundulea 61: 19-28.

Smith J.S.C., 1997. Effect of hybrid breeding on genetic diversity in maize. Book of abstract. The genetics and exploitation of heterosis in crops. An International Symposium, Mexico, p. 55.

Thirupathi R.M., Haribabu K., Mutyala G., Hameedunnisa B., 2012. Heterosis for yield and yield components in okra (*Abelmoschus esculentus* (L.) Moench). Chileanjar, 72(3): 316-325.

Voica N., 2001. Genetics – science of heredity Reduta Publishing House, Craiova.

Wietholter P., Cruz de Melo Sereno M.J., Freitas Terra T., Delmar Dos Anjos E., Barbosa Neto J.F., 2008. Genetic variability in corn landraces from Southern Brazil. Maydica, 53: 151-159.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PARTIAL RESULTS REGARDING THE MANAGEMENT OF FERTILIZATION AND FUNGICIDES TREATMENTS ON PREMIUM WHEAT VARIETIES

Cristian Florinel CIOINEAG, Stelica CRISTEA

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: cristian.cioineag@gmail.com

Abstract

The paper aims to present the results of research carried out in the first year of doctoral studies, as a part of the doctoral thesis. The theme taken into research monitors the influence of differentiated application of fertilizers and fungicides on the premium genetics wheat varieties provided by Probstdorfer Saatzucht Romania Company. For highlighting the results, the obtained yield, the amount of protein (%), the wet gluten content (%) and the hectoliter weight were analyzed. Each of the above mentioned factors have been analyzed both separately and in interaction, in order to assess their impact on the crop of premium varieties. The research plot has been implemented at the Agricultural Research and Development Station of Teleorman and followed the statistical rules for trifactorial experiences, being sown as randomized blocks. The initial choice of the theme was based on the concept of healthy food, which humanity is facing with nowadays. Our intention was to propose a model for introducing in Romanian farms, under optimal conditions, the new premium wheat genetics, that offers high quality flours. Thus, would no longer be necessary to use improvers in the production of bread, indispensable for the daily food of the Romanians. Being frequently debated, the subject of food quality and, by default, of life, influenced by the intern yields with poor quality indices, as well as the imports of non-compliant products from other countries, seriously threaten national health and wellbeing and imperatively requires that the path of research and of scientific works to be directed in this regard. Among the findings emerging from this analysis it can be observed the premium varieties tendency for a superior valorisation of the nitrogen fertilization, both in terms of production stability, as well as of superior level of monitored bakery indices, prerequisite for a sustainable socio- economic development.

Key words: *premium wheat, premium genetics, quality indices, yield.*

INTRODUCTION

This paper is based on the doctoral research theme “Research on the management of fertilization and of fungicides treatments application on the tested Premium wheat varieties”.

The necessity of choosing the research topic was based on the problem of poor bread flour quality used by manufacturers and bakery producers in Romania, putting their choices on the poor grain quality produced by the local farms, two thirds of the produced wheat does not meet quality standard (Campeanu and Dumitru, 2002).

Going into the depth of the problem and questioning a number of about 50 farmers from the south of the country (Calarasi, Constanta, Ialomita, Giurgiu and Teleorman counties), was discovered the common argument that unites them: “Why to produce quality when nobody pays differently?” (original study).

Premium wheat, recognized and accepted in the scientific literature in Romania as hard gains (Figure 1) are a class of superior quality indices (high protein, gluten, sedimentation etc.), ideal for obtaining bread quality. Other similar terms accepted for hard grains are E-Weizen (Germany), Red Hard Winter Wheat (US), Premium Weizen (Austria) etc. (Berca, 2011; Berca, 2013).

For quotations offered by international markets, there is a clear differentiation of wheat quality classes (Figure 1). Unfortunately, no account is taken of this aspect regarding the purchase of cereals on the Romanian market.

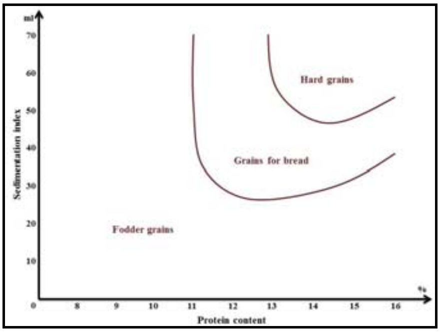


Figure 1. Wheat division in quality classes based on protein content and sedimentation index (Munteanu, 2003)

MATERIALS AND METHODS

There were taken 6 wheat varieties, of which 5 Premium wheat varieties (Adesso, Arnold, Gallio, Laurenzio and Midas) and 1 variety of A-Class breading wheat (Balaton), the latter being similar to local varieties.
Made available by the company Probstdorfer Saatzucht Romania (http://www.probstdorfer.ro), the varieties mentioned above are the result of the Research Institute Donau Saatzucht GesmbH & Co KG, with headquarters in Probstdorfer, Austria (http://www.saatzucht-donau.at).
The Premium wheat disease resistance was analysed compared with Balaton (control), over the main foliar disease complex (*Blumeria graminis, Puccinia recondite, Mycospharella graminicola*) and ear disease (*Gibberella zeae*) (Cristea and Berca, 2013; Cristea, 2005; Gheorghies and Cristea, 2002).
The field follows the rules of experimental technique, the experience were sown in a trifactorial randomized blocks (Figure 2).

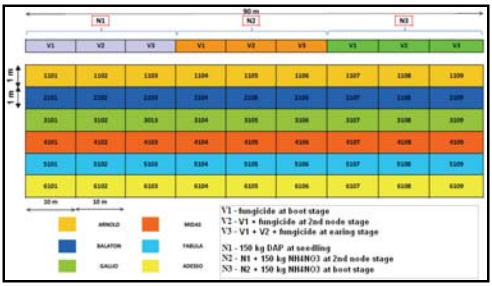


Figure 2. The technological scheme after which the experimental field was made

The proposed layout is modelled around the 3 factors (variety, fertilizer, fungicide) and aim to optimize the technology used on the farm, both in terms of production levels and the cost reduction per unit area.
The three factors that were analyzed in the presented model, were as follows:

1. F1 – variety factor:
   a. Adesso,
   b. Arnold,
   c. Gallio,
   d. Laurenzio,
   e. Midas,
   f. Balaton.
2. F2 – fertilization factor:
   a. N1 – 150 kg DAP applied in autum before preparing the soil;
   b. N2 – N1 + 150 kg NH_4NO_3 applied at the 2nd node stage (EC > 30);
   c. N3 – N2 + 150 kg NH_4NO_3 applied at the boot stage (EC > 40).
3. F3 – treatment factor:
   a. V1 – tebuconazole applied at the boot stage (EC > 40);
   b. V2 – V1 + tebuconazole applied at the 2nd node stage (EC > 30);
   c. V3 – V2 + tebuconazole applied at the earing stage (EC > 50).

The research plot has been implemented on the field provided by ARDS Teleorman in the fall of 2013, in a crop rotation after peas. After harvesting, yields were determined. Samples of 2 kg/plot were used for laboratory analysis for qualitative indicators.
Laboratory equipment used for this purpose was Infratec 1241 Grain Analyser. Indicators analyzed were: production/ha adjusted to 14% moisture (kg/ha), protein content (%), wet gluten content (%) and hectoliter weight (kg/hl). The obtained data were processed and interpreted using ANOVA statistical program.

RESULTS AND DISCUSSIONS

The analysis of obtained yields

In the chart below (Figure 3) are highlighted the results of average production for the 1st factor (variety).

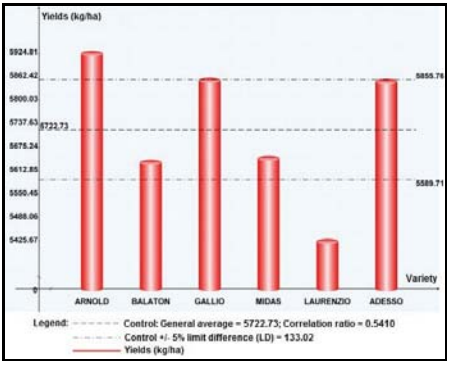


Figure 3. Single factor analysis of the variety over the obtained production/unit area

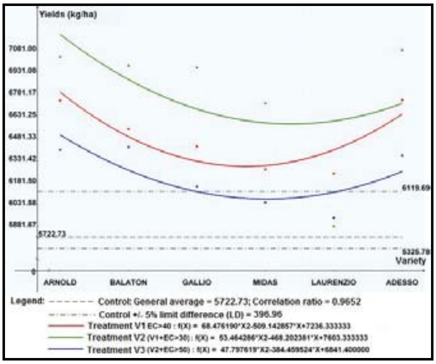


Figure 5. Trifactorial analysis on variety, treatment and fertilization over the obtained yield/unit area

Assuming that the obtained values are exclusively for F1, it shows Arnold variety on first position outside the confidence interval, then by Adesso, Gallio also above the average. In contrast, Laurenzio variety is in the last place as production level, with a difference of 500 kg/ha less then Arnold variety. Balaton, it is close to average production and is within the limit confidence.

Analysing a trifactorial sequence (Figure 4), fertilization-treatment-variety, we can observe a positive linear trend between N1, N2 and N3. For each sequence the applied treatments were monitored and the direct influence can be observed as an increase of production for each variety from V1 to V2, with a maximum of 600 kg for Balaton (N2-V1V2).

Also the application of V3 (treatment at flowering stage) affects production in each of the situations described, which is due to the phenomenon of phytotoxicity (Figure 5).

Analysis of protein and wet gluten content

There is a correlation between protein and wet gluten content of wheat grains, although the two quality parameters only partially define the final product (flours) quality. A study conducted by Ingver and Koppel (2004) from Jogeva Plant Breeding Institute (Estonia), demonstrated that there is a strong correlation between the physicochemical parameters and the breading volume.

In protein (Figure 6) and gluten content analysis, Laurenzio variety obtained the highest values, followed by Arnold and Adesso.

In V2N2 it can be seen that, according to other authors, the values are high, for N3 it's causing a phenomenon of plant exposure to pathogens pressure and thus the values decrease below the average (Cristea, 2005).

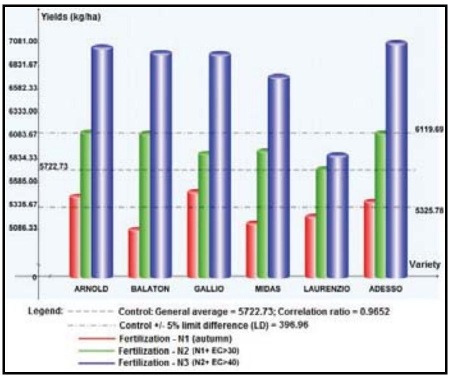


Figure 4. Trifactorial analysis on variety, fertilization and treatment over the obtained yield/unit area

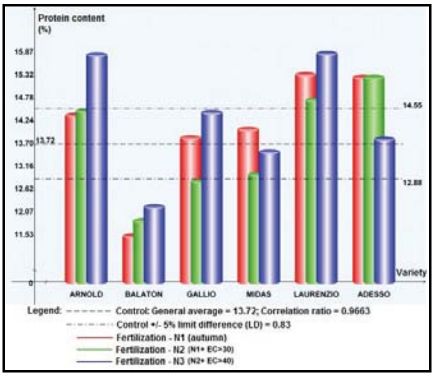


Figure 6. Trifactorial analysis on variety, fertilization and treatment over the protein content of grains

The analysis of hectolitre weight

Hectolitre weight value defines the degree of compression of substances in grain and is a basic parameter of flour extraction with an important role in determining the efficiency of grinding. Also, influences the acquisition value of grain, higher values of 78-80 kg/hl being the first sign for high baking grains.

In the proposed model, hectoliter weight analysed in F1 (variety), highlights the difference between A class variety (Balaton) with only 75.57 kg/hl and Premium varieties with values between 79.53 kg/hl Gallio and 82.23 kg/hl Arnold (Figure 7).

Also, on the bifactorial analysis of F1-F2 and F1-F3, we observe non-significant differences in both cases (Figure 8), so the genetic potential of varieties is solely responsible for the differences.

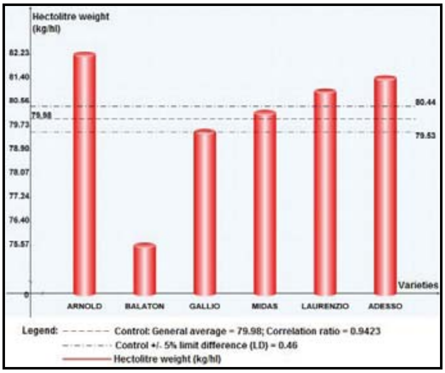


Figure 7. Monofactorial analysis of the variety over the hectoliter weight

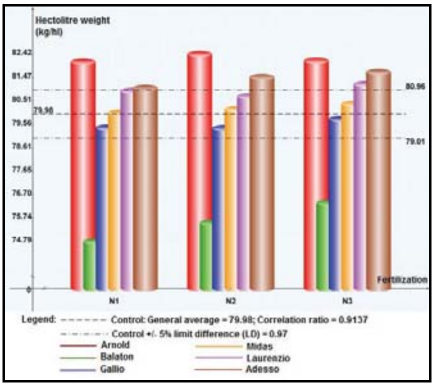


Figure 8. Bifactorial analysis on variety and fertilization over the hectoliter weight

CONCLUSIONS

1. Genetic potential of wheat varieties is the main factor influencing results on various technological schemes; in this case higher valuing potential differences were made by the Premium varieties.
2. The linear evolution of productions/unit area is evident in the case of split application of fertilizers; the model proposed has a maximum of near 120 kg active substance.
3. Diseases control is found as absolutely necessary.
4. The genetic potential of Premium varieties, regarding higher grain hectoliter weight is superior then the lower bakery class.
5. In terms of harness the applied technology, Premium varieties offers a positive response on application of nitrate fertilizers and also provides stable productions, ideal for growing on a large scale.

REFERENCES

Berca M., 2011. Agrotehnica, transformarea moderna a agriculturii. Ed. Ceres, Bucuresti.

Berca M., 2013. Tehnologii moderne pentru soiuri de grau Premium. Ed. Ceres, Bucuresti.

Campeanu Gh., Dumitru I.F., 2002. Progrese in Biotehnologie. Ed. Ars Docendi, Bucuresti.

Cristea M., Berca M., 2013. Researches concerning the caryopses micoflora of wheat to the varieties grown in Modelu Location, Calarasi County. Research Journal of Agricultural Science, vol. 45, Issue 1, p. 139-143.

Cristea S., 2005. Fitopatologie, vol II. Ed. Crisbook, Bucuresti.

Gheorghies C., Cristea S., 2002. Fitopatologie, vol. I. Ed. Ceres, Bucuresti.

Ingver A., Koppel R., 2004. Investigation of components of baking quality of wheat in Estonia, International Workshop on Modelling Quality Traits and their Genetic Variablity for Wheat. A satellite meeting of the VIII ESA Congress, INRA; Clermont-Ferrand, France. 18-21 July 2004.

Munteanu L.S., 2003. Fitotehnie. Ed. Ion Ionescu de la Brad.

xxx – http://www.probstdorfer.ro

xxx – http://www.saatzucht-donau.at

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY OF THE INFLUENCE OF THE SEEDING PERIOD AND SEED NORMA ON THE RAPESEED GENOTYPE

Gabriela Alina CIOROMELE [1], Maria CONTOMAN[2], Nicoleta AXINTI[1]

[1]University „Lower Danube” Galati, Faculty of Engineering and Agronomy Braila, 29 Calarasilor Street, Braila, Romania
[2]University „Lower Danube” Galati, Faculty of Food Science and Engineering, 111 Domneasca Street, Braila, Romania

Corresponding author email: acioromele@ugal.ro

Abstract

The research paper aimed the comparative study of Artoga variety rapeseed on the Moşescu V. Dobre II farm of Brăila County, in the agricultural year 2012 - 2013, sowed at different periods and densities, during which researches were carried out in the laboratory and on the experimental field. During the rapeseed vegetation there were analyzed climatic elements (temperature and precipitation), phenological observations in the field and biometric measurements in the laboratory. For the statistical interpretation of results, each variant of the experimental field was placed in triplicate and the data revealed a significant interaction between the two factors analyzed (sowing season and plant density/sq.) where it was found that with the delay of sowing date, the obtained yields of the variants were decreased significantly, being statistically ensured.

Key words*: rapeseed, seeding date, density.*

INTRODUCTION

Lately rapeseed experienced a rapid explosion of the cultivated fields both global and national, due to its yield per area unit, its sources of vegetable oils and economic value.

The rapeseed cultivation technology is a very important link for the sowing period because this work clearly influences a constant production (Diepenbrock, 2000; Bîlteanu, 2001; Muntean et al., 2011).

Sowing period is determined by the evolution of soil temperatures and depends on the area climate, and other important factors such as soil physical characteristics (Contoman, 2005).

Seeding period and crop density can significantly influence the productive components of rapeseed culture, so that for Romania the investigations revealed that the optimum sowing period is from late August to mid-September (Bîlteanu, 2001; Muntean et al., 2011; Buzdugan, 2013).

Seeding period significantly affects the crop yield and also the productive components of rapeseed (Karamanas et al., 2002; Munteanu et al., 2011). Optimal density for autumn rapeseed culture is influenced to a lesser extent by the morphological features of the genotypes currently in culture (Ştefan, 2011; Taylor et al., 2002).

An important role in the establishment of the sowing period is also presented by the vegetation period that needs to be covered by the rapeseed plants in order to achieve frost resistance and the adverse conditions during winter (Muntean, 1997; Camp, 2005).

Gîngioneanu believes that rapeseed sowing in September leads to production declines by 35-50% due to insufficient development during autumn.

Late sowing makes plants grow weaker, reduce the ability of branches forming and form a small number of primary leaves while the optimum sowing period leads to a normal development and under optimal parameters of the physiological processes (Schulz, 1995).

MATERIALS AND METHODS

The experiment took place in the agricultural year 2012-2013 and was located on a farm from Braila County, Lanurile City, on a saline chernozem soil type, using as a biological material the Artoga rapeseed variety.

The main objectives of this paper aimed the determination of the optimum sowing period and the rapeseed crop density in the agro-pedological area of Moşescu V. Dobre II society.

As a method for the positioning of the field the subdivided parcels method was used, thus the experimental scheme included the following factors:

- A factor represented by the sowing period that had 3 graduations:
  - a1 - September 01;
  - a2 - September 10;
  - a3 - September 20.
- B factor represented by the plant density / sq. with 3 graduations:
  - b1 - 40 grains germinate / sq.;
  - b2 - 50 grains germinate / sq.;
  - b3 - 60 grains germinate / sq.

The polyfactorial experiment was placed in order to investigate and assess the real influence of two factors on the rapeseed production on the farm, which has a number of 9 variants, each variant being placed in three repetitions.

During the vegetation period, phenological observations were made on the plant vegetation period of the experimental variants in regard to the action of the two analyzed factors and the determinations of productivity elements: the number of emerged plants/sq., the percentage of resistant plants to climatic conditions of the analyzed agricultural year, the number of branches / plant, number of siliques per plant, number of seeds in a capsule, the 1000 grains weight, hectoliter mass and determination of physical production.

The statistical processing of the results was performed by the analysis of variance method, using MS Office Excel – Anova test, where as a witness the average of all experiments was used.

RESULTS AND DISCUSSIONS

Mobile P presented values between 45 ppm and 51 ppm while the mobile K had values that ranged between 212 and 223 ppm, values obtained on the depth profile of 0-40 cm, the soil being characterized through a very good supply of nitrogen and phosphorus and good for potassium.

Table 1. Chemical properties of saline chernozem soil in the experimental field

Horizons	Ap	Am	ACsc
Depth (cm)	0-10	30-40	40-60
Water pH	7.91	7.99	8.11
Carbonates ($CaCO_3$%)	0.88	1.81	3.4
Humus (%)	3.25	3.16	2.84
Nitrogen index	3.21	3.16	2.82
Reserve humus (t/ha)	129		
Mobile P (ppm)	51	45	-
Mobile K (ppm)	233	212	-

Climate particularities of the 2012-2013 agricultural year showed much wormer and precipitations poor seasons in comparison to the previous period proving that these features had profound effects on the vegetation condition of crops.

During the rapeseed culture vegetation period, taken as the experiment, the precipitations recorded positive values above normal average in September, October, December, January, February, March and May, the highest values recorded were recorded in December (107 mm) when the normal average was exceeded by 74 mm (Figure 1).

From the thermal point of view, the agricultural year 2012-2013, during the vegetation period, was characterized as a normal year compared with the normal average.

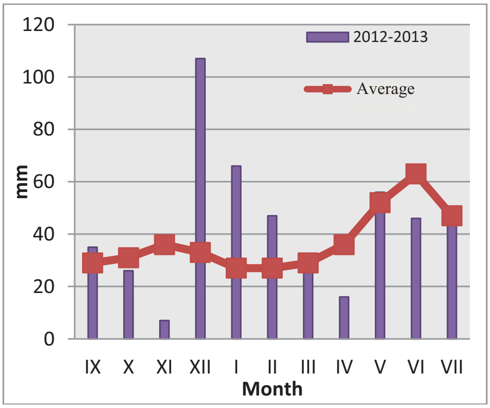


Figure 1. Precipitations recorded during the vegetation period

The largest positive temperatures were recorded in September, month in which was placed the experiment, when the difference from the normal average normal was + 4.4°C (Figure 2).

In terms of climate, the year 2012-2013 can be characterized as a normal year in terms of temperatures but much richer in precipitation.
It should be noted that in March of 2013 the temperatures fell sharply on 26.03.2013 when there was a temperature -2°C and a snow layer of 10 cm that persisted for 2 days.
The highest moisture deficit was recorded in November, when the recorded values were lower by 29 mm precipitations against the normal value.

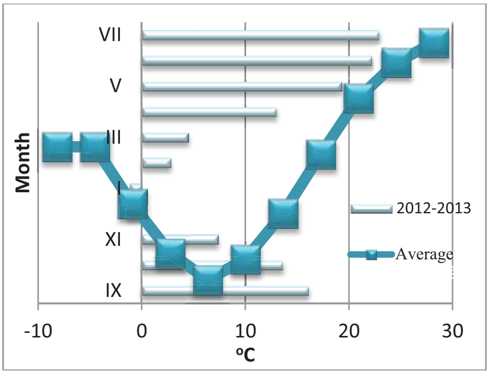


Figure 2. Temperatures during the vegetation period

From sowing to physiological maturity, the rapeseed goes through several phases of growth that produce a number of important changes both qualitative and morphological. The vegetative cycle of rapeseed can be divided into two stages, separated by the floral initiation.

Table 2. The vegetation period of Artoga hybrid depending on the sowing period

Nr.	Phenophase	01.09.2012	10.09.2012	20.09.2012
1	Sowing	01.09.2012	10.09.2012	20.09.2012
2	Plant emergence	10.09.2012	18.09.2012	01.10.2012
3	Stem elongation	14.03.2013	19.03.2013	24.03.2013
4	Bud	16.04.2013	18.04.2013	20.04.2013
5	Blooming	22.04.2013	25.04.2013	27.04.2013
6	Formation of siliques	13.05.2013	15.05.2013	18.05.2013
7	Curing - harvesting	17.06.2013	20.06.2013	23.06.2013
Total growing season		290 days	283 days	276 days

Thus, in the first step of the terminal bud the leaves are formed and in the second stage the inflorescence is formed. Thus, the variants sown on 09/20/2014 recorded the shortest period while the variants sown in the first decade of September recorded the longest vegetation period (290 days).
The average percentage of emerged plants fluctuated between 87.5 and 96% (Table 3), the average percentage of emerged plants in regard with the whole experiment being 92.35%.

Table 3. The percentage of plants emerged in the experimental plot

Variant	Germinated grains/sqm	Emerged plants/sqm	Emerged plants %
a_1b_1	40	38	95
a_1b_2	50	48	96
a_1b_3	60	56	93.3
a_2b_1	40	37	92.5
a_2b_2	50	46	92
a_2b_3	60	56	93.3
a_3b_1	40	35	87.5
a_3b_2	50	45	90
a_3b_3	60	55	91.6
Experiment average			92.35

The number of emerged plants/sqm of the sown variants in the first decade of September showed higher values compared to the variants sown in September 10 and September 20, 2012.

Table 4. The percentage of resistant plants during winter in the experimental plot

Variant	Emerged plants/sqm	Resistant plants/sqm	Resistant plants %
a_1b_1	38	35	92.1
a_1b_2	48	44	91.6
a_1b_3	56	51	91.07
a_2b_1	37	33	89.19
a_2b_2	46	41	89.1
a_2b_3	56	51	91
a_3b_1	35	29	82.8
a_3b_2	45	37	82.2
a_3b_3	55	48	87.2
Average experience			88.47

The average percentage of resistant plants ranged between 82.2 and 92.1%, experiment average was 88.47% resistant plants.
Following the data presented in Table 4 it can be seen that the percentage of plants from variants sown in the first decade of September had the highest values, it exceeds 90% regardless of the number of grains sown. The variants which recorded maximum values of 87% were those sown in the last decade of September, thus being observed that a3b1 and a3b2 variants obtained the lowest percentage of resistant plants.

From the data obtained it can be concluded that the farm area of where was set the experimental field, the sowing period significantly influenced the plant resistance to winter, while the B factor action (crop density) did not affect this percentage.
The observations on the number of branches per plant were performed on 03/10/2013, being selected 10 plants of each 5 points from each experimental variant.
Their number varied between 7 and 16 ramifications, it being higher in variants exhibiting a density of 40 gb/sqm (Table 5).
From the results shown in Table 5 the interaction of the two analyzed factors was ensured statistically in almost all variants. A_2b_1 variant achieved a very significant positive difference whereas the a1b1 and a3b1 variants obtained significantly distinct positive differences.

Table 5. Interaction influence between the sowing period and the thickness sowing on the number of branches / plant

Variant	No. of branches/ plant	%	Difference	Significance
a_1b_1	14	124.7	2.78	**
a_1b_2	11	98.03	-0.22	-
a_1b_3	9	80.21	-2.22	°
a_2b_1	16	142.6	4.78	***
a_2b_2	12	106.95	0.78	-
a_2b_3	8	71.30	-3.22	°°
a_3b_1	14	124.77	2.78	**
a_3b_2	10	89.12	-1.22	-
a_3b_3	7	62.38	-4.22	°°°
Average	11.22	100	-	-

DL 5% = 1.75; DL 1% = 2.42; DL 0.1% = 3.33
DL - difference limit

A_1b_3, a_2b_3, a_3b_3 variants registered negative differences and were statistically ensured. Compared to the average of the variants with a smaller number of branches/plant was recorded for the variants that had the highest density at sowing (60 grains/sqm).
The maximum number of branches was recorded by a_2b_1 variant, followed by a_1b_1 variant.
Under the action of the two factors used in the experimental field it was followed also another element of productivity the number of siliques/plant. It fluctuated between 509 and 663 capsule/plant, the maximum was recorded by a_1b_1 variant.

In the variants sown with 40 grains/sqm, the number of siliques was directly proportional to the seeding period, so that the agropedological conditions of the area where the experimental field was placed thus the minimum number of siliques/plant was recorded for the variant sown on 20 September (Figure 3).
In the case of the variants sown on 20 September the number of siliques/plant was inversely proportional to the density of sowing. Thus for the data obtained, the lowest number of siliques was recorded for the sown variant with 40 grains/sqm while the maximum was obtained for the a_3b_3 version.

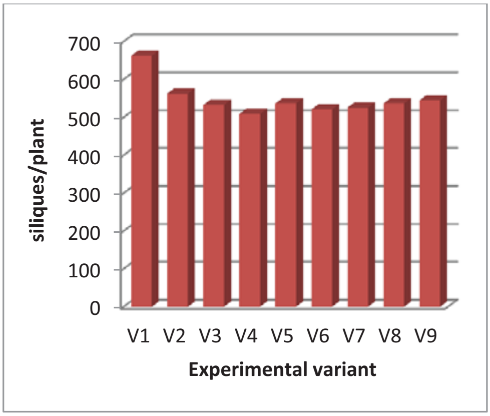


Figure 3. Number of siliques/plant

The average number of seeds in siliques ranged between 25 and 28 seeds, the a1b1 variant recording the greatest number of seeds.
The MMB of seeds was not influenced by the action of the two analyzed factors this varying between 4.0 and 4.2 g in all experimental variants, while the hectoliter mass varied between 65.8 and 67.5, the two qualitative indices was not influenced by the combined action of the factors examined in the experiment.
In agricultural production, both natural factors and those by which man does not interfere in an isolated way on plants, but simultaneously, thus were influencing each other (Dimancea S., 1966).
In the case of the experimental field experience, the total production was clearly influenced by seeding period, which was reflected in the recorded yields because the Artoga genotype genetic capacity is much higher.

Table 6. Production obtained in experimental variants and statistical interpretation

Variant	Harvest Kg/ha	Difference from control	Significance
a_1b_1	3729.5	+ 1072.34	***
a_1b_2	2976	+318.8	**
a_1b_3	2608	-49.16	-
a_2b_1	2975	+ 317.8	**
a_2b_2	2642	-15.16	-
a_2b_3	2380	-277.16	°°
a_3b_1	2272	-385.16	°°°
a_3b_2	2281	-376.16	°°°
a_3b_3	2051	-606.16	°°°
Average	2657.16	-	

DL 5% = 195.22 kg/ha
DL 1% = 268.89 kg/ha
DL 0.1% = 370.18 kg/ha

The recorded productions shown in Table 6 demonstrate that the technological link for rapeseed crop and also the seeding period influenced the production. The maximum average yields were recorded for all variants sown on 01.09.2012, these oscillating between 2608 and 3729.5 kg/ha, their average exceeding the average of yields of the variants sown on 10 September and 20 September 2012 (Table 6).
Statistically speaking, a_1b_1 variant achieved a very significant difference from the control (the average of variants), while a_1b_2 and a_2b_1 variants obtained significant differences.
A_3b_1, a_3b_2 and a_3b_3 variants achieved very significant negative differences and a_2b_3 variant obtained significant distinct negative differences compared to the control.
An important role in the obtaining of high production for the experiment had placed the first factor (seeding period) while the action of b factor (crop density) influenced to the lesser extent.

CONCLUSIONS

The number of branches per plant was significantly influenced by plant density /sqm, density of 40 gb/sqm with an increase of approximately 50% compared to the density of 60 pl/sqm.
The number of siliques/plant was influenced by both the sowing period and also by the plant density; the number of seeds in a capsule was approximately constant, with no significant difference due to the combined action of the two analyzed factors.
The sown variants in the first decade of September showed positive differences very distinctive and significantly distinctive, the striking action of the factor on production.
Negative meanings were recorded in all variants sown in the last decade of September;
For the farm area, the optimal sowing period was between 1-10 September and the norm was 40 germinate grains/sqm, overcoming them entailing a significant decrease in production.

REFERENCES

Bîltenu Gh., 2001. Fitotehnie vol. 2. Editura Ceres, Bucureşti.

Buzdugan L., Năstase D., 2013. Rapiţa de toamnă. Editura Academiei Române, Bucureşti, p. 272-277.

Contoman Maria, 2005. Bazele ecotehnologice ale culturilor de câmp – Vol. I. Editura Fundației Universitare ,,Dunărea de jos,, Galați, p. 153.

Diepenbrock W., 2000. Yield analysis of winter oilseed rape (*Brassica napus* L.): a review. Field Crops Res., 67.

Gîngioveanu I., Olaru L., 1999. Fitotehnie. Reprografia Universității din Craiova, p. 167-171.

Karamanos R.E., Harapiak J.T., Flore N.A., 2002. Fall and early spring seeding of canola (*Brassica napus* L.) using different methods of seeding and phosphorus placement. Can. J. Plant Sci. 82: 21-26.

Muntean L., 1997. Mic tratat de fitotehnie, plante oleaginoase, textile, tuberculifere şi rădăcinoase, Vol. II. Ed. Ceres, Bucuresti.

Muntean L.S., Cernea S., Morar G., Duda M., Vârban D., Muntean S., 2011. Fitotehnie. Editura Academic Pres, Cluj-Napoca.

Schulz R.R., 1995. Plant development and yield of oilseed rape as influenced by time of sowing variety and seed rape. In: proc., Intern. Rapseed Cingr., 9thCambridge, UK.

Stefan M., Constantinescu E., 2011. Fitotehnia III-IV. Craiova.

Tabără V., 2005. Fitotehnie. Plante oleaginoase şi textile., Ed. Brumar, Timişoara.

Taylor A.J., Smith C.J., 2002. Effect of sowing date and seeding rate on yield and yield components of irrigated canola (*Brassica napus* L.) grown on a red-brown earth in south-eastern Australia, Australian Journal of Agricultural Research 43.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ACHIEVEMENTS AND PROBLEMS IN THE WEED CONTROL IN OIL-BEARING SUNFLOWER (*Helianthus annuus* L.)

Grozi DELCHEV, Mitko GEORGIEV

Department of Plant Production, Faculty of Agriculture, Trakia University, 6000, Stara Zagora, Bulgaria

Corresponding author email: delchevgrd@dir.bg

Abstract

Chemical control has emerged as the most efficient method of weed control. Herbicides combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more effective than when they are applied alone in sunflower crops. Their combined use often leads to high synergistic effect on yield. Introduction of new sunflower Clearfield and Express Sun technologies marks a new stage in the weed control in this crop, including against Orobanche cumana Wall. Problem is a post-effect of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation. Most of the information in sunflower relates to conventional technology for the weed control. On some issues are published contrary opinions, due primarily to the different conditions under which the experiments were conducted and also the biological characteristics of the investigated cultivars and hybrids. It is insufficient studied the effect of the herbicides on the sunflower yield that occurs by treatment the crop with the tank mixtures of herbicides, stimulators and fertilizers. A serious problem is also the volunteers of the Clearfield and Experess Sun sunflower. They have resistance to herbicides different from that one of conventional sunflower hybrids. There is no information still in the scientific literature to control of these volunteers.

Key words: *herbicides, seed quality, seed yield, sunflower, weed control.*

REVIEW

Regular crop rotation is an important preventative measure in the overall protection of sunflower from weeds (Crnobarac et al., 1994). According Wanikorn (1991) when the sunflower is weeded during the first four weeks after emergence, crop yields decreased from 10% to 40%.

A large number of authors examine the efficacy of large number of herbicides and herbicide combinations to fight problematic weeds in conventional technology for cultivation of sunflower (Kovacevic, 1983; Gimesi, 1986; Sarno et al., 1986; Tei, 1986; Savka, 1988; Yarovenko et al., 1988; Covarelli, 1988; Salera and Baldini, 1988; Desplantes, 1989; Petkova et al., 1990; Tei et al., 1991; Lyubenov and Milanova, 1992; Rapparini, 1986, 1993 and 1994; Zech, 1993; Milanova and Atanasava, 1994; Marocchi, 1995; Paganini and Meriggi, 1995; Archenault and Sagot, 1996; Ilieva, 1997; Retamal and Duran, 1998; Markovic et al., 1998 and 2000; Iliev et al., 1999; Michel, 2001; Ribeiro and Cavaco, 2003; Laureti, 2005; Gormonchik, 2006; Axionov, 2010; Brighenti et al., 2002, 2012 and 2012; Kirchenko and Saratov, 2012).

The results of the Deibert (1989) showed that the yields of sunflower seeds and oil content in seeds were not significantly different between tillage systems and other mechanized tillage on the one hand and systems with minimal processing and chemical weed control on the other hand. Suspension fertilizers series Lactofol ensure better physiological development of sunflower plants and increase the yield of grain. Best results are obtained when Lactofol was administered in a stage of the fourth pair of leaves of the sunflower (Pavlova et al., 1992).

The use of non-selective herbicides containing glyphosate, glyphosate-ammonium and glyphosate-trimezium are highly effective against perennial weeds such as *Cirsium arvense* Scop. and *Convolvulus arvensis* L. They have quick initials effect and duration of action and do not allow the perennial weeds to restore vegetation in the sunflower. Not reported phytotoxic events in sunflower sown after their application, since these herbicides are leafy and fallen in the soil break down very quickly (Covarelli et al., 1991 and 1991; Covarelli and Contemori, 1998).

Jursik et al. (2011) studied in much Herbicide combinations found that the most efficient herbicide is oxyfluorfen and the most efficient combination is fluorochloridone + acetochlor. Highest phytotoxicity (68-81%) is recorded after the vegetation applying oxyfluorfen, followed by flumioxazin (23-45%). The phytotoxicity of the herbicide fluorochloridone, acetochlor, bifenox is lower (6-27%).

According to García and Labrada (1997) in sunflower herbicide combination trifluralin + prometrin is more effective than trifluralin - used alone before sowing with incorporation and prometrin - after sowing before emergence. Grain yield increased by 30 % and profitability by 288% compared with hand hoes control. The authors found that in high rainfall efficiency of prometryn reduced by more than 58%.

Complete destruction of *Sorghum halepense* Pers. from seeds and rhizomes is possible by the application of herbicides phenoxy-ethyl, fluazifop-butyl, haloxyfop-ethoxyethyl and kuinox-ethyl height of *Sorghum halepense* Pers. 15 - 30 cm (Markovic et al., 1985; Tosev and Drazic, 1985). Herbicide Fuzilad may be applied in tank mixtures with a large number of herbicides in antibroadleaved oilseed sunflower and oil seed canola (Hemmen and Konradt, 1991).

Ryabtsev et al. (2012) reported that the conditions of the Altai region in Siberia, the highest yields are obtained with the combination of pre-sowing introduction of Treflan + vegetation treatment with Fuzilad forte. According to the authors, 50 % of the yield is determined by herbicides. Saskevich et al. (2011) found that of the conditions Belarus 68-69% of the sunflower yield depends on chemical weed control.

Jat and Giri (2000) and Suresh and Reddy (2010) report that the use of herbicide Stomp (pendimethalin) at sunflower increases production by 56%. Herbicide Dual Gold destroys 90% of annual graminaceous and broadleaf weeds in corn and sunflowers crops (Khan and Hassan, 2003). Herbicides Dual Gold, Stomp and Trophy have high efficacy against annual weeds in sunflower (Patalaha al., 2009).

According Tracchi et al. (1998) herbicide Raft (oxadiargyl) is one of the most effective soil herbicides in conventional technology for sunflower growing.

The high efficiency of herbicides Afalon (linuron), Galigan (oxyfluorfen), Pledge (flumioxazin), Proponit (propisochlor) and Stomp (pendimethalin) introduced on different levels of fertilization is reported by Nádasy et al. (2007).

In experiments which are carried out in Thailand, Rungsit al. (1986) found that the herbicides napropamide and metolachlor and herbicide mixtures linuron + napropamide and linuron + metolachlor are highly effective against a large number of graminaceous and broadleaf weeds common in sunflower crops.

According to the results obtained from Holop and Protasov (1999), for soil and climatic conditions of the Northeast Belarus Racer (flurochloridone) is the most effective herbicide. The herbicidal combination flurochloridone + S-metolachlor had no effect and only against *Datura stramonium* L. and *Xanthium strumarium* L. (Simić et al., 2012).

Even minimal residues in the spraying tank of herbicides for the control of broadleaf weeds in cereal crops, such as dicamba, clopyralid or chlorsulfuron applied alone and in combination with antigraminaceous herbicides sethoxydim and diclofop cause strong phytotoxicity in the sunflower. The decrease in yield can reach to 40% (Derksen, 1989).

The studies of Fletcher et al. (1996) on the persistence of the four different herbicides - atrazine, chlorsulfuron, glyphosate and 2.4-D in the canola, sunflower and soybean showed that the persistence chlorsulfuron leads to a lower yield of grain in canola and soybean, in comparison with sunflower. Persistence of atrazine on these three cultures was lower.

According to trials were done by Drazic and Glusac (1988), the herbicidal mixtures atrazine + metolachlor, atrazine + alachlor, atrazine + linuron, metolachlor + linuron used in the cultivation of maize, reducing the weeds density in sunflower and wheat sown in the next growing season. The obtained results show that, in some of such mixtures there is a tendency to decrease the yield, but the differences were not statistically significant.

Zand et al. (2009) studied persistence of several herbicides containing sulfunilureya used in wheat on Subsequent rotation maize, sunflower, canola, chickpeas and soybeans. Were studied herbicides Apirus (sulfosulfuron) Megaton (chlorsulfuron) Bromitsid + Topic (bromoxynil + MCPA + clodinafop-propagril), Total (sulfosulfuron + mesosulfuron) and Atlantis (mesosulfuron + iodosulfuron). The authors found that herbicides Megaton and Total decreased sunflower yield by 15% and 50%.

Gajić-Umiljendić et al. (2012) found that the sunflower is sensitive to residues in the soil of the herbicide clomazone as compared to maize and barley.

According Caramete (1985) stability in the soil of used in sunflower herbicides in descending line is: linuron, monolinuron, metribuzin, prometrin, trifluralin. Last herbicide is degraded even by sunlight and needs immediate incorporation after its introduction in the soil. After a mechanical hoeing (cultivation) the quantities of these herbicides in soil decreased by 14-30% and after two hoes - by 25-50%.

Gosselin and Bey (1998) reported about sunflower hybrids resistant to the herbicide combination metazachlor + quinmerac.

Creation of sustainable hybrids of tribenuron-methyl allows the use of larger range of herbicides in sunflower, to a more effective chemical control of *Cirsium arvense* Scop. and some annual broadleaf weeds. Resistant genes are transferred from wild tribenuron-methyl resistant sunflower species. This new technology for weed control is economically more profitable than conventional technology (Jocić et al., 2008 and 2011).

Knežević et al. (2011) studying the elements of the new Clearfield technology and the hybrids resistant to imidazolinones, reported that this technology for weed control is also economically more profitable than conventional technology. It is used to control all of weeds in sunflower crop with only one treatment (Konstantinovic and Meseldzija, 2004; Konstantinovic et al., 2010). Clearfield technology is more effective against weeds in comparison with the soil herbicides terbutilizan and acetochlor and tank mixtures between them (Konstantinovic et al., 2010a).

According to Al-Khatib et al. (1998), resistance to imazethapyr at imazethapyr-resistant genotypes sunflower due to changes in the acetolactate synthesis, making them 25 times more resistant to this herbicide as compared to sensitive biotypes.

Malidza et al. (2005), Mitric and Vuckovic (2008) and Vrbnicanin et al. (2008) reported that in connection with the increasing problems associated with the change of the species composition of weed problems and control of certain weed species will grow more sunflower hybrids tolerant of imidazolinone and tribenuron-methyl. In the near future some conventional soil herbicides can be banned from the market due to their long persistence and contamination of soil and water.

In production will increasingly share of Clearfield and Express Sun technologies over conventional technology. Additional advantages of the two new technologies for weed control are more flexible timetable for the implementation of herbicides and to suppress the growth of perennial and some annual weeds (Malidza et al., 2004 and 2006).

In the next crop in the rotation, special attention should be given to the control of volunteer of sunflower hybrids tolerant of imidazolinone and tribenuron-methyl, which have resistance to herbicides other than that of conventional hybrids (Malidza, 2006).

Tonev et al. (2009) found that the simultaneous introduction of herbicides Express (tribenuron-methyl) and Gallant Super (haloxyfop-methyl) together with adjuvant Trend as a tank mixture, leading to phytotoxicity in sustainable tribenuron-methyl sunflower hybrid PR64E83. Symptoms of phytotoxicity are the result of the large temperature range air 2-3 days before and after the application of the tank mixture - low night temperatures and high daily temperatures. Herbicides Pledge (fluxofenin) and Goal (oxyfluorfen) used in conventional technology, applied in the same phase, exhibit much higher phytotoxicity in the sunflower, which has a negative effect on the yield.

Herbicide Intervix (imazamox + imazapyr) used in Clearfield technology for treatment of imidazolinone-resistant sunflower hybrids has no-effect on common wheat, barley, canola, maize and sugar beet (Suzer and Buyuk, 2010).

The most effective and most cost-effective way to control *Orobanche cumana* Wall. is the creation of sunflower hybrids resistant to this weed or hybrids that are resistant to herbicides based on imidazolinones (Skoric and Jocic, 2005; Soare et al., 2005; Masirevic and Malidza, 2006). Due to the high efficiency of imazethapyr against *Orobanche cumana* Wall. the fight against this parasitic weed in imazethapyr-resistant sunflower hybrids is conducted chemically rather than selection time (Alonso et al., 1998).

In the same vein are research and Garcia-Torres and Lopez-Granados (1991) and Garcia-Torres et al. (1994). According to the authors herbicides imazethapyr, imazapyr and chlorsulfuron effective against *Orobanche cumana* Wall. The required levels of herbicide vary depending on the degree of the inoculum and of the environmental conditions. Herbicide triasulfuron, imazaquin, primsulfuron, acetochlor and metazachlor are less effective. Imazamethabenz and metolachlor are ineffective against this parasitic weed.

Horvath and Osztrogonac (1991) find that the herbicide Goal (oxyfluorfen) inhibits the development of secondary haustories of *Orobanche cumana* Wall. in sunflower and severely hampers the development of weeds. The effect is stronger in vegetation treatment, compared with soil introduction of herbicide. The vegetation treatment with Goal leads to stronger phytotoxicity in the sunflower plants.

CONCLUSIONS

Chemical control has emerged as the most efficient method of weed control.

Herbicides combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more effective than when they are applied alone in sunflower crops. Their combined use often leads to high synergistic effect on yield.

Introduction of new sunflower Clearfield and Express Sun technologies marks a new stage in the weed control in this crop, including against *Orobanche cumana* Wall.

Problem is a post-effect of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation.

Most of the information in sunflower relates to conventional technology for the weed control. On some issues are published contrary opinions, due primarily to the different conditions under which the experiments were conducted and also the biological characteristics of the investigated cultivars and hybrids.

It is insufficient studied the effect of the herbicides on the sunflower yield that occurs by treatment the crop with the tank mixtures of herbicides, stimulators and fertilizers.

A serious problem is also the volunteers of the Clearfield and Experess Sun sunflower. They have resistance to herbicides different from that one of conventional sunflower hybrids. There is no information still in the scientific literature to control of these volunteers.

REFERENCES

Al-Khatib K., Baumgartner J.R., Peterson D.E., Currie R.S., 1998. Imazethapyr resistance in common sunflower (*Helianthus annuus*). Weed science, 46(4): 403-407.

Alonso L.C., Rodriguez-Ojeda M.I., Fernandez-Escobar J., Lopez-Ruiz-Calero G., 1998. Chemical control of broomrape (*Orobanche cernua* Loefl.) in sunflower (*Helianthus annuus* L.) resistant to imazethapyr herbicide. Helia, 21(29): 45-54.

Archenault C., Sagot C., 1996. Le point sur le chardon dans le tournesol. Oleoscope, (no 36): 25-27.

Axionov I., 2010. The use of minimum tillage in the cultivation of sunflower in Southern Ukraine steppe conditions. Helia, 33(53): 221-227.

Brighenti A.M., Moraes V.J., Oliveira Júnior R.S., Gazziero D.L.P., Voll E., Gomes J.A., 2002. Persistence and phytotoxicity of the herbicide atrazine applied on corn crop on successive sunflower crop. Planta Daninha, 20(2): 291-297.

Brighenti A.M., Rocha W.S., Souza Sobrinho F., Castro C., Martins C.E., Muller M.D., 2012. Application of reduced rates of ACCase-inhibiting herbicides to sunflower intercropped with *Brachiaria ruziziensis*. Helia, 34(54): 39-48.

Brighenti A.M., Souza Sobrinho F., Rocha W.S., Castro C., Martins C.E., Muller M.D., 2012a. Reduced rates of herbicides applied to imidazolinone-resistant sunflower crossbred with *Brachiaria ruziziensis*. Helia, 34(54): 49-58.

Caramete A., 1985. Study of the herbicide residues resulting from single or combined applications in sunflower crops. Analele Institutului de cercetari pentru protectia plantelor, Bucuresti, Romania, no 18: 251-256.

Covarelli G., 1988. Ricerche sperimentali sul diserbo del girasole in coltura principale ed intercalare. Informatore Agrario, 44(13): 113-121.

Covarelli G., D'Alessandro F., Salera E., 1991. Selettivita di alcuni prodotti erbicidi di pre-emergenza nel girasole germinato ma non emerso. Informatore Agrario, 47(8): 86-88.

Covarelli G., Pino A., Marroni M.G., 1991a. Possibilita di ridurre la dose di impiego di erbicidi ad applicazione fogliare nella preparazione del letto di semina del girasole. Informatore Agrario, 47(8): 71-75.

Covarelli L., Contemori R., 1998. Weed control efficacy for a new contact herbicide. Atti delle Giornate Fitopatologiche, p. 423-428.

Crnobarac J., Cupina T., Glusac D., Dusanic N., 1994. Rational production technology of sunflower. Zbornik radova - Poljoprivredni fakultet u Novom Sadu, Institut za ratarstvo i povrtarstvo, 22: 349-365.

Deibert E.J., 1989. Reduced tillage system influence on yield of sunflower hybrids. Agronomy journal, 81(2): 274-279.

Derksen D.A., 1989. Dicamba, chlorsulfuron, and clopyralid as sprayer contaminants on sunflower (*Helianthus annuus*), mustard (*Brassica juncea*), and lentil (*Lens culinaris*), respectively. Weed science, 37(4): 616-621.

Desplantes G., 1989. Combattre les dicotyledones dans le tournesol. Phytoma, no. 407: 33-34.

Drazic D., Glusac D., 1988. The effect of Atrazin residues on wheat and sunflower. Pesticidi, 3(2): 89-91.

Gajić-Umiljendić J., Jovanović-Radovanov K., Radivojević Lj., Šantrić Lj., Đurović R., Đorđević T., 2012. Maize, sunflower and barley sensitivity to the residual activity of clomazone in soil. Pesticidi i fitomedicina, 27(2): 157-165.

García R., Labrada R., 1997. Valoración de tratamientos herbicidas en girasol (*Helianthus annuus* L.). Fitosanidad, 1(1-4): 38-42.

Garcia-Torres L., Lopez-Granados F., 1991. Progress of herbicide control of broomrape (*Orobanche* spp.) in legumes and sunflower (*Helianthus annuus* L.). 5th International Symposium of Parasitic Weeds, Nairobi (Kenya), CIMMYT, p. 306-309.

Garcia-Torres L., Lopez-Granados F., Castejon-Munoz M., 1994. Pre-emergence herbicides for the control of broomrape (Orobanche cernua Loefl.) in sunflower (*Helianthus annuus* L.). Weed Research, 34(6): 395-402.

Gimesi A., 1986. Napraforgo hibridek herbicidtolerancia kiserleteinek eredmenyei. Novenyvedelem, 22(10): 456-458.

Gormonchik I., 2006. The effectiveness of herbicides on crops of sunflower. Plant protection, 30 (1): 93-95.

Gosselin N., Bey J., 1998. Nouvel interet de l' association metazachlore + quinmerac pour lutter contre l' Ammi majus en culture de tournesol. Journees internationales sur la lutte contre les mauvaises herbes. Dijon (France), p. 9-11.

Holop Y.A., Protasov N.I., 1999. Efficacy of herbicides in crops of sunflowers. International agragrny magazine, no 6: 25-27.

Horvath Z., Osztrogonac J., 1991. Effect of the herbicide Goal 2E, containing oxyfluorfen, in limiting the individual number of populations of sunflower broomrape (*Orobanche cumana* Wallr.). Novenyvedelem, Hungary, 27(3): 128-132.

Iliev A., Prisadashki W., Kostadinov D., Donchev S., 1999. Opportunities to reduce consumption levels for spraying of sunflower crops with herbicides. Agricultural Science, 37 (1): 32-36.

Ilieva D., 1997. Study susceptibility of sunflower hybrid Santa Fe and its parental lines to some herbicides. Plant Science, 34 (3-4): 124-127.

Jat R., Giri G., 2000. Influence of nitrogen and weed control measures on weed growth, and seed and oil yields of sunflower (*Helianthus annuus*). Indian Journal of Agronomy, 45(1): 193-198.

Jocić S., Malidža G., Cvejić, Hladni N., Miklič V., Škorić D., 2011. Development of sunflower hybrids tolerant to tribenuron methyl. Genetika, 43(1): 175-182.

Jocic S., Malidza G., Hladni N., Gvozdenovic S., 2008. New sunflower hybrids tolerant to tribenuron-methyl. Zbornik radova - Institut za ratarstvo i povrtarstvo, 45(2): 89-95.

Jursik M., Andr J., Holec J., Soukup J., 2011. Efficacy and selectivity of post-emergent application of flumioxazin and oxyfluorfen in sunflower. Plant, Soil and Environment, 57(11): 532-539.

Khan M., Hassan W., 2003. Effect of S-metolachlor (Dual Gold 960 EC) on weed control and yields in different crops. Sarhad Journal of Agriculture, 19(3): 333-339.

Knežević S., Malidža G., Elezović I., Simić M., Glamočlija Đ., 2011. Critical periods for weed control and obtaining yield increase in sunflower (*Helianthus annuus* L.) torerant to imidazolinones. 11th Conference about Plant Protection, Zlatibor [Serbia], 111-112.

Konstantinovic B., Meseldzija M., 2004. Clearfield production system - advantages, disadvantages and possible outcomes. Biljni lekar, 32(2): 149-153.

Konstantinović B., Meseldžija M., Korać M., 2010. Weed florae and efficiency studies of herbicides in sunflower crops. Zaštita bilja, 61(2): 87-95.

Konstantinović B., Meseldžija M., Korać M., Mandić N., 2010. Weed control in sunflower crops by soil herbicides. Biljni lekar, 38(3): 225-232.

Kovacevic P., 1983. Proucavanje stepena efikasnosti herbicida selektivnih za suncokret i njihov uticaj na kvalitativna i kvantitativna svojstva merkantilnog materijala (semena) ove kulture gajenoj na cernozemu Telecke zaravni. [Study on efficiency of herbicides selected for sunflower and their effect on the qualitative and quantitative characteristics of the seed material of this crop cultivated on chernozem of Telecka plateau]. Dissertation.

Laureti D., 2005. Cropping techniques of sunflower must be improved to assure competitiveness [*Helianthus annuus* L.; Marches (Italy); Tuscany]. Informatore Agrario, 61(13): 57-61.

Lyubenov Z.A., Milanova S., 1992. Effects of some systems and combinations of herbicides on the quantity and quality of sunflower oil. Plant Science, 29 (3-4): 132-136.

Malidza G., 2006. Weed control in sunflower crops. Biljni lekar, 34(4-5): 398-411.

Malidza G., Glusac D., Orbovic B., 2005. Current situation and trends in the field of chemical weed control in sunflower. Zbornik radova - Naucni institut za ratarstvo i povrtarstvo, no. 41: 473-480.

Malidza G., Jocic S., Skoric D., 2006. Tribenuron-tolerant sunflower. Biljni lekar, 34(4-5): 411-419.

Malidza G., Jocic S., Skoric D., Orbovic B., 2004. Clearfield production system for sunflower. Zbornik radova - Naucni institut za ratarstvo i povrtarstvo, no. 40: 279-290.

Markovic M., Tesic M., Egifanic Lj., 1985. Fitofarmakoloska vrednost herbicida u suzbijanju divljeg sirka u secernoj repi, soji i suncokretu. Conference: Jugoslovensko savetovanje o primeni pesticida. Struga, 22-26.

Marocchi G., 1995. Pre-emergenza, si diserba la coltura del girasole. Terra e Vita, 36(4): 66-68.

Masirevic S., Malidza G., 2006. Problem and control of broomrape (*Orobanche* spp.). Biljni lekar, 34(4-5): 353-360.

Milanova C., Atanasava C., 1994. Resistance of new Bulgarian sunflower hybrids to some herbicide combinations and systems. Plant Science, 31(1-2): 102-106.

Mitric S., Vuckovic B., 2008. Preliminary bioassay for determination of threshold doses of herbicides. Acta Herbologica, 17(2): 161-166.

Nádasy E., Kazinczi G., Nádasy M., 2007. Relationship between herbicide application and mineral nutrition of sunflower. 8-th Slovenian Conference on Plant Protection (8. slovensko posvetovanje o varstvu rastlin), Radenci (Slovenia), p. 304-308.

Paganini U., Meriggi P., 1995. Il controllo delle infestanti nel girasole. Tecniche applicabili in post-emergenza. Agronomica, no.2: 33-37.

Patalakha L.M., Goren I.N., Bulavina L.G., 2009. The effect of herbicides on the activity of the soil in the planting sunflower. Plant Protection and Quarantine, no 3: 26-27.

Pavlova A., Bachvarov P., Kovacheva T., 1992. Additional foliar feeding of sunflower plants with suspension fertilizers Laktofol. Soil Science, Agrochemistry and Ecology, 27(3-4): 36-40.

Rapparini G., 1988. Diserbo del girasole: come, quando, perche. Informatore Agrario, 44(15): 97-103.

Rapparini G., 1993. Per il controllo delle infestanti del girasole e sufficiente il trattamento di pre-emergenza. Informatore Agrario, 49(8): 119-131.

Retamal N., Duran J.M., 1998. Application of herbicides in sunflower crop. Vida Rural, no 63: 48-50.

Riabtsev V.I., Deryanova E.G., Oleshko V.P., 2012. The cultivation of sunflower in Altayskogo steppe region. Advances in science and technology APK, no 2: 34-36.

Ribeiro J.R., Cavaco M., 2003. Proteccao integrada de oleaginosas: amendoim - cartamo- colza - girassol - soja: lista dos produtos fitofarmaceuticos: niveis economicos de ataque. Divulgacao. Monograph.

Salera E., Baldini M., 1988. Le infestanti e il loro controllo nella coltura del girasole. Informatore Agrario, 44(13): 125-131.

Saratov O.Z., Kirichenko V.V., 2012. The effectiveness of sustainability assessment of the starting material of sunflower at different doses of herbicide evrolayting. Breeding and nasinnitstvo: Mizhvidomchi tematichnosti Naukova zbirnik, no 101: 84-89.

Sarno E., D'Alessandro F., Vinciguerra P., 1986. Primi risultati di una prova sul controllo chimico delle erbe infestanti la coltura del girasole in Sicilia. Informatore Agrario, 42(31): 51-57.

Saskevich P.A., Kozlov S.N., Kazharsky V.R., 2011. The harmfulness of weeds in sunflower. Bulletin of the Belarusian State Academy of Agriculture, no 4: 90-98.

Savka E.S., 1988. Effect of pre-Surfacing seed herbicides on the photosynthetic activity of sunflower plants. Monograph.

Simić M., Dragičević V., Knežević S., Radosavljević M., Dolijanović Ž., Filipović M., 2012. Effects of applied herbicides on crop productivity and on weed infestation in different growth stages of sunflower (*Helianthus annuus* L.). Helia, 34(54): 27-38.

Skoric D., Jocic S., 2005. Broomrape (*Orobanche cumana* Wall.) and its possible control by genetic and chemical means. Uljarstvo, 36(1-2): 15-22.

Soare T., Soare G., Calcagno F., Calcagno F., Bozzini A., Calcagno L., 2005. Sunflower breeding for alternative genetic resistance to the parasite *Orobanche cumana* Wall. (*Helianthus annuus* L.). Journal of Genetics and Breeding, 59(3-4): 269-275.

Suresh G., Reddy B.N., 2010. Effect of weed control practices on weed dry matter, production potential and nutrient uptake of sunflower (*Helianthus annuus*) in Vertisols. Indian Journal of Agricultural Sciences, 80(1): 33-37.

Suzer S., Buyuk H., 2010. Residual effects of spraying imidazolinone-family herbicides on Clearfield(R) sunflower production from point of view of crop rotation. Helia, 33(52): 25-35.

Tei F., 1986. Ricerche sperimentali sul diserbo del girasole in presenza di flora infestante macroterma. Informatore Agrario, 42(13): 107-110.

Tei F., Covarelli G., Onofri A., Baldoni G., D'Alessandro F., Salera E., 1991. Flora infestante e diserbo chimico selettivo del girasole. Informatore Agrario, 47(8): 77-85.

Tonev T., Mitkov A., Dotchev Ch., Tityanov M., 2009. Possibilities of SU-efficient technology for weed control in sunflower. Plant Sciences, 46(2): 161-166.

Tosev M., Drazic D., 1985. Possibilities of Johnson grass (*Sorghum halepense*) control. Glasnik zastite bilja, 8(12): 391-394.

Tracchi G., Ballasso G., Magli G., 1998. Oxadiargyl. A new herbicide for sunflower and vegetable crops (*Helianths annuus* L.). Atti delle Giornate Fitopatologiche, p. 333-338.

Vrbnicanin S., Bozic D., Malidza G., Dusanic N., Pavlovic D., Barac M., 2008. Tolerance of sunflower (*Helianthus annuus* L.) to imazethapyr. Helia, 31(48): 85-94.

Wanikorn N., 1991. Weed competition and chemical weed control in sunflower (*Helianthus annuus* L.). Kasetsart Univ., Bangkok. Dissertation.

Yarovenko V.V., Bodnya V.I., Krainyuk M.S., 1988. The persistence of Treflan. Plant Protection, no 2: 42-43.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ACHIEVEMENTS AND PROBLEMS IN THE WEED CONTROL IN OILSEED CANOLA (*Brassica napus* L.)

Grozi DELCHEV, Mitko GEORGIEV

Department of Plant Production, Faculty of Agriculture, Trakia University, 6000, Stara Zagora, Bulgaria

Corresponding author email: delchevgrd@dir.bg

Abstract

Herbicides combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more effective than when they are applied alone in canola crops. Their combined use often leads to high synergistic effect on yield. Data regarding herbicide for effective control of cruciferous weeds in crops of oilseed canola are quite scarce even in worldwide. It is still search effective herbicides for their control in this culture. Problem is a post-effect of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation. Most of the information in canola relates to conventional technology for the weed control. There is not information about the new Clearfield technology in oilseed canola and used hybrids resistant to imazamox. A serious problem is also the volunteers of the Clearfield canola. They have resistance to herbicides different from that one of conventional canola hybrids. There is no information still in the scientific literature to control of these volunteers.

Key words: *canola, herbicides, seed quality, seed yield, weed control.*

REVIEW

Integrated weed control in oilseed canola is a combination of preventative, mechanical and chemical methods to reduce environmental pollution. To be economically efficient, application of herbicides must be done in accordance with damage thresholds prevailing weeds (Lukacs and Halasz, 1987; O'Donovan, 1991; Klaus, 1992; O'Donovan and Newman, 1996). Chemical weed control is more effective than mechanical processing (Dann et al., 1987).
Adamczewski and Selmeczi (1994) found that herbicides Amadeus, Kresopur and their combinations with Lontrel do not exhibit phytotoxicity to the winter canola, and provide better control of broadleaf weeds. Amadeus has fewer efficacies against *Galium aparine* L., *Chenopodium album* L., *Lamium purpureum* L. and *Lamium aplexicaule* L. Seed yield increases from 9 to 25% after application of these herbicides. Leyhe et al. (1994) also reported a high herbicidal efficacy and selectivity of Lontrel in oilseed canola. Lontrel control perennial broadleaf weeds 85% (Wei et al., 2010).
According to Nagy and Ador (2000) herbicide combination Starane + Lontrel + Perenal has excellent efficacy against all weeds in the canola crops. Herbicide mixture Lontrel + Galant Super is more effective than herbicide mixture Butizan Star + Galant Super (Shimi et al., 2009). The combination Lontrel + Treflan is not effective against *Malva sylvestris* L. and *Silybum marianum* Gaertn. (Shimi et al., 2006). The combined herbicide Lontrel Grand is more effective than the combined herbicide Galera against perennial broadleaf weeds (Gadzhieva and Poloznyak, 2006).
According to data of Ali (2001) the use of S-metolachlor, alone and in combination with other herbicides in reduced doses decreased the density of weeds in canola crops by 50-60%.
Arif et al. (2001) found in experiments in Pakistan that isoproturon is the most effective herbicide for the control of the majority of weeds in winter canola compared with other herbicides, and conventional methods of weed control. Number of weeds per m^2 is the smallest and plant height, number of pods per plant, number of seeds in a pod, 1,000 seeds weight and grain yield were the highest at treatment Isoproturon 75 WP at a dose of 520 g/ha.
Many authors in their experiments establish the efficacy of various herbicides and herbicide

combinations in weed control in canola crops and their positive effect on the yield of seeds (Chow et al., 1983; Blackshaw and Harker, 1992; Blackshaw et al. 1992; Brennan et al., 1992 and 1992a; Brennan and Thill, 1993 and 1993; Davis et al., 1993; Kirkland, 1995 and 1996; Downey, 1997; Shaw, 1997; Oliveira Junior, 2001; Pérez Fernández et al., 2001; Skuryat and Maslakova, 2002; Tsyuganov et al., 2004; Bulavin et al., 2007; Luzhinskiy et al., 2011).

Chaudhry et al. (2011) investigated five herbicides: Stomp (pendimethalin), Partner (isoproturon), Zenkor (metribuzin), and Dual Gold (S-metolachlor) applied after sowing and before emergence and Topic (clodinafop-propargyl) attached vegetation. The application of Stomp, Zenkor, Partner and Dual Gold lead to reduce of broadleaf weeds by 98%, 97%, 96% and 94% and Topic does not affect at these weeds. The highest grain yield is obtained at Stomp, followed by Dual Gold and Partner. Zenkor decreased grain yield, although high herbicidal efficacy against weeds.

Similar results were reported by Khan and Hassan (2003) and by Khan et al. (2008). The authors found significant phytotoxic effect of Zenkor on canola. Herbicides Treflan, Dual Gold and Stomp have high selectivity to the culture. Grain yield, number of branches and number of pods per plant, number of seeds in a pod and 1000 seeds weight are highest in the application of Treflan. Majid et al. (2003) also reported a high herbicidal efficacy of the trifluralin. Annual broadleaf weeds are controlled more effectively than trifluralin compared to the other weed species.

In a similar vein are research of Pourazar and Habibiasl (2003). According to the authors, combining Treflan and Sonalen leads to more successful weed control compared with multiple soil processing. In were used alone both herbicides their effectiveness against weeds is much lower. Treflan herbicide cannot control *Sinapis arvensis* L., *Raphanus raphanistrum* L., *Silybum marianum* Gaertn, *Geranium macrorrhizum* L. and other cruciferous weeds.

Wyszkowski and Wyszkowska (2004) reported that the use of Treflan change the chemical composition of oilseed canola and *Sinapis arvensis* L. Treflan leads to accumulation of more N_2 and trace elements such as Na and Mg in the above-ground weight and seeds. This is associated with reduced enzyme activity and generally has a negative effect on canola plants. Cruciferous weeds are the most dangerous weeds in canola, because of their difficult control in its crops. Polish mustard is dominant among these species (Wall, 1992; Shimi et al., 2004; Salimi et al., 2009). In the absence of adequate herbicides, most efficient way to control these weeds is the burning of the stubble after the predecessor. Thus, it is killed all weeds emerged and 43% of seeds of cruciferous weeds in the soil. According to those alleging in Iran experiments burning does not have a serious effect on soil microorganisms or on other physicochemical aspects of soil (Salimi et al., 2007).

Research of Nikolova and Chipeva (2007) indicate that there are a large number of resistant biotypes of *Sinapis arvensis* L., which cannot be destroyed with the herbicide 2.4-D (Maton).

According to data of Khan et al. (2003) herbicide Fuzilad has the best antigraminaceous effect compared with Ronstar, Topic, Puma Super and Azhil. Grain yield and the values of the abovementioned structural elements are the highest at Fuzilad. Targa Super also has high efficacy against graminaceous weeds in canola crops (Millet, 1986). According to data of Ziminska et al. (1991 and 1994) in oilseed canola, vegetation herbicides Alatrif and Propalin are more effective than soil herbicides Lasso and Triflurotox. According Jabran et al., (2010) the addition of plant extracts to Stomp (pendimethalin) increase the herbicidal efficacy and allows reduction in dosage in view of environmental protection.

Poloznyak (2002, 2003, 2008 and 2010) reported about a high efficiency of herbicides Argon, Zelek Super, Galera and Sirius in crop of spring canola. Tsyuganov and Klochkova (2006), Tibets and Saskevich (2006) and Saskevich et al. (2009) reported for high efficacy of herbicides Lontrel, Teridoks, Butizan, Trophy, Roundup Max, Fuzilad Forte and Targa Super and different combinations between them in oilseed canola crops.

Miklaszewska et al. (2000) reported that the preparation Olbras 88 used as adjuvant to 28 herbicides in winter canola and maize increases their efficiency more compared with adjuvants Tsitovet, Adbios, Atpol and Atplus.

Concomitant use of herbicides and insecticides in canola does not reduce their effectiveness and fat and protein contents and increases the glucosinolate content (Mrowczynski et al., 1991; Leonov and Yurgel, 2002; Murawa and Warminski, 2004 and 2005).

The investigations of Fletcher et al. (1996) on the persistence of the four different herbicides - atrazine, chlorsulfuron, glyphosate and 2.4-D in canola, sunflower and soybean showed that persistence of chlorsulfuron leads to a lower yield of grain in canola and soybean, in comparison with sunflower. Persistence of atrazine on these three cultures was lower. Kim and Vanden (1997) and Kim et al. (1997) also found a high phytotoxicity of residues amounts at chlorsulfuron in the soil to canola. According Paradowski (1994) herbicides Glean (chlorsulfuron) and Logran (triasulfuron) applied to optimal doses and terms of wheat have a negative persistence on oilseed canola and sugar beet.

Wall et al. (1995) and Wall (1997) researching the tolerance of conventional canola and sunflower hybrids to tribenuron-methyl + thifensulfuron-methyl (Granstar super) from 2 leaf stage to 7 leaf stage of ccanola found that phytotoxic events are weakest in stage 2-3 leaf.

Treatment of canola immediately after germination during cotyledons stage is possible phytotoxic effect under the influence of many herbicides applied in optimal doses (Lemerle and Hinkley, 1991).

Zand et al. (2009) study the persistence of several containing sulfonylurea herbicide used in wheat on subsequent in the rotation maize, sunflower, canola, chickpeas and soybeans. Were studied herbicides Apirus (sulfosulfuron) Megaton (chlorsulfuron) Bromitsid + Topic (bromoxynil + MCPA + clodinafop-propagril), Total (sulfosulfuron + mesosulfuron) and Atlantis (mesosulfuron + iodosulfuron). The authors found that herbicides Atlantis and Megaton reduce yield canola by 13 and 20%.

In a similar vein are the studies of Dongiovanni et al. (2000) according to which after the use of triasulfuron and metsulfuron in wheat crops, the safe interval to sowing of canola is 3 to 6 months depending on weather conditions. According Bulavin at al. (2009) residues of the used in wheat herbicide Laren (metsulfuron), can reduce seed yield in canola by 9-21% and oil content in the seeds can reduce by 27-28%. The losses are maximal in hot weather and dry soil, which impede the normal degradation of the herbicide in the soil.

The use of herbicides Triflurotox and Butizan in spring canola leads increase in the fat content in the seeds. Used herbicides do not affect the protein, phytin, phosphorus, phenolic compounds or macronutrients (P, K, Mg) in canola oil (Adomas, 2003 and 2005). The same author, exploring the influence of herbicide substances trifluralin (Triflurotoks), alachlor + trifluralin (Alatrif), metazachlor (Butizan), clopyralid (Lontrel), in several cultivars of spring canola found that weather conditions have a significant impact on the content of glucosinolates in the seeds. Their content is influenced more by the weather than by the application of herbicides (Adomas, 2004). According Kivachitskaya (2007) treatment of spring canola with Teridoks leads to minimal residual amounts of the herbicide in the seeds.

According to data of Treikale et al. (2006) treatment with herbicide Sultan (metazachlor) against dicotyledonous weeds in vegetation period of canola is more efficient than its treatment after sowing before emergence of the crop. Dimitrova and Ivanova (2007) researching some herbicides for weed control in oilseed canola, found that the Sultan is highly efficient against broadleaf weeds and Fuzilad and Azhil - against graminaceous weeds.

Blackshaw (1989 and 1989) reported that the new sulfonylurea herbicide DPX A7881 (ethametsulfuron-methyl) controls weeds from the family *Brassicaceae*, as *Sinapis arvensis* L., *Raphanus raphanistrum* L., *Capsella bursa-pastoris* L., that are not controlled with the existing soil herbicides for weed control in winter canola. Weed control is most effective when DPX A7881 is supplied in stage 2-6 leaf of canola and weeds. This herbicide treated in this stage, shows high selectivity to series varieties and hybrids spring canola (Lichtner et al., 1995). Herbicide mixtures of vegetation herbicide DPX A7881 with antigraminaceous herbicides Fuzirad Forte, Galant Super, Targa Super and Naboo Extra do not exhibit antagonism in its herbicidal activity (Harker et al., 1995). Fuzilad herbicide can be applied in a tank mixtures with a large number antibroadleaved herbicides in oilseed canola and oilseed sunflower (Hemmen and Konradt, 1991).

There are triazine-resistant (TR) spring canola cultivars that allow efficient chemical control of weeds with triazine herbicides. These cultivars usually give 20 to 30% lower yield than normal, triazine-sensitive (TS) canola varieties. Lower crop yields TR varieties due to impaired electron flow between II and I photo systems in the process of photosynthesis. Triazine-resistant hybrids will enter the production if created TR parental genotypes with normal photosynthetic capacity (Beversdorf et al., 1988; McMullan et al., 1994).

Compared to traditional soil and foliar herbicides, the use of contact total herbicide glufosinate-ammonium (Basta) in canola provides better control of the all weeds. It is used in the established in Canada by way of genetically engineering; transgenic glufosinate ammonium tolerant lines spring oilseed canola (Kumar et al., 1998; Rieger et al., 1999).

The use of biologically active substances in stage of flowering oilseed canola increased seed yield (Todorov et al., 2010). Preharvest desiccation of canola increased seed yield. Their qualitative parameters do not change the use of desiccant before harvest (Marchiori et al., 2002).

CONCLUSIONS

Literature review demonstrates the views of cited authors formulated a series of laws. Chemical control has emerged as the most efficient method of weed control.

Herbicides combinations and tank mixtures of herbicides with adjuvants, fertilizers, growth regulators, fungicides, insecticides, are more effective than when they are applied alone in canola crops. Their combined use often leads to high synergistic effect on yield.

It gave information about the canola hybrids resistant to glufosinate-ammonium and triazine. However, these hybrids are GMOs and are banned within the European Union including and in Bulgaria.

Although without claim to be exhaustive literature review should be noted, data regarding herbicide for effective control of cruciferous weeds in crops of oilseed canola are quite scarce even in worldwide. It is still search effective herbicides for their control in this culture.

Problem is the persistence of some herbicides used in the predecessors on succeeding crops, which is directly related to the weather conditions during their degradation.

Literature review gives an idea that most of the information in canola relates to conventional technology for the weed control. It is published opposing views even for them on some issues, due primarily to the different conditions under which the experiments were conducted and the biological characteristics of the tested cultivars and hybrids.

There is not information about the new Clearfield technology in oilseed canola and used hybrids resistant to imazamox.

A serious problem is also the volunteers of the Clearfield canola. They have resistance to herbicides different from that one of conventional canola hybrids. There is no information still in the scientific literature to control of these volunteers.

REFERENCES

Adamczewski K., Selmeczi J., 1994. Spring weed control in winter rape by herbicide Amadeus 46.25 WP. Materials of the 34-th Research Session of Institute of Plant Protection. Part 2, Pruszynski, S.; Lipa, J. (eds.), Poznan (Poland), p. 125-128.

Adomas B., 2003. The yield and quality of seeds of spring rape (*Brassica napus* var. *oleifera* F. *annua*), yellow lupin (*Lupinus luteus* L.) and narrow-leaved lupin (*Lupinus angustifolius* L.) depending on the pesticides used. Dissertation.

Adomas B., 2004. The glucosinolates content in spring rape seeds under the influence of herbicides. Journal of Plant Protection Research, 44(3): 259-265.

Adomas B., 2005. Content of selected minerals in the seeds of spring rape and white mustard treated with herbicides. Acta Scientiarum Polonorum. Agricultura, 4(2): 5-15.

Ali A., 2001. Effectiveness of different weed control methods in canola (*Brassica napus* L.). Dissertation, 100-106.

Arif M., Ihsanullah K., Khan S., 2001. Effect of various weed control methods on the performance of canola. Sarhad Journal of Agriculture, 17(3): 321-324.

Beversdorf W.D., Hume D.J., Donnelly-Vanderloo M.J., 1988. Agronomic performance of triazine-resistant

and susceptible reciprocal spring canola hybrids. Crop science, 28(6): 932-934.
Blackshaw R.E., 1989. Synergistic mixes of DPX-A7881 and clopyralid in canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 3(4): 690-695.
Blackshaw R.E., 1989. Control of Cruciferae weeds in canola (*Brassica napus*) with DPX A7881. Weed science, 37(5): 706-711.
Blackshaw R.E., Harker K.N., 1992. Combined post emergence grass and broadleaf weed control in canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 6(4): 892-897.
Blackshaw R.E., Kanashiro D., Bekkaoui F., Cosby W.L., Babic I., Moloney M.M., 1992. Development of canola (*Brassica napus*) expressing resistance to acetolactate synthase inhibiting herbicides. Proceedings of the First International Weed Control Congress, Volume 2. Melbourne, Vic. (Australia): Weed Science Society of Victoria Inc. 90-92.
Brennan J.S., Thill D.C., 1993. Evaluation of postemergence herbicides and herbicide additive combinations for weed control in canola. Research progress report - Western Society of Weed Science. Meeting held March 9-11, 1993, Tucson, Arizona, III/77-III/79.
Brennan J.S., Thill D.C., 1993a. Evaluation of preplant incorporated, preemergence, and postemergence herbicides for weed control in canola. Research progress report - Western Society of Weed Science. Meeting held March 9-11, 1993, Tucson, Arizona, III/80-III/81.
Brennan J.S., Thompson C.R., Thill D.C., 1992a. Evaluation of preplant incorporated and postemergence herbicides for weed control in canola. Research progress report - Western Society of Weed Science, Meeting held on March 9-12, 1992, Salt Lake City, Utah, III/59-III/60.
Brennan J.S., Thompson C.R., Thill D.C., 1992. Evaluation of postemergence herbicides for weed control in canola. Research progress report - Western Society of Weed Science, Meeting held on March 9-12, 1992, Salt Lake City, Utah. III/61-III/62,
Bulavin L.A., Nebyshinets S.S., Belanovsky M.A., Gerdovich S.W., Kankevits V.A., 2007. The effect of the terms of tillage and herbicides on weed infestation and yield of spring rape. Agriculture and breeding in Belarus: collection of scientific papers, no 43: 205-213.
Bulavin L.A., Nebyshinets S.S., Belanovsky M.A., Gerdovich S.W., Kankevits V.A., Apresian O.G., 2009. The aftereffect herbicide Laren on spring rape. Agriculture and breeding in Belarus: Collection of scientific works, no 45: 63-73.
Chaudhry S.U., Hussain M., Iqbal J., 2011. Effect of different herbicides on weed control and yield of canola (*Brassica napus*). Journal of Agricultural Research, 49(4): 483-489.
Chow P.N.P., O'Sullivan P.A., Hunter J.H., Kirkland K.J., 1983. Control of barley and wheat in canola with BAS 9052. Canadian Journal of Plant Science, 63(4): 1099-1102.
Davis E.S., Stougaard R.N., Fay P.K., 1993. Herbicides for weed control in canola: what are the options? Montana agresearch, 10(2): 6-10.
Dimitrova M., Ivanova R., 2007. Efficiency and selectivity of herbicides in winter rape. Plant Science, 44 (4): 365-367
Downey R.K., 1997. Present status of herbicide tolerant canola in Canada. GCIRC Bulletin, (no 13): 41-42.
Fletcher J.S., Pfleeger T.G., Ratsch H.C., Hayes R., 1996. Potential impact of low levels of chlorsulfuron and other herbicides on growth and yield of nontarget plants. Environmental toxicology and chemistry, 15(7): 1189-1196.
Hajiyev G.I., Poloznyak E.N., 2006. The effectiveness of new herbicides against perennial dicotyledonous weeds in crops of sugar beet and oilseed rape. Agroecology, no 4: 21-24.
Harker K.N., Blackshaw R.E., Kirkland K.J., 1995. Ethametsulfuron interactions with grass herbicides on canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 9(1): 91-98.
Hemmen C., Konradt M., 1991. Fusilade 2000 - selektives Grasherbizid fuer Raps und andere breitblaettrige Kulturen. Gesunde Pflanzen, 43(6): 179-192.
Jabran K., Cheema Z.A., Farooq M., Hussain M., 2010. Lower doses of pendimethalin mixed with allelopathic crop water extracts for weed management in canola (*Brassica napus*). International Journal of Agriculture and Biology, 12(3): 335-340.
Khan I.A., Hassan G., 2003. Efficacy of pre-emergence herbicides on the yield and yield components of canola. Asian Journal of Plant Sciences, 2(3): 251-253.
Khan I.A., Hassan G., Khan M.A., 2003. Efficacy of post-emergence herbicides for controlling weeds in canola. Asian Journal of Plant Sciences, 2(3): 294-296.
Khan, I.A., Hassan G., Marwat K.B., Daur I., 2008. Efficacy of some pre and post-emergence herbicides on yield and yield components of canola. Pakistan Journal of Botany, 40(5): 1943-1947.
Kim S.M., Hur J.H., Han D.S., William H.V.B., 1997. Chlorsulfuron-induced phytotoxicity in Canola (*Brassica napus* L.) seedlings. Korean Journal of Weed Science, 17(2): 199-206.
Kim S.M., Vanden W.H., 1997. Carbon allocation and translocation in chlorsulfuron-treated canola (Brassica napus). Weed science, 45(4): 466-469.
Kirkland K.J., 1995. HOE 075032 for wild mustard (Sinapis arvensis) control in canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 9(3): 541-545.
Kirkland K.J., 1996. Use of incorporated non-incorporated granular trifluralin for annual grass control in barley (*Hordeum vulgare*), wheat (*Triticum aestivum*), and canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 10(4): 907-913.
Kivachitskaya M.M., 2007. Determination of residual amount of herbicide Teridox chromatography method

in seeds and canola oil. Plant Protection, no 31: 346-353.
Klaus M., 1992. Integrated weed control illustrated in the case of winter rape. Gesunde Pflanzen, 44(8): 251-254.
Kumar A., Rakow G., Downey R.K., 1998. Genetic characterization of glufosinate-ammonium tolerant summer rape lines. Crop science, 38(6): 1489-1494.
Lemerle D., Hinkley R.B., 1991. Tolerances of canola, field pea, lupin and faba bean cultivars to herbicides (*Brassica napus; B. campestris; Pisum sativum; Lupinus albus; L. angustifolius; Vicia faba*). Australian Journal of Experimental Agriculture, 31(3): 379-386.
Leyhe A., Trozelli H., Knaus K., 1994. Lontrel 100 - new prospects for selective weed control in beet, oilseed rape and maize. Zeitschrift fuer Pflanzenkrankheiten und Pflanzenschutz, 14: 577-581.
Lichtner F.T., Dietrich R.F., Brown H.M., 1995. Ethametsulfuron methyl metabolism and crop selectivity in spring oilseed rape (*Brassica napus* L.). Pesticide biochemistry and physiology, 52(1): 12-24.
Lukacs P., Halasz G., 1987. Realization of the research results achieved in the cultivation of oil-seed plants (sunflower and rape). Olaj, Szappan. Hungary, 36(4): 97-101.
Luzhinsky D.V., Pilyuk Y.E., Bulavin L.A., 2011. The fight against the contamination of crops crop of volunteer canola. Zemlyarobstva i APB raslin: navukova-praktychny chasopis, no 4: 36-37.
Majid A., Nawaz N., Hazara R., Yousaf M., Baig D., 2003. Weed dynamics, growth and yield of rapeseed canola in response to trifluralin efficacy under rainfed conditions. Pakistan Journal of Arid Agriculture, 6(2): 53-63.
Marchiori Júnior O., Inoue M.H., Braccini A.L., Oliveira Júnior R.S., Avila M.R., Lawder M., Constantin J., 2002. Quality and yield of canola (*Brassica napus*) seeds after pre-harvest desiccant application. Planta Daninha, 20(2): 253-261.
McMullan P.M., Daun J.K., DeClerq D.R., 1994. Effect of wild mustard (*Sinapis arvensis*) competition on yield and quality of triazine-tolerant and triazine-susceptible canola (Brassica napus). Canadian journal of plant science, 74(2): 369-374.
Miklaszewska K., Adamczewski K., Stachecki S., 2000. Olbras 88 EC - nowy dodatek olejowy do herbicydow. Monograph.
Millet J.C., 1986. Targa. Son interet en culture de colza et tournesol [quizalofop - ethyl; antigraminee de postlevee]. Defense des Vegetaux, 40(2-4): 17-20.
Mrowczynski M., Dorna J., Grala B., Adamczewski K., Paradowski A., Urban M., Palosz T., Stepniewski J., 1991. Effectiveness and rentability of separate use of insecticides and herbicides as compared to the use of insecticides in tank mix with herbicides in oilseed rape. Materials of the 30-th Research Session of Institute for Plant Protection. Part 2. Pruszynski, S. (ed.), p. 273-279.
Murawa D., Warminski K., 2004. Yielding of spring rape exposed to different plant protection agents. Acta Scientiarum Polonorum. Agricultura, 3(2): 221-233.
Murawa D., Warminski K., 2005. Effect of varied plant control on the chemical composition of spring rapeseed. Acta Scientiarum Polonorum. Agricultura, 4(1): 77-87.
Nagy I., Ador Sz., 2000. Provoked trial with Starane 250 EC for weed control options in winter rape. Növényvédelem Hungary, 65: 245-250.
Nikolova B., Chipeva S., 2007. Resistance to weed Sinapis arvensis to herbicides based on 2.4-D. Plant Sciences, 44 (4): 349-353.
O'Donovan J.T., 1991. Quackgrass (*Elytrigia repens*) interference in canola. Weed science, 39(3): 397-401.
O'Donovan J.T., Newman J.C., 1996. Manipulation of canola plant density and herbicide rate for economical and sustainable weed management. Proceedings: Second international weed control congress, 3, Brown, H. Cussans, G. Devine, M. Duke, S. Fernandez-Quintanilla, C. Helweg, A. Labrada, R. Landes, M. Kudsk, P. Streibig, J.C. (eds.).- Slagelse (Denmark), p. 969-974.
Oliveira Junior R.S., 2001. Carryover of imazaquin and alachlor + atrazine to the successional canola crop. Ciencia Rural, 31(2): 219-224.
Paradowski A., 1994. Carryover effect of chlorsulfuron and triasulfuron applied to winter wheat on yield of winter rape and sugar beet. Materials of the 34-th Research Session of Institute of Plant Protection. Part 2, Pruszynski, S.; Lipa, J. (eds.), Poznan (Poland), p. 129-134.
Pérez Fernández M.A., Calvo Magro E., López Martín M., 2004. Biological control of Briza maxima L. and Raphanus raphanistrum L. using rhizobacteria. 44th Scientific Meeting of Spanish Society for the Study of Pastures, Salamanca (Spain), p. 151-156.
Poloznyak E.N., 2002. Argon in crops of spring rape. Integrirannye system for plant protection. Present and future. Soroka, S.V.; Supranovich, R.V.; Bug S.F.; Trepashko, L.I.; Zhukova, M.I.; Timofeev, N.N. (ed.), Minsk, Balarus, p. 58-60.
Poloznyak E.N., 2003. Highly protivozlakovy herbicide in crops of spring rape. Plant Protection, no 27: 170-172.
Poloznyak E.N., 2008. Regulation of the number of plants dvudolnyh weeds in rape. Plant Protection, no 32: 65-70.
Poloznyak E.N., 2010. The effectiveness of domestic girbitsida Sirius 400 in crops of winter and spring rape. Zemlyarobstva i APB raslin: navukova-praktychny chasopis, no 5: 57-59.
Pourazar R., Habibiasl J., 2003. Control of weed in canola (*Brssica napus* L.) by Chemical and Mechanical Methods, Agricultural and Natural Resources Research, p. 40-43.
Rieger M.A., Preston C., Potter T., Powles S.B., 1999. Gene flow from transgenic canola to wild radish (*Raphanus raphanistrum*) - a model system to determine the risks. Proceedings of a symposium held at Keele, UK, p. 131-136.
Salimi H., Ahmadi M., Barjasteh A., Hatami S., Delghandi M., Fereidoonpour M., Ghanbari D., Narimani V., Unes Abadi M., Nazer Kakhki H.,

2009. Cruciferous weeds (*Brassicaceae*) of canola fields in ten provinces of Iran. Pajouhesh And Sazandegi, 22(1): 25-36.

Salimi H., Samavat S., Shimi P., 2007. Investigating efficacy of flaming in decreasing wild mustard (*Sinapis arvensis* L.) seed bank in canola. Plant Protection Reseach (Iran), p. 15-19.

Saskevich P.A., Tibets J.L., Gurikova E.I., 2009. Agroecological assessment of plant protection products in the cultivation of spring rape. Bulletin of the Belarusian State Academy of Agriculture: Scientific-methodical magazine, no 2: 83-87.

Shaw C., 1997. Herbicide tolerant canola, a farmer perspective. Western Society of Weed Science, v. 50: 11-12.

Shimi P., Din F., Pur R., 2009. Investigating efficacy of clopyralid produced by two different manufacturers and their over dose effect on canola. Plant Protection Research, p. 10-17.

Shimi P., Jahedi A., Bagherani N., Ghanbari B., Darioosh A., 2004. Testing new Herbicides for Weed Control in Oilsee rape fields with Emphasis on the Control of Wilde Mushard (*Sinapis arvensis* L.). Plant Pests and Diseases, p. 1-9.

Shimi P., Poorazar R., Jamali M., Bagherani-Torshiz N., 2006. Evaluating clopyralid as a broad leaf herbicide in canola fields of Iran. Pakistan Journal of Weed Science Research, 12(4): 307-311.

Skuryat A., Maslyakova S.V., 2002. Agroecological features the use of pesticides in the protection Yawovi Oz and rape. Integrirannye system for plant protection. Present and future. Soroka, SV.; Supranovich, R.V.; Bug S.F.; Trepashko, L.I.; Zhukova, M.I.; Timofeev, N.N. (ed.), Minsk, Belorussia, 284-287.

Tibets J.L., Saskevich P.A., 2006. Comparative efficacy of herbicides with vozdelivanii spring rape. Agroecology, no 4: 182-185.

Todorov G., Ivanova P., Delibaltova B., Kolev T., Nenkova D., 2010. Influence of some biologically active substances on the development and productivity of winter canola. Plant Sciences, 47 (1): 41-45.

Treikale O., Pugacova J., Afanasjeva I., 2006. Efficiency of the herbicide Sultan 50 sSK. in spring rape sowing. Latvijas Lauku konsultataciju un izglitibas centrs, Ozolnieki, Jelgava reg. (Latvia), p. 66-68.

Tsyuganov A.R., Saskevich P.A., Vildflush I.R., Prokopenko D.B., 2004. Efficacy sovmestnoto use of fertilizers and plant protection products at vyraschivaniiyarovoy wheat and spring rape. Svremenni problems on rastenievdstvoto in Republika Belarusians and Hungary. Tsyuganov, A.R. (ed.), p. 11-17.

Tsyuganov A.R., Klochkova O.S., 2006. Comparative efficacy of herbicides in spring rape. Agroecology. Number 4: 197-202.

Wall D.A., 1992. Flurtamone for wild mustard (*Sinapis arvensis*) control in canola (*Brassica napus*). Weed technology: a journal of the Weed Science Society of America, 6(4): 878-883.

Wall D.A., 1997. Effect of crop growth stage on tolerance to low doses of thifensulfuron:tribenuron. Weed science, 45(4): 538-545.

Wall D.A., Derksen D.A., Friesen L.F., 1995. Canola (*Brassica napus*) response to simulated sprayer contamination with thifensulfuron and thifensulfuron: tribenuron (2:1). Weed technology: a journal of the Weed Science Society of America, 9(3): 468-476.

Wei Y., Guo Q., Feng J., 2010. The occurrence regularity of weeds and its chemical control techniques in spring rape fields of no tillage with furrow sowing. Journal of Northwest Agriculture and Forestry University, 38(2): 184-190.

Wyszkowski M., Wyszkowska J., 2004. Chemical composition of spring rape and white mustard and the enzymactic activity of soil contaminated with Treflan 480 EC. Annales Universitatis Mariae Curie-Sklodowska. Sectio Agricultura, 59 (4): 1631-1638.

Zand E., Khaymi M., Diaji R., Yavari H., Yazdi M., 2009. Response of rotational crops of wheat to soil residues of sulfonylurea herbicides. Iranian Research of Plant Protection, v. C: 20-22.

Ziminska Z., Turos M., Bakuniak E., Kroczynska H., 1994, Nowy ekonomiczny i skuteczny preparat do zwalczania chwastow w rzepaku (New more efficient herbicide for oil seed rape production.), Monograph.

Ziminska Z., Bakuniak E., Krawczyk M., 1991. Alatrif 38 EC and Propalin 60 WP - combined herbicides for pre-emergence weed control in oilseed rape. Materials of the 31-st Research Session of Institute for Plant Protection. Part 2. Pruszynski, S. (ed.), p. 171-175.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON SAFFLOWER (*Carthamus tinctorius* L.) CROP IN THE CONDITIONS OF SOUTHEASTERN ROMANIA

Aurora DOBRIN, Doru Ioan MARIN

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: aur_ora_1@yahoo.com

Abstract

Safflower is an important crop for agriculture and industry (food, pharmaceuticals, cosmetics, etc.).
The paper includes results regarding the influence of variety and fertilizer level on the safflower seeds yield and yield components obtained in the 2013-2014 agricultural year. The experiment was conducted at the Experimental farm Moara Domnească of U.A.S.V.M. Bucharest. Observations and biometric measurements in dynamics were performed on plant height, number of branches per plant, number of heads per plant, seeds yield, thousand seed weight.
Significant differences were observed between varieties and between fertilizer levels. The highest seeds yield was for fertilizer level $N_{90}P_{60}K_{60}$, i.e. between 2064.32 kgha^{-1} variety CW 88 OL and 2184.2 kgha^{-1} variety Zanzibar.
The results obtained are important for the study of adaptability of safflower varieties CW 1221, CW 88 OL and Zanzibar in the conditions provided by Southeastern Romania.

***Key words**: Carthamus tinctorius L., fertilization, variety, yield, 1,000 seeds weight.*

INTRODUCTION

Safflower is a thistle-like annual plant with a strong erect central stem, glabrous, with many primary branches which may produce secondary and tertiary branches.
Each branch ends with a globular flower head (capitulum) provided with spines.
The leaves are ovate-obovate, alternate, the lower ones are sessile and acuminate. The inflorescence is a dense capitulum of flowers, invested with involucres of green ovoid bracts. The florets are small, tubular, sessile composed on type 5.
Stem height, number of branches, presence of spines on the leaves and on flower heads varies depending on the variety and environmental conditions. The fruit is an achene smooth, shiny and angular which differ depending on the variety (Dajue and Mündel, 1996; Axinte et al., 2006).
Safflower has been cultivated since ancient times in China, Egypt and India. In the Middle Ages it was grown in Europe, Central America and South America. In the United States safflower started to be cultivated in the year 1925 (Walsh et al., 2008).
Safflower culture has importance to agriculture, the main reason of this cultivation being the following: high resistance to drought and soil salinity; tolerance to high temperatures and drought; mature seeds are not shaken and cannot be eaten by birds because of their specific inflorescence; it can be introduced into crop rotation in any agricultural system, including organic, having a deep root system; cultivation and harvesting can be fully mechanized; and it has lower production costs. (Gilbert, 2008; Cucu, 2014).
Safflower seeds are used in food industry for the production of oil. Depending on the variety there are two kinds of oil: oil with a high content of linoleic acid, and oil with a high content of oleic acid. Safflower seeds are used both in the pharmaceutical industry, because of their therapeutic properties, and in varnish and paint industry (O'Brien, 2008; Dajue and Mündel, 1996).
Flowers are also used in food industry as a spice and natural food colouring, being less expensive than saffron (*Crocus sativus*). In textile industry, flowers are used for their yellow, red, red-purple, olive and mustard, pigments and in pharmaceutical and cosmetic industry for their many therapeutic properties (Dajue and Mündel, 1996).
The flour obtained from seed has high protein content and can be used in bakery industry and

for animal feed. Seeds can also be used as food for birds (Salunkhe, 1992; Dajue and Mündel, 1996).

The cakes remaining after oil extraction can be used as organic fertilizer (Buia et al., 1965).

MATERIALS AND METHODS

Research was conducted on a reddish preluvosoil at the Experimental Field Moara Domnească-Ilfov. The experiment was placed within a factorial plots design with three replications.

Factor A – three varieties of safflower: CW 88 OL, CW 1221 and Zanzibar.

Factor B-fertilizer level with 5 graduations ($N_0P_0K_0$ - Control, $N_{60}P_0K_0$, $N_{90}P_0K_0$, $N_{90}P_{60}K_0$, $N_{90}P_{60}K_{60}$).

Oats was the previous crop before safflower.

All three safflower varieties were sown in the second decade of March, at a depth of 5 cm at a distance of 50 cm between rows and 8-10 cm between plants (density corrections were made at row).

During the growing season, biometric measurements were performed on plant height, number of branches, number of heads to highlight their growth and development in relation to technological factors and climatic conditions; plots yield and the qualitative indices of the yield (1000 seeds weight, hectoliters weight) were also measured.

Table 1. Climatic conditions in the 2013-2014 agricultural year at Moara Domneasca, Ilfov

Month	Temperature (°C)		Rainfall (mm)	
	Year 2013-2014	Normal	Year 2013-2014	Normal
October	14.00	11.00	81.70	35.80
November	8.30	5.30	17.60	40.60
December	-0.20	0.40	1.20	36.70
January	-0.50	-0.30	33.20	30.00
February	1.20	-0.90	7.60	32.10
March	8.90	4.40	37.30	31.60
April	13.40	11.20	116.00	48.10
May	19.30	16.50	88.00	67.70
June	19.90	20.20	113.00	86.30
July	22.80	22.10	38.00	63.10
August	24.10	21.10	26.20	50.50
September	18.40	17.50	60.60	33.60
Sum/Average	12.47	10.71	620.40	556.10

Temperatures and rainfalls are very important for the sowing date, growth and development of safflower. In first period of safflower vegetation temperatures and rainfall above normal annual averages were recorded (Figure 1). The average annual temperature for 2014 was 12.47°C, being higher by 1.76°C degrees than the normal average temperature (10.71°C) (Table 1). The amount of rainfall for 2014 was 620.40, i.e. 64.3 higher than the multiannual average values (Table 1). During the months of March, April, May and June higher values than normal for these months were recorded and in July and August, the values were lower than normal (64.2 mm to 113.6 mm) (Figure 1).

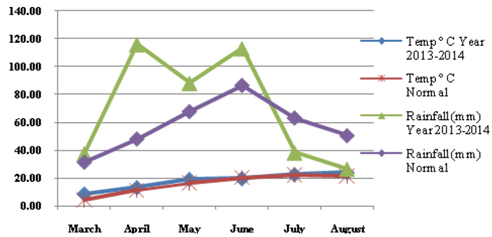


Figure 1. Climatic conditions for March-August 2014 at Moara Domneasca, Ilfov

RESULTS AND DISCUSSIONS

The growth and development of safflower plants.

Following the ***biometric measurements*** performed in the dynamics of plants height, we noticed a significant difference between the fertilization levels, with values between 79.40 cm in the Zanzibar variety (unfertilized variant) and 90.57 cm in the variant fertilized with $N_{90}P_{60}K_{60}$ in the CW1221 variety. Safflower height increased proportionally in relation to the fertilizer level in all varieties. The average value per variety was 87.15 cm in CW88OL, followed by CW1221 with 86.87 cm and Zanzibar with 85.7 cm (Table 2).

The measurement of the number of main branches per plant showed high variability between species and between fertilize levels, being 4.34 in the Zanzibar variety (without fertilization) and 7.51 in the CW88OL variety fertilized with $N_{90}P_{60}K_{60}$.

The CW88OL variety recorded no significant differences in the number of main branches per plant between the fertilizer levels. The highest average value per variety was 6.62 main branches per plant in CW88OL, followed by variety CW1221 with 6.29 branches and variety Zanzibar with 5.44 (Table 3).

Table 2. Fertilizer level influence on safflower plant height (cm) - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			Zanzibar		
	cm	%	Difference	cm	%	Difference	Cm	%	Difference
N_0 P_0K_0	84.17	100.00	Control	83.37	100.00	Control	79.40	100.00	Control
$N_{60}P_0K_0$	85.27	101.30	1.10	85.40	102.43	2.03	84.30	106.17	4.90
$N_{90}P_0K_0$	87.23	103.64	3.07	87.47	104.92	4.10	87.50	110.20	8.10
$N_{90}P_{60}$ K_0	88.73	105.42	4.57	87.53	105.00	4.17	87.60	110.33	8.20
$N_{90}P_{60}K_{60}$	90.37	107.36	6.20	90.57	108.64	7.20	89.70	112.97	10.30
Avarage	87.15	103.55	2.98	86.87	104.20	3.5	85.70	107.93	6.3
	LSD 5%=1.563; LSD 1%=2.222; LSD 0.1%=3.218			LSD 5%=1.586; LSD 1%=2.254; LSD 0.1%=3.264			LSD 5%=1.821; LSD 1%=2.588; LSD 0.1%=3.748		

Table 3. Number of main branches per plant of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			ZANZIBAR		
	Main branches / plant	%	Difference	Main branches / plant	%	Difference	Main branches / plant	%	Difference
N_0 P_0K_0	6.26	100.00	Control	5.10	100.00	Control	4.34	100.00	Control
$N_{60}P_0K_0$	6.37	101.81	0.11	6.03	118.24	0.93	5.38	123.96	1.04
$N_{90}P_0K_0$	6.47	103.30	0.21	6.40	125.56	1.30	5.52	127.19	1.18
$N_{90}P_{60}$ K_0	6.48	103.57	0.22	6.67	130.72	1.57	5.76	132.72	1.42
$N_{90}P_{60}K_{60}$	7.51	119.97	1.25	7.25	142.22	2.15	6.21	143.09	1.87
Avarage	6.62	105.73	0.36	6.29	123.35	1.19	5.44	125.39	1.10
	LSD 5%=2.457; LSD 1%=3.493; LSD 0.1%=5.059			LSD 5%=0.963; LSD 1%=1.369; LSD 0.1%=1.982			LSD 5%=0.026; LSD 1%=0.037; LSD 0.1%=0.053		

The number of heads per plant (Table 4) varied between 4.00 in the Zanzibar unfertilized variant and 13.40 in the CW88OL variant fertilized with $N_{90}P_{60}K_{60}$. Thus, there was a significant difference between the fertilizer levels and between the varieties.

The maximal values for all varieties were recorded in the variant fertilized with $N_{90}P_{60}K_{60.}$

The average values of the formed heads /plant/ varieties were the following: variety CW88OL - 10.45 heads/plant, variety CW1221 - 9.61 heads/plant, and variety Zanzibar - 7.50 heads/plant.

Achene yield

The influence of the variety and fertilizer level on the safflower yield is represented in Table 5

The Achene yield was highest in all varieties for the fertilizer level with $N_{90}P_{60}K_{60}$, being between 1.764,46 $kgha^{-1}$ in CW88OL and 1.828,75 kg ha^{-1} in Zanzibar.

Table 4. Fertilizer level influence on capitulum number per plant of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW88OL			CW1221			ZANZIBAR		
	heads /plant	%	Difference	heads /plant	%	Difference	heads /plant	%	Difference
N_0 P_0K_0	7.40	100.00	Control	6.11	100.00	Control	4.00	100.00	Control
$N_{60}P_0K_0$	8.55	115.54	1.15	7.73	126.51	1.62	5.50	137.50	1.50
$N_{90}P_0K_0$	11.00	148.65	3.60	10.00	163.67	3.89	7.00	175.00	3.00
$N_{90}P_{60}$ K_0	11.88	160.54	4.48	11.00	180.03	4.89	9.00	225.00	5.00
$N_{90}P_{60}K_{60}$	13.40	181.08	6.00	13.20	216.04	7.09	12.00	300.00	8.00
Avarage	10.45	141.16	3.05	9.61	157.25	3.5	7.50	187.50	3.5
	LSD 5%=1.986; LSD 1%=2.823; LSD 0.1%=4.087			LSD 5%=1.500; LSD 1%=2.132; LSD 0.1%=3.087			LSD 5%=1.679; LSD 1%=2.386; LSD 0.1%=3.455		

Table 5. Achene yield ($kgha^{-1}$) of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety											
	CW 88OL			CW 1221			ZANZIBAR			Avarage/ fertilizer level		
	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference	$Kgha^{-1}$	%	Difference
N_0 P_0K_0	1214.00	100.00	Control	890.64	100.00	Control	1305.16	100.00	Control	1136.60	100.00	Control
$N_{60}P_0K_0$	1754.00	144.48	540.00	1291.63	145.02	400.99	1605.12	122.98	299.96	1550.25	136.39	299.96
$N_{90}P_0K_0$	1883.20	155.12	669.20	1523.30	171.03	632.66	1883.28	144.29	578.12	1763.27	155.13	578.12
$N_{90}P_{60}$ K_0	1906.80	157.07	692.80	1634.20	183.46	743.56	2166.00	165.96	860.84	1902.33	167.37	860.84
$N_{90}P_{60}K_{60}$	2064.32	170.04	850.32	1878.33	210.90	987.69	2184.20	167.35	879.04	2042.28	179.68	879.04
Avarage	1764.46	145.34	550.46	1443.62	162.09	552.98	1828.75	140.12	523.59	1678.95	147.72	542.35
	LSD 5%=82.716;LSD 1%=117.583 LSD 0.1%=170.254			LSD 5%=27.072; LSD 1%=38.483; LSD 0.1%=55.722			LSD 5%=16.287; LSD 1%=23.152; LSD 0.1%=33.524			LSD 5%=42.025; LSD 1%=59.739; LSD 0.1%=86.500		

Table 6. Thousand seed weight (g) of safflower crop - Moara Domnească, 2014

Fertilizer level	Variety								
	CW 88OL			CW 1221			ZANZIBAR		
	g	%	Difference	g	%	Difference	g	%	Difference
$N_0 P_0K_0$	41.33	100.00	Control	41.12	100.00	Control	42.47	100.00	Control
$N_{60}P_0K_0$	41.76	101.04	0.43	41.77	101.60	0.66	43.11	101.51	0.64
$N_{90}P_0K_0$	42.62	103.12	1.29	42.51	103.38	1.39	44.67	105.18	2.20
$N_{90}P_{60} K_0$	43.95	106.33	2.62	43.76	106.43	2.64	45.47	107.06	3.00
$N_{90}P_{60}K_{60}$	44.08	106.65	2.75	44.68	108.67	3.56	46.71	109.98	4.24
Average	42.75	103.43	1.42	42.77	104.01	1.65	44.49	104.75	2.02
	LSD 5%= 0.049; LSD 1%=0.070; LSD 0.1%=0.101			LSD 5%=0.018; LSD 1%=0.026; LSD 0.1%=0.037			LSD 5%=0.020; LSD 1%=0.029; LSD 0.1%=0.042		

Analysis of quality indicators (thousand seeds weight)

Table 6 shows that thousand seed weight was influenced by the variety and fertilizer level. Statistically provided significant differences were observed between the fertilizer levels in all varieties analyzed. The highest average values for thousand seed weight were recorded in the Zanzibar variety - 44.49 g. Fertilization with complex fertilizers increased the thousand seed weight with about 6% to application of NP and 8% to the application of NPK.

CONCLUSIONS

Research performed in 2014 showed that plant growth and yields were influenced by the type and dose of fertilizer.

The achene yield varied between 890.64 $kgha^{-1}$ in the CW1221 control variant fertilization, and 2184.2 $kgha^{-1}$ in Zanzibar on fertilizer level $N_{90}P_{60}K_{60}$.

Fertilization based exclusively on nitrogen resulted in an average increase production of 413.6 kg $kgha^{-1}$.

The application of phosphorus and potassium increased the yield by about 139 kg/ha.

The number of capitulum per plant and thousand seed weight also recorded maximum values in complex fertilizers with NPK (between 12-13.4 capitulum/plant and 44.08 - 46.71g /1000 seeds).

Considering the yield obtained, the safflower varieties studied proved good adaptability to the pedo-climatic conditions of Moara Domnească, Ilfov County.

ACKNOWLEDGEMENTS

This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765

REFERENCES

Axinte M., Borcean I., Roman Gh.V., Munteanu S.L., 2006. Fitotehnie, Editor „Ion Ionescu de la Brad”, Iaşi, p. 383-384.

Buia Al., Nyarady A., Ravaruț, 1965. Botanical agriculture vol.I-II, Editor Agro-Silvica, Bucharest.

Cucu M.E., 2014. Research regarding oilseeds crops species growing in ecological agriculture production system, in North Dobrudja. Scientific Papers. Series A. Agronomy, Vol. LVII.

Dajue L., Mündel H.H., 1996. Safflower. *Carthamus tinctorius* L. Promoting the conservation and use of underutilized and neglected crops. 7. Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute, Rome, Italy.

Gilbert J., 2008. International safflower production- an overview Proceedings of the 7th International Safflower Conference, Wagga Wagga, New South Wales, Australia.

O'Brien R.D., 2008. Fats and Oils: Formulating and Processing for Applications. Third Edition, Editor CRC Press.

Salunkhe D.K., 1992. World Oilseeds. An Avi book Editor Springer Science & Business Media.

Walsh V., Chaplin T., Eastaugh N., 2008. Pigment Compendium: A Dictionary and Optical Microscopy of Historical Pigments. Editor Routledge.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PRODUCTIVITY AND HARVEST QUALITY OF MAIZE AND PEA IN INTERCROPPING, IN THE ORGANIC AGRICULTURE SYSTEM

Elena Mirela DUŞA, Gheorghe Valentin ROMAN

University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: mirela.dusa@yahoo.com

Abstract

Organic agriculture system is focused on the creation of greater crop diversification and on the reduction of negative effects for food quality and the environment, especially on the reduction of synthetic pesticide use. In organic agriculture production system, an important role is assigned to crop rotation, catch crops and intercropping. The aim of this research is to observe the productivity and harvest quality of maize and pea in relation with the intercropping system in order to know their adaptability to reddish preluvosoil area conditions of the central part of South Romanian Plain, in the organic agriculture production system. The experiment was carried out in 2007-2009 period, in Moara Domnească Experimental Field. Maize and pea were sown in alternating rows (1 row of maize, 2 rows of pea), 25 cm between the rows of pea and 22.5 cm from the maize rows. In intercropping, maize had a density of 5 plants/m^2, and pea of 70 plants/m^2. There were determined several parameters like the productivity elements, grain yields, land equivalent ratio and the chemical composition of grains. In pure stand, maize produced 3551 kg/ha. For comparison, the maize intercropped with pea produced 2953 kg/ha. Pea had a yield of 2926 kg/ha in sole crop and 2015 kg/ha in intercropping with maize. The grains of the maize intercropped with pea contained 9.45% proteins, 4.83% fats and 67.83% starch. Pea seeds from intercropping contained 26.75% proteins, 1.42% fats and 38.52% starch. In conclusion it can be said that intercropping had a slight influence on the productivity elements and on the yield.

Key words: *intercropping, organic agriculture, land equivalent ratio, maize, pea.*

INTRODUCTION

Agriculture is one of the practices that are affecting substantially the environment. For example, modern agriculture is accelerating the rate of biodiversity loss and is one of the major drivers of climate change and human induced changes to the nitrogen cycle (Rockström et al., 2009).

Organic or sustainable management systems is focused on the creation of greater crop spatial and temporal diversification in crop rotation, and a reduction in the negative effects for food quality and environment, specifically a reduction in synthetic pesticide use (Lazauskas, 1990; Anderson, 2010). Organic agriculture is a perfect fit for intercropping as fossil-fuel-based inputs and synthetic pesticides are not allowed (Vandermeer, 1992).

The purpose of intercropping is to generate beneficial biological interactions between the crops. Intercropping can increase grain yields and stability, more efficiently use of available resources, reduce weed pressure and sustain plant health (Hauggaard-Nielsen et al., 2003; Jensen et al., 2006).

When grain legumes are intercropped with cereals, larger quantities of better quality organic matter inputs are produced leading to greater productivity benefits compared with continuous maize monocrops (Schmidt et al., 2003; Rochester, 2011).

Cereal - legume intercropping appears to be a useful component of ecological intensification (Doré et al., 2011), an approach to produce more food per unit resource to achieve positive social outcomes without negative effects on the environment (Hochman et al., 2011).

Legumes intercropped with cereals can provide not only nitrogen, but also other minerals, soil cover, as they also smother weeds, provide habitat for pest predators, and increase microbial diversity (Vandermeer 1992; Li et al., 2007).

If intercropping is, indeed, experiencing a renaissance in response to problems with monoculture, this should not be seen as going back to ancient peasant ways, but, rather, as adopting useful aspects of the practice to modern agriculture (Machado, 2009).

The aim of this research was to analyse the productivity and crop quality of maize and pea in relation with the intercropping system in order to know their adaptability to reddish preluvosoil area and pedoclimatic conditions of the central part of South Romanian Plain, in the organic agriculture system.

MATERIALS AND METHODS

The experiment was carried out in three subsequent years i.e. 2007-2009, in Moara Domneasca Experimental Field, in the organic agriculture system, in randomized variants (Dusa, 2009).

The representative soil for this area belongs to the reddish preluvosoil type, presenting the following characteristics: loamy-clay texture; medium humus content in A horizon (2.77%) and relatively high in A/B horizon (about 1.2%); slight neutral-acid reaction in A horizon (pH 6.29-6.64); phosphorus content of 17 ppm PAL (poorly medium supplied); potassium content of 184 ppm KAL (well supplied) (Mihalache et al., 2009).

The climatic conditions during the experimental period were as follows: the average maximum monthly temperature (27.8^{o}C) was reached in July (2006-2007 period), while the minimum temperature of -1.4^{o}C was registered in February (2006-2007). The average annual precipitation for those three years was of 46.1 mm and the total rainfall in 2007, 2008 and 2009 period, during the crop growing season (April to September) were 241 mm, 245 mm and 237.8 mm respectively (Dusa, 2013).

The seeds used for experiments were organic and in all 3 years, the seeding parameters were the same. Thus, both the maize from sole crop and the one intercropped with pea was sown at 70 cm between rows, 28.6 cm between plants on the row, the seeding depth was of 5 cm, and density of 5 plants/m^2.

In intercropping, maize and pea were sown in alternating rows (1 row of maize, 2 rows of pea), at 25 cm between pea rows and 22.5 cm from the maize rows. The density of pea plants in intercropping was of 70 plants/m^2.

Several parameters were determined in this experiment, such as: agronomical parameters (productivity elements and seed yields), competition parameters (land equivalent ratio) and quality parameters (protein, fat and starch content).

The spatial distribution was as shown below (Figure 1):

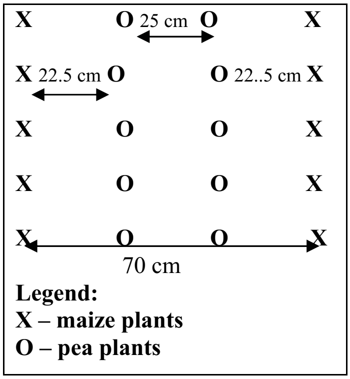


Figure 1. Spatial arrangement for maize–pea intercropping

All plants in each plot were hand-harvested at full maturity, and grain yields were determined for sole crops and intercrops individually.

Based on grain yield and the areas each intercrop occupied, the land equivalent ratio (LER) was calculated using the following equation (Willey and Osiru, 1972):

$$LER = Y_{i.c.1}/Y_{s.c.1} + Y_{i.c.2} / Y_{s.c.2} \quad (1)$$

where:

$Y_{i.c.1}$ - crop 1 yield in intercropping;

$Y_{i.c.2}$ - crop 2 yield in intercropping;

$Y_{s.c.1}$ - crop 1 yield in sole crop;

$Y_{s.c.2}$ - crop 2 yield in sole crop.

When LER values are higher than 1, means that there is an advantage of intercropping in terms of the use of resources for the plant growth compared to sole cropping.

When LER values are lower than 1, means that sole cropping use the resources more efficiently in comparison with intercropping (Sullivan, 2003).

During the vegetation period there were not applied organic or mineral fertilizers on the field. After harvesting, the vegetal residues were crushed and incorporated into the soil. Also, during the vegetation period there were not observed significant attacks of pests or pathogens.

RESULTS AND DISCUSSIONS

A. Yield components and grain yield at maize. Regarding the yield components, in table 1 it can be observed that maize plants from sole crop formed cobs of 20.5 cm in length, with an average of 14.8 rows/cob and 597 grains/cob. Percentage of grains weight per cob was of 79.2% and the TGW of 284.2 g.

The maize intercropped with pea formed cobs of 19.4 cm in length, 14.6 grain rows/cob and 565 grains/cob. The percentage of grains weight per cob was of 77.9% and TGW was 271.7 g (Table 1).

Maize from sole crop had an average yield of 3551 kg/ha. Compared to the control, maize yield from intercropping with pea was 598 kg/ha lower, i.e. 2953 kg/ha (Figure 2).

Table 1. Yield components at maize, in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Yield components	Maize sole crop	Maize-pea intercropping
	Average 2007-2009	
Cob length (cm)	20.5	19.4
Number of grain rows/cob	14.8	14.6
Number of grains/cob	597.1	565.0
% of grains weight/cob	79.2	77.9
TGW (g)	284.2	271.7

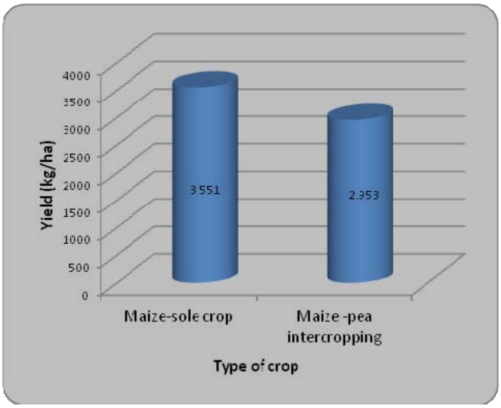


Figure 2. Average maize yields, in sole crop and in intercropping with pea (Moara Domneasca Experimental Field, 2007-2009)

B. Yield components and grain yield at pea. In terms of yield components, pea plants from sole crop formed, on average 5.5 pods/plant, 28.3 grains/plant, 4.8 grains/pod and TGW was 176.8 g. In intercropping, pea plants formed 4.6 pods/plant, 21.6 grains/plant, 4.3 grains/pod and the TGW was 163.3 g.

Table 2. Yield components at pea in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Yield components	Pea sole crop	Pea-maize intercropping
	Average 2007-2009	
Number of pods/plant	5.5	4.6
Number of grain/plant	28.3	21.6
Number of grains/pod	4.8	4.3
TGW (g)	176.8	163.3

On average for 2007-2009 period, pea produced 2470 kg/ha. Compared with the average, in sole crop the yield was of 2926 kg/ha, and in intercropping of 2015 kg/ha, i.e. 911 kg/ha less than the control (difference that is statistically ensured) (Table 3).

Table 3. Average yields at pea, in sole crop and in intercropping with maize (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Pea			
	Yield (kg/ha)	Difference from sole crop		Significance
		kg/ha	%	
Pea sole crop	2926	Mt.	100	-
Pea-maize intercropping	2015	-911	68.86	ooo

LSD 5% = 119.5 kg/ha
LSD 1% = 281.0 kg/ha
LSD 0.1% = 590.8 kg/ha

C. Chemical composition and protein yields. As far as the chemical composition is concerned, table 4 shows that maize grains from the sole crop had the following content: 12.71% moisture, 10.13% proteins, 5.30% fats and 66.94% starch.

The maize grains from intercropping with pea, had 12.74% moisture, 9.45% proteins, 4.83% fats and 67.83% starch.

In sole crop, at pea, the moisture was of 11.78 % and in intercropping with maize the average was 11.54%. The protein content was of 26.84% in sole crop and of 26.75% in intercropping. The content of fats at the pea seeds was of 1.46% in the sole crop and of 1.42% in intercropping with maize. Pea had a starch content of 40.30% in sole crop and of 38.52% in intercropping.

Table 4. Chemical composition of maize and pea grains, in sole crop and in intercropping (Moara Domneasca Experimental Field, 2007-2009)

Type of crop	Moisture (%)	Protein (% dm)	Fats (% d.m.)	Starch (% d.m.)
Maize (sole crop)	12.71	10.13	5.30	66.94
Pea (sole crop)	11.78	26.84	1.46	40.30
Maize intercropped with pea	12.74	9.45	4.83	67.83
Pea intercropped with maize	11.54	26.75	1.42	38.52

As far as the protein content is concerned, in table 5 it can be seen that in sole crop, maize produced on average 360 kg/ha proteins and pea 785 kg/ha proteins. The total protein yield of maize-pea intercropping was of 818 kg/ha (Table 5).

D. Land equivalent ratio. Between 2007 and 2009, the partial LER ranged between 0.68 for pea and 0.83 for maize.

A LER value of 1.0, indicates no difference in yield between the intercrop and monocultures (Mazaheri and Moveysi, 2004). Any value greater than 1.0 indicates a yield advantage for intercrop.

The total LER was of 1.51, which means that there is a real advantage of intercropping maize with pea compared to sole crop. Thus, an area planted as sole crop would require 51% more land to produce the same yield as in intercropping (Table 6).

Table 5. Protein yields at maize and pea in sole crop and in intercropping (Moara Domnească Experimental Field, 2007-2009)

Type of crop	Grain yield (kg/ha)		Total yield (kg/ha)	Protein yield (kg/ha)		Total protein yield (kg/ha)
	Maize	Pea		Maize	Pea	
Maize (sole crop)	3551	-	3551	360	-	360
Pea (sole crop)	-	2926	2926	-	785	785
Maize-pea intercropping	2953	2015	4968	279	539	**818**

Table 6. Land equivalent ratio for maize-pea intercropping (Moara Domneasca Experimental Field, 2007-2009)

	Type of crop	Yield in intercropping (kg/ha)	Yield in sole crop (kg/ha)	Partial LER
	Maize	2953	3551	0.83
	Pea	2015	2926	0.68
Total LER	-	-	-	**1.51**

CONCLUSIONS

Intercropping had a slight influence on the yield components and on the yield. Thus, in intercropping, the maize formed cobs slightly lower than the control, with a less number of grains per cob. Also, the TGW had lower values.

Pea from the sole crop formed a higher number of pods and seeds per plant than the plants from intercropping. This means that in intercropping, there was a competition between plants for light, water and nutrients.

Fukai and Trenbath (1993) pointed out that when two species are associated, the crops interact in such a way that when one exerts a negative effect on the other, the principal of competition is established.

The highest yields were evaluated both at the maize and pea from the sole crop. Compared to the control, which produced on average 3551 kg/ha, the yield of maize from intercropping was 598 kg/ha lower, i.e. 2953 kg/ha.

In intercropping, the yield of pea was diminished by 31.14% (i.e. 911 kg/ha) than the control which produced 2926 kg grains/ha, due to the effect of competition between the two species.

Regarding the chemical composition, the results of the analysis showed that the maize grains from intercropping contained 12.74% moisture, 9.45% protein, 4.83% fats and 67.83% starch.

The pea grains from intercropping with maize contained 11.54% moisture, 26.75% protein, 1.42% fats and 38.52% starch. These values were not very different from those of the maize and pea in sole crop.

In sole crop, maize produced on average 360 kg/ha proteins and pea 785 kg/ha proteins. The total protein yield/ha for maize-pea intercropping was of 818 kg/ha.

Based on the partial LER of each crop from intercropping, where the values were close, it is believed that the maize and pea complemented each other mutually in the utilization of the resources for agricultural production.

The total LER for maize-pea intercropping was greater than 1, namely 1.51. This value means that an area planted as sole crop would require 51% more land to produce the same yield as in intercropping.

REFERENCES

Anderson R.L.A., 2010. Rotation design to reduce weed density in organic farming. Renewable Agriculture and Food Systems, 25 (3): 189-195.

Doré T., Cadoret K., Makowski D., Malézieux E., Munier-Jolain N., Tchamitchian M., Tittonell P., 2011. Facing up to the paradigm of ecological intensification in agronomy: revisiting methods, concepts and knowledge. Eur. J. Agron. 34: 197-210.

Dusa E.M., Roman Gh.V., 2013. Research on intercropping effect on crop productivity and yield quality of maize (*Zea mays* L.) and soybean (*Glycine max* (L.) Merril), in the organic agriculture system. Scientific Papers, UASVM Bucharest, Series A, Agronomy, LVI, p. 391-394.

Fukai S., Trenbath B. R., 1993. Processes determining intercrop productivity and yields of component crops. Field Crops Research, 34: 247-271.

Hauggaard-Nielsen H., Ambus P., Jensen E.S., 2003. The comparison of nitrogen use and leaching in sole cropped versus intercropped pea and barley. Nutrient Cycling in Agroecosystems, 65: 289-300.

Hochman Z., Carberry P.S., Robertson M.J., Gaydon D.S., Bell L.W., McIntosh P.C., 2011. Prospects for ecological intensification of Australian agriculture. Eur. J.Agron.

Jensen E.S., Ambus N., Bellostas N. et al., 2006. Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and prevention of N-losses in European organic farming systems: proceedings of the European Joint Organic Congress. Odense, Denmark, p.180–181.

Lazauskas P., 1990. Agrotechnika prieš piktžoles, Mokslas, ISBN 5-420-00206-X Vilnius, Lietuva.

Li L., Li S.M., Sun J.H., Zhou L.L., Bao X.G., Zhang H.G., Zhang F.S., 2007. Diversity enhances agricultural productivity via rhizosphere phosphorus facilitation on phosphorous-deficient soils. Proceedings of the National Academy of Sciences 104: 11192-11196.

Machado S., 2009. Does intercropping have a role in modern agriculture? In: Journal of Soil and Water Conservation, March/April edition, 64 (2): 55-57A.

Mazaheri D., Oveysi M., 2004. Effects of intercropping of two corn varieties at various nitrogen levels. Iranian Journal of Agronomy, 1: 71-76.

Mihalache M., Ilie L., Marin D.I., 2009. Research concerning the effect of management systems on physical and chemical properties of reddish preluvosoil from Moara Domneasca experimental field. Annals of the University of Craiova, Agriculture – Montanology – Cadastre Series, XXXIX: 428-432.

Popescu E.M., 2009. Cercetări privind culturile agricole intercalate pentru sistemul de agricultură ecologică în zona de sud a României. Phd thesis, Bucharest.

Rochester I.J., 2011. Sequestering carbon in minimum-tilled clay soils used for irrigated cotton and grain production. Soil Till. Res., 112: 1-7.

Rockström J., Steffen W., Noone K., Persson Å., Chapin F.S., Lambin E.F., Lenton T.M., Scheffer M., Folke C., Schellnhuber H.J., Nykvist B., de Wit C.A., Hughes T., van der Leeuw S., Rodhe H., Sörlin S., Snyder P.K., Costanza R., Svedin U., Falkenmark M., Karlberg L., Corell R.W., Fabry V.J., Hansen J., Walker B., Liverman D., Richardson K., Crutzen P., Foley J.A., 2009. A safe operating space for humanity. Nature, 461: 472-475.

Schmidt O., Clements R.O., Donaldson G., 2003. Why do cereal–legume intercrops support large earthworm populations? Appl. Soil Ecol., 22:181-190.

Sullivan P., 2003. Intercropping principles and production practices. Appropriate Technology Transfer for Rural Areas Publication. http://www.attra.ncat.org.

Vandermeer J., 1992. The ecology of intercropping. New York, NY: Cambridge University Press.

Willey R.W., Osiru D.S.O., 1972. Studies on mixtures of maize and beans (*Phaseolus vulgaris*) with special reference to plant population. Journal of Agricultural Science, 79: 519-529.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ALLELOPATHIC EFFECT OF OREGANO (*Origanum onites* L.) ON GERMINATION AND SEEDLING DEVELOPMENT OF SOME WEED AND CULTIVARS

Sabri ERBAŞ, Ruziye KARAMAN, Hasan BAYDAR, Arif ŞANLI

Suleyman Demirel University, Faculty of Agriculture, Department of Field Crops, 32260, Isparta, Turkey

Corresponding author email: sabrierbas@sdu.edu.tr

Abstract

The present study carried out at Suleyman Demirel University, Faculty of Agriculture of the Department of Field Crops in 2010. The aim of the study was to examine allelopathic effects of oregano oil (Origanum onites L.) on germination and seedling development of amaranth (Amaranthus retroflexus L.), dock (Rumex crispus L.) and mustard (Sinapis arvensis L.) and crop plants [wheat (Triticum aestivum cv Gün 91), sunflower (Helianthus annuus cv. Sirena) and chickpea (Cicer arietinum)]. Seeds of these plants were germinated in petri and pot. Oregano oil doses for petri study was 0 (control), 3, 6, 10 and 20 µl, for pot study was 0 (control), 0.5, 1.0, 2.0 and 4.0 mg kg^{-1}. The germination rate, root length, seedling length and dry matter in each germination condition were investigated. All parameters were significant ($p<0.01$). The germination rate of seeds in petri and pot at control application was determined as 16.0 and 46.7% for amaranth, 53.3 and 74.0% for dock, 56.0 and 72.0% for mustard, 89.3 and 92.0% for sunflower, 100.0 and 100.0% chickpea, 100.0 and 100.0% for wheat, respectively. The lowest oregano oil doses (3 µl and 0.5 mg kg^{-1}) in petri and pot study reduced, germination rate of dock, amaranth and mustard dramatically, germination rate of other plants did not change. The increased doses of oregano oil in petri and pot study negatively affected the root length of dock, amaranth and mustard. The seedling length of amaranth, mustard and dock at 0.5 mg kg^{-1} dose was decreased compared to control. As a result, it was determined that oregano oil (3 µl and 0.5 mg kg^{-1}) at low doses significantly inhibited weed seed germination and was less damaging to crop plants seed germination.

Key words: *allelopathy, oregano oil, germination, seedling growth.*

INTRODUCTION

There are large numbers of weeds in agricultural production areas. 7000 species in the world and 1800 species in Turkey have been identified as harmful weeds in agricultural areas and their damage is around 32% in our country (Aydın and Tursun, 2010). Herbicides compose 50% of all pesticides used in the world. Herbicide use has increased due to easier and quicker application to large areas and expensive labour force in agriculture. This situation can cause to an irreversible problem (Rice, 1984).
One of the most important strategies against weeds is phytotoxic damage in the agricultural areas, which depends on preventing the enzyme activity, inhibiting germination and growth of plant compounds. So far, studies on extracts with herbicidal effects derived from secondary metabolites in plants have been demonstrated. Monoterpenes are the major compounds responsible for phytotoxic effect. Lavandula (*Lavandula hybrida* L.), oregano (*Origanum onites*), sage (*Salvia officinalis* L.), mint (*Mentha piperita*), rosemary (*Rosmarinus officinalis*) and fennel (*Foeniculum vulgare*) essential oil as well as many from medicinal and aromatic plants are obtained, and the main components of these oils are monoterpenes.
One of the alternative methods is to use the allelopathic substances (secondary metabolites, allelochemicals) against weeds, pests and plant diseases. Awareness of the availability of these substances in biological control against weeds increased the importance of allelopathic effects in crop production practices (Rice, 1984). Allelopathy is defined as a limiting or enhancing effect as the development of plants of each other as a result of various chemical mechanisms (Türkmen and Turhan, 2006).
The aim of this research was to determine allelopathic effects of oregano oil (*O. onites* L) on germination and seedling development of amaranth (*A. retroflexus* L.), dock (*R. crispus* L.) and mustard (*S. arvensis* L.) and crop plants

[wheat (*T. aestivum* cv Gün 91), sunflower (*H. annuus* cv. Sirena) and chickpea (*C. arietinum*)].

MATERIALS AND METHODS

This research was carried out Suleyman Demirel University, Faculty of Agriculture at the Department of Field Crops. In this study, three weeds species and three cultivated species were used as plant material. Oregano essential oil was obtained from hydrodistillation.

Weed seeds were collected during the months of July to September 2009 from the crop cultivation areas.

In petri experiments; 0 (control), 3, 6, 10 and 20 µl doses, in pot experiment; 0, 0.5, 1.0, 2.0, and 4.0 mg kg^{-1} doses of oregano oil was applied (Azirak and Karaman, 2008; Gülsoy et al., 2008). Twenty five seeds were put into perti dishes and 10.0 ml distilled water was added to each petri dishes. Field soil with the texture clayed-calcareus, with pH 8.1, Cation Exchange Capacity 36.0% and total salt composition 0.025%, rich in lime (75.4 K_2O da^{-1}) and with poor organic material (1.34%). Only distilled water was used for control doses.

Seeds within petri dishes and pots were allowed to germinate during 15 days at room temperature (25°C). At the end of this period, germination rate, root and stem length and dry matter rate were investigated.

Gas Chromatography/Mass Spectrometry (GC-MS) analysis of the oregano oil was performed on Shimadzu 2010 Plus GC-MS equipped with a Quadrapole (QP-5050) detector. The analysis was performed under the following conditions: capillary column, CP-Wax 52 CB (50 m x 0.32 mm, film thickness 0.25 µm); injector and detector temperature, 240°C; stove heat program, from 60°C (10 min. hold) to 90°C rising at 4°C/min., and increasing to 240°C (11.5 min. hold) rising at 15°C/min.; flow speed, 1 psi; detector: 70 eV; ionization type, EI; carrier gas, helium (20 ml/min.); sample injected 1 µl. Identification of constituents was carried out with the help of retention times of standard substances by composition of mass spectra with the data given in the Wiley, Nist, Tutor library (Stein, 1990).

This experiment was designed in completely randomized plot design with 3 replications. Germination time in experiments was determined according to ISTA (2009) rules.

All characters means were subjected to analysis of variance (ANOVA) using SAS (1998) program and differences among treatments were separated with Duncan Multiple Range Test. Before the analyses, data was normalized with arcsine transformation.

RESULTS AND DISCUSSIONS

GC-MS analysis, a total of 6 components was identified in oregano oil. The major component in oregano oil was carvacrol (91.39%). The other components were cymene, gamma terpinen, linalool, isoborneol and myrecene, 4.01, 1.55, 1.51 1.44 and 0.10%, respectively (Table 1). Species, oil doses and their interaction was significant (P<0.01 level) for all the investigated characters in petri and pot experiments (Table 2).

Table 1. The essential oil composition of oregano oil

Components	RT	Rate (%)
Gamma terpinene	17.6	1.55
Cymene	19.2	4.01
Linalool	39.9	1.51
İsoborneol	46.1	1.44
Myrecene	50.1	0.10
Carvacrol	74.2	91.39

RT: Retention time

Essential oils have different effects on plant growth one of which is the inhibition of germination (Foe et al., 2002; Barney et al., 2005). As seen in Table 3, germination rates were decreased with the increased doses of oregano oil in both petri and pot experiments. In petri experiment, dock and sunflower seeds at doses above 3 µl and chickpea seed at doses above 10 µl were did not germinate. While amaranth and mustard seeds germinated only in the control application, oregano oil completely inhibited germination of amaranth and mustard seeds. Wheat seeds in control application completely germinated, but germination decreased with higher doses of oregano oil at the lowest germinate was observed in 20 µl. In pot experiment, while germination of wheat and chickpea seeds were not affected by 1.0 mg kg^{-1} dose compare to control application, germination of sunflower seeds were decreased by 67.4% at the same dose. Germination of dock, amaranth and mustard seeds decreased by 39.2, 89.3 and 76.8%, respectively, at 1.0 mg kg^{-1} oregano oil application.

Dudai et al. (2000) indicated that monoterpenes, comprising essential oils, inhibit germination of seeds at low levels and the plants exposed to monoterpene steam were damage seriously.

Azirak and Karaman (2008), reported that while 3 and 6 µl application to *Coriandrum sativum, Foeniculum vulgare, Lavandula stoechas, Pimpinella anisum, Rosmarinus officinalis* and *Salvia officinalis* essential oils did not affected germination, 10 and 20 µl application reduced germination of 7 weed seeds significantly; namely *Alcea pallida, Amaranthus retroflexus, Centaurea salsotitialis, Raphanus raphanistrum, Rumex nepalensis, Sinapis arvensis* and *Sonchus oleraceus*.

Allelochemicals affect physiological interactions such as photosynthesis and respiration, cell division, cell development, membrane permeability, and ion exchange (Ağar et al., 2006). Scrivanti et al. (2003) emphasized that essential oils destroyed cell organelles in root apical meristem and damaged cell membranes causing slow root growth.

The application of oregano oil has been adversely affected seedling root length in petri and pot experiments. Root length of dock was decreased by 93.8% compared to control application at 3 µl dose in petri experiment. While root length of sunflower, chickpea and wheat at control application were 10.31, 5.57 and 6.22 cm, their root lengths at 3 µl dose were 3.94, 3.85 and 3.58 cm, respectively.

Root lengths of dock, amaranth and mustard at 0.5 mg kg^{-1} dose in pot experiments were decreased 26.4, 8.5 and 25.5%, respectively. The roots of sunflower seedlings among crop plants have much less damaged compare to the roots of chickpea and wheat at 0.5 mg kg^{-1} (Table 4).

Monoterpenes limited oxygen intake thus preventing germination and growth. Penuelans et al., (1996) reported that α-pinene reduced oxygen consumption in soybean cotyledons, which prevented seed germination and plant growth. Averages of stem length of all species generally decreased with increasing essential oil doses in both of experiment. The stem length of dock, sunflower, chickpea and wheat at 3 µl dose compared to control application in petri experiment were decreased by 74.1, 6.2, 14.6, 26.4%, respectively.

In pot experiment, while stem length of sunflower, chickpea and wheat at control application were 20.82, 21.65 and 24.93 cm, their stem length at 0.5 mg kg^{-1} dose decreased to 18.39, 15.69 and 19.98 cm, respectively. The stem length of sunflower seedlings at the lowest doses at the both experiments (3 µl and 5 mg kg^{-1}) had shortened.

Topal and Kocaçalışkan (2006) reported juglon which is important component of walnut, decreased seedling length of *Sinapis arvensis* (48.1%), *Cirsium arvense* (79.0%) and *Lamium amplexicaule* (74.9%). Same researchers at the same time chlorophyll content decreased at higher doses. The same study, stem length of wheat and amount of chlorophyll decreased 11.1% and 20.2%, respectively.

Dry matter content of seedlings of all species was raised with increasing dose of oregano oil in both experiments (Table 6). The highest dry matter was determined in chickpea seedlings in petri experiment and in wheat seedling in pot experiments.

CONCLUSIONS

As a result, allelochemicals are important to avoid herbicide residues in crops, environmental damage. Essential oils, one of most important of these chemicals, can be used directly instead of herbicides, are the basis of new synthetic herbicides. In this study, germination of weed seeds significantly inhibited reduced at lower dose applications, while germination rates of cultivated species were not adversely affected at same doses

Table 2. The variance analysis for germination rate, root and stem length and dry matter of rate in petri and pot experiments

VS	DF	Petri				Pot			
		Germination rate MS	Root length MS	Stem length MS	Dry matter rate MS	Germination rate MS	Root length MS	Stem length MS	Dry matter rate MS
Species	5	7100.9**	24.5**	49.1**	1619.3**	7499.6**	88.9**	626.2**	1033.9**
Dose	4	97.7**	70.6**	64.9**	635.4**	12046.8**	140.4**	381.1**	1152.7**
Species x Dose	20	627.7**	6.7**	15.1**	503.9**	589.6**	18.8**	50.6**	661.9**
Error	60	11. 9	0.2	0.1	3.5	20.0	0.3	0.6	5.4
CV (%)		13.3	23.1	12.9	15.4	10.9	14.8	10.4	13.1

** Significant at P ≤ 0.01, CV: Coefficient of Variation, MS: Mean square

Table 3. Average germination rates (%) in petri and pot experiments

	Petri						Pot					
Species	**0 µl**	**3 µl**	**6 µl**	**10 µl**	**20 µl**	**Avr.**	**0 mg kg^{-1}**	**0.5 mg kg^{-1}**	**1.0 mg kg^{-1}**	**2.0 mg kg^{-1}**	**4.0 mg kg^{-1}**	**Avr.**
Dock	53.3 aC	45.3 bB	0.0 cC	0.0 cC	0.0 cB	**19.7**	74.0 aB	50.0 bD	45. 0 cB	5.0 dC	0.0 eB	34.8
Amaranth	16.0 aD	0.0 bD	0.0 bC	0.0 bC	0.0 bB	**3.2**	46.7 aC	25.0 bE	5.0 cD	0.0 cC	0.0 cB	15.3
Mustard	56.0 aC	0.0 bD	0.0 bC	0.0 bC	0.0 bB	**11.2**	72.0 aC	54.0 bB	16.7 cD	0.0 dC	0.0 dB	28.5
Sunflower	89.3 aB	14.0 bC	0.0 cC	0.0 cC	0.0 cB	**20.7**	92.0 aA	85.0 aB	30.0 bC	0.0 cC	0.0 cB	41.4
Chickpea	100.0 aA	95.3 aA	50.0 bB	7.0 cB	0.0 cB	**50.5**	100.0 aA	100.0 aA	96.7 aA	66.7 bB	0.0 cB	72.7
Wheat	100.0 aA	90.0 aA	66.7 bA	66.7 bA	15.0 cA	**67.7**	100.0 aA	100.0 aA	96.7 abA	90.0 bA	30.0 cA	83.3
Average	**69.1**	**40.8**	**19.5**	**12.3**	**2.5**		**80.8**	**69.0**	**48.4**	**26.9**	**5.0**	

*Differences between doses and species were indicated with lower and capital letters at the 1% level. Values within a column followed by the same letter are not significantly different.

Table 4. Average root lengths (cm) in petri and pot experiments

	Petri						Pot					
Species	**0 µl**	**3 µl**	**6 µl**	**10 µl**	**20 µl**	**Avr.**	**0 mg kg^{-1}**	**0.5 mg kg^{-1}**	**1.0 mg kg^{-1}**	**2.0 mg kg^{-1}**	**4.0 mg kg^{-1}**	**Avr.**
Dock	2.10 aD	0.13 bB	0.00 bB	0.00 bC	0.00 bB	**0.45**	3.11 aC	2.29 bC	1.90 bcC	1.40 cC	0.00 dB	**1.74**
Amaranth	3.49 aC	0.00 bB	0.00 bB	0.00 bC	0.00 bB	**0.70**	1.42 aD	1.30 aC	1.13 aC	0.00 bD	0.00 bB	**0.77**
Mustard	2.39 aCD	0.00 bB	0.00 bB	0.00 bC	0.00 bB	**0.48**	2.16 aD	1.61 bC	1.13 cC	0.00 dD	0.00 dB	**0.98**
Sunflower	10.31 aA	3.94 bA	0.00 cB	0.00 cC	0.00 cB	**2.85**	13.24 aA	10.76 aA	1.77 bC	0.00 bD	0.00 bB	**5.15**
Chickpea	5.57 aB	3.85 bA	3.25 bA	0.20 cB	0.00 cB	**2.57**	12.39 aA	9.13 bA	3.45 cB	2.06 cB	0.00 dB	**5.41**
Wheat	6.22 aB	3.58 bA	3.00 bA	2.04 cA	0.75 dA	**3.12**	10.13 aB	7.31 bB	6.12 cA	3.91 dA	2.80 eA	**6.05**
Average	**5.01**	**1.92**	**1.04**	**0.37**	**0.13**		**7.08**	**5.40**	**2.58**	**1.23**	**0.47**	

*Differences between doses and species were indicated with lower and capital letters at the 1% level. Values within a column followed by the same letter are not significantly different.

Table 5. Averages of stem length in petri and pot experiments (cm)

	Petri						Pot					
Species	**0 µl**	**3 µl**	**6 µl**	**10 µl**	**20 µl**	**Avr.**	**0 mg kg^{-1}**	**0.5 mg kg^{-1}**	**1.0 mg kg^{-1}**	**2.0 mg kg^{-1}**	**4.0 mg kg^{-1}**	**Avr.**
Dock	1.93 aD	0.50 bD	0.00 cC	0.00 cC	0.00 cB	**0.49**	4.29 aC	4.16 aC	3.20 bCD	2.40 cC	0.00 dB	**2.81**
Amaranth	2.90 aC	0.00 bD	0.00 bC	0.00 bC	0.00 bB	**0.58**	2.77 aD	2.75 aC	2.45 aDE	0.00 bD	0.00 bB	**1.59**
Mustard	1.94 aD	0.00 bD	0.00 bC	0.00 bC	0.00 bB	**0.39**	2.52 aD	2.49 aC	1.61 bE	0.00 cD	0.00 cB	**1.32**
Sunflower	11.16 aA	10.47 aA	0.00 bC	0.00 bC	0.00 bB	**4.33**	20.82 aB	18.39 bA	4.64 cC	0.00 dD	0.00 dB	**8.77**
Chickpea	5.63 abB	4.81 bB	5.81 aA	1.90 cB	0.00 dB	**3.63**	21.65 aB	15.69 bB	10.26 cB	4.59 dB	0.00 eB	**10.44**
Wheat	5.31 aB	3.91 bC	2.68 cB	2.25 dA	1.85 dA	**3.20**	24.93 aA	19.98 bA	18.58 bA	13.59 cA	11.50 cA	**17.72**
Average	**4.81**	**3.28**	**1.42**	**0.69**	**0.31**		**12.77**	**10.58**	**6.84**	**3.43**	**1.92**	

*Differences between doses and species were indicated with lower and capital letters at the 1% level. Values within a column followed by the same letter are not significantly different.

Table 6. Averages of dry matter rates in petri and pot experiments (%)

	Petri						Pot					
Species	**0 µl**	**3 µl**	**6 µl**	**10 µl**	**20 µl**	**Avr.**	**0 mg kg^{-1}**	**0.5 mg kg^{-1}**	**1.0 mg kg^{-1}**	**2.0 mg kg^{-1}**	**4.0 mg kg^{-1}**	**Avr.**
Dock	6.26 bE	21.00 aB	0.00 cC	0.00 cC	0.00 cB	**5.45**	12.47 cC	19.70 bB	27.60 aBC	28.50 aA	0.00 dB	**17.65**
Amaranth	8.37 aDE	0.00 bD	0.00 bC	0.00 bC	0.00 bB	**1.67**	15.60 bC	24.47 aB	2.50 cE	0.00 aC	0.00 aB	**8.51**
Mustard	53.10 aA	0.00 bD	0.00 bC	0.00 bC	0.00 bB	**10.62**	47.80 bA	63.60 aA	33.67 cAB	0.00 dC	0.00 dB	**29.01**
Sunflower	16.83 bC	21.94 aB	0.00 cC	0.00 cC	0.00 cB	**7.75**	12.70 cC	21.47 bB	39.37 aA	0.00 dC	0.00 dB	**14.71**
Chickpea	11.53 bD	12.34 bC	16.79 bB	44.00 aA	0.00 aB	**16.93**	7.30 cD	8.50 cC	13.90 bD	23.90 aB	0.00 dB	**10.72**
Wheat	29.93 bcB	27.53 cA	29.54 bcA	31.23 bB	34.80 aA	**30.61**	19.50 eB	21.40 dB	23.47 cC	28.30 bA	39.03 aA	**26.34**
Average	**21.00**	**13.80**	**7.72**	**12.54**	**5.80**		**19.23**	**26.52**	**23.42**	**13.45**	**6.51**	

*Differences between doses and species were indicated with lower and capital letters at the 1% level. Values within a column followed by the same letter are not significantly different.

REFERENCES

Ağar G., Battal P., Türker M., Erez M.E., Yıldırım N., 2006. Investigation of allelopathic effects of some plant extracts on the germination of corn (*Zea mays* L.) kernels. Allelopathy Symposium, 13-15 June Yalova-Turkey, p. 47-51.

Aydın O., Tursun N., 2010. Determination of allelopathic effects of some plant originated essential oils on germination and emergence of some weed seeds. Kahramanmaraş Sütçü İmam Üniversity Journal of Nature Science, 13(1): 1-7.

Azirak S., Karaman S., 2008. Allelopathic effect of some essential oils and components on germination of weed species. Acta Agriculturae Scandinavica Section B, Soil and Plant Science, 58: 88-92.

Barney J.N., Hay A.G., Weston L., 2005. Isolation and characterization of allelopathic volatiles from mugwort (*Artemisia vulgaris*). Journal of Chemical Ecology, 31: 247-265.

Dudai N., Larkov O., Mayer A.M., Mayber A.P., Putievsky E., Lerner H.R., 2000. Metabolism of essential oils during inhibition of wheat seed germination. In: Black, M., Bradford, K.J., Vanquez-Ramos, J. (Eds.), Seed Biology Advanced and Application Cabi publishing, Wallingford, p. 315-320.

Foe, V.D., Simone F.D., Senatore F., 2002. Potential allelochemicals from the essential oil of *Ruta graveolens*. Phytochemistry, 61: 573-578.

Gülsoy S., Özkan K., Mert A., Eser Y., 2008. Chemical compounds of volatile oil obtained from fruit of Crimean Juniper (*Juniperus excelsa*) and leaves of Turkish plateau oregano (*Origanum minutiflorum*) and allelopathic effects on germination of Anatolian Black Pine (*Pinus nigra subsp. pallasiana*). Biological Diversity and Conservation, 1(2): 105-114.

ISTA, 2009. The international rules for seed testing. Zurichstr. 50, CH-803 Bassersdorf, Switzerland. ISBN-13 978-3-906549-53-8.

Penuelans J., Ribas-Carbo M., Giles L., 1996. Effects of allelochemical on plant respiration and oxygen isotope fractionation by the alternative oxidase. Journal of Chemical Ecology, 22: 801-805.

Rice E.L., 1984. Allelopathy. Academic Press Inc, New York, p. 130-188.

SAS Institute, 1998. INC SAS/STAT user's guide release 7.0, Cary, NC, USA.

Scrivanti L.R., Zunino M.P., Zygadlo J.A., 2003. *Tagetes minuta* and *Schinus areira* essential oils as allelopathic agends. Biochemical System Ecology, 31: 568-572.

Stein S.E., 1990. National Institute of Standards and Technology (NIST) Mass Spectral Database and Software, Version 3.02, Juen USA.

Terzi İ., Kocaçalışkan İ., Benlioğlu O., 2006. Effects of juglone applied in pregerminative stage on growth of cucumber seedlings with respect to physiological and anatomical parameters. Dumlupınar University Journal of Science Institute, 10: 25-32.

Topal S., Kocaçalışkan İ., 2006. Allelopathic effect of juglone sprey to some weed and crops species. Allelopathy Symposium, 13-15 June 2006, Yalova-TURKEY, p. 69-80.

Türkmen O.S., Turhan H., 2006. Allelopathic effect of some plant extracts on germination of weed and crop species. Allelopathy Symposium, 13-15 June 2006, Yalova-TURKEY, p. 59-68.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

MEASURING OF YIELD AND YIELD COMPONENTS OF WINTER RAPESEED VARIETIES ON DIFFERENT PLANTING DATES

Abbas FALLAH TOOSI

Khorasan Razavi Agriculture & Natural Resources Research Center, SPII Department, Iran

Corresponding author email: afallahtoosi@yahoo.com

Abstract

Planting date is an important factor affecting crop yield, yield components and quality, especially in cold regions. In order to elucidate the effect of sowing dates on the yield and yield components of six winter oilseed rape (Brassica napus L.) varieties, an experiment was conducted in Mashhad. A split plot layout within randomized complete block design with four replications was used in the experimentation. Four sowing dates consider as main plots, consist September 6th, September 21st, October 6th and October 21st and six winter rapeseed varieties (Fornax, Okapi, Colvert, Talayeh, SLM046 and Orient) were in the subplots. Variables including plant height, seed yield, LAI, CGR, NAR, TDM and HI were measured. Results showed sowing time significantly affected on TDM, LAI, CGR, plant height, seed yield and HI and they improved by early sowing dates. The most suitable varieties were Fornax and Colvert respectively.

***Key words**: Brassica napus, sowing dates, oilseed.*

INTRODUCTION

Rapeseed (*Brassica napus* L.) is one of the leading edible oil crops that is now one of the most important oil crops in the Iran. Sowing time is very important for rapeseed production because sowing at proper time allows sufficient growth and development of a crop to obtain a satisfactory yield. Rapeseed has high value of oil (40-45%) and protein (39%) (Eskandari and Kazemi, 2012).

Rapeseed oil contains a desirable profile of saturated fatty acids (7%) and high level of unsaturated fatty oleic acids (about 61%) and medium level of unsaturated fatty linoleic acids (21%) and linoleic acid (11%) (Molazem et al., 2013).

The seed yield and maturity of rape seed plants are greatly influenced by environmental conditions regardless of genotypes. Therefore, whenever a new genotype/variety is developed or introduced in a region, an appropriate package of production practices must be developed.

Since rapeseed planting has been very common in Khorasan Razavi province, therefore, whenever a new variety is developed or introduced in this region, an appropriate package of production practices include sowing time must be developed. According to the importance of the growth period in this plant , it is necessary to evaluate the distinct planting dates. Hence some experiments have been conducted in this field by (Ghasemi et al., 1996 and Mandal et al., 1994) in which they insisted on early planting. Furthermore other scientists such as Jenkins and Leich (1996), Walton and Bowden (1999), emphasized on the importance of the planting dates .Although numerous studies have been handled on the sowing dates, any location requires it special planting dates because of having distinct climatic features.

MATERIALS AND METHODS

The experiment was conducted on 2010 growing season at Agriculture and Natural Resources Research Station of Toroq, Mashhad in East - North of Iran (36°, 13', 12" and 54°, 43', 14" E) with annual rainfall of 286 mm. Soil texture was silty loam with the moderate amount of organic matter and nutrient elements. Each experimental plot included 4 planting rows with 5 meter length. Distance of planting on rows was 30 cm and planting density was 70 plants per m^2. The study was carried out using rapeseed cultivars (Colvert, Fornax, Okapi, SLM046, Orient, Talayeh) as main plot factor and sowing dates (Sep. 6^{th}, Sep. 21^{st} and Oct. 6^{th}, Oct. 21^{st}) as subplot factor in a split plot experiment based on randomized complete block design (RCBD) with 4 replications. Leaves, stems and pods were separately taken from three plants of each plot and plant growth parameters such as plant height, number of leaves, fresh and dry weight were recorded. All data from the experiment were subjected to analysis of variance (ANOVA) using SAS 9.1 package, the means compared with Duncan's test and all graphs were drown using Excel.

RESULTS AND DISCUSSIONS

The results showed that the planting date significantly affected yield and yield components of rapeseed (Table 1). Based on results obtained, plant height was significantly affected by the different sowing dates. The maximum plant height was recorded on Sep. 21^{st}, whereas the minimum plant height was gained on Oct. 21^{st} (Table 1). Results about the effect of different varieties on plant heights also showed Fornax was the longest variety and Okapi was oroduced the shortest plants (Table 2). The interaction effects of planting date and varieties showed Fornax and Colvert varieties were significantly sensitive to the early planting.

Results indicated that planting date significantly affected number of pod per plant, number of seed per pod and 1000 seed weight. Late planting significantly reduced number of pods per plant, number of seeds per pod and 1000 seed weight (Table 2). The differences among the varieties were noticeable (Table 1). Interactions between variety and planting dates indicated that, Colvert had the most sensitivity to late sowing date and Orient and Talayeh had the least sensitivity to planting date respectively.

The results of effect of planting time on seed yield showed that the late planting time significantly reduced the seed yield. Based on results planting date at Oct. 21s caused reduced the yield nearly 50% (Table 2). Results showed the Fornax variety produced the highest seed yield and significantly produced more seed yield to compare with the other varieties. However, early planting of Colvert could increase the yield of this variety.

The capacity of transforming of photosynthetic materials from sink to source can display with Harvest Index. The result of analysis variance demonstrated that late planting reduced the H.I. significantly (Table 1). Considering this parameter in the varieties showed huge difference among them. Results showed Fornax had the highest H.I. amoug the varieties. The correspondent effect of variety and planting date was significant on this parameter. Late planting time reduced the H.I. in SLM046 and Okapi, while other varieties were not very sensitive.

Based on collected data delay on the postponement in planting time significantly reduced Total Dry Mater almost in all six verities. The highest amount of TDM was obtained by Colvert (1006 gr/m^2) in first planting time and SLM046 on last planting date produced the lowest TDM (255 gr/m^2).

Results indicated that the planting date did not significant affected on LAI of six verities. The effect of sowing dates was not noticeable before the rosette stage. After the rosette stage by changing the environmental conditions and increasing the temperature and light the LAI growth is almost obvious. This condition continuous until flowering stage and two weeks later. The LAI was different among distinct varieties and based on data analysis Fornax and Colvert had highest LAI.

According to different stages of growth, the CGR was very slow at early stages of growth like rosette and before this stage. It is slow because neither the plant canopy was completed, nor environmental conditions were good for plat growth. Also after the rosette stage by increasing the temperature and increasing light by sunny days the plant growth increased, significantly. Hence, the growth parameters such as leaf area, dry matter, increased meaning fully, CGR increased to this condition maintained until the flowering stage. At the flowering stage the CGR was maximum. Delay in planting time reduced the CGR. The amount of CGR on Sep.6th was 3.2 and on Oct.21st was 1.4 gr $m^{-2}day^{-1}$ The CGR was different among distinct varieties, so it was 3.8 on Okapi, since Fornax for the first planting date had the lowest CGR among the varieties.

Table 1. Effect of planting date on rapeseed characteristics, Mashhad -Toroq

Planting Date	Plant Height (cm)	No. of Secondary Branches	No. of Sheaths / Plant	No. of Seed / Sheath	Sheath Length (cm)	1000 Seed Weight (gr)	Seed Yield (kg / ha)	Harvest Index **(%)**
Sep.6^{th}	101.7^{b}	1.25^{a}	31^{a}	19.7^{a}	7.2^{ad}	3.5^{a}	2850^{a}	37^{a}
Sep.21^{st}	107.4^{a}	1.17^{a}	28^{b}	19.1^{a}	7.4^{a}	3.2^{b}	2498^{b}	34^{b}
Oct.6^{th}	97.9^{c}	0.33^{b}	22^{c}	18.9^{a}	6.9^{bc}	2.9^{C}	1346^{d}	33^{c}
Oct.21^{st}	$97,7^{c}$	0.38^{b}	21^{c}	18.5^{s}	6.6^{C}	2.9^{C}	1467^{c}	32^{d}

Table 2. The mean of Agronomical features of six varieties of rapeseed Mashhad -Toroq

Variety	Plant Height (cm)	No. of Secondary Branches	No, of Sheaths /Plant	No, of Seed / Sheath	Sheath Length (cm)	1000 Seed Weight (gr)	Seed Yield (kg / ha)	Harvest Index **(%)**
Colvert	102.4^{abc}	1.44^{a}	32^{a}	13.3^{b}	5.9^{e}	3.5^{a}	2305^{b}	33^{c}
Fornax	104.4^{a}	1.00^{b}	29^{b}	19.2^{a}	7.3^{bc}	3.1^{d}	2471^{a}	37^{a}
Okapi	95.1^{d}	$0.7\ 5^{bc}$	21^{cd}	19.7^{a}	6.7^{d}	3.0^{c}	1526^{f}	30^{d}
Orient	103.2^{ab}	0.38^{d}	22^{cd}	20.3^{a}	7.9^{a}	3.1^{d}	1953^{d}	36^{b}
Slm046	100.2^{C}	0.44^{cd}	20^{d}	20.7^{a}	7.0^{C}	3.2^{b}	1902^{e}	36^{b}
Talayeh	101.8^{bc}	0.64^{bcd}	24^{c}	21.4^{a}	7.4^{d}	3.1^{b}	2035^{c}	36^{b}

*Values followed by similar upper case letters in a column are not significantly different at $p<0.05$

CONCLUSIONS

The planting date is considered as significant parameter which approximately stimulates all of the growth influenced by early planting. The early planting generally increases the quantity and quality of yield simultaneously. The following parameters were also influenced by plant date: the plant height, number of secondary branches. The yield components like number of sheath per plant, number of seed per sheath and seeds weight were also affected by early planting any were increased on dates like September 6th, 21st October planting dates. Finally, the studies demonstrated that the two varieties (Fornax *s* Colvert) were suitable for planting in Mashhad region.

REFERENCES

Eskandari H., Kazemi K., 2012. Changes in germination properties of rape (*Brassica napus* L.) as affected by hydropriming of seeds. Journal of Basic and Applied Scientific Research, 2: 3285-3288.

Ghasemi K., Ghalibaaf H.M.K., AIyari H., 1996. The investigation of different date of planting on seed yield and components of yield in four different canola cultivars in Tabriz region. Proceeding of 5th congress of Agronomy, Karag, Iran.

Jenkins P.D., Leitch M.H., 1996. Effect of sowing date on the growth and yield of winter oilseed rape. J.Agri.Sci., camb.105: 405-420.

Manda LS.M., Mishra K., Patra A.K., 1994. Yield loss in rapeseed and mustard due to aphid infestation in respect of different varieties and dates of sowing. Orissa Journal of Agri. Res., p. 58-62.

Molazem D., Azimi J., Dideban T., 2013. Measuring the yield and its components, in the canola in different planting date and plant density of the West Guilan. International Journal of Agriculture and Crop Sciences, 6 (12): 869-872.

Walton G.P.S., Bowden B., 1999. Environmental impact on canola yield and oil. Proceeding of the 10th International Rapeseed Congress, Canberra, Australia, p. 6.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY OF SAFFLOWER CULTIVARS YIELD AND YIELD COMPONENTS UNDER DIFFERENT SUPPLEMENTARY IRRIGATION CONDITIONS

Abbas FALLAH TOOSI, Mehdi AZIZI

Khorasan Razavi Agriculture & Natural Resources Research Center, SPII Department, Iran

Corresponding author email: afallahtoosi@gmail.com

Abstract

Safflower is an adapted plant with our country conditions. In order to study of safflower cultivars yield and yield components under different supplementary irrigation conditions an experiment was conducted in khorasan. The experimental design was split plot based on Randomized Complete Block Design with four replications. Factors were included five levels of irrigation, i.e., no irrigation, irrigation at rosette stage, flowering stage, seed filling stage and irrigation in flowering+ seed filling as the main factors , and sub factors were cultivars in three levels. Results showed that the effect of supplementary irrigation on HI, seed number per main head, seed number per branch, 1000 kernel weight and seed yield was significant.

Key words: *Carthamus tinctorius, water stress, seed yields, harvest index.*

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is member of Asteraceae family with having vertical root type that can penetrate to soils a depth of two to three meters (Bagheri and Sam-Daliri, 2011). Safflower is one of the oldest crops, traditionally, grown for its seeds, which is used as edible oil and as birdseed and used for coloring and flavoring foods and for making red and yellow dyes, especially before cheaper aniline dyes became available, and in medicines (Zohary and Hopf, 2000). This plant is considered as a drought and salinity-tolerant crop (Gecgel et al., 2007; Ozturk et al., 2008; Majidi et al., 2011), able to extract water at soil moisture contents that are not available to the majority of crops (Weiss, 2000). The deep root and the many fine laterals, allow safflower to survive in periods of moisture shortage also limit.

Kar et al. (2007) observed that under water deficit condition, supplemental irrigation during reproductive phases had a significant effect on increasing seed yield.

Damage caused by water shortages, reduced production due to delays or failure of plant establishment, weakening or loss of established plants, the plants prone to pests and diseases, changes in the plant biochemical and physiological metabolism and decrease crops quality.

Lovelli et al. (2007) showed that the harvest index in safflower did not significantly change in 5 irrigation regimes with a restoration of 100%, 75%, 50%, 25%, and 0% of the maximum crop evapotranspiration, but seed yield declined sharply when drought was severe (Lovelli et al., 2007).

Supplemental irrigation in order to improve and stabilize production, small amounts of water are added to crops which are essentially rainfed, during periods which rain cannot provide sufficient moisture for normal development of plants (Oweis, 1997). Supplemental irrigation also had a significant effect on grain yield. Therefore, while applying one irrigation, only 392 kg ha^{-1} of grain yield was obtained, and yield was enhanced by 48% when two irrigations were applied over the single irrigation. With three irrigations, 1258 kg ha^{-1} of grain yield was obtained, 220% higher than for a single irrigation. Omidi Tabrizi (2006) evaluated safflower genotypes under 3 different environmental conditions, in Karaj, Isfahan, and Darab in Iran, and indicated significant differences among genotypes in seed and oil yield.

MATERIALS AND METHODS

The experimental design was split plot based on Randomized Complete Block Design with four replications. Factors were included five levels of irrigation, i.e., no irrigation, irrigation at rosette stage, flowering stage, seed filling stage and irrigation in flowering+ seed filling as the main factors, and sub factors were cultivars in three levels (promising line 411,Sina and Syrian). Leaves, stems and pods were separately taken from three plants of each plot and plant growth parameters such as plant height, number of leaves, main branches, secondary braches, main heads, secondary heads, seed per head, 1,000 seeds weight, fresh and dry weight were recorded. All data from the experiment were subjected to analysis of variance (ANOVA) using SAS 9.1 package, the means compared with Duncan's test and all graphs were drowning using Excel.

RESULTS AND DISCUSSIONS

Results of analysis of variance indicated that the main effect of supplementary irrigation on HI was significant ($P<0.05$). Based on results the I_3 and I_5 treatments with 23.35% and 27.74% of HI were showed the highest amount of HI respectively. Although I_2 showed the highest amount of biomass but I_3 and I_5 were showed the highest amount of HI and it seems supplementary irrigation in flowering stage had the highest effect on economical yield by increasing productive growth. Omidi et al. (2006) reported that he found a significant positive correlation between biological yield and seed yield of safflower on his experiment. Patel and Patel (1993) reported that, the stage to flowering and grain filling as a critical stage of safflower growth stages to irrigation. Results also indicated that the highest biomass was obtained in promising line 411 with 2.03 kg/m^2. Promising line 411 had the highest plant height, and could produce more biomass than the other two cultivars.

Results showed the effect of supplementary irrigation on number of seeds per main head was significant ($P<0.05$) (Table 1) and the highest number of seeds were produced in treatment $I_{3,}$ and in treatment I_1 the lowest number of seeds per main head was obtained. As the number of head per plant and the number of seeds per head of safflower are the important factors that effect on yield of this plant, I_3 by producing more seeds per head to compare with other treatments ranked as a superior treatment.

Based on results 1000 seed weight significantly differed between irrigation treatments ($P<0.05$) and treatment of I_3 by amount of 43.70 (gr) of 1000 seed weight had the highest weight while irrigation treatment I_1 produced the lowest one (38.04 gr) (Table 1). Analysis of variance showed that variety was significantly ($P<0.05$) affected 1000 seed weight and the highest 1000 seed weight was recorded in Sina (Table 1) by amount of 44.44 and it was not observed any significant differences between this cultivar to compare with promising line 411 by 1000 seed weight of 41.74 gr (Table 2).

The effect of supplementary irrigation on traits: stand establishment, days to stem elongation, flowering and end of flowering and plant height, biomass, number of total heads, number of branches, and number of hollow seeds and number of main branch were not affected by water stress.

Results of analysis of variance showed that supplementary irrigation significantly affected yield of safflower cultivars. Results of main effects indicated that treatment of I_3 with production of 423.43 kg/ha seeds. Interaction effects of supplementary irrigation and cultivars also significant and based on results Syrin in treatment I_3 by production of 512.18 kg/ha seed, ranked as the highest cultivar and Sina in treatment number one with production of 249.37 was the lowest cultivar and irrigation treatment.

Mean comparison results of main effects showed the superiority of irrigation at flowering stage in compare with the other treatments and the highest yield was obtained in flowering stage in promising line 411 with 423.43 kg/ha.

CONCLUSIONS

In this study we found that complementary irrigation in flowering stage had the highest effect on economical yield by increasing productive growth and increased HI significantly, seed number per main head, seed number per branch and 1000 seed weight also increased by supplementary irrigation. Since irrigation at flowering stage increased yield in water limitation conditions, irrigation is one of great importance factors to improving yield and also promising line 411was classified as a superior cultivar.

Table 1. Mean Comparison the main effects of safflower cultivars and irrigation in Khorasan

S.O.V	Treatments	Seed/Main Head	Seed/Secondary Head	1000 Seed Weight(gr)	Seed Weight of Secondary Head	Yield
Supplementary Irrigation	I_1	17.97b	21.95b	34.04b	062b	292.46b
	I_2	20.80ab	25.75b	40.72ab	0.81ab	363.71ab
	I_3	24.53a	40.03a	43.70a	0.90ab	423.43a
	I_4	21.32ab	34.88a	40.65ab	1.03a	352.59ab
	I_5	22.12ab	36.15a	42.35a	1.08a	388.92a
Variety	C_1	22.21a	32.38a	41.74a	1.03a	389.63a
	C_2	21.35a	30.78a	37.10b	0.74b	352.12a
	C_3	20.48a	32.10a	44.44a	0.89ab	350.92a

*Values followed by similar upper case letters in a column are not significantly different at $p<0.05$

Table 2. Mean Comparison the interaction effects of safflower cultivars and irrigation in Khorasan

Irrigation levels	Cultivars	Seed/Main Head	Seed/Secondary Head	1000 Seed Weight(gr)	Yield (kg/ha)
I_1	C_1	17.20b	22.665fg	40.91abcd	324.00bcd
	C_2	21.40ab	26.30cdefg	32.41e	249.37d
	C_3	23.80ab	28.30bcdefg	44.35ab	304.00bcd
I_2	C_1	14.40b	25.25defg	38.56bcde	426.88ab
	C_2	17.40b	16.90g	36.90cde	341.26bcd
	C_3	18.10b	23.70efg	43.15abc	322.99bcd
I_3	C_1	26.85a	38.75abc	44.75ab	361.43bcd
	C_2	22.20ab	37.75abc	40.34abcd	396.68abc
	C_3	24.55ab	31.95bcdef	46.03a	512.18a
I_4	C_1	25.10ab	44.20a	42.00abcd	429.68ab
	C_2	17.70b	35.65abcde	35.88de	369.21bcd
	C_3	21.15ab	40.25ab	44.08abc	258.88cd
I_5	C_1	19.50ab	31.05bcdef	42.49abcd	406.15ab
	C_2	23.40ab	37.30abcd	39.96abcd	404.08ab
	C_3	23.45ab	36.30abcd	44.59ab	356.54bcd

*Values followed by similar upper case letters in a column are not significantly different at $p<0.05$

REFERENCES

Bagheri H., Sam-Daliri M., 2011. Effect of water stress on agronomic traits of spring safflower cultivars (*Carthamus Tinctorius*). Australian Journal of Basic and Applied Sciences, 5(12): 2621-2624.

Gecgel U., Demirci M., Esendal E., 2007. Seed yield, oil content and fatty acids composition of safflower (*Carthamus tinctorius* L.) varieties sown in spring and winter. International Journal of Natural and Engineering Sciences, 1: 11-15.

Kar G., Kumar A., Martha M., 2007. Water use efficiency and crop coefficients of dry season oilseed crops. Agricultural Water Management, 87: 73-82.

Lovelli S., Perniola M., Ferrara A., Tommaso T.D., 2007. Yield response factor to water (ky) and water use efficiency of *Carthamus tinctorius* L. and *Solanum melongena* L. Agricultural Water Management, 92: 73-80.

Majidi M.M., Tavakoli V., Mirlohi A., Sabzalian M.R., 2011. Wild safflower species (*Carthamus oxyacanthus* Bieb.): A possible source of drought tolerance for arid environments. Aust. J. Crop Sci. 5: 1055-1063.

Omidi Tabrizi A.H., 2006. Stability and adaptability estimates of some safflower cultivars and lines in different environmental conditions. J Agric Sci Technol., 8: 141-151.

Oweis T., 1997. Supplemental Irrigation: A highly efficient water use Practice. International Center for Agricultural Research in the Dry Areas (ICARDA). Aleppo, Syria.

Ozturk E., Ozer H., Polet T., 2008. Growth and yield of safflower genotypes grown under irrigated and non-irrigated conditions in a highland environment. Plant Soil Environ. 54(10): 453-460.

Patel N.C., Patel Z.G., 1993. Performance of safflower under different irrigation scheduling in south Gujarat. Annals of Agriculture Research, 41(1): 109-110.

Weiss EA., 2000. Oilseed Crops. Blackwell Publishing Limited, London,UK.

Zohary D., Hopf M., 2000. Domestication of plants in the Old World, 3rd edition. Oxford University Press, p. 211.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

QUANTITATIVE AND COMPLEX ASSESMENT OF MALTING BARLEY GENOTYPES IN RELATION TO THEIR USE FOR THE BREEDING

Stanko GEORGIEV[1], Silviya VASILEVA[2], Marina MARCHEVA[2], Nevenka GANUSHEVA[2], Neli MITEVA[2]

[1] Institute for Plant Genetic Resources "K. Malkov" (IPGR), 4122 Sadovo, Bulgaria
[2] Agricultural University, Dep. Genetics and Plant Breeding, 12 Mendeleev str., 4000 Plovdiv, Bulgaria

Corresponding author e-mail: silviya.valentinova@gmail.com

Abstract

The investigation was conducted on the experimental field of the Agricultural University - Plovdiv, during the period 2010 - 2013 year. The present study includes 24 local and foreign genotypes two-row barley. For the first time have been assessed advantages of perspective genotypes as initial material by applying the "Model of quantitative and complex assessment" of the breeding lines and varieties in relation to their use in different barley breeding directions. The model was created as a methodology, approach and mathematical expression by Prof. Georgiev (2013) and can be applied in all cultures. Based on this model there was established the advantages of studied genotypes in the corresponding direction and combination of beneficial traits in each of them. As a result may be selected the most perspective varieties for barley breeding, implementation in practice and selection the trends in the most suitable parental forms for hybridization.
Analysis of the results reveal five of studied cultivars: ***Caravela*** *(102.17 p.),* ***Kaskadior*** *(101.30 p.),* ***Neda*** *(103.83 p.) and* ***Gorast*** *(101.0 p.) which exceed the standard* ***(Obzor****-95.63 p.) with the highest comprehensive overall assessment, which make them useful for direct application in the malting barley breeding .The advantages of using method was that allow us not only to estimate the common comprehensive assessment of the studied genotypes as a initial material, but It gave us the possibility to see exactly in which breeding areas they have strong express traits.*

Key words*: initial material, barley breeding, selection, two-row barley, yield.*

INTRODUCTION

To achieve good results in the barley breeding, is necessary to use different initial genetic material, which have to be preliminary studying (Ganusheva et al., 2004; Zakova et al., 2004; Vulcheva et al., 2008).
The main malting barley breeding problems are referring to the improvement of traits related to productivity, quality, adaptive potential and suitability for mechanized farming (Marcheva et al., 2005; Spunar et al., 2008).
The barley breeding program represents the characterization of agronomic, grain and malt quality traits of potential new genotypes (Knežević et al., 2004, Marcheva and Koteva, 2013). Testing of newly cultivars in different environmental condition giving us the possibility of estimation genotypes / environments interactions and characteristics of the variety or group of varieties to one unit in order to make them comparable and measurable. That means all parameters and directions to obtain a numerical representation (Georgiev et al., 2013).

MATERIALS AND METHODS

The experimental work is carried out on the field of the Agricultural University - Plovdiv, during the period 2010-2013 year.
Current research involves analysis of 24 varieties two-row barley with different origin. Genotypes 82105326, 89105100, 96105023, 96105024, 96105027, 96105046, 96105050, 99105020, 99105030, I-Da/102 are provided by the National Gene Bank (IPGR) - Sadovo. Perspective breeding lines 508, 511, 622 are result from the breeding work done in the department of "Genetics and Plant breeding", Agricultural University - Plovdiv. There are also used cultivars: Alexis, Beta Ketzoras, Emon, Kamenitza, Caravela, Cascadior, Obzor and newly established varieties Neda and Gorast as initial material (Table 1). Orphey and

Kyfi are provided from the Institute of Agriculture, Karnobat.
Obzor is used as a standard and all studied genotypes have been compared with it.

Table 1. Genotypes used as an initial material

N	Genotype	breeding line/cultivar	Origin
1	Obzor St	cultivar	Bulgaria
2	82105326	Weibills/Clara	Germany
3	89105100	Biiru/Hadaka	Japan
4	96105023	Felice	France
5	96105024	Douchka	France
6	96105027	Baronesse	France
7	96105046	Teleno	France
8	96105050	Freke	France
9	99105020	NRPB801116/Cameo	France
10	99105030	VDH405388/Ragtime	France
11	508	breeding line	Bulgaria
12	511	breeding line	Bulgaria
13	622	breeding line	Bulgaria
14	ID-a/102	cultivar	Syria
15	Alexis	cultivar	Germany
16	Beta Ketzoras	cultivar	Hungary
17	Emon	cultivar	Bulgaria
18	Kamenitza	cultivar	Bulgaria
19	Caravela	cultivar	Portugal
20	Kaskadior	cultivar	Bulgaria
21	Neda	cultivar	Bulgaria
22	Gorast	cultivar	Bulgaria
23	Orphey	cultivar	Bulgaria
24	Kyfi	cultivar	Hungary

To assess promising breeding lines and varieties is used “The model of quantitative and complex assessment” of prof. S. Gergiev, applied for the first time in malting barley in current research.
Transformation of agronomic evaluation data of the studied samples to mathematical model was based on the equation introduced by Федин и кол. (1978).

$$H=a_1 \bar{x}_1+a_2 \bar{x}_2+\ldots+a_n \bar{x}_n$$

Where H is the middle value of breeding index of the trait.
$\bar{x}_{1,} \bar{x}_2 \bar{x}_n$ are the real values of single trait:
$a_{1,}$ $a_{2,}$ a_n are coefficients of the specific weight or importance of the trait
In quantitative and complex assessment there are introduced not single traits and breeding index, but used the breeding directions. Input equation is transformed by prof. Georgiev (1988, 2013) in the following form:

$$H=a_1A+a_2B+a_3C+a_4D+a_5E$$

Where adapted for the malting barley, breeding direction:
“A” is a real yield for the different genotypes;
“B” - biological features;
“C” - vegetation period;
“D” - malting-technological qualities;
“E” - ability for mechanized harvesting.
Because the analyzed traits participated in the every breeding direction are measured with the different measurement units-kg, %, day, degree and go on, they have to be transformed in simple numbers to be done comparable. To achieve this transformation we give different numbers as coefficients for specific weight or importance of the traits as following:
a_1= 30:; a_2 =20:, a_3 =10: a_4 =30: a_5 =10. Sum has to be 100 (Table 2)
All these numbers are given for the real value of the traits of standard. There were studied and analyzed some of the important quantitative and qualitative traits in relation to productive potential and malting quality.
Yield (A) is reported based on real production of every genotype in three consecutive years, calculated in comparison with standard.
The second barley breeding direction (B) reflects the adaptive potential of genotypes. It is determined by the ability of plants to survive in spite of abiotic and biotic stress factors. The cold resistance was assessed by the percentage of surviving plants after wintering in field conditions during the three years of study. Drought tolerance is determined based on degree of root and seedling depression of plants in terms of osmotic stress (Божанова, 2007). With higher number are evaluated genotypes with a lower degree of depression, which corresponds to their drought tolerance. Percentage of uninfected plants of economically significant diseases in natural conditions, without extra inoculation has been established. Highest number as a coefficient is given to uninfected genotypes.
The vegetation period (C) is reported in days, with higher coefficient values were assessed forms with short vegetation period.
The values of the traits determining brewing technology qualities (D) are reported by standard laboratory methods in the Institute of Agriculture, Karnobat.
Indicators that measure the criterion suitability for mechanized harvesting (E) are; plant height,

resistance to beaten down, uniformity and spike impairment. The rated values of these parameters are calculated according the standard cultivar Obzor.

RESULTS AND DISCUSSIONS

The data from agronomic characteristics of promising studied lines and cultivars is in different units. Application of mathematical model of Quantitative and complex assessment allows to transform all data into simple numbers, and make possible comparison between them.

Coefficient of importance for each selection criteria is determined according to its significance in the barley breeding program. The sum of all is equal to 100 points (Table 2).

Table 2. Breeding directions and coefficients of importance

Breeding directions	Indicators of phenological observations, biometric measurements and laboratory analyzes		Coefficient of importance of the direction	Coefficient of importance of the trait
Yield (A)	Yield		**A-30**	A_1-30
Biological features (B)	Cold resistance		**B-20**	B_1-5
	Drought resistance			B_2-5
	Disease resistance	Resistance to Powdery mildew		B_3-4
		Resistance to Loose smut		B_4-1
		Resistance to Stripe disease		B_5-1-
		Rust disease		B_6-3
		Resistance to BYDV		B_7-1
Vegetation period (C)	Vegetation period		**C-10**	C_1-10
Malting-technological qualities (D)	Protein content		**D-30**	D_1-7
	Extract content			D_2-6
	Starch			D_3-6
	Uniformity – 2.5-2.8			D_4-6
	Mass of 1000-kernels			D_5-5
Ability for mechanical harvesting (E)	Plant height		**E-10**	E_1-2
	Resistance to lodging			E_2-4
	Uniformity of tillers			E_3-2
	Spike impairment			E_4-2

The yield, as a breeding direction of paramount importance in all cultures, current barley breeding program is given highest coefficient - 30. To be established the "best cultivar" or „perspective line", they have to exceed the yield of standard - Obzor -575kg/ha^{-1}, which has 30 points as a coefficient of importance of this trait.

According to this model for quantitative and complex assessment the newly approved cultivar Neda gives yield 691 kg/ha^{-1} ·What number of points will receive it? We calculate 691/575 =120 % x a_1 - 30 = 36.0 points. In this way is calculating yield of all varieties· Some of significantly more productive varieties with highest numbers than the standard are: Gorast (656 kgha^{-1} = 34.23 points), Kaskadior (650 kgha^{-1} = 33.91 p.), Kamenitza (630 kgha^{-1} = 32.87 p.), 96105046 (623 kgha^{-1} = 32.50 p.), Beta Ketzoras (623 kgha^{-1} = 32.50 p.), Caravela (623 kgha^{-1} = 32.50 p.) and Orphey (619 kgha^{-1} = 32.30 p.) (Table 3).

Biological features presented by the criterion B, whose total value is 20 points, includes the traits cold, drought resistance and resistance to diseases. Each of them is with coefficient 5, 5 and 10 points, respectively. Resistance to abiotic stress factors is established according to Material and methods. Coefficient of importance 5 to cold resistance is given to the actual values of Obzor cultivar. Cultivars Neda (5.6 points) and Kamenitza (5.6 p.) received the highest number of points due to a proportion of wintered plants (95%) compared to the standard (85%), respectively 5.6=(5x95)/85. Similar calculations are for drought tolerance of the studied genotypes. Criteria for disease resistance (B), according to the applied mathematical model - maximum coefficient is given to immune varieties. Current research is conducted in natural inoculation, therefore we can not state with certainty that the lack of damage to some varieties due to their resistance. For greater precision high number's values are given to 100% uninfected plants. Economically significant barley diseases in Bulgaria recent years are: Powdery mildew (note 4), Loose smut (1), Stripe disease (1), Rust disease (3) and BYMV (1), each receiving a different number values depending on distribution and the total is 10 points. In case of lack of Loose smut attack and BYMV all genotypes are evaluated with 1 point. For other diseases, on a reported assault shall be placed and to calculate the percentage of healthy plants. According to the complex evaluation of studied varieties, all of them has coefficient over 10 points and are perspective in Biological features breeding direction (B). With higher adaptive potential are Emon (17.45 points), Kamenitza (18.05 p.), Neda (17.71 p.) and Orphey (17.20 p.) (Table 3).

Table 3. 100 note quantitative and complex evaluation of perspective barley breeding lines

	Yield (A)	Biological features (B)							Veget. period (C)	Malting-technological qualities (D)					Ability for mechanical harvesting (E)			
	Yield - /note/	Cold resistance /note/	Drought resistance /note/	Resistance to Powdery mildew /note/	Resistance to Loose smut /note/	Resistance to Stripe Disease /note/	Rust disease /note/	Resistance to BYDV /note/	Vegetation period /note/	Protein content /note/	Extract content /note/	Starch /note/	Uniformity – 2.5-2.8 /note/	Mass of 1000-kernels /note/	Plant height /note/	Resistance to lodging /note/	Uniformity of productive tillers /note/	Spike impairment /note/
Genotype	$A_1$30	$B_1$5	$B_2$5	$B_3$4	$B_4$1	$B_5$1	$B_6$3	$B_7$1	$C_1$10	$D_1$7	$D_2$6	$D_3$6	$D_4$6	$D_5$5	$E_1$2	$E_2$4	$E_3$2	$E_4$2
Obzor St	30	5	5.00	2.4	1	0.4	1.5	1	10	7.00	6	6	6	5	2	3.6	1.8	2
82105326	22.6	4.4	4.37	2.0	1	0.8	1.5	1	13.1	6.93	5.9	5.0	5.9	5.4	1.8	4.0	1.8	1.8
89105100	20.8	4.4	4.03	2.8	1	0.8	1.8	1	10.0	7.12	5.7	5.0	6.0	5.7	1.8	4.0	2.0	1.8
96105023	30.3	4.1	5.39	1.6	1	0.7	1.2	1	10.0	7.33	5.9	6.0	5.5	5.5	1.8	4.0	2.0	1.8
96105024	30.8	4.1	4.93	2.4	1	0.5	0.9	1	10.0	7.02	5.5	6.1	5.8	6.2	1.7	4.0	1.6	2.0
96105027	24.8	2.4	4.46	1.2	1	0.4	0.6	1	13.1	7.11	5.9	6.1	6.1	5.5	1.8	4.0	2.0	2.0
96105046	32.5	5.0	4.59	1.6	1	0.4	1.5	1	10.0	7.17	6.0	6.4	5.8	4.7	1.6	4.0	1.8	2.0
96105050	32.1	4.1	4.91	1.2	1	0.7	1.5	1	10.0	7.24	6.0	5.0	6.0	4.7	1.6	4.0	2.0	2.0
99105020	31.8	4.1	4.50	2.4	1	0.6	1.2	1	13.1	7.23	6.2	6.7	5.4	4.4	1.6	4.0	2.0	2.0
99105030	31.2	4.1	4.89	2.4	1	0.6	1.2	1	13.1	7.21	5.8	6.6	5.4	4.6	1.6	4.0	1.6	2.0
508	26.2	4.7	4.19	2.8	1	0.7	0.6	1	6.5	6.95	5.9	4.7	5.9	4.7	1.7	4.0	1.8	1.8
511	25.6	4.7	4.57	1.2	1	0.7	0.9	1	6.5	7.08	5.9	4.6	5.4	4.4	1.2	4.0	2.0	1.8
622	24.5	4.7	4.54	3.2	1	0.7	0.9	1	**13.1**	6.81	5.7	4.7	6.1	5.2	1.9	3.6	1.6	1.8
ID-a/102	21.3	3.5	**5.19**	0.8	1	0.9	0.6	1	13.1	6.81	5.9	5.2	6.0	4.8	1.5	3.6	1.8	1.6
Alexis	26.1	4.1	4.37	2.4	1	0.4	1.2	1	13.1	7.01	6.0	5.6	6.1	3.7	1.5	4.0	2.0	1.6
B.Ketzoras	**32.5**	5.3	4.48	2.4	1	0.3	1.8	1	6.5	7.09	6.0	6.4	5.6	5.9	2.0	3.6	2.0	2.0
Emon	31.4	5.3	5.06	2.4	1	0.6	2.1	1	10.0	6.73	6.0	6.2	6.1	5.5	2.1	3.6	1.8	2.0
Kamenitza	**32.9**	**5.6**	5.06	2.8	1	0.5	2.1	1	6.5	6.86	5.6	6.0	5.7	5.3	1.9	3.6	1.6	2.0
Caravela	**32.5**	5.3	5.06	2.4	1	0.7	1.5	1	13.1	6.96	5.8	6.6	5.9	4.8	2.0	3.6	2.0	2.0
Kaskadior	**33.9**	5.3	4.90	2.4	1	0.5	1.2	1	10.0	7.08	6.0	6.7	5.9	5.8	1.6	4.0	2.0	2.0
Neda	**36.1**	**5.6**	4.71	2.8	1	0.6	1.8	1	10.0	7.14	5.5	6.4	5.9	5.6	1.8	4.0	2.0	2.0
Gorast	**34.2**	5.3	4.63	2.8	1	0.7	1.5	1	10.0	7.17	5.5	6.0	5.6	5.9	1.7	4.0	2.0	2.0
Orphey	**32.3**	5.0	**5.51**	2.4	1	0.7	2.1	1	6.5	7.11	6.1	6.6	4.6	4.6	2.0	3.6	1.8	2.0
Kyfi	24.5	4.4	4.34	2.0	1	0.5	1.5	1	10.0	6.88	5.9	4.6	4.8	5.2	1.5	4.0	1.6	1.6

Three groups are observed according vegetation period in the survey: genotypes with 225, 217 and 210 days. As a breeding direction – C, 10 coefficient is given to the standard Obzor with 217 days vegetation. The cultivar is with winter-spring biotype. According to mathematical model perspective forms for the breeding will be those with highest number - 13.3 points (210 days vegetation). Most of them are typical spring forms, which are not that suitable for Bulgarian agro-meteorological conditions. Among genotypes with early vegetation, only breeding line 622 is with winter biotype (13.1 p.).

Main traits formed malting-technological qualities (D) of barley are: protein content, extract, starch, uniformity and mass of 1000-kernels. Total value of the breeding direction (D=30 points) coefficient, decomposes to component traits according to their importance. are given to the standard Obzor. Malting quality is determined mainly by low protein content. In this study protein content of lines and cultivars vary from 9.43% (for 96105023) to 16.88% (for Emon). With coefficient 7 for Obzor (13.52%), the note of the breeding line with lowest protein content, as perspective for malting barley breeding will be (7*(100-9.43)/100-13.52)=7.33 points. At the opposite, for the other traits, important for barley breeding programs are genotypes with higher percent extract, starch, uniformity and higher values of mass for 1000-kernels. For example if one genotype has 78.8% extract (99105020), then the number's value will be (6*78.8)/76.6 (Obzor).

Mainly indicators that determine the direction ability for mechanized harvesting (E) are plant height, resistance to beaten down, uniformity of productive tillers and spike impairment. In general, according to significance of breeding direction is given coefficient of importance 10. Coefficients values of studied genotypes varies from 8.36 points to 9.77 p. with maximum score 10, which defines all lines as suitable for mechanized harvesting and determines progress in breeding improvement works in malting barley in that direction.

Possible coefficient values that can reach the standard Obzor can be 100 points, in case that plants are not infected by diseases (Table 4). All other varieties are compared with the standard and if they exceed, receive higher values on specific criteria and thus in the common overall assessment.

Table 4. Quantitative and complex evaluation

N	Variety/breeding line	Total bal	
		points	%
1	Obzor St	95.63	100.00
2	82105326	89.24	93.32
3	89105100	85.68	89.60
4	96105023	95.08	99.42
5	96105024	95.54	99.90
6	96105027	89.30	93.38
7	**96105046**	**97.04**	**101.48**
8	96105050	95.05	99.39
9	**99105020**	**99.25**	**103.79**
10	**99105030**	**98.17**	**102.65**
11	508	85.04	88.93
12	511	82.40	86.17
13	622	90.94	95.09
14	ID-A/102	84.34	88.19
15	Alexis	91.23	95.40
16	Beta Ketzoras	95.71	100.09
17	**Emon**	**98.70**	**103.21**
18	Kamenitza	95.84	100.22
19	**Caravela**	**102.17**	**106.83**
20	**Kaskadior**	**101.30**	**105.93**
21	**Neda**	**103.83**	**108.57**
22	**Gorast**	**101.00**	**105.61**
23	Orphey	94.88	99.22
24	Kyfi	85.27	89.17

Based on the comprehensive evaluation of studied varieties, which percentage exceed the standard in complex of traits are: 96105046 (1.48%), 99105020 (3.79%), 99,105,030 (2.65%), Emon (3.21%), Caravela (6.83%), Kaskadior (5.93%), Neda (8.57%) and Gorast (5.61%). Depending on this, varieties and lines can be recommended for testing and introduce directly in production, and as an initial material for crosses.

CONCLUSIONS

As a result of conducted quantitative and complex assessment of studied genotypes, variety Neda (103.83 points) is with highest comprehensive assessment, followed by Caravela (102.17 p.), Kaskadior (101.30 p.) and Gorast (101.0 p.). Applied mathematical model show us the varieties and breeding lines, which possess many positives traits combined in complex and allow us to prefer these varieties, as the best parents for the hybridization, to combine the desirable and appropriate traits in hybrid generations of the barley breeding.

Using the method it is possible to identify the advantages of the relevant genotypes in different breeding directions. The most productive ones stand newly established varieties in Bulgaria: Neda (36.05 p.) and Gorast (34.23 p.), with an average value of direction A=30 points (for Obzor).

Considerable variety of forms seen in the direction B (biology features). With high adaptive potential according quantitative and complex assessment are genotypes: Emon (17.45 points), Kamentitza (18.05 p.), Caravela (16.95 p.), Neda (17.50 p.), Gorast (16.92 p.) and Orphey (17.71 p.) etc.

With short vegetation 210 days (13.3 points) differ genotypes: 82105326, 96105027, 99105020, 99105030, 622, ID-a/102, Alexis and Caravela. All of them can be donors of desirable traits in vegetation period breeding direction-C.

With good brewing technological qualities and highest complex assessment over 30 points are: 96105023 (30.23 p.), 96105024 (30.65 p.), 96105027 (30.63 p.), 96105046 (30.05 p.), Beta Ketzoras (30.88 p.), Emon (30.43 p.), Caravela (30.05 p.), Kaskadior (31.46 p.), Neda (30.51 p.) and Gorast (30.11 p.).

All studied samples fully cover the requirements for mechanized harvesting, as shown by their similar coefficients of importance in this direction (from 8.36 to 9.77 with maximum points 10).

As a result some of the tested genotypes with high overall value and highest comprehensive evaluation in breeding direction brewery technological qualities were selected as initial parental forms in crosses.

REFERENCES

Божанова В., 2007. Изследване на сухоустойчивостта на твърда пшеница чрез депресията на растежа при осмотичен стрес. II-ра научна конференция

"Проблеми на влакнодайните и зърнено-хлебни култури", Чирпан, p. 78-83.
Георгиев С., 1988. Агробиологично и технологично проучване на таксономичните разновидности фъстъци (*A. hypogaea* L.) при условията на Централна Южна България. Дисертация за присъждане на научната степен "Доктор на селскостопанските науки".
Федин М.А., Силис Д.Я., Смиряев А.В., 1978. Метод индексов, основанный на дискриминантных функциях для отбора сортов. Генетика количествеых признаков селсохозяйственны растений. Наука, Москва, p. 58-62.
Vulcheva D., Vulchev D., 2008. Studies on phenotypic diversity in models double-breasted winter barley introduction. Union of Scientists-Stara Zagora, International Scientific Conference, June 5-6.
Ganusheva N., Dimova D., Toshev N., 2004. Prospective study of two-row barley lines. Plovdiv, Scientific Works, Vol. XLIX, p. 159-164.
Georgiev S., Ganusheva N., Stamatov S., Deshev M., 2013. Approaches and methods as a model in the breeding of self-pollinated crops. Academic Publishing Agricultural University
Knežević D., Pržulj N., Zečević V., Đukic N., Momčilović V., Maksimović D., Mićanovic D., Dimitrijević B., 2004. Breeding strategies for barley quality improvement and wide adaptation Kragujevac J. Sci., 26: 75-84.
Marcheva M., Koteva V., 2013. Correlation between quantitative traits and quality parameters of barley, cultivated in different environmental conditions. Proceedings of the Second Scientific Conference with international participation "Theory and Practice in Agriculture" UF, November 22 to 24, Undola, p. 25-32.
Marcheva M., Gorastev Ch., Bozhanova V., 2005. Evaluation of drought tolerance of perspoctive barley lines of a complex population. Collection of scientific works of the Balkan Conference, 80th anniversary of the establishment of the Institute of Agriculture - Karnobat, June 2, 2005, Selection and agrotechnics arable crops, p. 173-178.
Spunar J., Blumel H., Fouquin G., 2008. Global warming impact-winter barley as reserve crop for brewing industry in the traditional European countries declaring exclusive or dominant spring malting barley utilization. Proceedings of the 10th International Barley Genetics Symposium 5-10 April, Alexandria, Egypt, p. 395-405.
Zakova M., Benkova M., 2004. Genetic Diversity of Genetic Resources of Winter Barley Maintained in the Genebank in Slovakia. Czech J. Genet. Plant Breed., 40 (4): 118-126.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

Plantago lanceolata L. CROPS – SOURCE OF VALUABLE RAW MATERIAL FOR VARIOUS INDUSTRIAL APPLICATIONS

Alice GRIGORE[1], Corina BUBUEANU[1], Lucia PIRVU[1], Lucian IONITA[2], George TOBA[3]

[1]National Institute for Chemical-Pharmaceutical R&D, 112 Vitan St., Bucharest, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, Districti 1, Bucharest, Romania
[3]Center Studies and Research Center of Agroforestry Biodiversity „Acad.David Davidescu", 13 September St., Bucharest, Romania

Corresponding author email: alicearmatu@yahoo.com

Abstract

Plantago lanceolata L. (ribwort plantain) belonging to Plantaginaceae family is a perennial cosmopolitan species which shows high ecological plasticity, being found naturally in grassy areas on roadsides, in pastures and in crops as weeds. The species has a wide range of more or less developed industrial applications. In this review are presented data regarding ribwort plantain cultivation (cultivated area and input requirements), the main biologically active constituents, review of existing industrial applications, potential directions of use based on new achievements in biotechnology or on improvement of extraction and formulation technology (pharmaceutical products, supplements for veterinary use, cosmetics, insecticides, other intermediary products), restricting factors that could inhibit larger industrial use (issues related to the crop input, inconsistency in quality of the end-product, etc.), recommendations to use bio-products based on Plantago lanceolata raw material.
Although Plantago lanceolata L. is considered a weed, scientific data prove its importance in various domains and also open new directions for development of new and valuable natural products.

***Key words**: Plantago lanceolata, plantain, crop, applications.*

REVIEW

AREAS OF ORIGIN AND CURRENT CULTIVATION

Plantago lanceolata L. (ribwort plantain) belonging to Plantaginaceae family is a cosmopolitan species - from Iceland south and east to Spain, northern and central Asia (www.pfaf.org).

In UK *Plantago lanceolata* is a relatively new crop while in Germany this species is one of the most cultivated (Europam). In Poland, ribwort plantain is a species recommended for enriching grassland biodiversity (Seidler-Lozykowska, 2009) and in Romania this species is mainly collected from the wild but there is a small cultivated area too (the main cultivar is "de Cluj", registered in 1975). In Slovenia, considering the principle of sustainable use, natural populations of *Plantago lanceolata* L. are successively introduced in the National Collection of Medicinal and Aromatic Plants (MAP's), where further activities (multiplication of plant materials, morphological and/or chemical characterization, selection and other pre-breeding studies) needed for future cultivation purposes are foreseen (Baričevič et al., 1994).

In Austria ribwort plantain is grown in the more humid areas; in the Mühlviertel county, province of Upper-Austria, ribwort plantain, marjoram, common balm, and peppermint are the most important crops, about 65% of the total herb acreage in this region being organic grown (Ruckenbauer, 2004).

GROWING CONDITIONS – INPUT REQUIREMENTS

Ribwort plantain is a perennial herb which shows high ecological plasticity, being found naturally in grassy areas on roadsides, in pastures and in crops as weeds. It shows moderate demands regarding soil and climatic factors. Resist well in drought and cold winters and it can tolerate maritime exposure (www.pfaf.org). This plant is not picky towards previous crop in the field, but is better to be sown after the land is cleaned of weeds and leaves, without plant debris. The plant could be maintained in culture 4-5 years (Roman et al., 2009). Physical purity of seed shall be a minimum of 85% and 75% germination (Roman et al., 2009). Plantain exploits nutrients from fertilizer, bringing special production increases.

Kolodziej (2006) showed that plantain cultivation without mineral fertilisation application produce significantly lower yields of leaves, characterised however by the highest active substances content and better sanitation.

Generally, in plantain crops have not noticed important diseases or pests. The annual production which can be obtained is about 10-12 tones of fresh leaves and 1.5 to 2 tones of dry leaves, respectively (Roman et al., 2009).

Significant differences were evident in plants grown under controlled conditions for all characters except seed number per capsule, indicating a genetic basis to population differences observed in the field. Inflorescence number per plant and capsule number per inflorescence showed significant variation within populations (Primack et al., 1981).

MAIN CONSTITUENTS

According to European Medicine Agency (EMEA) (EMEA, 2010) and other sources, the main constituents of *Plantago lanceolata* are:

Iridoidglycosides: Iridoidglycosides are chemotaxonomic markers of *Plantago* genus (Rymkiewicz, 1979). According to the iridoid fingerprint, *Plantago* species are classified as follows: species containing mainly aucubin and their derivatives (*P. major*, *P. cornuti*, *P. gentianoides*), species containing mainly aucubin and their derivatives like 10-O-acetyl-aucubin, monomelitoside and monomelitoside derivatives (*P. subulata*, *P. media*), species containing aucubin and catalpol (*P. lanceolata*, *P. altissima*, *P. argentea*, *P. lagopus*, *P. atrata*) and species containing aucubin and plantarenaloside (*P. afra*, *P. scraba*) (Taskova et al., 2002).

The herbal substance contains about 2-3% iridoidglycosides with aucubin and catalpol as the main compounds, as well as asperuloside, globularin and desacetylasperuloside-acid methylester (Handzhieva et al., 1991).

The iridoid content depends on the maturity of the leaves. Young leaves contain up to 9%, while in the older ones iridoids are present only in traces (Klockars et al., 1993). Chemical variation within and between individuals was studied and it was found that young and intermediate age leaves have the highest content of catalpol while aucubin (biosynthetic precursor of catalpol) is predominant in the leaves of intermediate age and less in the mature ones (Bowers et al., 1992).

Significant variation in iridoid glycosides (IGs) content between shoot and root tissues across development was also observed: allocation of IGs into root tissues linearly increased from younger to older plants, while non-linear shifts in allocation of IGs during ontogeny were observed for shoot tissues. Finally, root:shoot ratios only weakly explained overall allocation of resources into defenses, with young stages showing a positive relationship, while older stages showed a negative relationship between root:shoot ratios and IG concentrations. Ontogenetic trajectories in plant quality and defenses within and among plant tissues can strongly influence insect herbivores' performance and/or predation risk; thus, they are likely to play a significant role in mediating species interactions (Quintero et al., 2012).

Mucilage: ~6.5%. *P. lanceolata* leaves contain polysaccharides with L-arabinose (~20%), D-galactose (~28%), D-glucose (~6%), D-manose (~2%), L-manose (~4%), D-galacturonic acid (~31%), D-glucuronic acid (~7%), and minor proportions of L-fructose and D-xilose. Chromatographic separation of the crude polysaccharide resulted in the obtainment of three distinct fractions, out of which 2 are neutral and a molecular weight between 8000-45000 Da, and one is acidic and it has a molecular weight of 70000Da (Braeutigam et al., 1985).

Polyphenols: Acteoside (verbascoside) is the main phenyletaonidic compound in *P. lanceolata*; other compounds are cistanoside F, lavandulyfolioside, plantamajoside and isoacetoside (Murai et al., 1995).

Based on the differences in polyphenolic compounds structure (iridoids, flavonoids, phenyletanoids) of different *Plantago* species, a classification in two groups was proposed: one group with *P. asiatica* and *P. major* as main representatives and the other one with *P. depressa* and *P. lanceolata* (Nishibe et al., 1995).

Chemotaxonomic analysis of *Plantago* genus showed that caffeic, vanilic, ferulic , syringic and p-cumaric acids occur most frequently but there is no chemotaxonomic semnification for this aspect (Andrzejewska-Golec et al., 1986). The herbal substance also contains 6.5% tannins, phenolic carboxylic acids including p-hydroxybenzoic-, protocatechuic, gentisinic-, chlorogenic- and neochlorogenic acid (Maksyutina, 1971), among others.

It was showed that cultivated ribwort plantain has a higher polyphenol composition, both in terms of quality (various phenolic compounds with antioxidant character) and quantitative (1000 mg/100 g) than of wild specimens (Varban and Varban, 2012).

Flavonoids class includes apigenin and luteolin as well as their derivatives with the main compounds apigenin-6,8-di-C-glucoside and luteolin-7-O-glucuronide, luteolin-7-O-glucoside and 7-O-glucuronide-3'-glucoside, in addition to the 7-O-glucuronyl-glycosides of apigenin and luteolin as well as apigenin-7-O-glucoside and 7-O-glucuronide (EMEA, 2011; Wichtl, 2004).

Volatile oil: The volatile compound proportion corresponds to 0.05%, 0.03% and 0.001% of fresh weight for fruits, leaves and scapes, respectively. Thirty-five and twenty-six components were identified from fruits and leaves, respectively, while scapes contained only seven volatile components as it was showed by GC/MS. The major constituents of fruits were oct-1-en-3-ol (24.9%), hexahydrofarnesylacetone (15.7%), vanillic acid (9.8%) and neophytadienes (>10%); leaves contained mainly oct-1-en-3-ol (41.1%), (E),4(3-oxo-2,6,6-trimethylcyclo-hex-2-en-1-yl)-3-buten-2-ol (15.6%), 6-(3-hydroxy-1-butenyl)-1,5,5-trimethyl-7-oxabicyclo[4,1,0]heptan-3-ol (6.9%) and benzoic acid (6.3%). Neophytadienes were mainly found in both scapes of wild ribworts and leaves of seedling cultures (Fons et al., 1998).

Other compounds. The coumarin aesculetin, the xanthophyll decomposition product loliolide and small amounts of a hemolytic and antimicrobial saponin are also present. Inorganic constituents include 1% silicilic acid and mineral salts with a high proportion of zinc and potassium (EMEA, 2011).

REVIEW OF *PLANTAGO LANCEOLATA* USES

Plantago lanceolata raw material is suitable for various applications. There are about 45 registered international patents concerning *Plantago lanceolata* leaves and only few are applied in industry.

Pharmaceutical products:

Generally, plantain leaves are applied externally to heal sores and wounds; against furuncles, against insect and snake bites (Pieroni et al., 2004; De Natale et al., 2007; Tita et al., 2009) and internally as expectorant, antitussive, emollient, anti-inflammatory, astringent, antimicrobial, bronchitis, laryngo-tracheal catarrh, diarrhoea (Tita et al., 2009; Neves et al., 2009).

Plantaginis lanceolatae folium has monograph in European and British Pharmacopoeia, ESCOP, German Commission E and French Avis aux fabr. monographs and also a monograph published on EMEA (Herbal Medicinal Products committee assessment). Plant material of interest for pharmaceutical purposes is represented by whole or fragmented, dried leaf and scape of *Plantago lanceolata* L.

According to EMEA, traditional uses for *Plantago lanceolata* leaves are: “Indications for the internal administration are catarrhs of the respiratory tract and inflammation of oral and pharyngeal mucosa. Externally applied it is used for inflammation of the skin”.

According to the overviews of the market in the Member States of the European Union, there were herbal preparations with a well-established use status (herbal substance (cut); dry extract, liquid extract, soft extract, expressed juice from the fresh herb) and also herbal preparations under traditional use (herbal substance (cut), powdered herbal substance, liquid extract, syrup) (EMEA, 2011).

European manufacturers use Plantaginis folium (alone or in combination with other plants) for various medicinal purposes: digestion (Finland, Romania), expectorant (Slovenia, Italy, Romania), antimicrobial, astringent, soothing irritations (Poland, Belgium) or in various forms: herbal tea, tablets, syrup, etc.

In homeopathy - drugs with medical prescription - *Plantago lanceolata* is commercialized as drops, granules.

Cosmetics

Plantago lanceolata leaves are used in cosmetic industry by many European manufacturers for a large variety of products: creams, lotions, solution for spa use, etc.

An *in vivo* study conducted in Germany by Rahn Cosmetics AG (http://www.rahn-group.com/en/cosmetics/product/20/) showed that a product containing *Plantago lanceolata* water extract, *Mahonia aquifolium* and salicylic acid effectively reduces existent skin impurities and optimises the skin appearance due to its antibacterial, keratolytic and antiinflammatory action.

In Switzerland, another company utilizes *Plantago lanceolata* leaf extract for enhancing collagen production and wound healing and for exerting an antioxidant effect (http://www.anshulindia.com/pdfs/DSM%20Pentapharm%20Products.pdf).

Products for veterinary use

Leaves are edible and sometimes eaten as vegetable. *Plantago lanceolata* is occasionally grown as a fodder crop and considered to be of better quality than *Plantago major* (Gurib-Fakim, 2006). It may also be recommended as an alternative to hay in sheep (Al-Mamun et al., 2007).

Ribwort forage is new as feedstuffs to piglets, but have previously been fed to deer, calves, lambs and young rabbits with good growth performance results. One of the first studies on the impact on growth performance, digestibility and coliform counts of feeding ribwort forage to piglets showed that the higher digestibility of non-starch polysaccharides observed with inclusion of ribwort is a result of increased hindgut fermentation due to more easily degradable polysaccharides in the herbs than the cereals. The use of fibre-rich feedstuffs to weaned piglets was promising, but the low palatability of ribwort could limit the inclusion level in the diet (Ivarsson et al., 2011).

Moreover, it was showed that in the case of European wild boar (*Sus scrofa* L.), *P. lanceolata* has a high digestibility coefficient and digestible energy content (Quijada et al., 2012).

Studies on calves showed good results too. *Plantago lanceolata* L. dried leaves are used as tea as an appetizer and digestive and the fresh leaves are topically applied with cream from cows' milk and bread or clay as a suppurative (also for cows, especially for treating inflamed hooves) (Pieroni et al., 2009). Also, the inclusion of *P. lanceolata* as a supplemental forage significantly reduces the egg output of gastrointestinal nematodes in calves (Sievers et al., 2006).

Another study showed the healing potential of water-soluble extract of *Plantago lanceolata* as a topical ointment on experimental tendinitis in burros induced by bacterial collagenase. The positive effects of the *Plantago* in the healing of tendinitis can be attributed to its anti-inflammatory properties owing to acteoside, a phenylethanoid, which inhibits arachidonic acid in the cyclooxygenase pathway (Oloumi et al., 2011).

Insecticide

A recent study showed that *P. lanceolata* extracts have potential for use in the development of new products to control the coffee leaf miner (*Leucoptera coffeella* Guérin-Mèneville & Perrottet) by reducing its oviposition and egg hatching, apparently as a result of action of plant metabolites on the embryo. Adults originating from eggs treated with the extract exhibited similar survival rates, but a higher female/ male ratio (Alves et al., 2011).

The compounds found in *Plantago lanceolata* have potential for use in selectively targeting plant-parasitic nematodes in pest management systems. Further research is needed to isolate and identify *Plantago*-specific compounds, to determine their toxicity to additional plant-parasitic nematodes, and to understand the fate of these compounds in soil (Meyer et al., 2006).

Metal removal

P. lanceolata can be used as a good bioindicator for heavy metal accumulation in industrial and urban areas. Data on accumulative capacity allow us to recommend this species not only for Zn and Pb, but for indication of Cd, too (Dimitrova and Yurukova, 2005).

In a study carried out to evaluate copper resistance by rhizosphere microorganisms from *Plantago lanceolata* L., the results indicated that some isolates are potential agents for copper bioremoval and bacterial stimulation of copper biosorption by this herbal species. Speciation of copper revealed high copper biotransformation, reducing Cu(II) to Cu(I), capacity (Andreazza et al., 2012).

Other intermediary products

A large variety of intermediary products for various further uses are produced in Europe: hydroalcoholic extract - Romania, France, liquid extract -Bulgaria, Poland, dry extract - Bulgaria, Poland, Slovakia, mother tincture - France, glycerine extract – France.

These extracts are standardized and they can be applied in many different final products, from cosmetics to nutritional supplements.

APPLICATIONS UNDER STUDY

In vitro cultures are already used for plant regeneration and micropropagation. As regards callus culture, it was proved that the leaf and root mucilage content in the intact plant of *P. lanceolata* is 10% g/g dw and in seeds is 5% g/g dw while in the callus is about 14.75%g/g dw. Callus could have up to 3 times more mucilage than seeds, leaf and root parts (Mirmasumi et al., 2001).

Also, hairy root cultures are able to biotransform an outer precursor such as cinnamic acid into a phenolic derivative. Further investigation should be carried out in order to optimize the culture conditions and increase the bioproduction of biologically active metabolites. -*P. lanceolata* may be transformed by *Agrobacterium rhizogenes* and two phenylethanoid heterosides, i.e. p-cumaroyl-glucose and feruloyl-glucose are neo-synthesized and accumulated in the roots of seedlings fed with cinnamic acid (Fons et al., 2008). A recent study showed that a phenolic acid mixture produced during the fungal proliferation protected acteoside from breakdown, possibly via its antioxidant activity and metal complexing ability. It was shown that plant-associated microorganisms can increase or decrease the stability of chief metabolites in herbal matrices, and can significantly alter the chemical pattern of the plant matrix (Kiss et al., 2013).

Products based on improvement of extraction and formulation technology are also developing. New type of nanomaterials has been already synthesized using iridoidic extract separated from *Plantago lanceolata* by successive extraction in aqueous media. The obtained nanodrops were then encapsulated in silica resulting porous core - shell particles which were characterized by Dynamic Light Scattering and electronic microscopy confirming the nanostructure of the new biomaterials. Preclinical tests performed on mice revealed a positive action on the healing process, and the crude extract processed as nanopowder showed a protective action against diarrhoea disorder (Radu et al., 2009).

Moreover, these days modified polysaccharides have been the major area of scientific research. Polysaccharides such as starch, cellulose, chitosan, dextrin, guar-gum, psyllium are cost effective, biodegradable and quite efficient towards various technological processes - drug-delivery, agriculture (insecticide and pesticide delivery), water treatment (removal of toxic metal ions from waste water and flocculation) and membrane technology (Kaith and Kumar, 2007).

RESTRICTING FACTORS THAT COULD INHIBIT LARGER INDUSTRIAL USE

As regards the agricultural raw material, there are some issues related to the crop input. *Plantago lanceolata* is a common weed and some of the manufacturers use wild crafted raw material which leads to inconsistency in quality of the end-product. Much attention should be paid to conditions for cultivation which are essentials to valuable end-products. The contents of aucubin and acteoside are extremely lower in plants grown in the shade. Moreover, the contents of aucubin and acteoside are apparently lower in the plants treated with nitrogen than in those that did not receive it, although nitrogen application enhances the growth of the cultivars, especially the top fresh weight (Yoshifumi et al., 2001).

The content of aucubin and catalpol varies also depending on the time of harvesting. Before the flowering period the content of aucubin is very low in every organ and reaches its maximum in autumn with aucubin at levels of 1-3% and catalpol up to 1% (EMEA, 2011).

Mucilage content is lower than in *Plantago ovata* which gives about 25% of good quality mucilage. This mucilage has various industrial applications (thickener, hydrocolloidal agent) as well as medicinal properties (source of dietary fibres, hypocholesterolemic and antidiabetic activities). Because of the poor yield, *P. lanceolata* mucilage is not suitable enough for industrial production.

Ribwort plantain grows well under cool temperatures, improving its productivity in dry. In a study developed in US it was showed that plantain growth rates were greater in September than they were in July, increasing by 62% in the normal and 29% in the wet treatment. Imposition of summer drought on plantain increased winter survival from <10% in the normal and wet treatments to 41% in the dry treatment (Howard Skinner et al., 2002).

After harvesting the herb has to be dried directly to avoid fermentative processes. After hydrolysis aucubin is converted to dark brown polymers, which are responsible for the dark coloration of improperly dried drug material. The herbal substance is commonly dried at temperatures of 40-50°C. During this process the content of aucubin decreases. Drying at room temperature results in aucubin contents twice as high (EMEA, 2011).

As regards industrial raw material, especially for pharmaceutical applications, there are some research gaps that need to be filled. There are no consistent human data available regarding pharmacodynamic and pharmacokinetic properties of *Plantago lanceolata* leaves. Although various pharmacological effects have been described for the total extract of *Plantago lanceolata* and constituents thereof, these effects or dose response studies have never been verified in controlled clinical studies. Also, for children and adolescents no data are available, thus, the oromucosal administration should be limited to adults.

Plantain is generally considered as one of the most important dicotyledons that cause allergic diseases in Europe. Further studies on polyamine and allergy relation with other genus are carried out; the results of this research are in progress.

Regarding the above mentioned aspects, high and sometimes restrictive *costs* are involved for clinical trials, classic or organic cultivation (comparing to wild crafting), additional operations for primary processing.

RECOMMENDATIONS TO USE BIO-PRODUCTS BASED ON *PLANTAGO LANCEOLATA* RAW MATERIAL

Some measures concern the improvement of quality and yield of raw material and biologically active constituents. In this respect, studies for selecting mutants with high stress or salt resistance, freezing tolerance or with high bioactive compound contents should be carried out. Also, optimization of post-harvest processes to maintain a good yield of active principles, initiation of large scale organic cultivation and also improvement of technology for primary and secondary processing are important steps for high valorification of *Plantago lanceolata*. Product quality is ensured also by standardization, especially for pharmaceutically products; in this case, the quality and thus the concentration of active compounds is much more relevant than the total yield.

As regards pharmaceutical products, there is a strong need for appropriate pharmacological testing and controlled clinical studies. New pharmaceutical applications of ribwort plantain were already verified on animal models: immunostimulant effect, antitoxic effect, procoagulant effect, antihelminthic effect, antiulcerous activity.

Further studies on polyamine and allergy relation with other genus having different species, which have different allergy degrees, should be continued.

Veterinary medicine is also a niche that is worth to exploit both for food and non-food use of ribwort plantain. No less important is the financial help for cultivation; it is important to understand the influence of controlled conditions for natural, inovative and high quality end-products.

ACKNOWLEDGEMENTS

This work was carried out under postdoctoral program POSDRU/89/1.5/S/63258; Project PN II Partnership No. 134/2012 and FP7 project "Crops2Industry" No. 227299.

REFERENCES

Al-Mamun M., Tanaka C., Hanai Y., Tamura Y., Sano H., 2007. Effects of plantain (*Plantago lanceolata* L.) herb and heat exposure on plasma glucose metabolism in sheep. *Asian-Aust. J. Anim. Sci*., 20 (6): 894-899.

Alves D., Oliveira D., Carvalho G., Santos H., Carvalho D., Santos M., Carvalho H., 2011. Plant extracts as an alternative to control *Leucoptera coffeella* (Guérin-Mèneville) (*Lepidoptera*: *Lyonetiidae*). Neotrop Entomol., 40 (1): 123-8.

Andreazza R., Okeke B., Camargo F., 2012. Characterization of copper-resistant rhizosphere bacteria from *Avena sativa* and *Plantago lanceolata* for copper bioreduction and biosorption. Biol Trace Elem Res, 146(1): 107-15.

Andrzejewska-Golec E., Swiatek L., 1986. Badania Chemotaksonomiczne rodzaju Plantago II. Analiza frakcji fenolokwasow. Herba Polonica, 32: 19-31.

Baričevič D., Černila M., Gomboc S., Habeler H., 1994. MEDPLANT - monitoring, characterization and evaluation software for medicinal and aromatic plants. SAA, Patent Nr. R 186/94, Ljubljana, Slovenija, 12.

Bowers M.D., Stamp N.E., 1992. Chemical variation within and between individuals of *Plantago lanceolata* (*Plantaginaceae*). Journal of Chemical Ecology, 18: 985-995.

Braeutigam M., Franz G., 1985. Structural features of *Plantago lanceolata* mucilage. Planta Medica, 51 (4): 293-7.

De Natale A., Pollio A., 2007. Plants species in the folk medicine of Montecorvino Rovella (inland Campania, Italy). Journal of Ethnopharmacology, 109 (2): 295-303.

Dimitrova I., Yurukova L., 2005. Bioindication of anthropogenic pollution with *Plantago lanceolata* (Plantaginaceae): metal accumulation, morphological and stomatal leaf characteristics. Phytologia Balcanica, 11 (1): 89-96.

European Medicine Agency, 2010. Assessment report on *Plantago lanceolata* L., folium, Draft, Community herbal monograph on *Plantago lanceolata* L., folium 2011.

Fons F., Gargadennec A., Rapior S., 2008. Culture of *Plantago* species as bioactive components resources: a 20-year review and recent applications. Acta Bot. Gallica, 155 (2): 277-300.

Gonda S., Kiss A., Emri T., Batta G., Vasas G., 2013. Filamentous fungi from *Plantago lanceolata* L. leaves: Contribution to the pattern and stability of bioactive metabolites. Phytochemistry, 86, 127-136.

Gurib-Fakim A., 2006. *Plantago lanceolata* L. In: Schmelzer, G.H. & Gurib-Fakim, A. (Editors). Prota 11(1): Medicinal plants/Plantes médicinales 1 (CD-Rom). PROTA, Wageningen, Netherlands.

Handjieva N., Saadi S., Evstatieva L., 1991a. Iridoid glucosides from *Plantago altissima* L., *Plantago lanceolata* L., Plantago atrata Hoppe and *Plantago argentea* Chaix. Zeitschrift fur Naturforschung, 46c: 963-965.

Ivarsson E., Frankow-Lindberg B., Andersson H., Lindberg J., 2011. Growth performance, digestibility and faecal coliform bacteria in weaned piglets fed a cereal-based diet including either chicory (*Cichorium intybus* L) or ribwort (*Plantago lanceolata* L) forage. Animal, 5(4): 558-564.

Kaith B.S., Kumar K., 2007. In air synthesis of Psy-cl-poly(AAm) network and its application in water-absorption from oil-water emulsions *eXPRESS* Polymer Letters, 1 (7): 474-480.

Klockars G., Bowers D., Cooney B., 1993. Leaf variation in iridoid glycoside content of *Plantago lanceolata* (Plantaginaceae) and oviposition of the buckeye, *Junonia coenia* (Nymphalidae). Chemoecology, 4 (2): 72-78.

Kolodziej B., 2006. Effect of mineral fertilization on ribwort plantain (*Plantago lanceolata* L.) yielding. Acta Agrophysica, 8 (3): 637-647.

Maksyutina N., 1971. Hydroxycinnamic acids of *Plantago major* and *P. lanceolata.* Chemistry of Natural Compounds, 7 (6): 795.

Meyer S., Zasada I., Roberts D., Vinyard B., Lakshman D., Lee J., Chitwood D., Carta L., 2006. *Plantago lanceolata* and *Plantago rugelii* extracts are toxic to *Meloidogyne incognita* but not to certain microbes. Journal of Nematology, 38 (3): 333-338.

Mirmasumi M., Brahimzadeh H., Tabatabaei S., 2001. Mucilage production in tissue culture of *Plantago lanceolata*. J. Agric. Sci. Technol., 3: 155-160.

Murai M., Tamayama Y., Nishibe S., 1995. Phenylethanoids in the herb of *Plantago lanceolata* and inhibitory effect on arachidonic acid-induced mouse ear edema. Planta Medica, 61 (5): 479-80.

Neves J., Matos C., Moutinho C., Queiroz G., Gomes L., 2009. Ethnopharmacological notes about ancient uses of medicinal plants in Trás-os-Montes (northern of Portugal). Journal of Ethnopharmacology, 124 (2): 270-283.

Nishibe S., Tamayama Y., Sasahara M., Andary C., 1995. A phenylethanoid glycoside from *Plantago asiatica*. Phytochemistry, 38 (3): 741-743.

Oloumi M., Vosough D., Derakhshanfar A., Nematollahi M., 2011. The healing potential of *Plantago lanceolata* ointment on collagenase-induced tendinitis in burros (*Equus asinus).* Journal of Equine Veterinary Science, 31 (8): 470-474.

Pieroni A., Quave C., Villanelli M., Mangino P., Sabbatini G., Santini L., Boccetti T., Profili M., Ciccioli T., Rampa L., Antonini G., Girolamini C., Cecchi M., Tomasi M., 2004. Ethnopharmacognostic survey on the natural ingredients used in folk cosmetics, cosmeceuticals and remedies for healing skin diseases in the inland Marches, Central-Eastern Italy. Journal of Ethnopharmacology, 91 (2-3): 331-344.

Pieroni A., Giusti M., 2009. Alpine ethnobotany in Italy: traditional knowledge of gastronomic and medicinal plants among the Occitans of the upper Varaita valley, Piedmont. Journal of Ethnobiology and Ethnomedicine, 5: 32.

Plant for Future Database www.pfaf.org.

Primack R., Antonovics J., 1981. Experimental ecological genetics in Plantago V. components of

seed yield in the ribwort plantain *Plantago lanceolata* L. Evolution, 35 (6): 1069-1079.
Quijada R., Bitsch N., Hodgkinson S., 2012. Digestible energy content of pasture species in growing European wild boar (*Sus scrofa* L). J Anim Physiol Anim Nutr (Berl), 96 (3): 421-7.
Quintero C., Bowers M., 2012. Changes in plant chemical defenses and nutritional quality as a function of ontogeny in *Plantago lanceolata* (*Plantaginaceae*). Oecologia, 168 (2): 471-81.
Radu N., Cristescu I., Coprean D., 2009. Biological properties of nanomaterials based on irridoidic compounds. In: Nanobiosystems: Processing, Characterization, and Applications II, ed. Kobayashi, N., Ouchen, F., Rau, I., Proc. of SPIE Vol. 7403, doi: 10.1117/12.828874.
Radu N., Corobea C., Rau I., 2009. New nanobiomaterials based on irridoidic compounds. In: *Nanobiosystems: Processing, Characterization, and Applications II*, ed. Kobayashi, N., Ouchen, F., Rau, I., Proc. of SPIE Vol. 7403, doi: 10.1117/12.828874.
Ruckenbauer P., 2004. Report from the state of Austria - forming part of IENICA project (www.ienica.net).
Roman G., Toader M., Andreevici I., Turza F., Dragomir D., 2009. Patlagina (*Plantago lanceolata* L.). In: Ghid practic-cultivarea plantelor medicinale si aromatice in sistem ecologic. Ed. Rentrop&Straton, p. 100-102.
Rymkiewicz A., 1979. Badania nad gatunkami z rodzaju Plantago L. z uwzglednieniem karpologii i chemotaksonomii. Monogr. Bot., 57: 71-103.
Seidler-Lozykowska K., 2009. Medicinal plant seeds as an element of increasing biodiversity of grassland, *SALVERE* - Regional Workshop in Poland, p. 45-47.
Sievers G., Nannig S., 2006. Effect of the supplementary feeding with *Plantago lanceolata* on the egg output of gastrointestinal nematodes in calves. Archivos de Medicina Veterinaria, 38 (3): 233-238.
Skinner H., Gustine D., 2002. Freezing tolerance of chicory and narrow-leaf plantain. Crop Sci., 42: 2038-2043.
Taskova R., Evstatieva L., Handjieva N., Popov S., 2002. Iridoid patterns of genus *Plantago* L. and their systematic significance. Z. Naturforsch., 57 c: 42-50.
Tita I., Mogosanu G., Tita M., 2009. Ethnobotanical inventory of medicinal plants from the South-West of Romania. Farmacia. 57 (2): 141-156.
Varban R., Varban D., 2012 Comparative Study of the Active Ingredients Content *Plantago lanceolata* L. ProEnvironment, 5: 248-250.
Wichtl M, editor. 2004. Herbal Drugs and Phytopharmaceuticals: A Handbook for Practice on a Scientific Basis, 3rd edition. Stuttgart (D): Medpharm GmbH Scientific Publishers, p. 456-460.
Yoshifumi T., 2001. Effects of temperature, shade, and nitrogen application on the growth and accumulation of bioactive compounds in cultivars of *Plantago lanceolata* L. Japanese Journal of Crop Science, 70 (4): 548-553.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDY ABOUT VARIABILITY OF *Lathyrus tuberosus* L. FRUITS AND BEANS

Nicolae IONESCU[1], Mihaela Ioana GEORGESCU[2],
Aurelian PENESCU[2], Sorin Gabriel IONESCU[2]

[1]Agricultural Research and Development Station Piteşti, 5 Piteşti-Slatina road,
117030, Piteşti, Romania
[2]University of Agronomical Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd, 011464, Bucharest, Romania

Corresponding author email: nicolaeionescu50@gmail.com

Abstract

Being a common weed L. tuberosus experienced a growing spread in agriculture white luvicsoils from southern territory. The cause is the best its adaptability to the existing conditions. The studies of its variability may bring some new information on how the adaptation has occured, as well as highlighting some new features of the fruits and beans of this species. Racemous fruits has lengths between 9 and 20 cm, with a higher frequency to 12-14 cm. Number of pods of racemous fruit was between 1 and 6, predominantly by 2-3 pods. Pods length was between 2.2 and 3.6 cm, with the higher percentage between 2.8 and 3.0 cm. Pod width was between 3.5 and 5.2 mm, with greater frequency from 4.4-4.6 mm. Number beans in a pod varied between 0.5 and 4.1, with higher frequency of 1.8-2.1. Chickling grain length was between 3.5 and 5.2 mm, 4.1-4.3 mm hugh frequency. Thickness between 2.8-3.9 mm grain was, and the dominant were between 3.0-3.3 mm.

Key words: *Lathyrus tuberosus, racemous fruit, pods, beans.*

INTRODUCTION

One of the common weeds in agriculture is the sweet pea *Lathyrus tuberosus* L. (Bayer code: LATTU) (Anghel et al., 1975). Being Eurasian origin, species prefer edge of fields planted with winter cereals, orchards and hay crops (Krähmer, 2014). With its tendrils weed is able to climb and flourish over the cereals, or may cover horticultural species. In meadows formed bushes easily observed. As feed *L. tuberosus* is considered a plant worthless. Fruits, especially grains contains various alkaloids and therefore are considered toxic. Instead of the root tubers are recommended in food (Bianco, 2001), as raw or prepared (Chirilă, 2001).

In July the plant blooms and flowers with red-purple petals are grouped into broad racemous inflorescences. Pods fruit are obvious, cylindrical- slightly flattened, without hairs (Bărbulescu, 1988). Beans that are spherical-less sharp form, 3-6 mm in diameter, weighing 2.4-2.5 g/100 seeds. Hilum grain is small, characteristic.

Of course these are general morphological characteristics, but by taking measurements under different vegetation, might bring some new elements to describe this common weed species in agriculture. Ripening pods and beans held in August. In the present study we analyzed the final phase: the length of the racemous fruits, the number of pods from an inflorescence, weight, length and thickness of pods, the number and weight of grains from racemous fruits. Grains were determined length, thickness and absolute weight.

MATERIAL AND METHODS

Measurements were conducted during the month of August 2014 on *L. tuberosus* mature plants. Plants were chosen from the edge surfaces that have been grown and harvested winter wheat. Crops were located on the highest plateau (330 m) of the station. Were randomly selected 100 *L. tuberosus* plants harvested from which only one racemous in the central portion of the shoots. The 100 fruits were measured and determined: the length (in the place of attachment to the top) and the number and weight of pods formed. Husks, one of the central portion of the racemous, were measured by three characters: the length, width and weight. Total grains and weight of a raceme were recorded later. From grains formed in a raceme was choses nonselective one, which was measured length and thickness. Total grains in a raceme were fixed and absolute weight (the weight of a thousand grains- TGW).

Morphological characters measured were then analyzed by drawing frequency polygons (FP %) or histograms. For most measurements have been used in class intervals, and only when the number of pods of a racemic fruit, absolute values were used. The study in this species histograms revealed the following:

- Modal values (highest frequency);
- Limits the diversity of characters ranged studied;
- The specific of each character of the area analyzed plant ecotype.

Between characters analyzed were established some correlations with which have been observed and their trends within ecotype studied. The expression values were made using Excel and analysis of variance (the rows of variation). Statistical parameters were calculated using the formulas:

- $\bar{a} = \frac{\Sigma x}{n}$, ā = media, and x = values ;
- S^2 (variance) $= \frac{1}{n-1}\left[\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right]$;
- S (standard error) = $\sqrt{S^2}$;
- S % (variation coefficient) = $\frac{S}{\bar{a}}100$.

RESULTS AND DISCUSSIONS

Variability of *L. tuberosus* fruits. Racemous form a loose the plant that grows from 3 to 6 flowers. After fertilization are formed pods, with which to configure the final appearance of the fruit racemous (Prodan & Buia, 1958). By measuring the length of racemic at the top grip to have found some differing values (Figure 1). The modal value was at maximum length of 12-14 cm (44%).

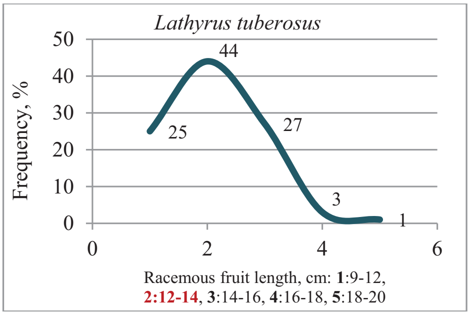


Figure 1. The frecvency of fruits length, *L. tuberosus* weed. Photo: racemious fruit in full bloom (**1**:9-12, **2:12-14**, **3**:14-16, **4**:16-18, **5**:18-20, cm)

The limits of variation of this character were between 9 and 20 cm. Shorter fruits (9-12 cm) had a frequency of 25%, while the long (16-18 cm and 18-20 cm) were rare (3% and 1%). Number of pods per fruit was formed between 1 and 6. The modal value shows that the highest frequency had a fruit with two pods- 30%, followed by the 3 pods (28%) and then those with 4 pods (26%). Fruits with one single pod were only 2% of the total, while those with 5 and 6 pods, in 10% and 4% respectively.

After counting, pods per racemous were weighed. The limits within which their weight has fluctuated were between 0.12 g and 0.75 g. Among a number of pods and weight of fruit established a positive correlation (Figure 2). The correlation coefficient (r = 0.742***) is very significant statistical assurance, demonstrating that plant *L. tuberosus* forming more inflorescences, these will be heavier.

Pods dimensions refer to the length and the thickness that they had. Long- pods form is the spear, almost cylindrical, glabrous nerves and reticulation. The modal value of the length of the pods was 2.8-3.0 cm (51%) (Figure 3).

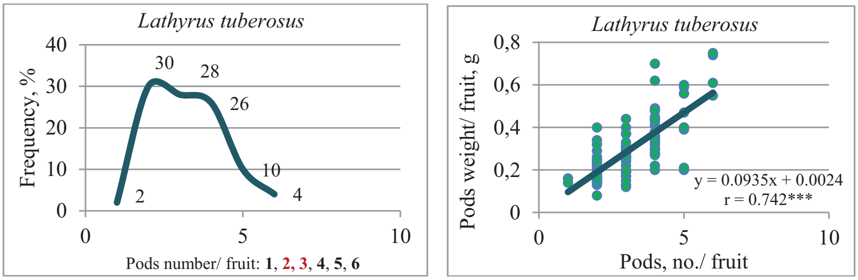


Figure 2. The frequency of pods number and correlation between the number and pods weight

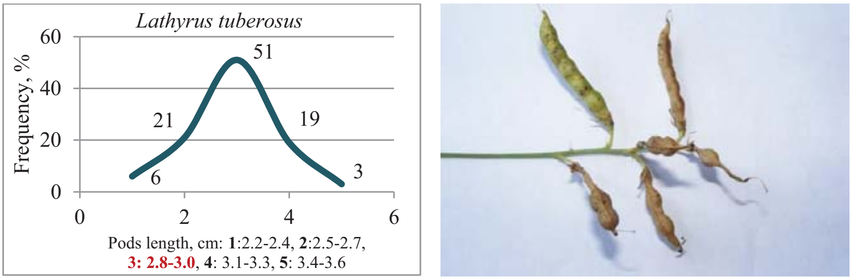


Figure 3. The frecvency of pods length; Photo: a racemous fruit with 6 pods

Lengths of 2.5-2.7 cm and 3.1-3.3 cm of pods were close and specific frequencies of 21% and 19%. 2.2-2.4 cm long pods were frequency of 6%, while those with 3.4-3.6 cm, 3%.

Pods thickness is variable, usually between 4-6 mm (Săvulescu et al., 1957). From the measurements it was found that the modal value was 4.4-4.6 mm (33%) (Figure 4). The limits of variation of the width of pods were between 3.5 and 5.2 mm. Pods of 4.1-4.3 mm and 4.7-4.9 mm had frequencies of 23% and 25%. Other thickness ranging from 3.7-4.0 mm and 5.0-5.2 mm had frequencies of 7% and 8% respectively. Only pods with 3.5-3.7 mm in thickness accounted for only 4% frequency. Between the length of pods and their thickness was established a positive correlation (r = 0.214).

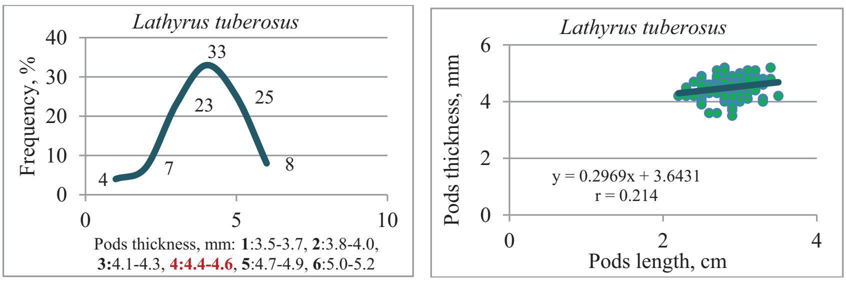


Figure 4. The frecvency of pods thickness and correlation between pods length and pods thickness (**1**:3.5-3.7, **2**:3.8-4.0, **3**:4.1-4.3, **4:4.4-4.6**, **5**:4.7-4.9, **6**:5.0-5.2, mm)

The number of grains that formed on a raceme fruit varied greatly. Modal value was located at 5-7 grains/ fruit. The limits within which they varied were between 3 and 19. Number between 3 and 10 was major - 92%, and between 11 and 19 were below 10% (Figure 5).

Between the number of grains of racemous and weight achieved a highly significant correlation (r = 0.922***). This means that as the plant has conditions to form fruit with several seeds, they will be heavier.

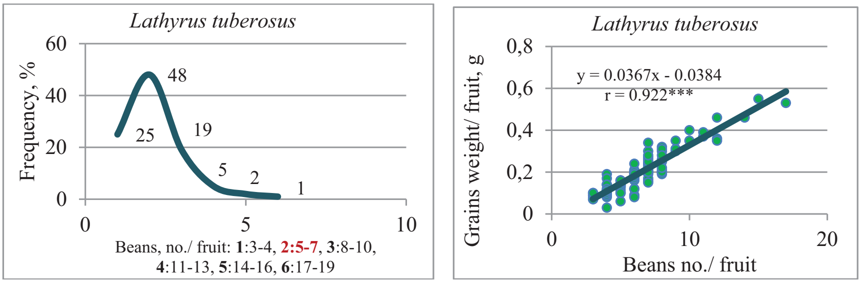


Figure 5. The frecvency of grains number and correlation between grains number and grains weight (**1**:3-4, **2:5-7**, **3**:8-10, **4**:11-13, **5**:14-16, **6**:17-19)

<u>Variability of *L.tuberosus* beans.</u> Grains are formed in the pods may vary between 3 and 6, which are spherical in shape, slightly angular, and warty. Determinations of the number of beans in a pod showed variability rather big (Figure 6). Modal value shows the number between 1.8 and 2.1 grains/pod (34%). Limits the average number fluctuated between 0.5 and 4.1. Less than 10% frequency in number of grains were 0.6-1.3 and 2.6-4.1. *L. tuberosus* grain sizes are between 5-6 mm long, with oval hilum, short and rather small. Grain analysis was done both by measuring the length and thickness of their beans. The grain length had modal value between 4.1 and 4.3 mm (Figure 7).

Grain length limits were between 3.5 and 5.2 mm. Frequencies of grain length of 22% were obtained both in length of 3.8-4.0 mm and of 4.7-4.9 mm. Grains 3.5-3.7 mm long and 5.0-5.2 mm represented only 2% and 8% respectively.

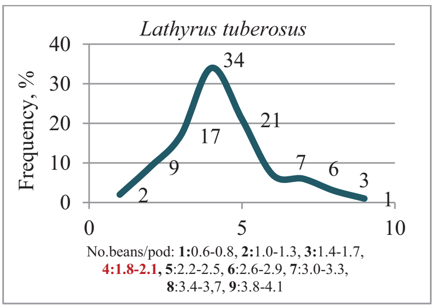


Figure 6. The frequency of bean number from pod (**1**:0.5-0.8, **2**:1.0-1.3, **3**:1.4-1.7, **4:1.8-2.1**, **5**:2.2-2.5, **6**:2.6-2.9, **7**:3.0-3.3, **8**:3.4-3.7, **9**:3.8-4.1)

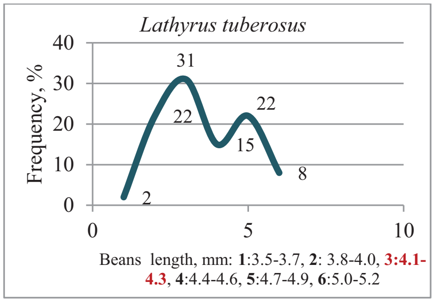


Figure 7. The frecvency of bean length (**1**:3.5-3.7, **2**:3.8-4.0, **3:4.1-4.3**, **4**:4.4-4.6, **5**:4.7-4.9, **6**:5.0-5.2, mm)

Grain thickness was specific variability. Modal value of the thickness was 3.0-3.1 mm (29%) and very close to it in the 3.2-3.3 mm (28%). The beans were thick, so their frequency reduced more and more. Between the length and thickness of *L. tuberosus* grains established a positive correlation, slightly increasing (r = 0.282) (Figure 8).

Absolute mass of grains showed a fairly high variability. Modal value stood at 30-35 grams (30%), and limits were between 5 and 50 g. About 80% of beans were weighed between 20 and 40 g (Figure 9). Correlations obtained between grain weight and dimensions themselves- absolute length and thickness were positive. The relationship between thousand grain weight- TGW, and the length grain was close (r = 0.436***), while correlation between the TGW and the thickness of the grains was less labile (r = 0.208*) (Figure 10).

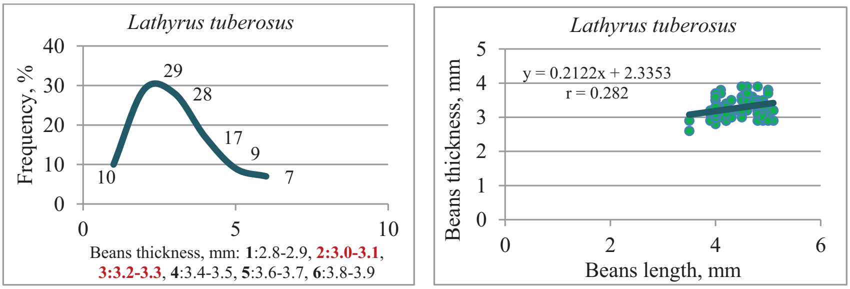


Figure 8. The frecvency of grains thickness and correlation between grains length and grains thickness (**1**:2.8-2.9, **2:3.0-3.1, 3:3.2-3.3**, **4**:3.4-3.5, **5**:3.6-3.7, **6**:3.8-3.9, mm)

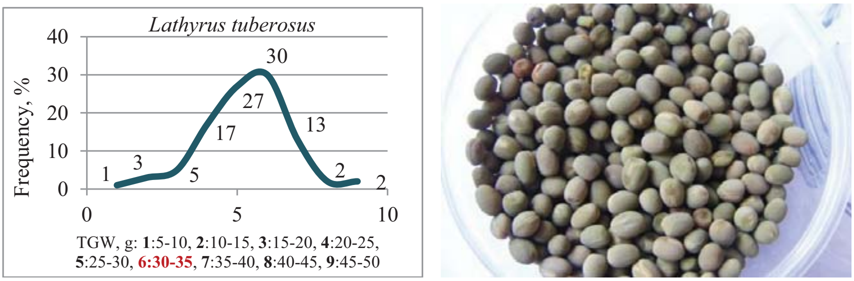


Figure 9. The frequency of beans weight expressed by TGW, *L. tuberosus* weed (**1**:5-10, **2**:10-15, **3**:15-20, **4**:20-25, **5**:25-30, **6:30-35**, **7**:35-40, **8**:40-45, **9**:45-50)

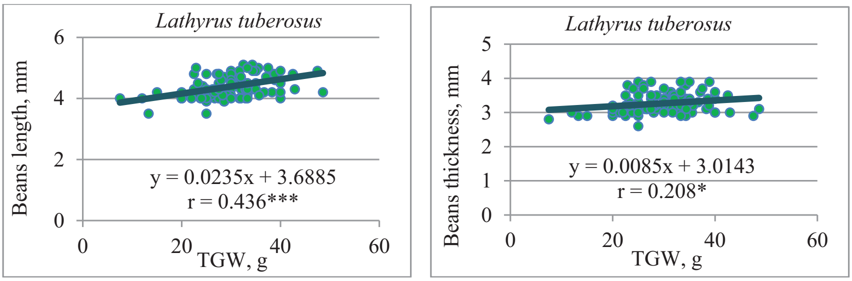


Figure 10. Correlations between TGW and beans dimensions: length and thickness

Other aspects of variability in *L. tuberosus* fruit and grains. To better characterize the analyzed parameters were calculated a series of statistical indices- table 1 and 2.

From the average of the racemous fruits shows that had a length of 13 cm, number of pods in fruit was 3, pods of racemous weight was 0.3 g, pod length was about 3 cm, with a thickness of 4.5 mm. The number of grains of fruit was 6.5, and the weight thereof was 0.20 g. The beans were the average of the pod 2, a length of 4.4 mm, a thickness of 3.3 mm and TGW of about 30 g.

CONCLUSIONS

A common species which is lately spread is *L. tuberosus*. Variability study aimed reproductive parts: fruits and beans of species. Characters findings revealed weed ecotype adapted white luvicsoil of station (Table 3).

Table 1. Statistic indices of *Lathyrus tuberosus*: a-fruits

Indices	Multiple racemous fruits						
	Racemous fruit length, cm	Pods number/ fruit	Pods weight/ fruit, g	Pods length, cm	Pods width, mm	Beans number/ fruit	Beans weight/ fruit, g
Average, ā	13.23	3.24	0.31	2.86	4.49	6.48	0.20
Variance, s^2	2.5280	1.3560	0.0215	0.0702	0.1356	7.0602	0.0112
Standard deviation, s	1.5900	1.1645	0.1467	0.2650	0.3682	2.6571	0.1056
Coef. of variation, s%	12.02	35.94	48.02	9.26	8.20	41.00	53.01

Table 2. Statistic indices of *Lathyrus tuberosus*: b- beans- grains

Indices	Beans, grains			
	No./ pod	Length, mm	Width, mm	TGW, g
Average, ā	2.07	4.39	3.27	29.90
Variance, s^2	0.3620	0.00014	0.0818	49.6288
Standard deviation, s	0.6017	0.0120	0.2861	7.0448
Coef. Of variation, s%	29.27	0.27	8.76	23.56

Table 3.The structure and distribution of analysis values from *Lathyrus tuberosus* fruits and grains

Racemous	The pods variability			The beans/ grains variability			
fruit length cm, %	No. per fruit, %	Length, cm %	Width mm %	No. per pod, %	No. per fruit, %	Length, mm %	Width, mm %
9-12 25%	1 2%	2.2-2.4 6%	3.5-3.7 4%	0.5-0.8 2%	3-4 25%	3.5-3.7 2%	2.8-2.9 10%
12-14 44%	**2 30%**	2.5-2.7 21%	3.8-4.0 7%	1.0-1.3 9%	**5-7 48%**	3.8-4.0 22%	**3.0-3.1 29%**
14-16 27%	**3 28%**	**2.8-3.0 51%**	4.1-4.3 23%	1.4-1.7 17%	8-10 19%	**4.1-4.3 31%**	**3.2-3.3 28%**
16-18 3%	4 26%	3.1-3.3 19%	**4.4-4.6 33%**	**1.8-2.1 34%**	11-13 5%	4.4-4.6 15%	3.4-3.5 17%
18-20 1%	5 10%	3.4-3.6 3%	4.7-4.9 25%	2.2-2.5 21%	14-16 2%	4.7-4.9 22%	3.6-3.7 9%
	6 4%		5.0-5.2 8%	2.6-2.9 7%	17-19 1%	5.0-5.2 8%	3.8-3.9 7%
				3.0-3.3 6%			
				3.4-3.7 3%			
				3.8-4.1 1%			

REFERENCES

Anghel G., Nyárády A., Păun M., Grigore S., 1975. Botanică. Ed. Didactică şi pedagogică, Bucureşti, p. 307-308.

Bărbulescu C., 1988. Mică enciclopedie agricolă. Ed. Ştiinţifică şi Enciclopedică, Bucureşti, p. 307-308.

Bianco V.V., 2001. Piante spontanee della flora Albanese utilizzabili come ortaggi e piante da condiment. Allestimento Tecnomack- Bari, Italy, p. 53-79.

Chirilă C., 2001. Biologia buruienilor. Organografie, corologie, dinamică, importanţă. Ed. Ceres, Bucureşti, p. 52-54, 119-129.

Prodan I., Buia A., 1958. Flora mica ilustrată a R.P.R. Ed. Agro- Silvică de Stat, Bucureşti, p. 304-306.

Krähmer H., 2014. EWRS Newsletter no. 125, p. 11-14.

Săvulescu T., Grinţescu I., Guşuleac M., Morariu I., Nyárády A., Nyárády E.I., Todor I., Ţopa E., 1957. Flora R.P.R. Ed. Academiei R.P.R., p. 405-445.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PROTEIN, STARCH, AMINO AND FATTY ACIDS CONTENT IN CORN HYBRIDS DEVELOPED AT NARDI FUNDULEA IN NATURAL CLIMATIC CONDITIONS

Lucian Horia IORDAN, Teodor MARTURA, Eliana ALIONTE, Cătălin LAZAR

National Agriculture Research and Development Institute Fundulea, Călăraşi county, Nicolae Titulescu street, nr 1, Romania

Corresponding author email: iordanhoria@gmail.com

Abstract

Corn is one of the most important crops in Romanian agriculture. Cultivated area varies little from year to year, ranging between 2.7 to 3.0 million hectares. Corn has the greatest production potential and also the widest range of uses of all the grain crops. The NARDI-Fundulea's program for improving protein quality in corn hybrids was initiated in 1967 when first source of genes responsible for the synthesis of lysine and tryptophan amino acids were introduced, namely, opaque two (o2) and floury-2 (fl 2). Currently, at NARDI, there is an intensive breeding program aiming the create valuable hybrids for both productive potential and quality traits through the use of valuable genetic resources (genes) for high protein content, improving local populations, and inducing endosperm modifier genes in opaque hybrids. The analysis for essential amino acids, protein content and protein quality, made between 2011 and 2013, has shown that the average protein content was 9.77% with a maximum of 10.6% in Olimpius corn hybrid. The average amino acid content was 7.53%, with a maximum of 8.41% in F 165/11 hybrid. The average content of essential amino acids was 2.71%; average lysine content 0.26%.Next to high content of protein and essential amino acids NARDI's corn hybrids are rich in fatty acids. Average fat content in top hybrids was 4.53%. F 376 and Mostiştea corn hybrids had the highest fatty acids content compared to the average (F 376 (5.00%) and 4.93% Mostiştea).

Key words: *hybrid corn quality, protein content, starch, fatty-acids, essential amino acids.*

INTRODUCTION

Maize (*Zea mays* L.) is the crop with highest production at world level and it occupies the third place (after wheat and rice) in the top of cultivated surfaces. The surface cultivated with maize is increasing yearly due to multiple uses of this crop: as food for humans and animals, pharmaceutical industry, composite materials but especially due to increasing demand as bio-fuel. Maize is considered as one of the most important energetic crops because it is able to accumulate high quantities of carbohydrates.

According to FAO data, 20-22% of the world maize production is used for human nutrition and 70-72% is consumed as forage due to the high coefficient of dry matter conversion of maize into milk meat and eggs.

Corn had a high percentage of essential amino acids, especially threonine, valine and phenylalanine but it is poor in lysine and tryptophan. This problem was partially solved by the discovery and use for improvement of protein quality of the opaque-2 and floury-2 genes (Mertz et al., 1964; Salamini et al., 1983). These genes are modifying the zein ratio from endosperm in favor of lysine and tryptophan.

At NARDI-Fundulea, the maize breeding program was focused on two main objectives: rising of yield potential and improvement of grain quality. At the beginning the autochthon genetic material (local populations and

Romanian corn varieties with good grain quality) was used, but, during 1970-1980 period foreign genetic sources were used especially for opaque-2 and floury-2 genes.
The aim of our current researches includes creation of productive hybrids, with high protein and amino and fatty acids content based on identification of new sources for genes implied in synthesis of these compounds.

MATERIALS AND METHODS

In order to release valuable hybrids to farmers, in terms of quality, we test in the maize breeding field of NARDI-Fundulea about 150 to 200 new hybrid combinations every year. During 2011 to 2013 more than 400 hybrids and 100 inbred lines and local populations were analyzed.
All analyzed samples were from NARDI's corn breeding field and from contest and orientation comparative maize cultures in which no irrigation and open pollination conditions were applied. We note that the years 2011 and 2013 were normal in terms of climatic conditions and were very favorable for maize culture. The agricultural year 2012, was very dry during the critical silking and kernel forming phase that occurred in July; that month that was practically rainfall free (2 mm) during which, drought and heat affected the kernel development with negative impact on the crop amount but grain's quality index wasn't badly affected. Before sowing time, around 80-90 kg (active substance) of nitrogen and ammonium nitrate fertilizer was applied for maize; phosphorus was applied to wheat (previous crop).
The analysis for the protein, fatty acids and starch content was performed at NARDI's Laboratory for Grain Quality. The analysis for amino acids content was performed at NIBAN-Baloteşti (National Institute for Biology and Animal Nutrition), at the Chemical Analysis and Nutritional Physiology Laboratory.
The equipment used was a Surveyor Plus HPLC system, Thermo Electron, equipped with PDA detector.

RESULTS AND DISCUSSIONS

Enhancing of the content and quality of protein was a priority objective.
Increasing of protein content and quality has been a priority in maize breeding program at NARDI-Fundulea. Initially were used local populations, especially local populations from Moldova with a protein content of between 10.8 to 14.6% (Gologan et al., 1966). After the discovery of the favourable effects of the gene opaque-2 (02) by Mertz et al in 1964, the breeding activity was focused on this direction.
Increased protein content and quality led to a decline in production due to a negative correlation yield/ quality. According to Alexander (1988) breeding activity has made a significant progress in simultaneous improvement of both traits (high yields with up to 12% protein content).
The hybrids analyzed during the years 2011-2013 are all authorized hybrids some of them consecrated by farmers use other just officially recorded.
The three years average of protein content for all the 15 tested hybrids was 9.77%, this average was higher in 2011 when it exceeded 10.2% (Table 1). The hybrids Olimpius, F322 and Milcov exceeded significantly the experimental average with more than 7.5%.
The lowest protein content among the test hybrids was recorded for F 475 M with an average of 9.13%. The grains of this hybrid presented the highest content in starch.
Since 1967, at NARDI-Fundulea were introduced the first sources for opaque-2 mutant genes from USA, Italy and France in order to improve the quality of corn protein.
The first hybrids with opaque gene had a farinaceous endosperm and they were more susceptible to pathogens and attacks of insect pests. It was necessary a selection for

endosperm texture modifying genes (Cosmin et al., 1974; Neguț et al., 1982). Only breeding for hard endosperm and high lysine / protein ratio can lead to competitive hybrids both quantitatively and qualitatively.

Table 1. Protein content (%) of some corn hybrids created in NARDI-Fundulea
Fundulea 2011-2013, rainfed

No. CRT.	HYBRID	PROTEIN %			X	%	DIFF.	SIGNIF.
		2011	2012	2013				
1	Olimpius	11.3	10.4	10.1	10.60	108.5	0.83	**
2	F 322	11.1	10.2	10.3	10.53	107.8	0.76	**
3	Milcov	10.5	11.3	9.7	10.50	107.5	0.73	**
4	F 540	11.0	10.3	9.8	10.36	106.0	0.59	*
5	Paltin	10.7	9.1	9.9	9.90	101.3	0.13	
6	Crişana	9.5	9.6	10.5	9.87	101.0	0.10	
7	F 376	10.7	9.4	9.2	9.77	100.0	0.00	
8	Rapsodia	10.3	9.8	9.0	9.70	99.3	-0.07	
9	Mostistea	10.4	9.1	8.9	9.47	96.9	-0.30	
10	Iezer	10.3	9.1	8.9	9.43	96.5	-0.34	
11	Generos	9.1	9.9	9.3	9.43	96.5	-0.34	
12	Campion	9.4	9.3	9.5	9.40	96.2	-0.37	
13	Neptun	9.6	9.3	9.1	9.32	95.5	-0.44	
14	Olt	9.7	9.0	9.1	9.27	94.9	-0.50	
15	F 475 M	9.6	9.0	8.8	9.13	93.4	-0.64	0
	Exp. mean	**10.2**	**9.6**	**9.5**	**9.77**	**100.0**	**0.00**	
	LSD 5 % 1% 0.1 %						0.53 0.70 0.92	

A new stage of improving quality protein in maize kernels is represented by the discovery of the gene dzs10 (Zarkadas, 1997; Olsen et al., 2003). The gene dzs10 induce a high methionine content. The maize kernels rich in essential amino acids are more efficient in human food and animal feed.

Worldwide, the most developed program for improvement of quality protein in maize was conducted at CIMMYT. For countries of South America and Africa, where maize is used as staple food, specialists of CIMMYT promoted maize hybrids with the endosperm modifying genes and also rich in essential amino acids.

Up to now, were isolated about 500 naturally occurring amino acids. After biochemical and physiological importance they have in human body there are essential amino acids: threonine (Thr), valine (Val), phenylalanine (Phe), isoleucine (Ile), leucine (Leu), lysine (Lys), methionine (Met); semi- essentials amino acids: serine, arginine, cystine, tyrosine; and non-essential amino acids:, aspartic acid, glutamic acid, glycine and alanine.

Essential amino acids are produced only in plants, animals being forced to extract them from food. Threonine is an amino acid indispensable for normal growth process and metabolism of proteins; phenylalanine is required for the memory process and normal intellectual activity; izoleucine is required for synthesis of haemoglobin. Lysine contributes to the development of tissues and synthesis of vital substances as: antibodies, hormones, enzymes; tryptophan prevents pellagra, it is indispensable for a normal intellectual activity and it contributes in decreasing of the intensity of the depressive states. Methionine decreases the amount of blood cholesterol, protects the kidneys, it is natural chelating agent for heavy metals.

The protein and essential amino acids contents (according to the analysis performed at NIBAN-Baloteşti) of some new hybrids released at NARDI-Fundulea is presented in Table 2.

The mean protein content was 9.8 with a maximum of 10.8% for hybrid F 150/11. The average percentage of total amino acids content was 7.53 %, with a maximum of 8.41% for the hybrid F165/11. The average percentage of essential amino acids content was 2.71%, with a maxim for hybrid F 39/11 (3.04%).

The average lysine percentage was 0.26%, with a minimum of 0.22% recorded for hybrid F 100/11 and maximum of 0.29% for hybrid F 13616 A/08 (Table 2).

The natural variability of oil content in maize is 3.5-6.0% (Alexander, 1988 b). Most of the oil is contained in the embryos. An efficient method for rising the oil content is the selection of hybrids with larger embryos. A genotype is considered rich in oil if the oil percentage is above 6%.

The quality of the maize oil is very good and it contains: 0.8 to 12.7% palmitic acid; 1.3 to 4.3% of stearic acid; 20.0 to 24.4% oleic acid and linolenic acid 51-60%, it is rich in vitamin A and E, and it is cholesterol free.

Table 2. Essential amino acids and protein contents (in %) to some new hybrids released at NARDI-Fundulea. Fundulea 2013, rainfed

Hibryd	**Protein**	**Total amino acids**	**Sum of essential amino acids**	**Including**						
				Thr	**Val**	**Phe**	**Isl**	**Leu**	**Lys**	**Met**
	%	%	%	%	%	%	%	%	%	%
F 133-08	8.8	7.48	2.72	0.35	0.36	0.35	0.23	1.06	0.23	0.14
F 100-11	8.3	6.91	2.52	0.32	0.33	0.32	0.21	0.98	0.22	0.14
F 13616 A/08	10.3	8.26	2.95	0.47	0.39	0.39	0.26	1.00	0.29	0.15
F 39-11	10.4	8.23	3.04	0.46	0.38	0.38	0.25	1.14	0.28	0.16
F 67-11	10.3	7.24	2.62	0.48	0.31	0.31	0.24	0.81	0.27	0.15
F 150-11	10.8	7.97	2.88	0.48	0.34	0.34	0.29	0.89	0.28	0.15
F 165-11	10.4	8.41	3.13	0.51	0.35	0.35	0.24	1.24	0.25	0.17
F 238-11	9.7	6.97	2.47	0.42	0.30	0.30	0.21	0.84	0.23	0.14
F 31-11	9.7	6.95	2.43	0.40.	0.31	0.31	0.21	0.78	0.27	0.14
F 474-11	9.3	6.83	2.39	0.38	0.29	0.33	0.21	0.80	0.24	0.14
Mean	***9.8***	***7.53***	***2.71***	***0.43***	***0.36***	***0.36***	***0.24***	***0.96***	***0.26***	***0.15***

In Romania, the food industry cover the demand for maize oil from the embryos resulted from the de-germination process of maize kernels used for producing maize flour meal, flaked maize and starchy products.

Although NARDI-Fundulea hasn't a special maize breeding program to improve oil content, the corn hybrids registered of our institute have a high oil content (4.53% on average) (Table 3). Hybrids F 376 (5%) and Mostiştea (4.93%)

significantly exceeded the average of the studied hybrids.

Starch is the most important component of maize endosperm. The starch content of the endosperm can be up to 80-90%.

Worldwide, more than 75% of the starch is extracted from corn, in USA is percentage rise up to 95% (Wurzberg, 1986). High starch content of corn grain made possible the development of a specific industry around it. Development of starch industry has led to specialization in maize breeding: for starch with high amylose content it is used the mutant *ae* (White, 1994) and for amylopectin-rich starch it is used the mutant *wx* (Fergason, 1994).

Table 3. Oil content (%) for some registred maize hybrids created at NARDI –Fundulea

Fundulea 2011-2013, rainfed

HIBRYD	OIL (%)			MEAN	% from general mean	Diff.	Signifficance
	2011	2012	2013				
F 376	5.5	4.6	4.9	5.00	110.4	0.50	**
Mostiştea	5.2	4.7	4.9	4.93	108.8	0.40	*
Campion	5.3	4.5	4.7	4.83	106.7	0.30	
Iezer	4.6	4.5	5.0	4.70	103.8	0.17	
Crişana	4.8	4.4	4.9	4.70	103.8	0.17	
Paltin	4.7	4.6	4.4	4.57	100.9	0.04	
F 540	4.4	4.6	4.7	4.57	100.9	0.04	
Milcov	4.5	4.6	4.6	4.57	100.9	0.04	
Olt	4.4	4.3	4.6	4.43	97.8	-0.10	
Rapsodia	4.4	4.2	4.7	4.43	97.8	-0.10	
Olimpius	4.2	4.4	4.6	4.40	97.1	-0.13	
F 322	4.2	4.2	4.4	4.27	94.5	-0.26	
F 475 M	4.4	3.8	4.5	4.23	93.3	-0.30	
Generos	4.1	3.9	4.3	4.10	90.5	-0.43	0
Neptun	3.9	4.1	4.3	4.10	90.5	-0.43	0
Media	***4.6***	***4.4***	***4.6***	***4.53***	***100.0***	***0***	
DL 5% DL 1% DL 0.1%						0.35 0.46 0.61	

The corn hybrids rich in amylose have a specific market because of high amylose starch demand from textile industry and fabrication of waterproof cellophane films required by the packaging industry.

Rich corn amylopectin was discovered in a population of corn in China, the endosperm of this population is dull with a waxy aspect - called for this reason *waxy*. Corn rich in amylopectin is used in dairies and cheese, paper and textile industries.

In Romania, there are particular concern for improving the quality of starch at ARDS Turda (Haş et al., 2004).

The *amylacea* variety is used as a genetic source for raising the starch content in maize hybrids.

The hybrids created and tested at NARDI Fundulea in 2011-2013 had an average of starch content of 71.33% (Table 4). A higher percentage of starch 72.2% was recorded in 2012, a very dry year, which shows that under water and heat stress, the starch anabolism is less affected than anabolism of proteins and fats.

Although there are no statistically significant differences among hybrids in terms of starch content, however, one may remark hybrids F 475 M (72, 63%) and Generos (72.1%).

Table 4. Starch content (%) for some corn hybrids released at NARDI -Fundulea

Fundulea 2011-2013, rainfed

HYBRID	STARCH (%)			MEAN	%	Diff.	Significance
	2011	2012	2013				
F 475 M	72.1	73.5	72.3	72.63	103.3	1.30	
Generos	72.1	72.9	71.3	72.10	101.1	0.87	
Rapsodia	71.9	72.3	70.8	71.66	100.5	0.33	
Olt	71.1	72.1	71.5	71.56	100.3	0.23	
Iezer	71.4	72.5	70.7	71.53	100.3	0.20	
F 376	71.1	72.0	71.0	71.36	100.0	0.00	
Crişana	70.6	72.8	70.5	71.33	100.0	0.00	
F 322	70.4	72.4	71.0	71.33	100.0	0.00	
Mostistea	70.0	72.8	70.9	71.23	99.8	-0.10	
Olimpius	70.2	71.8	71.2	71.10	99.7	-0.23	
Paltin	70.0	71.2	71.7	71.00	99.5	-0.33	
F 540	70.5	71.8	70.8	71.00	99.5	-0.33	
Campion	70.6	72.0	69.9	70.83	99.3	-0.50	
Neptun	69.1	72.5	70.6	70.70	99.2	-0.63	
Milcov	70.9	70.4	70.6	70.60	98.9	-0.73	
Mean	***70.8***	***72.2***	***71.0***	***71.33***	***100.0***	***0.00***	
DL 5 %						1.33	
DL 1 %						1.79	
DL 0.1 %						2.35	

CONCLUSIONS

The average protein content of studied maize hybrids was 9.77% with values varying from 9.13 and 10.6%.

The average total amino acids percentage was 7.53% and that of essential amino acids was 2.71%.

The average oil content was 4.53%, with values varying from 4.10 to 5.00%

The average starch content was 71.33%.

REFERENCES

Alexander D.E., 1988 a. Breeding special nutritional and industrial types. In G.F., Sprague and J.W. Dudley (ed.). Corn and corn improvement 3 rd ed., Agronomy, 18: 369-88.

Alexander D.E., 1988 b. High oil corn: breeding and nutritional properties. Proc. 43rd Annu., Corn Sorgum Res. Conf: 97-105.

Cosmin O., Neguț C., Sarca Tr., Cãbulea I., Voicu Ecaterina, 1974. Ameliorarea conținutului şi calității proteinelor la porumb. Probleme de genetică teoretică şi aplicată, VI (5): 410-450.

Gologan I., Angela Moşneagã, Achirei T., 1966. Compoziția chimică a populatiilor de porumb din Moldova. An. ICCPT Fundulea, XXXII C: 341-351.

Haş I., Haş Vochița, Cãbulea I., Grecu C., Copândeanu Ana, Calbarean Carmen, Legman V., Rotari A., 2004. Ameliorarea porumbului pentru utilizări speciale. Probleme de genetică teoretică şi aplicată XXXVI (1-2): 45-75.

Fergason V., 1994. High amylase and waxy corns. In: A.R. Hallauer (ed), Specialty Corns: 56-77. CRC Press Boca, Boca Raton, FL.

Mertz E.T., Bates L.S., Nelson O.E., 1964. Mutant gene that changes protein composition and increases lysine content of maize endosperm protein. Science: 145, 279.

Neguț C., Cosmin O., Sarca Tr., Bica N., Ulinici Victoria, Reştea Th., Craiciu D., 1982. Rezultate obținute în ameliorarea calității proteinelor la porumb. An. ICCPT-Fundulea, XLIX: 53-62.

Olsen M.S., Krone T.L., Phillips R.L., 2003. BSSS 53 as a donor source for increased whole kernel methionine in maize. Selection and evaluation of high – methionine inbreds and hybrids. Crop Science, 43 (5): 1632-1634.

Salamini F., Dfonzo N., Fornasari E., Gentinetta E., Reggiani R., Soaye C., 1983. Mucronate, Mc, a dominant gene of maize which interacts with opaque-2 to suppress zein synthesis. Theor. Appl.Genet., 65:123.

Zarkadas C.G., 1997. Assessment of the protein quality of native white floury maize, desigred IAPO-13, by amino acid analysis. J.Agric. Food Chem; 45: 1062-1069.

Wurzberg O.B., 1986. Introduction, in Modified Starches Proprieties and Uses. Wurzberg, O.B., Edit. CRC Press Boca, Boca Raton, FL: 4.

White P.J., 1994. Properties of corn starch. In: A.R.Hallauer (ed): Specialty Corns: 30-54. CRC Press Boca. Boca Raton, FL.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

BEHAVIOUR OF NEW WINTER GRAIN VARIETIES IN SOUTH DOBROGEA

Vasile JINGA[1], Carmen LUPU[1], Anamaria GIUMBA[2], D. MANOLE[2]

[1]Research-Development Institute for Plant Protection, 8 Ion Ionescu de la Brad Blvd, District 1, 013813, Bucharest, Romania
[2]S.C. SPORT AGRA S.R.L. Amzacea, 10 Mare Street, Constanta District, Romania

Corresponding author email: vasilejinga23@gmail.com

Abstract

The paper aimed to present the main pathogens of wheat, barley and two-rowed barley crops and the yields obtained in 2014 at S.C. SPORT AGRA SRL Amzacea, Constanta district on demonstrative plots. Climatic conditions of autumn 2013 and spring 2014 provided a favorable development of small grains studied. Protection against foliar diseases of the three cereal crops was done using three treatments with Bumper 250 EC, Artea 330 EC and Prosaro 250 EC fungicides, no attack of powdery mildew (*Blumeria graminis*) was registered. *The attack of Rhyncosporium secalis and Pyrenophora tritici-repentis in barley and two-rowed barley presented a low level, except the Casanova barley variety (10.8%). On wheat, the pathogens Septoria tritici and Pyrenophora tritici-repentis had low attack levels, except the cultivars Akratos, Renan, Jinda, Epos and Evina with higher attack. The pathogen Puccinia striiformis had the lowest values of attack, except the variety Andelka (5%). Concerning the* correlation between the yields and the pathogens incidence and severity*, the lowest yields in wheat crop were obtained with Arkeos (4250 kg/ha) and Renan varieties (4300 kg/ha). The highest yields were obtained with Ingenio (7600 kg/ha) and Katarina varieties (7930 kg/ha). For barley crop, the lowest yield was 5858 kg/ha for Gerlach and Casanova varieties and the best yields were 7500 kg/ha for Kendy variety and 8000 kg/ha for Laverda variety. To the two-rowed barley crops, the yields were between 5600 kg/ha for Trasco variety and 6200 kg/ha for Metaxa variety. Quality indices of wheat grains were between 72 and 78.7% hectoliter mass.*

Key words: *behaviour, winter grain, phytosanitary status, production, Dobrogea.*

INTRODUCTION

Romanian varieties of winter wheat occupies a percentage of more than 70% of the cultivated area (Muntean et al., 2003).

In the last 10 years, various cereal varieties created by foreign companies have been cultivated without being deeply known their behavior in the climatic conditions of Dobrogea.

Our research aims to analyze the behavior of 17 varieties of wheat, 8 varieties of barley and 3 varieties of two-rowed barley, in climatic conditions from Amzacea area in agricultural year 2013-2014, atypical in terms of rainfall. The efficiency of integrated control is directly dependent on the biology of the pest, parasite-host plant relationship, being influenced by climatic conditions that characterize a particular crop area or a certain stage of the plant vegetative cycle (Jinga et al., 2013).

MATERIALS AND METHODS

Experience has been placed on S.C. SPORT AGRA S.R.L. Amzacea, Constanta. The studied crops were winter crops: barley, two-rowed barley and wheat. The experience was situated on a land belonging to the South Dobrogea plateau, represented by cambic chernoziom with a profile deeper than other chernozioms, a blackish-brown soil of 40-50 cm thickness, medium texture (Demeter, 2009). The content of nutrients was: mobile P index - 72; N index - 4; Humus - 3.11; K index - 200; Neutral pH - 7.2. The climate is deeply temperate continental, with an average annual temperature of 10.7-11.7°C, with a high temperature in the period 20th June to 15th August. Meteorological data are presented in Table 1. Sowing was carried out on 16th October 2013. Treatment of seeds was carried out with thiamethoxam + fludioxinil + difenoconazole in dose of 1.5 l/t.

Due to the climatic conditions of the year 2014, for the prevention and control of foliar and ear diseases, 3 treatments were performed: Treatment I *Bumper 250 EC* prochloraz 45%), 1 l/ha; Treatment II *Artea 330 EC* - (cyproconazole 80 g/l + propiconazole 250 g/l) 0.4 l / ha; Treatment III - Prosaro 250 EC - (tebuconazole 125 g/l + prothioconazole 125 g/l) 0.75 l / ha. Lambda-cyhalothrin 50 g/l, at a dose of 0.15 l/ha were used for specific pest control. Observations and collections of biological samples were made on April 2014 in terms of knowledge of technological elements such as: prior crop, basic fertilization, sowing date, amount of seed, emergence date, plant density (Table 2).

The attack rate was calculated with the formulas RA%= F*I/100, F%-frequency of the attacked organs, I – intensity of the organ' attack.

Table 1. Meteorological data 2013-2014

Month	Temp monthly average ºC	Temp min ºC	Temp max ºC	Rainfall mm	Humidity %
Sept	18.6	14.5	22.7	2.1	60.1
Oct	13.2	9.9	16.4	3.0	77.9
Nov	11.2	8.7	13.6	1.5	84.4
Dec	2.9	-0.1	5.9	0.4	85.4
Jan	3.9	1.2	6.6	113.0	88.4
Feb	4.6	2.0	7.2	2.0	83.8
Mar	8.8	5.6	12.0	40.5	64.6
Apr	12.0	8.9	15.1	42.0	74.2
May	16.8	12.8	20.8	61.5	72.1
June	21.0	17.0	25.0	22.8	72.9
July	23.5	26.0	21.0	30.0	75.0

Production quality indexes were determinated in order to corelate the obtained production with crop quality (humidity and M Hl).

RESULTS AND DISCUSSIONS

Results on phytosanitary status of winter crops are presented in Tables 2 and 3. Due to heavy rains in the entire vegetation period, the attack of pathogens that cause diseases was very aggressive, requiring the 3 pesticides treatments. It can be seen that all three treatments reduced the intensity of the attack. *Rhyncosporium secalis* and *Pyrenophora teres on* to two-rowed barley and barley presented a RA (attack rate) low (2-3%), except the variety Casanova (10.8%). In wheat, the pathogens *Septoria* tritici and *Pyrenophora graminis* showed attacks low (2-3%), except varieties Akrata (5%) Jinda (5%), Epos (7%) and Ewina (4.5%), with greater attack. *Puccinia striiformis* presented low levels of attack (1.5-2.5%), except the variety Andelka (5%). Data on yields obtained in experimental plots are shown in Table 3. In autumn two-rowed barley crops were obtained yields of 5600-6200 kg/ha. In barley crops, productions were between 5858 - 8000 kg/ha. The wheat productions ranged from 4250 to 7930 kg/ha. In terms of production quality indexes in most wheat crops were over 76.6 kg hectoliter mass.

Figure 1. Winter grain crops - observations in field

CONCLUSIONS

To prevent and control the pathogens that cause diseases in autumn cereal crops were necessary, in climatic conditions of the 2014 year, 3 treatments with fungicides. This has led to the absence of *Blumeria graminis* attack. Attack of *Rhyncosporium secalis* and *Pyrenophora* teres on to two-rowed barley and barley showed a low degree of attack. In wheat, pathogens *Septoria tritici* and *Pyrenophora* graminis showed reduced attack degrees, as the pathogen *Puccinia striiformis*. The yields obtained in conditions of 2014 ranged between 5600-6200 kg/ha for two-rowed barley, between 5858-8000 kg/ha for barley and between 4250 to 7930 kg/ha for wheat. For all analyzed varieties, hectoliter weight was influenced by rainfall, showing values above 76.6 kg/hl.

ACKNOWLEDGEMENTS

This research work was carried out with the support of Ministry of Agriculture and Rural Development, by SECTORIAL ADER 2020, Contract no. 512/2011 "Integrated protection of crops in rotation crops from agroforestry farms, farms that include grassland with high ecological value and Natura 2000 areas".

Table 2. Winter cereals phytosanitary status

Variety	*Rhincosporium secalis*			*Pyrenophora teres*			*Pyrenophora graminis*		
	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)
TWO-ROWED AUTUMN BARLEY									
Trasco	50	3	1.5	60	3	1.8	-	-	-
Metaxa	30	2	0.6	70	3	2.1	-	-	-
Malwinta	80	4	3.2	40	3	1.2	90	3	2.7
BARLEY									
Cristelle	70	3	2.1	60	4	2.4	60	7	4.2
Wendy	50	3	1.5	40	5	2.0	-	-	-
Antonella	30	2	0.6	50	3	1.5	-	-	-
Laverda	60	4	2.4	40	4	1.6	-	-	-
Scarpia	70	3	2.1	60	4	2.4	80	3	2.4
Henriette	60	8	4.8	-	-	-	70	6	4.2
Gerlach	80	2	1.6	-	-	-	70	8	5.6
Casanova	90	12	10.8	80	7	5.6	70	14	9.8
WHEAT									
Variety	*Septoria* tritici.			*Pyrenophora graminis*			*Puccinia striiformis*		
	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)	F (%)	I (%)	RA (%)
Katarina	30	7	2.1	50	3	1.5	-	-	-
Ilinca	70	4	2.8	50	5	2.5	60	5	3.0
Andelka	50	5	2.5	60	5	3.0	50	10	5.0
Renata	20	5	1.0	30	5	1.5	-	-	-
Genius	60	3	1.8	50	7	3.5	40	5	2.0
Joker	30	5	1.5	40	5	2.0	-	-	-
Florian	30	2	0.6	20	5	1.0	30	8	2.4
Akratos	40	10	4.0	25	10	2.5	30	5	1.5
Hystar	30	3	0.9	20	5	1.0	-	-	-
Apache	50	3	1.5	60	8	4.8	-	-	-
Renan	60	8	4.8	70	10	7.0	-	-	-
Altigo	50	2	1.0	60	3	1.8	-	-	-
Jindra	50	10	5.0	40	5	2.0	-	-	-
Epos	70	10	7.0	80	3	2.4	-	-	-
Einstein	60	5	3.0	70	10	7.0	-	-	-
Ewina	50	9	4.5	70	8	5.6	-	-	-
Arkeos	50	3	1.5	60	10	6.0	50	5	2.5
Ingenio	50	8	4.0	60	9	5.4	-	-	-
Illico	70	5	3.5	60	7	4.2	-	-	-

Table 3. Technological sheet for winter crops

Variety	Seed norm (kg /ha)	Date of sowing	Emergence date	Number of plants in the emergence	Number of plants in the spring	Yield (kg / ha)	Quality index	
							U %	M Hl (kg/hl)
	TWO-ROWED AUTUMN BARLEY							
Trasco	160	16-Oct	28-29 oct	408	1320	5600		
Metaxa	160	16-Oct	28-29 oct	320	1188	6200		
Malwinta	160	16-Oct	28-29 oct	280	1104	5900		
	BARLEY							
Cristelle	160	16-Oct	28-29 oct	268	960	7200		
Wendy	160	16-Oct	28-29 oct	400	1120	7500		
Antonella	160	16-Oct	28-29 oct	280	1000	6700		
Laverda	160	16-Oct	28-29 oct	280	1080	8000		
Scarpia	160	16-Oct	28-29 oct	268	1312	6270		
Henriette	160	16-Oct	28-29 oct	292	1120	7219		
Gerlach	160	16-Oct	28-29 oct	308	1240	5858		
Casanova	160	16-Oct	28-29 oct	332	1184	5858		
	WHEAT							
Katarina	200	16-Oct	28-29 oct	520	928	7930	13	78
Ilinca	200	16-Oct	28-29 oct	422	828	7100	14.1	78
Genius	200	16-Oct	28-29 oct	504	1160	6313	13.8	78.5
Joker	200	16-Oct	28-29 oct	620	788	7000	14.2	78.7
Florian	200	16-Oct	28-29 oct	412	868	6600	13	77.7
Akratos	200	16-Oct	28-29 oct	448	812	4700	13.2	77.2
Hystar	80	16-Oct	28-29 oct	168	692	7100	13.2	73.6
Apache	180	16-Oct	28-29 oct	552	1172	5100	12.4	74.6
Renan	180	16-Oct	28-29 oct	460	1112	4300	13.4	76.6
Altigo	180	16-Oct	28-29 oct	320	1192	7200	13.4	74
Jindra	180	16-Oct	28-29 oct	480	800	5900	12.7	76.8
Epos	180	16-Oct	28-29 oct	560	852	4600	13	75.2
Einstein	180	16-Oct	28-29 oct	460	1132	5600	13.6	74.3
Evena	180	16-Oct	28-29 oct	480	816	5000	14.1	77.6
Arkeos	180	16-Oct	28-29 oct	540	732	4250	13.8	70.9
Ingenio	180	16-Oct	28-29 oct	400	828	7600	12.9	72.5
Illico	180	16-Oct	28-29 oct	520	660	7500	14.1	76.2

REFERENCES

Demeter T., 2009. Pedologie generala, Ed. Credis, Buc.

Jinga V., Iliescu H., Stefan S., Sandru L., Andrei A.M., Lixandru M., Lazureanu C., 2010. Pathogens in early stages of winter barley crops - prevention and control. rdipp.ro vol .2.

Jinga V., Manole T., Gradila M, Dudoiu R., Giumba A.M., Manole D., 2014. Starea fitosanitara a cerealelor de toamna in Dobrogea. Rom J. lant Protection, http://www.rjpp.ro/index.php/archive/2014, on line.

Muntean L.S., Roman Gh., Borcean I., Axinte M., 2003. Fitotehnie, Ed. I. I. de la Brad.

Sorhenț C., Borcean I., 2009. Research concerning the behaviour of some winter wheat cultivars with differentiated fertilisation in the flooding valley of the Mureș river. Research Journal of Agricultural Science, 41.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF EXTRA POTASSIUM SUPPLY ON CORN YIELD AND SEED QUALITY UNDER DEFICIT IRRIGATION CONDITIONS

Yakup Onur KOCA[1], Mustafa Ali KAPTAN[2], Osman EREKUL[1], Ümit ALKAN[3]

[1]Adnan Menderes University, Faculty of Agriculture, Department of Crop Science, Aydın - 09100, Turkey
[2]Adnan Menderes University, Faculty of Agriculture, Soil Science Department, Aydın - 09100, Turkey
[3]Adnan Menderes University, Faculty of Agriculture, Bio system Engineer Department, Aydın - 09100 Turkey

Corresponding author email: koca2002@hotmail.com

Abstract

Deficit water treatment studies and some practices to reduce the effects of drought on plant can be made in Mediterranean region. Therefore the study was carried out at three different supplies as non-fertilization, standard fertilization [210 kg.ha^{-1} pure N, 60 kg.ha^{-1} pure P, 60 kg.ha^{-1} pure K (NH_4NO_3, P_2O_5 and K_2O – 60 kg.ha^{-1} with 15-15-15 composite before planting and H_2NCONH_2 – 150 kg.ha^{-1} with urea before first water)] and extra potassium (standard fertilization +60 kg.ha^{-1} K_2SO_4) and three irrigation doses (500 mm, 400 mm and 300 mm) during development stages [(8 leaf stage (V8), before Tasselling (VT), after blister, milk stage and dough stage)] in the Aegean region of Turkey during 2013 summer growth periods. The experiment was a randomized block design with three replications. 31G98, 31D24 and NK-Arma corn cultivars were used to material of the experiment. Seed yield and some yield components such as cob length, the number of seed per cob and 1000 seed weight were measured. Additionally some seed quality traits such as oil content, protein content, starch content, ASH and cellulose contents of corn seed were also measured in the study. The results of this study showed that extra potassium supply was effected on seed yield, the seed number in corncob and ash and cellulose contents of corn seed positively. However 1000 seed weight, corncob length, oil, protein, starch contents of corn seed didn't effect or negatively affect with extra potassium supply. It was revealed that seed yield, 1000 seed weight, oil and starch contents of corn seed were decreased with deficit water treatments (300 mm and 400 mm) according to standard water treatment (500 mm). In contrary that cob length, the number of seed per cob, protein, ASH and cellulose contents of corn seed values does not give similar responses (increasing or decreasing) with deficit water treatments. The highest seed yield was obtained from 31G98 corn cultivar in standard irrigation dose (500 mm) and extra potassium treatment because of having high thousand seed weight. As a result of the experiment, it was suggested that extra potassium treatment should increase yield and some properties of corn but only extra potassium isn't exactly effective against negative effects of drought.

Key words*: corn, seed yield, 1000 seed weight, protein rate, ASH rate, oil rate.*

INTRODUCTION

Human population is increasing by 1.65 percent every year. Thus food production must be increased with agricultural products (Rafat et al., 2012). Drought is one of the important stress factors for plant growth. Especially limited water sources are a prohibitive factor for improving crop production (Zhang, 2004).
Annual corn production is highly dependent on irrigation supplies on the world (Ebrahimi et al., 2011). Similarly irrigation water is becoming an increasingly limited resource in many areas of Mediterranean region (Edmeads et al., 1994). Corn is affected by water deficits especially during the seed filling period. Magnitude of the effect from water stress depends on occurrence time, intensity of the stress, growing phase and genotype (Nejad et al., 2010).
Various experiments carried out for water efficiency under deficit irrigation condition during crop growing cycle (Li et al., 1999; Deng et al., 2002; Zhang et al., 2004). Additionally all of them were shown that deficit irrigation during the seed filling period negatively affected quantity and quality of corn seed (Fabeiro et al., 2001; Kang et al., 2002; Zhang et al., 2006).
Water stress was effected at the pollination stage (pre-flowering stage) will induce embryo abortion, and thus a lower yield (Kramer and

Boyer, 1995). Water deficit pre and post flowering stage caused seed abortion and ultimately reduces the number of seed (Bänziger et al., 1999). The most effective of drought stress on seed weight was during seed filling because of causing small seed sizes (Wardlaw and Willenbrink, 2000; Mut and Akay, 2010).

There are some studies about different practices such as planting date, genotype selection, reduced tillage, and diversification of crop, organic matter and mineral application to reduce drought vulnerability (Carr, 2010; Knutson et al., 2011; Allen, 2012). Potassium application is the one of treatments for maximum yield against the effects of drought on plant. Because potassium plays a vital role in control of ionic balance and regulation of stomas for water use (Reddya et al., 2004; Rafat et al., 2012). Besides potassium is a primary regulator for osmotic potential while maintaining low water potential of crop. Therefore, accumulating K+ in their tissues may play an important role for crops under drought condition (Zare et al., 2014). The study were investigated to influence of standard and extra potassium fertilizer (60 $kg.ha^{-1}$ K_2SO_4) on seed yield and its components and seed quality parameters under deficit irrigation conditions.

MATERIALS AND METHODS

The research was carried out in Aydin with typical Mediterranean climate (hot summer and mild winter), located in west Turkey at 37º44 N 27º44 E at 65 m above sea level; and was conducted during 2013. Initial result of soil analysis is shown in Table1.

Table 1. Soil texture and chemical analysis

Soil texture[1] (%)			pH^2	Organic mater[3]
Sand	Silt	Clay		(%)
72.0	16.7	11.3	8.4	1.2

Method of; [1]Bouyoucos; [2]1:2.5 Saturasyon; [3]Walkley-Black

(Bouyoucos G.J. 1962; Ayers and Westcot 1989; Walkley and Black 1934)

The experimental soil in studied field contains with sandy loamy structure with alkaline characteristic and it mixed with quite low organic matters.

Monthly temperature, total rainfall and long-term (1975–2013) values in Aydin shown in Table 2. The temperature of 2013 was higher than long term means expect for June and July. Rainfall data analysed that May, July and August were showed lower value than long term means.

Table 2. Monthly temperature and total rainfall during corn growth period and long-term mean (1975-2013) in Aydin

Months	Temperature (°C)		Precipitation (mm)	
	2013	Long term	2013	Long term
April	16.1	15.7	42.6	45.5
May	23.2	20.9	1.0	33.5
June	25.3	25.9	18.4	14.0
July	27.9	28.4	2.4	3.5
August	27.8	27.2	0.0	2.2
September	22.6	23.2	22.8	14.4

Experimental design

The experiment was set up as split block experimental design with 3 replications. All parcels were sowed April 26, 2013 and the first seed emergence observation was conducted on May 13, 2013. Each plot area was 28 m^2 (5 m x 5.6 m) and consisted of 8 rows. Distance between rows was 70 cm and intra row spaces were 18 cm. NK-Arma, P31G98 and 31D24 cultivars were used as the crop material. All cultivars are hybrid (F1) and have single cross corn (*Zea mays* L.) cultivar. NK-Arma is produced by Syngenta Turkey Co. Ltd., and the others are produced by Pioneer Turkey Seed Distribution and Marketing Co. Ltd.

Treatment factors were created out with non-fertilizer, standard fertilizer and extra potassium application. There was not been any applications fertilizers form to non-fertilizer parcels. Standard fertilizer application from soil was applied as 210 $kg.ha^{-1}$ pure nitrogen (NH_4NO_3) (60 $kg.ha^{-1}$ with 15-15-15 composite was applied immediately at the beginning of cultivation – 150 $kg.ha^{-1}$ with urea (H_2NCONH_2) before first water), 60 $kg.ha^{-1}$ phosphor (P_2O_5) and 60 $kg.ha^{-1}$ potassium (K_2O). Extra potassium application was formed to by being added to 60 $kg.ha^{-1}$ K_2SO_4 onto the standard fertilizer application.

Soil from the field experiment [(0-30 cm, 30-60 cm and 60-90 cm depth (Rd)] was put into pots. The water content of the soil after being saturated by irrigation and allowed to drain is called field capacity (FC). Crop can no longer take up water from the soil is referred wilting point (WP). The water held by the soil between field capacity and the permanent wilting point is considered available water. Corn is capable of using 50% of the available water (AW). Irrigation water requirement (100 mm) was calculated with the following formulas (Martin and Gilley, 1993; Lamm et al., 1994).

AW = Rd (FC-WP)/100

Irrigation doses was formed as standard (5X100 mm) during 5 times (V8, before VT, after blister, milk stage and dough stage), as deficit irrigation (4X100 mm) during 4 times (V8, before VT, after blister and milk stage) and as more deficit irrigation (3X100) during 3 times V8, before VT and after blister) at corn growth period. All irrigation applied and time were given in Table 3.

Table 3. Irrigation times in corn growing season

Irrigation time	Irrigation rate per plot		
	300 mm	400 mm	500 mm
20th June 2013	**X**	**X**	**X**
04th July 2013	**X**	**X**	**X**
12th July 2013	**X**	**X**	**X**
25th July 2013	-	**X**	**X**
06th August 2013	-	-	**X**
10th September 2013	Harvest time		
X: Applied 100 mm water			

The traits studied in this research were determined in the following ways:

Seed number per ear: The number of seeds in 10 ears was counted after they had been shelled, and was divided by the number of ears.

1000 seed weight: Thousand seed weights was calculated by taking four different samples of 100 seeds from the seed yield per plot and by weighing and averaging these samples.

Seed yield: Ears from each plot were dried for about three months at room temperature, and then the seed was shelled and weighed. Consequently, the seed yield.ha^{-1} was calculated by multiplying the computed seed weight for each plot.

Protein, starch, oil, ASH and cellulose content: Corn seed was analyzed using NIRS-FT (Bruker MPA) (Gislum et al., 2004). The samples were first packed (90 g) as uniformly as possible in mini sample cups with a depth of approximately 2.8 cm and a diameter of 9 cm.

Statistical analysis

All the plant data collected from all treatments were statistically analysed using the TARIST package software (Açıkgöz et al., 1994) as a split plot design with three replications using analysis of variance to evaluate the effect of different fertilization doses (non-fertilization, standard fertilization and extra potassium) and deficit irrigation levels (500 mm, 400 mm, 300 mm) on the corn. Means among treatments were compared using Least Significant Difference (LSD) at $P \leq 0.05$ probability.

RESULTS AND DISCUSSIONS

The calculated mean squares with variance analyses for treatment factors (different fertilization) and water doses (deficit doses) and cultivar and their interactions are presented in terms of seed yield, yield component and seed quality parameters in Table 3.

Table 4. The calculated mean squares with variance analyses for all components measured of corn

Variance Source	SY	NSC	TSW	PRO	STA	OIL	ASH	CEL
Irrigation doses (A)	397963.7**	23985.1ns	20594.1*	5.7**	3.1ns	0.2ns	0.0ns	0.0ns
Fertilizer doses (B)	1418856.3**	134239.6**	2386.3ns	17.8**	20.5**	0.1ns	0.0*	0.0ns
Cultivar (C)	8457.3ns	47041.4**	4120.0*	4.4**	8.0*	0.1ns	0.0**	0.2*
A x B	21546.5*	17533.4**	6300.1**	2.6**	9.3**	0.1ns	0.0ns	0.0ns
A x C	123418.3**	14743.1*	1832.0ns	1.6**	1.8ns	0.2**	0.0ns	0.1ns
B x C	114583.0**	1769.4ns	3324.0*	0.1ns	1.6ns	0.1ns	0.0ns	0.1ns
A x B x C	28522.7**	15037.1**	3285.0*	0.3ns	3.0ns	0.0ns	0.0*	0.1ns
Error 1	6247.7	13994.9	2910.7	0.1	2.0	0.1	0.0	0.1
Error	7959.4	4429.5	1229.4	0.1	1.6	0.0	0.0	0.0

** P<0.01; * P<0.05, ns: non-significant

SY: seed yield, NSC: number of seed per cob, TSW: 1000 seed weight, PRO.: protein, STA.: Starch, CEL.: cellulose

Table 5. Effect of extra potassium on seed yield and components of corn under deficit irrigation conditions

Treatment	İrrigation Dose	Cultivar	Seed yield ($kg.ha^{-1}$)	Number of seed per cob	1000 seed weight (g)
Non -fertilization	300 mm	31G98	4703.0	420.0	207.6
		31D24	4642.0	353.3	265.6
		NK-Arma	9961.0	595.7	249.5
	Average		6435.0	456.3	240.9
	400 mm	31G98	9038.0	405.0	264.2
		31D24	9508.0	622.3	324.3
		NK-Arma	7857.0	573.3	320.0
	Average		8801.0	533.6	302.8
	500 mm	31G98	7820.0	623.3	285.9
		31D24	7608.0	570.3	358.1
		NK-Arma	9147.0	581.0	341.0
	Average		8192.0	591.6	328.3
Average of non-fertilization			**7809.0**	**527,1**	**290.7**
Standard fertilization	300 mm	31G98	10094.0	545.3	310,7
		31D24	8727.0	529.0	339,1
		NK-Arma	9671.0	700.3	258.5
	Average		9497.0	591.6	302.8
	400 mm	31G98	12408.0	660.0	353.4
		31D24	13087.0	657.3	284.1
		NK-Arma	8670.0	695.3	352.6
	Average		11388,0	670.9	330.1
	500 mm	31G98	13390.0	594.3	272.3
		31D24	13311.0	625.7	317.3
		NK-Arma	10890.0	625.0	292.4
	Average		12530.0	615.0	294.0
Average of standard fertilization			**11139.0**	**625.8**	**308.9**
Extra Potassium supply	300 mm	31G98	10736.0	668.0	222.4
		31D24	11316.0	676.3	284.9
		NK-Arma	11103.0	657.3	285.6
	Average		11052.0	667.2	264.3
	400 mm	31G98	12426.0	622.3	320.5
		31D24	12990.0	656.0	321.0
		NK-Arma	12249.0	758.7	292.0
	Average		12555,0	679.0	311.2
	500 mm	31G98	13864.0	588.0	352.4
		31D24	13078.0	671.7	314.0
		NK-Arma	12072.0	675.3	340.6
	Average		13005.0	645.0	335.7
Average of Extra potassium supply			**12204.0**	**663.7**	**303.7**
Average of irrigation doses					
300 mm			8995.0	571.7	269.3
400 mm			10915.0	627.8	314.7
500 mm			11242.0	617.2	319.3
LSD irrigation*potassium*cultivar (0,05)			1466.0	109.4	57.6

Table 6. Effect of extra potassium on seed quality parameters on corn seed under deficit irrigation conditions

Treatment	İrrigation Dose	Cultivar	PRO (%)	STA (%)	ASH (%)	OIL (%)	CEL (%)
Non -fertilization	300 mm	31G98	7.4	73.2	1.3	3.5	2.2
		31D24	7.5	71.1	1.3	3.2	2.1
		NK-Arma	7.8	72.4	1.3	3.7	2.5
		Average	7.5	72.3	1.3	3.5	2.3
	400 mm	31G98	7.2	71.0	1.4	3.4	2.1
		31D24	7.5	73.2	1.3	3.5	2.1
		NK-Arma	6.7	72.5	1.3	3.5	2.4
		Average	7,1	72.2	1.3	3.5	2.2
	500 mm	31G98	8.1	72.2	1.4	3.9	2.4
		31D24	7.4	72.7	1.3	3.4	2.2
		NK-Arma	6.3	73.6	1.3	3.3	2.4
		Average	7.2	72.8	1.3	3.5	2.3
Average of non-fertilization			**7.3**	**72.4**	**1.3**	**3.5**	**2.3**
Standard fertilization	300 mm	31G98	9.2	69.7	1.4	3.4	2.1
		31D24	9.4	71.6	1.3	3.6	2.3
		NK-Arma	9.3	72.2	1.3	3.8	2.7
		Average	9.3	71.2	1.3	3.6	2.3
	400 mm	31G98	9.0	70.1	1.3	3.7	2.3
		31D24	9.2	72.2	1.4	3.7	2.4
		NK-Arma	7.8	71.3	1.3	3.6	2.3
		Average	8,6	71.2	1.3	3.7	2.3
	500 mm	31G98	8.9	69.4	1.3	3.5	2.3
		31D24	9.5	69.0	1.3	3.4	2.4
		NK-Arma	8.2	71.3	1.3	3.5	2.1
		Average	8.9	69.9	1.3	3.4	2.3
Average of standard fertilization			**8.9**	**70.8**	**1.3**	**3.6**	**2.3**
Extra Potassium supply	300 mm	31G98	8.8	68.7	1.4	3.6	2.6
		31D24	9.2	70.2	1.4	3.3	2.1
		NK-Arma	9.0	70.3	1.3	3.6	2.4
		Average	9,0	69.7	1.4	3.5	2.4
	400 mm	31G98	9.0	71.5	1.3	3.7	2.3
		31D24	8.7	70.7	1.3	3.8	2.4
		NK-Arma	7.4	72.0	1.3	3.7	2.4
		Average	8.4	71.4	1.3	3.7	2.4
	500 mm	31G98	7.4	72.8	1.3	3.6	2.3
		31D24	7.2	71.5	1.4	3.3	2.3
		NK-Arma	6.5	72.7	1.3	3.3	2.4
		Average	7.0	72.3	1.3	3.4	2.3
Extra potassium supply			**8.1**	**71.2**	**1.3**	**3.5**	**2.3**
Average of irrigation doses							
300 mm			8.6	71.1	1.3	3.5	2.3
400 mm			8.0	71.6	1.3	3.6	2.3
500 mm			7.7	71.7	1.3	3.5	2.3
LSD irrigation*potassium*cultivar (0,05)			-	-	0.1	-	-
LSD irrigation*cultivar (0,05)			0.4	-	-	0.2	-
LSD irrigation*treatment (0,05)			0.4	1.2	-	-	
LSD cultivar (0.05)			-	0.7	-	-	0.1

PRO.: protein, STA.: Starch, CEL.: cellulose

Irrigation dose x treatment factor x cultivar interaction was found to be significant seed yield, number of seed per cob, 1000 seed weight and ASH rate parameters. Furthermore, irrigation dose x treatment factor interaction was significant for protein and starch rate. Irrigation dose x cultivar interaction was significant for protein and oil rate.

Table 5 and Table 6 were edited as seed yield, yield component and seed quality parameters under deficit irrigation conditions.

Seed yield, number of seed per cob and 1000 seed weight were shown in Table 5. Treatment average of seed yield and number of seed per cob were increased with standard fertilization and extra potassium application according to non-fertilization. 1000 seed weight didn't give similar responses (sometime increasing and sometimes decreasing) with all the treatments. Otherwise it is shown that increasing water doses was increased seed yield and 1000 seed weight. Number of seed per cob and 1000 seed weight are mainly component for seed yield (Geetha and Jayaraman, 2000; Mohammadi et al., 2003). These components increased regularly in some treatments (standard fertilization and 400 mm water), whereas moved irregularly in the others (extra potassium and 500 mm water). We obtained that yield components (number of seed per cob and 1000 seed weight) should be moved regularly for maximum seed yield under deficit irrigation condition.

Protein rate, starch rate, oil rate, ASH and cellulose rate of corn seed provided in Table 6. Protein rate was increased with standard fertilization and extra potassium supply compared to control. Similarly increased water dose was increased protein rate of corn seed. But treatments (standard fertilization and extra potassium supply) were seen decreasing protein rate under deficit conditions owing to increasing seed yield. Therefore when protein rate was increasing, starch rate was decreasing with changing irrigation doses in extra potassium supply. The result parallel with the study result which density of starch in seed will increase consequently amount of protein will decrease (Nematı et al., 2009). Otherwise protein and starch rate moved irregularly in the other treatments (standard fertilizer and non-fertilizer). Average of ASH concentration of corn seed was stabile with all treatments and irrigation doses. The same as the average of oil rate was also little movements with all treatments and irrigation doses. The major factor for oil rate chancing was genotypes. The highest oil rate in the experiment was measured 31G98 cultivar under 500 mm irrigation and non-fertilization condition. The content of oil was also enhanced when seed development occurred under severe water stress (Roche et al., 2006).

Cultivar was significant for changing cellulose rate. 31G98 and NK-Arma cultivars were given higher cellulose rate than 31D24 with all treatments. Additionally these cultivars take higher cellulose rate score under 300 mm irrigation dose than 400 mm and 500 mm. So we said that deficit irrigation condition in all treatment may cause increasing cellulose rate of corn seed. Increasing cellulose rate was decreased animal feed quality. Therefore the result has showed that animal feed quality was decreased under deficit irrigation condition.

CONCLUSIONS

Based on the results of our study, we can be clearly seen that water shortage during milk stage and dough stage had a negative effect on seed yield and yield components. This results were shown that supplemental irrigation in seed feeling stages of corn is need to ensure maximum seed yield. Otherwise standard fertilization and extra potassium supply also reduced the negative effect of deficit irrigation condition and slightly positive effect for adequate yield.

Quality parameters of corn seed didn't move similarly seed yield and components. Seed quality parameters moved variably as increase or decrease unregularly under changing irrigation doses and chancing treatments (standard fertilizer and extra potassium).

ACKNOWLEDGEMENTS

This research was carried out Adnan Menderes University, Faculty of Agriculture research fields and also was financed from BAP Project No: ZRF-13005.

REFERENCES

Açıkgöz N., Aktaş M.E., Mokhaddam A.F., Özcan K., 1994. TARİST an Agrostatistical Packageprogramme for Personel Computer. E.Ü.Z.F. Tarla Bitkileri Kongresi, İzmir, Turkey.

Allen B.L., 2012. Dryland corn yield affected by row configuration and seeding rate in the northern Great Plains. Journal of Soil and Water Conservation, vol. 67 no. 1, p. 32-41.

Ayers R.S., Westcot D.W., 1989. Water quality for agriculture. FAO Irr. and Drain Paper Rome, No 29: 1-174.

Bänziger M, Edmeades G.O., Lafitte H.R., 1999. Selection for drought tolerance increases maize yields over a range of N levels. Crop Science, 39: 1035-1040.

Bouyoucos G.J., 1962. Hydrometer method improved for making particle size analysis of soil. Agron. J., 54: 464-465.

Carr M.K.V., 2010. The role of water in the growth of the tea (*Camellia sinensis*) crop: a synthesis of research in eastern Africa. Water productivity. Expl. Agric, 46(3): 351-379.

Deng X., Shan L., Shinobu I., 2002. High efficient use of limited supplement water by dryland spring wheat. Trans. CSAE 18 (5), 84-91.

Ebrahimi S.T., Yarnia M., Khorshidi M.B.B., Tabrizi E.F.M., 2011. Effect of Potassium Fertilizer on Corn Yield (Jeta cv.) Under Drought Stress Condition. American-Eurasian J. Agric. & Environ. Sci., 10 (2): 257-263.

Edmeads G.O., Chapman S.C., Bolanas J., Banziger M., Afitte H.R., 1994. Recent evaluation of progress in selection for drought in tropical maize, Maize Conference, Harare, Zimbabwe. 28 March-1 April. CYMMYT.

Fabeiro C., Martin de Santa Olalla F., de Juan J.A., 2001. Yield and size of deficit irrigated potatoes. Agric. Water Manage. 48, 255-266.

Geetha K., Jayaraman N., 2000. Path analysis in maize (*Zea mays* L.). Agric. Sci. Digest. 20: 60-1.

Gislum R, Micklander E, Nielsen J.P., 2004. Quantification of nitrogen concentration in perennial ryegrass and red fescue using near-infrared reflectance spectroscopy (NIRS) and chemometrics. Field Crops Research 88: 269-277.

Kang S., Zhang L., Ling Y., Hu X., Cai H., Gu B., 2002. Effects of limited irrigation on yield and water use efficiency of winter wheat in the loess plateau of China. Agric. Water Manage., 55: 203-216.

Knutson C.L., Haigh T., Hayes M.J., Widhalm M., Nothwehr J., Kleinschmidt M., Graf L., 2011. Farmer perceptions of sustainable agriculture practices and drought risk reduction in Nebraska, USA. Renewable Agriculture and Food Systems, Volume 26 (03): 255-266.

Kramer P.J., Boyer J.S., 1995. Water Relations of Plants and Soils. Academic Press, San Diego.

Lamm F.R., Manges H.L., Stone L.R., Khan A.H., Rogers D.H., 1994. Water requirement of subsurface drip-irrigated corn in Northwest Kansas. American Society of Agricultural Engineers, Vol. 38(2): 441-448.

Li F.M., Guo A.H., Wei H., 1999. Effects of clear plastic film mulch on yield of spring wheat. Field Crops Res., 63: 79-86.

Martin D.L., Gilley J.R., 1993. Irrigation Water Requirements. National Engineering Handbook, Chapter 2, United States Department of Agriculture Soil Conservation Service, Washington D.C., USA.

Mohammadi S.A., Prasanna B.M., Singh N.N., 2003. Sequentional path model for determining interrelationships among grain yield and related characters in maize. Crop Sci. 43: 1690-1697.

Mut Z., Akay H., 2010. Effect of seed size and drought stress on germination and seedling growth of naked oat (Avena sativa L.). Bulgarian Journal of Agricultural Science, 16 (No 4): 459-467.

Nejad S.D., Nejad T.S., Lack S., 2010. Study effect drought stress and different levels potassium fertilizer on K+ accumulation in corn.

Nematı A., Sedghı M., Sharıfı R.S., Seıed M.N., 2009. Investigation of Correlation between Traits and Path Analysis of Corn (*Zea mays* L.) Grain Yield at the Climate of Ardabil Region (Northwest Iran). Notulae Botanicae Horti Agrobotanici Cluj, 37 (1): 194-198.

Rafat N., Yarnia M., HassanPanah D., 2012. Effect of drought stress and potassium humate application on grain yield-related traits of corn. Journal of Food, Agriculture & Environment Vol.10 (2): 580-584.

Reddya A.R., Chaitanya K.V., Vivekanandanb M., 2004. Drought induced responses of photosynthesis and antioxidant metabolism in higher plants. J. Plant Physiol., 161, 1189-1202.

Roche J., Bouniols A., Mouloungui Z., Barranco T., Cerny M., 2006. Management of environmental crop conditions to produce useful sunflower oil components. Eur. J. Lipid Sci. Technol. 108: 287-297.

Walkley A., Black I.A., 1934. An Examination of the Degtjareff Method for Determining Soil Organic Matter, and A Proposed Modification of the Chromic Acid Titration Method. Soil Science Vol: 37(1): 29-38.

Wardlaw I.F., Willenbrink J., 2000. Mobilization of fructan reserves and changes in enzyme activities in wheat stem correlate with water stress during kernel filling. New Phytol., 148: 413-422.

Zare K., Vazin F., Hassanzadehdelouei M., 2014. Effects of potassium and iron on yield of corn (*Zea mays* L.) in drought stress Cercetări Agronomice în Moldova Vol.: XLVII, No. 1 (157): 39-47.

Zhang B., Li F.M., Huang G., Cheng Z.Y., Zhang Y., 2006. Yield performance of spring wheat improved by regulated deficit irrigation in an arid area. Agricultural Water Management, 79: 28-42.

Zhang B., Li F., Cheng Z., 2004. Temporal and spatial dynamics of soil moisture in intercropped maize under deficit irrigation with rainfall harvesting. J. Irrigation Drainage 23 (2), 49-51 (in Chinese).

Zhang J. 2004. Risk assessment of drought disaster in the maize-growing region of Songliao Plain, China. Agric. Ecosystems Environ., 102: 133-153.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECT OF EXTRA POTASSIUM SUPPLY ON FATTY ACID COMPOSITION OF CORN OIL IN DEFICIT IRRIGATION CONDITIONS: (SECTION B)

Yakup Onur KOCA[1], Aslı YORULMAZ[2], Osman EREKUL[1]

[1]Adnan Menderes University, Faculty of Agriculture, Department of Crop Science, Aydın – 09100, Turkey
[2]Adnan Menderes University, Faculty of Engineering, Department of Food Engineering, Aydın-09100 Turkey

Corresponding author email: e-mail: koca2002@hotmail.com

Abstract

The study investigates the influence of extra potassium application and deficit irrigation on fatty acid composition of corn oils. The field experiment was conducted with split plot design with three replications in Aydın location of Turkey in 2013. 31G98, 31D24 and NK-Arma corn varieties were grown with three different supplies as non-fertilization, standard fertilization [210 kg.ha^{-1} pure N, 60 kg.ha^{-1} pure P, 60 kg.ha^{-1} pure K 60 kg.ha^{-1} (NH_4NO_3, P_2O_5 and K_2O with 15-15-15 composite before planting and H_2NCONH_2 – 150 kg.ha^{-1} with urea before first water)] and extra potassium (standard fertilization +60 kg.ha^{-1} K_2SO_4) and three irrigation doses (500 mm, 400 mm and 300 mm) during development stages [(8 leaf stage (V8), before Tasselling (VT), after blister, milk stage and dough stage)]. Corn oil samples were obtained from corn seeds by soxhelet extraction using n-hexane and assessed for their fatty acid composition with a gas chromatograph. The data obtained from studies has shown that extra potassium application and deficit irrigation have significantly effected to fatty acid rates of corn oil of all varieties. Main fatty acids were linoleic, oleic and palmitic and ranged between 52.56-63.60%, 20.56-28.06%, 9.32-14.01% respectively. Besides heptadecanoic, linolenic, arachidic, stearic and eicosenoic acids were determined in small amounts. Extra potassium application increased linoleic (18:2), linolenic (18:3) and eicosenoic (20:1) but decreased palmitic (16:0), heptadecanoic (17:0), stearic (18:0) and oleic (18:1) fatty acid ratios. Deficit irrigation increased palmitic, linoleic and eicosenoic fatty acids, but decreased stearic, oleic, linolenic and arachidic acids.

Key words: *corn oil, deficit irrigation, palmitic acid, oleic acid, linoleic acid.*

INTRODUCTION

Fat intake can promote immune system and reply against disease, injury, and infection. Nowadays diet programs are taking adequate fat every day for numerous metabolic activities. For example A, D, and E vitamins require fat for proper absorption (Rodriguez et al., 2009) and fat provided energy and endurance of body (Mastaloudis and Traber, 2006).
Fats remain an effective regulator of many physiological functions (Lowery, 2004). Moreover many researchers have referred to the potency of several lipids as pharmaceutical in nature (Fauconnot and Buist, 2001; Watkins et al., 2001). Monounsaturated fatty acids may reduce cardiovascular risks (Perez-Jimenez et al., 2002). Besides polyunsaturated fatty acids help to reduce inflammation (Browning, 2003). Similarly polyunsaturated fatty acids increase E vitamin requirement (Hodwitt, 1974). So E vitamin content of vegetable oils are parallel with the polyunsaturated fat content of the oils (Lukaski, 2004).
Current dietary guidelines advise that 10% of fat intake should be obtained from monounsaturated sources, 10% from polyunsaturated and no more than 10% from saturated (Walter and Satai, 2009). Conversely fatty acid composition of vegetable oil can be influenced by many factors, such as temperature, cultivars, and fertilization period (Scollan et al., 2001; Karaca and Aytaç, 2007). Similarly saturated or unsaturated fatty acid ratio of oil are also effected by environmental factors such as temperature, location, water dose, geography, planting year and fertilizer

nutrient (Ahmad and Abdin 2000; Reynolds et al., 2005).

The current study investigates the influence of standard fertilization and extra potassium supply (60 kg.ha^{-1} K_2SO_4) on fatty acid composition of oil under deficit irrigation conditions.

MATERIALS AND METHODS

The research was carried out in Aydin province with typical Mediterranean climate (hot summer and mild winter), located in west Turkey at 37º44' N 27º44' E at 65 m above sea level; and was conducted in 2013. General characteristics of soil is given Table 1.

Table 1. Soil texture and chemical analysis

Soil texture[1] (%)			pH[2]	Organic mater[3]
Sand	Silt	Clay		(%)
72.0	16.7	11.3	8.4	1.2

Method of; [1]Bouyoucos; [2]1:2.5 Saturasyon; [3]Walkley-Black
(Bouyoucos G.J. 1962; Ayers and Westcot 1989; Walkley and Black 1934)

The experimental soil in the experiment has a sandy loamy structure with alkaline characteristic and it contains quite low organic matters.

Monthly temperature, total precipitation and long-term (1975–2013) temperature and precipitation values of Aydin is shown in Table 2. The temperature of 2013 was higher than long term means except for June and July. Rainfall data showed that May, July and August had lower values than long term means.

Table 2. Monthly temperature and total rainfall during corn growth period and long-term mean (1975–2013) in Aydin

Months	Temperature (°C)		Precipitation (mm)	
	2013	Long term	2013	Long term
April	16.1	15.7	42.6	45.5
May	23.2	20.9	1.0	33.5
June	25.3	25.9	18.4	14.0
July	27.9	28.4	2.4	3.5
August	27.8	27.2	0.0	2.2
September	22.6	23.2	22.8	14.4

Experimental design

The experiment was set up as split block experimental design with 3 replications. All parcels were sowed at April 26, 2013 and the first seed emergence observation was conducted at May 13, 2013. Each plot area was 28 m^2 (5 m x 5.6 m) and consisted of 8 rows. Distance between rows was 70 cm and intra row spaces were 18 cm. NK-Arma, P31G98 and 31D24 varieties were used as the crop material. All varieties were hybrid (F1) and had single cross corn (*Zea mays* L.) variety. NK-Arma was produced by Syngenta Turkey Co. Ltd., and the others were produced by Pioneer Turkey Seed Distribution and Marketing Co. Ltd.

Treatments

Treatment factors were created out with non-fertilizer, standard fertilizer and extra potassium application. Standard fertilizer application from soil was applied as 210 kg.ha^{-1} pure nitrogen (NH_4NO_3) (60 kg.ha^{-1} with 15-15-15 composite was applied immediately at the beginning of cultivation - 150 kg.ha^{-1} with urea (H_2NCONH_2) before first water), 60 kg.ha^{-1} phosphor (P_2O_5) and 60 kg.ha^{-1} potassium (K_2O). Extra potassium was applied by adding 60 kg.ha^{-1} K_2SO_4 onto the standard fertilizer application.

Irrigation doses

Soil from the field experiment [(0-30 cm, 30-60 cm and 60-90 cm depth (Rd)] was put into pots. The water content of the soil after being saturated by irrigation and allowed to drain is called field capacity (FC). Crop can no longer take up water from the soil is referred wilting point (WP). The water held by the soil between field capacity and the permanent wilting point is considered as available water (AW). Corn is capable of using 50% of the available water. Irrigation water requirement (100 mm) was calculated with the following formulas (Martin and Gilley, 1993; Lamm et al., 1994).

$$AW = Rd\ (FC-WP)/100$$

Table 3. Irrigation periods and doses in corn growing

Irrigation time	Irrigation rate per parsel		
	300 mm	400 mm	500 mm
20th June 2013	X	X	X
04th July 2013	X	X	X
12th July 2013	X	X	X
25th July 2013	-	X	X
06th August 2013	-	-	X
10th September 2013	Harvest time		
X: Applied 100 mm water			

Irrigation doses was applied as follows: standard (5X100 mm) during 5 times (V8, before VT, after blister, milk stage and dough stage), as deficit irrigation (4X100 mm) during 4 times (V8, before VT, after blister and milk stage) and as more deficit irrigation (3X100) during 3 times V8, before VT and after blister) at corn growth period. Irrigation periods and doses were given in Table 3.

The analysis of fatty acid composition of corn oil

Corn oil samples were obtained by solvent extraction using n-hexane. Fatty acid methyl esters were prepared according to International Union of Pure and Applied Chemistry (IUPAC) method and analysed by gas chromatography (Agilent 7890A, Santa Clara, CA). DB-23 fused silica capillary column (60 m, 0.25 mm i.d. and 0.25 µm film thickness) (J&W Scientific) was employed for separating individual fatty acids. Carrier gas was helium with a flow rate of 1 ml/min. Injector, column and detector temperatures were 230, 195 and 240°C, respectively. The split ratio was 80:1 and injection volume was 0.5 µl.

Statistical analysis

All the plant data collected from all treatments were statistically analysed using the TARIST package software (Açıkgöz et al., 1994) as a split plot design with three replications using analysis of variance to evaluate the effect of different fertilization doses (non-fertilization, standard fertilization and extra potassium) and deficit irrigation levels (500 mm, 400 mm, 300 mm) on the corn. Means among treatments were compared using Least Significant Difference (LSD) at $P \leq 0.05$ probability.

RESULTS AND DISCUSSIONS

The results of variance analysis for treatment factors (different fertilization) water doses (deficit irrigations) variety and their interactions are presented in terms of saturated and unsaturated fatty acids in Table 4. Irrigation dose x treatment factor x variety interaction was found to be significant in all parameters except for arachidic acid. Moreover, irrigation dose x treatment factor interaction was significant for arachidic acid. Table 5 and Table 6 tabulate the saturated and unsaturated fatty acids values.

Palmitic acid (C16:0), heptadecanoic acid (C17:0), stearic acid (C18:0), arachidic acid (C20:0) and their total values were shown as saturated fatty acids in Table 5. Palmitic and stearic decreased with increasing fertilization. Heptadecanoic acid ratios didn't change and arachidic acid averages moved erratically with standard and extra potassium fertilizations compared to control treatment. Increasing water doses decreased palmitic acid percentages and didn't affect heptadecanoic acid ratios.

Table 4. The result of variance analyses and mean squares values for saturated and unsaturated fatty acids of corn oil

Variance Source	Pal.	Hep.	Ste.	Ara.	Ole.	Lin.	Lino.	Eic.
Irrigation dose (A)	3.9**	0.0ns	0.3ns	0.3ns	21.6**	5.9*	0.0ns	0.0ns
Treatment (B)	3.1**	0.0ns	0.2*	0.0ns	0.9ns	10.5**	0.1**	0.0**
Variety (C)	26.4**	0.0**	1.4**	0.0ns	31.6**	8.72**	0.2**	0.0**
A x B	1.0ns	0.0**	0.0ns	0.1**	3.1**	5.5*	0.0ns	0.0**
A x C	0.8ns	0.0**	0.1ns	0.0ns	3.0**	2.4ns	0.1**	0.0**
B x C	0.8ns	0.0ns	0.2**	0.0ns	3.7**	2.0ns	0.0ns	0.0ns
A x B x C	1.2*	0.0*	0.1**	0.0ns	3.2**	10.9**	1.0**	0.0**
Error 1	0.2	0.0	0.1	0.0	0.2	0.7	0.0	0.0
Error	0.6	0.0	0.0	0.0	0.8	1.6	0.0	0.0

** P<0.01; * P<0.05, ns: non-significant

Pal.: Palmitic acid, **Hep.:** Heptadecanoic acid, **Ste.:** Stearic acid, **Ara.:** Arachidic acid, **Ole.:** Oleic acid, **Lin.:** Linoleic acid, **Lino.:** Linolenic acid, **Eic.:** Eicosenoic acid

Table 5. Effect of fertilization on saturated fatty acid rates of corn oil under deficit irrigation conditions

Treatment	Irrigation Dose	Cultivar	Palmitic Acid (C16:0)	Heptadecanoic Acid (C17:0)	Stearic Acid (C18:0)	Arachidic Acid (C20:0)	Total (%)
Non -fertilization	300 mm	31G98	13.01	0.06	1.92	0.41	15.40
		31D24	13.47	0.05	1.60	0.22	15.34
		NK-Arma	12.14	0.07	1.87	0.35	14.43
		Average	12.87	0.06	1.80	0.33	15.06
	400 mm	31G98	12.85	0.07	1.98	0.87	15.77
		31D24	12.67	0.06	1.59	0.47	14.79
		NK-Arma	11.50	0.07	2.16	0.37	14.10
		Average	12.34	0.07	1.91	0.57	14.89
	500 mm	31G98	12.28	0.07	1.80	0.35	14.50
		31D24	13.19	0.08	1.79	0.38	15.44
		NK-Arma	9.89	0.07	2.07	0.39	12.42
		Average	11.79	0.07	1.89	0.37	14.12
Average of non-fertilization			**12.33**	**0.07**	**1.86**	**0.42**	**14.68**
Standard fertilization	300 mm	31G98	12.73	0.07	1.55	0.32	14.67
		31D24	12.02	0.06	1.47	0.42	13.97
		NK-Arma	12.17	0.07	1.86	0.38	14.48
		Average	12.31	0.07	1.63	0.37	14.38
	400 mm	31G98	11.70	0.07	1.61	0.39	13.77
		31D24	12.16	0.07	1.65	0.35	14.23
		NK-Arma	9.85	0.06	2.22	0.38	12.51
		Average	11.24	0.07	1.83	0.37	13.51
	500 mm	31G98	12.71	0.05	1.52	0.53	14.81
		31D24	11.83	0.07	1.72	0.33	13.95
		NK-Arma	10.53	0.07	2.25	0.39	13.24
		Average	11.69	0.06	1.83	0.42	14.00
Average of standard fertilization			**11.74**	**0.07**	**1.76**	**0.39**	**13.96**
Extra Potassium supply	300 mm	31G98	12.82	0.07	0.97	0.45	14.31
		31D24	12.75	0.08	1.73	0.43	14.99
		NK-Arma	10.19	0.07	1.98	0.44	12.68
		Average	11.92	0.07	1.56	0.44	13.99
	400 mm	31G98	12.35	0.07	1.78	0.37	14.57
		31D24	12.35	0.08	1.57	0.40	14.40
		NK-Arma	10.87	0.07	1.85	0.39	13.18
		Average	11.86	0.07	1.73	0.39	14.05
	500 mm	31G98	11.47	0.04	1.66	0.29	13.46
		31D24	12.76	0.07	1.67	0.39	14.89
		NK-Arma	10.04	0.09	2.03	0.43	12.59
		Average	11.42	0.07	1.79	0.37	13.65
Extra potassium supply			**11.73**	**0.07**	**1.69**	**0.40**	**13.89**

Average of irrigation doses					
300 mm	12.37	0.07	1.66	0.38	14.48
400 mm	11.81	0.07	1.82	0.44	14.15
500 mm	11.64	0.07	1.84	0.39	13.93
LSD irrigation*potassium*cultivar (0.05)	1.24	0.02	0.33	-	-
LSD irrigation*potassium (0.05)	-	-	-	0.13	-

Table 6. Effect of fertilization on unsaturated fatty acid rates of corn oil under deficit irrigation conditions

Treatment	Irrigation Dose	Cultivar	Oleic acid (C18:1)	Linoleic acid (C18:2)	Linolenic acid (C18:3)	Eicosenoic acid (C20:1)	Total (%)
Non-fertilization	300 mm	31G98	24.91	58.09	1.23	0.15	84.38
		31D24	23.61	59.40	1.07	0.12	84.20
		NK-Arma	21.88	59.49	1.23	0.21	82.81
	Average		23.47	58.99	1.18	0.16	83.80
	400 mm	31G98	25.23	58.10	0.71	0.16	84.20
		31D24	23.32	61.07	1.57	0.24	85.20
		NK-Arma	26.72	55.77	1.31	0.20	84.00
	Average		25.23	58.38	1.20	0.20	85.01
	500 mm	31G98	24.90	59.16	1.22	0.17	85.45
		31D24	23.90	59.07	1.31	0.20	84.48
		NK-Arma	26.01	59.90	1.41	0.19	87.51
	Average		24.94	59.38	1.31	0.19	85.82
Average of non-fertilization			**24.55**	**58.92**	**1.23**	**0.18**	**84.48**
Standard fertilization	300 mm	31G98	23.24	60.55	1.19	0.18	85.16
		31D24	20.91	63.59	1.22	0.25	85.97
		NK-Arma	24.23	59.58	1.37	0.20	85.38
	Average		22.79	61.24	1.26	0.21	85.50
	400 mm	31G98	23.21	61.32	1.41	0.23	86.17
		31D24	23.63	56.96	1.32	0.17	82.08
		NK-Arma	26.91	59.04	1.29	0.20	87.44
	Average		24.58	59.11	1.34	0.20	85.23
	500 mm	31G98	25.32	58.65	1.07	0.12	85.16
		31D24	24.11	60.40	1.31	0.18	86.00
		NK-Arma	27.10	58.13	1.23	0.22	86.68
	Average		25.51	59.06	1.20	0.17	85.94
Average of standard fertilization			**24.30**	**59.80**	**1.27**	**0.19**	**85.56**
Extra potassium supply	300 mm	31G98	23.07	59.93	1.33	0.22	84.55
		31D24	23.34	59.97	1.35	0.25	84.91
		NK-Arma	24.95	60.72	1.33	0.22	87.22
	Average		23.79	60.21	1.34	0.23	85.57
	400 mm	31G98	24.23	59.64	1.28	0.20	85.35
		31D24	22.51	61.38	1.41	0.28	85.58
		NK-Arma	25.15	59.90	1.36	0.26	86.67
	Average		23.96	60.35	1.35	0.25	85.91
	500 mm	31G98	25.02	60.08	1.27	0.13	86.50
		31D24	23.54	59.85	1.43	0.20	85.02
		NK-Arma	25.64	59.38	1.50	0.26	86.78
	Average		24.80	59.80	1.40	0.20	86.20
Extra potassium supply			**24.18**	**60.12**	**1.36**	**0.22**	**85.88**
Average of irrigation doses							
300 mm			23.35	60.15	1.26	0.20	84.96
400 mm			24.59	59.28	1.30	0.22	85.38
500 mm			25.08	59.41	1.30	0.19	85.99
LSD irrigation*potassium*cultivar (0.05)			1.47	2.06	0.22	0.04	-

Steraic acid contents increased and arachidic acid averages moved erratically with increased water supply. The total saturated fatty acid value decreased with standard fertilization and extra potassium application. Similarly the same value decreased with increasing water doses. These results have shown that saturated fatty acid rates increased in deficit irrigation conditions. Therefore the standard fertilization and extra potassium reduced the deficit irrigation effects on the fatty acid rate of corn oil.

Oleic acid, linoleic acid, linolenic acid and eicosenoic acid and unsaturated fatty acid contents were shown in Table 6. Oleic acid rate of corn oil decreased with standard fertilization and extra fertilization, whereas linoleic acid, linolenic acid and eicosenoic acid averages increased with the treatments. Increasing water doses increased oleic and linolenic acid averages. Additionally linoleic and eicosenoic acid averages moved erratically with increased water doses. Total unsaturated fatty acid values increased with standard fertilization and extra potassium. The same value also raised with increasing water doses, however standard fertilization and extra potassium supply reduced the deficit irrigation effect on the unsaturated fatty acid content of corn oil.

Our results have shown that standard fertilization and extra potassium application decreased the total saturated fatty acids compared to non-fertilizer control. Similar results regarding to potassium effects of fatty acid composition of oil have also been reported by some studies (Mekki et al., 1999; Sawan et al., 2006). Froment et al., (2000) have stated that oleic acid and linoleic acid rates increased by extra potassium treatment. The other report has shown that application of nitrogen, phosphorus and potassium (standard fertilization) have the most beneficial effects among the treatments examined, affecting the oil seed quality (as indicated by better fatty acid profile in the oil) (Sawan et al., 2007). These results are compatible with the ones obtained in our study.

Water stress causes a significant reduction about 15% in the concentration of oleic acid. Baldini et al (2000) stated that, from the 8th days after flowering, with the increase in the biosynthesis of the oil, the enzyme D–9 desaturase starts to be active (Baldini et al., 2000). This enzyme has been proposed as being responsible for the accumulation of oleic acid (18:1) by unsaturated stearic acid (18:0), (Mckeon and Stumpf, 1982). Another enzyme leading to the oleic acid accumulation is D–12 desaturase, which catalyses the desaturation of oleic acid into linoleic acid (Stymme and Appelqvist, 1980). It could be considered that as seed maturity progressed, the oil yield of corn seed were affected by decreasing seed filling period after bilister stage under water deficit condition during seed filling.

When water was supplied, a major enhancement of oleic acid content was associated with a concomitant reduction of linoleic acid content and a decrease in saturated fatty acid content. Higher temperature increased the oleic acid content in seed. Oil content was enhanced under colder temperature and irrigation. The content of minor oil components was also enhanced when seed development occurred under high temperature and severe water stress (Roche et al., 2006).

Monounsaturated fatty acids may reduce cardiovascular risks (Perez-Jimenez et al., 2002). Besides, unsaturated fatty acids reduce inflammation and positively effect coronary heart disease (Browning, 2003). Similarly, polyunsaturated fatty acids increase the vitamin E requirement (Lukaski, 2004). Therefore, it may be said that standard fertilization and extra potassium affect human health positively in deficit irrigation condition.

CONCLUSIONS

Based on the results of our study, we can conclude that water shortage had a positive effect on saturated fatty acid rate and negative effect on unsaturated fatty acid rate of corn oil during milk stage and dough stage. Furthermore, fatty acid composition can be affected by standard fertilization and extra potassium supply in deficit irrigation condition.

ACKNOWLEDGEMENTS

This research was carried out Adnan Menderes University, Faculty of Agriculture research fields and also was financed from BAP Project No: ZRF-13005.

REFERENCES

Açıkgöz N., Aktaş M.E., Mokhaddam A.F., Özcan K., 1994. TARİST an Agrostatistical Packageprogramme for Personel Computer. E.Ü.Z.F. Tarla Bitkileri Kongresi, İzmirm Turkey.

Ahmad A., Abdin Z.M., 2000. Effect of sulphur application on lipid, RNA and fatty acid content in developing seeds of rapeseed (*Brassica campestris* L.). Plant Science, 150: 71-76.

Ayers R.S., Westcot D.W., 1989. Water quality for agriculture. FAO Irr. and Drain Paper No: 29: 1-174, Rome.

Baldini M., Givanardi R., Vanozzi G.P., 2000. Effect of different water availability on fatty acid composition of the oil in standard and high oleic sunflower hybrids.

Bouyoucos G.J., 1962. Hydrometer method improved for making particle size analysis of soil. Agron. J., 54: 464-465.

Browning L., 2003. n-3 polyunsaturated fatty acids, inflammation and obesity-related disease. The Proceedings of the Nutrition Society 62(2): 447-453.

De Caterina R., Gianetti J., Endres S., 1996. n-3 fatty acids and cardiovascular diseases: update to 1996. Giornale Italiano di Cardiologia 26, p. 563-578. (In Italian: English abstract).

Fauconnot L., Buist P., 2001. Gamma-linolenic acid biosynthesis: cryptoregiochemistry of delta6 desaturation. Journal of Organic Chemistry 66, p. 1210-1215.

Froment M.A., Turley D., Collings L.V., 2000. Effect of nutrition on growth and oil quality in linseed. Tests of Agrochemicals and Cultivars, No 21: 29-30.

Horwitt MK., 1974. Status of human requirements of vitamin E. Am J Clin Nutr., 27: 1182.

Karaca E., Aytaç S., 2007. Yağ bitkilerinde yağ asitleri kompozisyonu üzerine etki eden faktörler. O.M.Ü. Ziraat Fak. Dergisi, 22(1): 123-131.

Lamm F.R., Manges H.L., Stone L.R., Khan A.H., Rogers D.H., 1994. Water requirement of subsurface drip-irrigated corn in Northwest Kansas. American Society of Agricultural Engineers, Vol. 38(2): 441-448.

Lowery L.M., 2004. Dietary fat and sports nutrition: a primer. Journal of Sports Science and Medicine, 3: 106-117.

Lukaski H.C., 2004. Vitamin and Mineral Status: Effects on Physical Performance. Nutrition, Vol. 20 (7/8): 632-644.

Martin D.L., Gilley J.R., 1993. Irrigation Water Requirements. National Engineering Handbook, Chapter 2, United States Department of Agriculture Soil Conservation Service, Washington D.C., USA.

Mastaloudis A., Traber M., 2006. Vitamin E. In: Driskell J, Wolinsky I, editors. Sports Nutrition. Vitamins and Trace Elements. New York (NY): CRC/Taylor & Francis, p. 183-200.

Mckeon T.A., Stumpf P.K., 1982. Purification and characterization of the stearoil-acyl carrier protein desaturase and the acyl-acyl protein thioesterase from mature seeds of sunflower. The Journal of Bioch., 257 (20): 12141-12147.

Mekki B.B., El-Kholy M.A., Mohamed E.M., 1999. Yield, oil and fatty acids content as affected by water deficit and potassium fertilization in two sunflower cultivars. Egypt. J. Agron., 21: 67-85.

Perez-Jimenez F., Lopez-Miranda J., Mata P., 2002. Protective effect of dietary monounsaturated fat on arteriosclerosis: beyond cholesterol. Atherosclerosis, 163: 385-398.

Reynolds T.L., Nemeth M.A., Glenn K.C., Ridley W.P., Astwood J.D., 2005. Natural variability of metabolites in maize grain: differences due to genetic background. J Agric. Food Chem. 53(26): 10061-10067.

Roche J., Bouniols A., Mouloungui Z., Barranco T., Cerny M., 2006. Management of environmental crop conditions to produce useful sunflower oil components. Eur. J. Lipid Sci. Technol. 108: 287-297.

Rodriguez N.R., DiMarco N.M., Langley S., Denny S., Hager M.H., Manore M.M., 2009. Nutrition and Athletic Performance. Medicine and Science in Sports and Exercise, 41(3), 709-731.

Sawan Z.M., Hafez S.A., Basyony A.E., Alkassas A.R., 2006. Cottonseed, Protein, Oil Yields and Oil Properties as Affected by Nitrogen Fertilization and Foliar Application of Potassium and a Plant Growth Retardant. World Journal of Agricultural Sciences 2(1): 56-65.

Sawan Z.M., Hafezb S.A., Basyonyb A.E., Alkassasb A.R., 2007. Nitrogen, potassium and plant growth retardant effects on oil content and quality of cotton seed. GRASAS Y ACEITES, 58(3): 243-251.

Scollan N.D., Choi N., Kurt E., Fisher A.V., Enser M., Wood J.D., 2001. Manipulating the fatty acid composition of muscle and adipose tissue in beef cattle. Br. J. Nutr. 85: 115-124.

Stymme S., Appelqvist L.A., 1980. The biosynthesis of linoleate and linolenate in homogenate from developing soya been cotyledons. Plant Sci. Lett 17: 287-297.

Walkley A., Black I.A., 1934. An Examination of the Degtjareff Method for Determining Soil Organic Matter, and A Proposed Modification of the Chromic Acid Titration Method. Soil Science Vol: 37(1): 29-38.

Watkins B., Li Y., Seifert M., 2001. Nutraceutical fatty acids as biochemical and molecular modulators of skeletal biology. Journal of the American College of Nutrition 20, 410S-416S; discussion 417S-420S.

Watters J.L., Satia J.A., 2009. Psychosocial correlates of dietary fat intake in African-American adults: a cross-sectional study. Nutr. J. Vol: 25: 8-15.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

IDENTIFICATION AND QUANTIFICATION OF FUNGI ASSOCIATED WITH SEEDS OF BARLEY, IN TERMS OF 2014

Mali-Sanda MANOLE (CRISTEA), Stelica CRISTEA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania,

Corresponding author email: malismanole@yahoo.com

Abstract

Seeds are considered very effective means of plant pathogens transport over long distances. The use of seed material, free from pathogens, is one of the basic conditions for obtaining healthy crops. If infested seed is used for sowing, then the seed will cause diseases in crop and crop yields will be reduced considerably. The study aimed to identify and quantify the fungi associated with barley (Hordeum vulgare L.) seeds. We have analysed samples of seeds of barley varieties grown in the area of South-Eastern Romania. The mycoflora spectrum determined from analyzed samples consists of a variety of parasitic and saprophytic fungi. Species of Alternaria and Fusarium genera were the most frequently isolated with an incidence of 93.3% and 80% respectively. We also identified Curvularia lunata and Pyrenophora species with an incidence of 20% and 13.3% respectively. The group of saprophytic fungi like Oedocephalum sp., Penicillium sp., Rhizopus sp., Stemphylium sp., Trichoderma viride and Epicoccum purpurascens, was also isolated.

***Key words**: mycoflora, seeds, barley, varieties.*

INTRODUCTION

Barley (*Hordeum vulgare* L.) and wheat (*Triticum aestivum* L.) are two of the most important cereal crops in the entire world. Generally the most important factor in disease transmission from one year to another is the seed (Beratlief and Oprea, 1994). Infected seeds are the most frequent and richest source of transmission of pathogens, especially fungi (Alexandri et al., 1967; Hulea, 1973). The seeds quality as vegetal material of reproduction has a great influence on the crops' yield (Clear and Patrick, 1993). Barley seeds are rich in proteins, carbohydrates and mineral substances which represent a good medium for the development of microorganisms. Knowing the pathology of the seed makes it possible to prevent the introduction of new pathogen agents in the barley crop as well as to avoid the apparition of massive spread of infection in the field (Chong and Sheridan, 1982; Bateman and Kwasna, 1999; Kubiak and Korbas, 1999; Gheorghies and Cristea, 2001). Pathogens transmitted by seed, and those who like a vector seed, are a great problem which needs to be dealt with taking into consideration various management strategies, including aspects concerning their biology (Bărbulescu and Popov, 1995). A clear identification and quantification of the pathogen transmitted through seeds is necessary in order to determine the means of control and the active substances which are to be applied (Cană et al., 2010). Association of several fungal, in some cases, can induce the black-point phenomenon characterized by blackening of the embryo (Cristea and Berca, 2003).

MATERIALS AND METHODS

The study aimed to identify and quantify the associated fungi of barley (*Hordeum vulgare* L.) seeds. We have analized samples of barley seeds varieties grown in the area of South-Eastern Romania.
The samples which were examined were collected from various lots from local producers at the moment of harvest, in the climatic conditions of 2014. After harvesting, the samples were packed for transportation and storing them in order to maintain the physico -

chemical and microbiological analyzes up to the time of the laboratory in order to obtain more accurate results (Petcu, 2014). The biological material was represented by 15 barley samples such as: Alora baza, Amical, Andreea, Andrei, Cardinal, Compact, Friderichus, Hanzi baza, Maresal, Madalin, Orizont, Regent, Scarpia, Univers, Vanessa.
The barley seeds were placed in Petri dishes with a diameter of 8 cm on PDA culture medium (potato-dextrose-agar), sterilized at 121°C/20 min). The culture medium was prepared after the classic recipe (Hulea, 1969; Constantinescu, 1974). For each variety was analyzed a total of 100 seeds arranged in three variants each with three repetitions. The seeds have been not disinfected before this stage because we want to estimate the presence of pathogens on seeds surface not into seeds tissues. It had been determined the frequency of affected seeds by the identified micromycetes. The dishes were incubated at a temperature of 22°C for 10 days. The identification of micromycetes was performed with a *Zeiss Primo Star* microscope based on scientific literature (Raicu and Baciu, 1978; Hulea and Iliescu, 1986).

RESULTS AND DISCUSSIONS

The spectrum of identified pathogens includes fungi belonging to the *Ascomycotina* and *Deuteromycotina,* consisting of species of the genus - *Alternaria*, *Curvularia lunata, Epicoccum purpurascens, Fusarium, Oedocephalum, Penicillium*, *Pyrenophora, Rhizopus*, *Stemphylium* and *Trichoderma viride* (Table 1). The micromycetes *Alternaria* sp., *Penicillium* sp., *Rhizopus* sp., and *Fusarium* sp. were also detected on the seeds of other plant species in Romania (Cozea et al., 2011; Zala et al., 2011; Mardare et al., 2014; Pana et al., 2014).
It is noted that on the surface of the seeds, the *Alternaria* species were the most frequently 93.3% (Figure 1), the analyzed varieties developing colonies, except the Scarpia variety. Also, there was a high incidence of *Fusarium* species, which considered to be higly important pathogens for the seeds of barley; 80% of the species studied presented spores that developed colonies of the genus (*F. graminearum*, *F. moniliforme*), except the Andreea, Maresal and Regent varieties.
Epicoccum purpurascens, was detected with a 60% incidence*, Rhizopus* sp. and *Stemphylium* sp. with 40% incidence, are also part of the saprophytic determined.
The *Pyrenophora* species were detected in the Andreea, Orizont and Univers varieties, with 20% incidence. *Penicillium* species were identified in 33.3% of the analyzed varieties (Compact, Maresal, Madalin, Scarpia, Univers) and the *Oedocephalum* sp. in 20% (Amical, Friderichus and Madalin). In Andreea and Cardinal varieties*, Curvularia lunata* and *Trichoderma viride* saprophytes were determined in 13.3% of the cases.

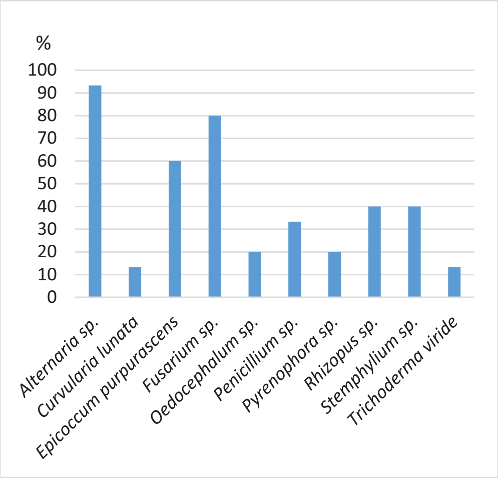


Figure 1. Incidence of pathogens spectrum on the seeds of barley analysed

Figure 2 presents aspects of the fungal colonization on barley seeds, in laboratory conditions on PDA culture medium.
Similar results were reported by other authors in the field of study of wheat seeds pathology (Cristea et al., 2008) as well as barley seeds pathology (Valceva, 2006; Karadjova, 1979 and Ivanov, 1980, cited by Georgieva-Andreeva al, 2011, Cristea-Manole et al, 2015), who have found infections similar to those of the fungi in the lots of seeds from the north of Bulgaria and southern Romania.

Table 1. Identified mycoflora in barley seeds

Microscopic fungi	Variety														
	Alora baza	Amical	Andreea	Andrei	Cardinal	Compact	Friderichus	Hanzi baza	Maresal	Madalin	Orizont	Regent	Scarpia	Univers	Vanessa
Alternaria spp.	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x
Curvularia lunata	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-
Epicoccum purpurascens	x	-	-	-	x	-	x	x	x	x	-	x	x	-	x
Fusarium spp.	x	x	-	x	x	x	x	x	-	x	x	-	x	x	x
Oedocephalum sp.	-	x	-	-	-	-	x	-	-	x	-	-	-	-	-
Penicillium sp.	-	-	-	-	-	x	-	-	x	x	-	-	x	x	-
Pyrenophora sp.	-	-	x	-	-	-	-	-	-	-	x	-	-	x	-
Rhizopus sp.	-	-	x	x	x	-	-	-	-	-	x	x	x	-	-
Stemphylium sp.	-	-	-	-	x	x	-	x	-	x	-	-	x	x	-
Trichoderma viride	-	-	x	-	x	-	-	-	-	-	-	-	-	-	-

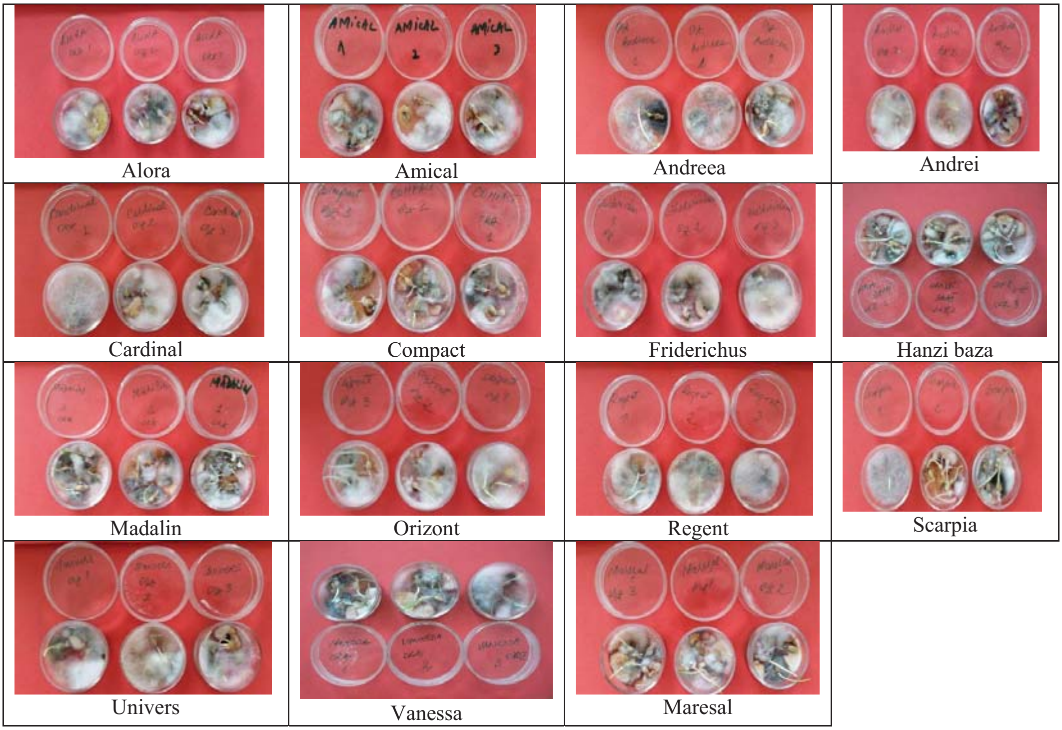


Figure 2. Fungal colonization of barley seeds

The varieties examined showed a variable number of fungi, which is between 3 and 7 pathogens. The lowest number of pathogens was identified Alora baza, Amical, Andrei, Maresal, Orizont and Vanessa varieties, and most pathogens were present on the seeds of the variety Cardinal (Figure 3).

CONCLUSIONS

Our research confirmed the presence of a large number of fungi associated barley seeds.

The fungi isolated from the seeds barley were included in the genera: *Alternaria, Curvularia, Epicoccum, Fusarium, Oedocephalum, Penicillium, Pyrenophora, Rhizopus, Stemphylium* and *Trichoderma.*

The most frequent pathogenic species isolated belong to the genus *Alternaria* and *Fusarium* and they colonized the barley seeds in most of the varieties studied, with an incidence of 93.3% and 80% respectively.

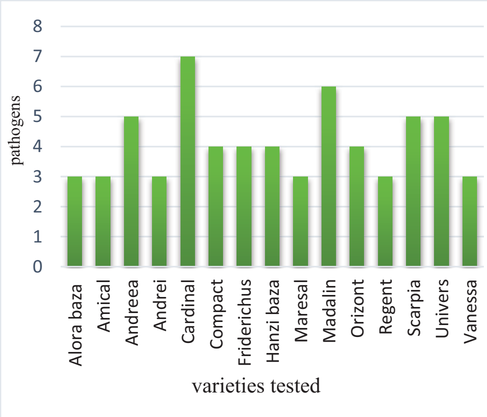


Figure 3. Fungi at seed level

ACKNOWLEDGEMENTS

This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

REFERENCES

Alexandri Al., Docea E., Olangiu M., Petrescu M., Pop, I., Radulescu E., Rafaila C., Severin V., 1967. Tratat de fitopatologie agricola, Vol.1. Ed. Academiei R.S.R. Bucuresti.

Bateman GL, Kwasna H., 1999. Effects of number of winter wheat crops grown successively on fungal communities on wheat roots. Applied Soil Ecology, 13: 271-282.

Bărbulescu A., Popov C., 1995. Recomandări privind tratamentul semințelor de grâu şi orz împotriva bolilor şi dăunătorilor. Probl. prot. plant., V. 19-20, p. 75-80.

Beratlief C., Oprea M. 1994. Ecosystem characteristics of agricultural products storages and health implication. Plant Protection issues, Bucharest, 13, 22, 44.

Cană L., Nagy E., N. Goga, Stoica V., Popov C., 2010. Research on improvement of small-grain cereals protection strategy against seed and soil-borne pathogens, Analele INCDA Fundulea, VOL. LXXVIII, no l, p. 131-138.

Chong L.M., Sheridan J.E., 1982. Mycoflora of barley (*Hordeum vulgare* L.) seed in New Zealand. New Zealand Journal of Botany, 20: 187-189.

Clear R.M., Patrick S.K., 1993. Prevalence of some seed borne fungi on soft white winter wheat seed from Ontario, Canada. Plant Dis.Sur.73: 143-149.

Constantinescu O., 1974. Metode şi tehnici în micologie. Ed. Ceres, Bucureşti.

Cozea A., Cristea S., 2011. Aspects regarding pathogen-enzymatic system interrelation at *Momordica charantia* naturalized in Romania. Romanian Biotechnological Letter, Vol. 16, No. 5, p. 6668-6672.

Cristea-Manole M.S., Cristea S., Ză1ă C., 2015. Research on mycoflora present in the caryopses of wheat (*Triticum aestivum*) in the S-E of Romania, in terms of 2014. Romanian Biotechnological Letter, Vol. 20, No. 1, p. 10183-10189.

Cristea C., Georgescu M., Pătraşcu N., Groza O., Ion L., 2008. Research regarding the phatology and anathomy of the seed the extention of wheat kernel. Scientific Papers, USAMV Bucharest, Seria A, Vol.LI, p. 280-287.

Cristea C.M., Berca M., 2013. Researches concerning the caryopses mycoflora of wheat to varieties grown in Modelu Location, Calarasi country, Research Journal of Agricultural Science (RJAS), vol 43.

Gheorghies C., Cristea S., 2001. Fitopatologie, Vol.1, Ed. Ceres, Bucuresti.

Georgieva-Andreeva Mariela, Raykov Svilen, Tanova Krasimira, 2011. Study of the seed microflora in wheat and barley grown in environmentally friendly conditions. Proceeding of the 4rd international symposium "New Research In Biotechnology" Scientific Bulletin Series F XV, Biotechnology, Bucharest, p. 37-40.

Hulea A., Negru Al., Severin V., 1973. Main Seed Crop Diseases. Ceres Publishing, Bucharest, p. 35-70.

Hulea A., 1969. Ghid pentru laboratoarele de micologie şi bacteriologie. Ed. Agrosilvica, Bucuresti.

Hulea A., Iliescu P., 1986. Determinator pentru identificarea mucegaiurilor potential toxigene. Societatea de Medicina Veterinara din R.S.Romania, Bucuresti.

Kubiak K., Korbas M.,1999. Occurrence of fungal diseases on selected winter wheat cultivars. Postepy w Ochronie Roslin 39 (2): 801-804.

Mardare Elena Ştefania, Cristea Stelica, Ză1ă R.C., 2014. Researches on the mycoflora of sunflower's achenes for the hybrids cultivated in Fetesti area, Ialomita country. Scientific Papers, USAMV Iasi, Seria Agronomie, vol, 57, nr 2, p. 213.

Raicu C., Baciu D., 1978. Patologia semintei. Editura Ceres, Bucuresti.

Pană M., Cristea S., Cernat S., Negrilă E. 2014. The mycoflora of barley- the varieties extension certificated at ards- Teleorman. Sciencific Papers, USAMV Iasi, Seria Agronomie, vol, 57, nr 2, p. 217.

Petcu C.D., 2014. Ambalaje utilizate in industria alimentara, cap. Materiale celulozice. Ed Granada, Bucuresti, p. 56-60.

Valcheva A., 2006. Study of mycological status of wheat for period 1994-2004. Plant Science, Sofia, 44: 35-39.

Valcheva A., 2006. Study of fungi prevalent in barley. Ecology and future, Sofia, 2: 47-50.

Ză1ă C.R., Cristea Stelica, Groza O., Cristea Mihaela Carmen, 2010. Pathogen fungus of the sunflower seed (*Helianthus annuus* L.) and their impact upon germination. Scientific Papers, USAMV Bucharest, Seria A, Vol. LIII, p. 454-459.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

LABORATORY RESEARCHES ON UNCONVENTIONAL METHODS FOR CONTROL OF COLORADO POTATO BEETLE (*Leptinotarsa decemlineata* L.)

Ciprian Nesu MIRCEA, Roland CHIVEREANU, Stefan CROITORU, Silviu MIRICA, Rada ISTRATE, Ioan ROSCA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: ioanrosca_usamv@yahoo.com

Abstract

Almost all over the world as in Romania, being Holarctic species, the Colorado potato beetle, (Leptinotarsa decemlineata L.), is by far the biggest pest for potato growers. Given increasing consumer demand of products without pesticides, concept best expressed by the emergence of the term of „ecological farming" is similar terms „organic farming" or „biological farming" used in other EU Member States. There are a few methods, taking into consideration organic or that work well against potato beetle. Some organic gardeners rely on a broad-spectrum of homemade sprays for reject insects, after the Rodale encyclopaedia. From literature is known that wood ash is highly toxic to adult and larval stages of the Colorado potato beetle continuously exposed to wood ash for periods of up to 10 days but remained low in topical applications. To determine the effect of the experimental products (Dust of grinded beetles dried at 105°C; decoction from grinded beetles dried at 105°C; ash of grinded beetles burned at 250°C; decoction from the ashes of burnt bugs to 250°C; Chilli pepper powder; decoction of Chilli pepper powder; chopped fresh peppers; decoction of fresh chopped peppers; tobacco decoction; check.), potato leaves were sprayed with decoction for about 3 seconds or powdered with dust or powder, put onto the Petri dishes. In present laboratory experiment defined the effect of the 9 extracts on Colorado potato beetle feeding and survival. Colorado potato beetle put onto the Petri dishes filled with leaves, was provided with 5 Colorado potato beetles adults or 5 larvae in stage L2-L3. The experiment was 24, 48 and 72 h long and involved the replacement and supplementing of feed. The test and control combinations (untreated dry leaves) were set up in 5 replications. After 24, 48, 72 and 96 hours the CPB adults or larvae were counted. Tests have shown that the products tested did not significantly effect in combating CPB nor on adults or larvae, either powdered or decoctions, without any repellent effect. So it have been rejected different opinions, spread among potato growers, concerning the use of different products non insecticides.

Key words: *Leptinotarsa decemlineata, control, homemade products.*

INTRODUCTION

Colorado potato beetle originating from North America, where it was first reported in 1824, it spread rapidly in the Americas, entering in 1921, in Europe, where it began a new extension across Old Word. In Romania, the Colorado beetle was reported in 1952 in the village Săpânța, then gradually spread throughout the territory, causing large damages especially on potato and *Solanaceae* vegetable crops. Adults and larvae feed on potato foliage and may reduce or destroy foliar surface till skeletonize the crop. Farmers who grow potatoes are familiar with the CPB (*Leptinotarsa decemlineata*). Adults and larvae are feeding on potato foliage and may reduce or destroy foliar surface till remain only main veins branch and stems of the plants. *Leptinotarsa decemlineata* or Colorado potato beetle (CPB), is the most economically damaging pest to potatoes in all areas of the Romania where is cultivated potato. Crop yield and financial losses attributed to CPB are not frequently published nor are they discussed in major reviews of pest biology and management (Rosca, 2003; Rosca and Istrate, 2009; Rosca et al., 2011). Till now in Romania as all over the world the chemical control of CPB is so far the main and the most successful method and due this fact there are registered and used a great number of insecticides, due to this fact appeared and develop resistance to different insecticides as a result of the resistant individual's selection. A few commercial botanical preparations are available for use on CPB. Rotenone (restricted material) is derived from the roots of a South American plant. Various products (Neemix™, BioNeem™, and MargosanO™) with the active ingredient azadirachtin (from neem tree seeds) have some efficacy against CPB in the early crop stages. Pyola™ is a natural insecticide product that combines canola oil with pyrethrins. Since much of the canola oil on the market is derived from genetically engineered plants, this product may or may not be acceptable for organic production (Anderman, 2000). A number of herbs and herbal extracts are also reputed to repel or inhibit CPB, though research has been far from thorough. Among the plants believed to have some effect are: *Nepeta cataria*, *Tanacetum vulgare*, *Salvia officinalis* (Kuepper, 2003), *Cannabis* spp. (Grossman, 1989), Q*uercus alba* extract (Barbara and Bradley, 1992), extracts from two Piperaceae species (Scott et al., 2003), *Solanum chacoense* extract (Williams and Williams, 1986), and citrus oils (Williams and Williams, 1988). It is worth to underline that could be possibilities for plant extracts to control insecticide resistant populations of pest in addition with other IPM used in practice, in conventional or organic agriculture and in this respect our researches were been done.

MATERIALS AND METHODS

Leptinotarsa decemlineata adults and larvae were collected from a potato culture in Lunguletu, Romania in 12 June 2014 (adults), 3 July 2014 (larvae), before the crop spraying. The adults and larvae pest were kept in laboratory, in plastic Petri dishes, at room temperature and under natural photoperiod, water and potato leaves were available at will. To determine the effect of the 9 experimental products named here "Variants" (1-dust of grinded beetles dried at $105^{o}C$; 2-decoction from grinded beetles dried at $105^{o}C$; 3-ash of grinded beetles burned at $250^{o}C$; 4-decoction from the ashes of burnt bugs to $250^{o}C$; 5-Chili pepper powder; 6-decoction of Chili pepper powder; 7-chopped fresh peppers; 8-decoction of fresh chopped peppers; 9-tobacco decoction) and check, on Colorado potato beetle feeding and survival. Potato leaves were sprayed with decoction for about 3 seconds or powdered with dust or powder, put onto the Petri dishes filled with leaves, was provided with 4 Colorado potato beetles adults or 4 larvae in stage L_2-L_3. The experiment was 24, 48, 72 and 96 hours long and not involved the replacement and supplementing of feed only leaves spraying with water. The test and control combinations (untreated dry leaves) were set up in 5 replications (Figure 1). After 24, 48, 72 and 96 hours the CPB adults or larvae were counted. Was studied, too, repellent effect of the 9 variants (of experiences regarding the effect of unconventional insecticide preparations) by placing in a corner of a rearing box of 21/21 cm. a treated leaf (according to the initially protocol), in the opposite corner, an untreated leaves and the center of the box were placed three larvae (L_2-L_3) noting larvae preference. Preference scoring was done by the surface of leaf chewed (0 = not eaten; 1 = surface eaten <10%; 2 = surface eaten <30%, 3 = surface eaten <50%, 4 = area eaten <75% and 5 = surface eaten <100%), considering that larva does not eat what is harmful for it.

Figure 1. Laboratory experiment in plastic Petri dishes

RESULTS AND DISCUSSIONS

Were generalized in the world of "connoisseurs" different empirical methods to control this dangerous pest such as: aqueous extract solutions obtained from the Colorado beetle held about a week (1-3 glasses of concentrate per liter of water), though in phytotoxic effect; chilly infusion (10-20 pieces are scalding hot peppers with boiling water and leave to infuse for 12-24 hours) diluted with water; aqueous detergent solution (1 teaspoon dish Ferry/1.5 l water); using ashes in course of tubers planting (under or around them); spraying the plants with soap suspension (2 liters of water 200 grams of soap /8 liters of water); suspension of ash and soap (1 kg of ash boiled in 10 liters of water for 15 minutes and leave 2 days, strain and add 50 g squirting after homemade soap or liquid splash concentrate is diluted 1/10); aqueous extract of walnut (leaves, fruits, bark) in 10 liters for 2-3 days at spraying potato extract strain; infusion of "big grass" (Oman or *Inula helenium*); dusting with ground chicken manure on plants previously moistened; concentrated solution of onion (http://hobbygradina.ro). Of course there are "stories" about using the Colorado beetle ash, but anyway, till now, no one has tried to demonstrate the effectiveness of these empirical methods. We have to underline that "ALL" preparations mentioned above are not approved to be used for controlling of Colorado potato beetle, the simple reason for this is that the results are not scientifically certified, possible standardization of such a product, a mandatory step for registration, cost and market potential outlets is not sufficiently extensive to cover these expenses. The determinations from June 16, at 96 hours after treatment, it was found that, compared to the control, there was an increase in the number of dead adults, not very large (0.4-0.6), in V2-V6 variants and V8, differences being statistically significant, in V1, no differences in mortality compared to controls, there are negative differences, in variants V7 and V9 (-0.2 -0.4 respectively) as presented in table 1. The determinations from July 7, at 96 hours after treatment, it was found that, compared to the control, there was an increase in the number of dead larvae, as for adults, not very large (0.4-1.2), in variants V6 respectively V1, differences being statistically significant, in V2, V3 and V9, no differences in mortality compared to controls, there are negative differences, in variants V4, V5, V7 and V8 (-0.2; -0.6; -0.8 respectively for two last variants) as presented in table 2.

Based on adult mortality, tested products can be divided into three categories: 6 products with greater efficacy than the control; 1 product which is similar to the control and 2 products with lower efficacy than in control. Based on larval mortality, tested products can be divided into three categories: 2 products with greater efficacy than the control; 3 products which are similar to the control and 4 products with lower efficacy than in control. Referring to repellent effect of those 9 variants by placing in a corner of a rearing box, a treated leaf, in the opposite corner, an untreated leaves and the center of the box were placed CPB larvae, noting larvae preference, on the scale from 0 to 5 (depending of leaf eaten surface), it is easy to observe, in table 3, that there is a clear repellent effect of some tested variants (scored through difference between leaf eaten surface of treated and untreated leaf, so, on the first places is V3-ash of grinded beetles burned at 250°C (difference of notes 2 that means leaf surface eaten <30%); there is no difference at V8-decoction of fresh chopped peppers and there is a negative difference at V7-chopped fresh peppers (-0.8, less than <10% surface eaten). Surface of eaten leaves, in case of untreated leaves is between note 3.8 (V2 and V3) and 0.8 (V7). In case of treated leaves surface of eaten leaves, is between note 2.2 (V2) and 1.0 (V5).

Table 1. Adults' mortality after 96 hours (16 June 2014)

Variants of treatments	Adults mortality (average after 96 hours)	Difference	Significance
V1	2.0	0	
V2	2.6	+0.6	***
V3	2.4	+0.4	***
V4	2.6	+0.6	***
V5	2.6	+0.6	***
V6	2.6	+0.6	***
V7	1.8	-0.2	oo
V8	2,4	+0.4	***
V9	1.6	-0.4	ooo
Check	2.0	-	-
DL 5%		*0.121*	
DL1%		*0.184*	
DL0.1%		*0.272*	

Table 3. Repellent effect of 9 variants in concordance with leaf damaged surface

Variants	1		2		3		4		5		6		7		8		9	
	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf	Treated leaf	Untreated leaf
Average	**1.4**	**1.6**	**2.2**	**3.8**	**1.8**	**3.8**	**1.2**	**2.4**	**1.0**	**2.4**	**1.4**	**2.0**	**1.6**	**0.8**	**2.4**	**2.4**	**1.8**	**2.4**
Difference	0.2		1.6		2		1.2		1.4		0.6		-0.8		0		0.6	

Table 2. Larvae' mortality after 94 hours (17 July 2014)

Variants of treatments	Larval mortality (average after 96 hours)	Difference	Significance
V1	2.8	1.2	***
V2	1.6	0	
V3	1.6	0	
V4	1.4	-0.2	ooo
V5	1.0	-0.6	ooo
V6	2.0	0.4	***
V7	0.8	-0.8	ooo
V8	0.8	-0.8	ooo
V9	1.6	0	
Check	1.6	-	-
DL 5%		*0.071087*	
DL1%		*0.119589*	
DL0.1%		*0.172449*	

CONCLUSIONS

- Our experiment proves that "story" about using the Colorado beetle ash, but anyway, till now, no one has tried to demonstrate the effectiveness of these empirical methods.
- Based on adult mortality, tested products can be divided into three categories: 6 products with greater efficacy than the control; 1 product which is similar to the control and 2 products with lower efficacy than in control.
- Based on larval mortality, tested products can be divided into three categories: 2 products with greater efficacy than the control; 3 products which are similar to the control and 4 products with lower efficacy than in control.
- All preparations tested in experiment are not good enough in order to be approved to be used as registered pesticides for controlling of Colorado potato beetle, the results are not scientifically certified, possible standardization of such a product, a mandatory step for registration, cost and market potential outlets is not sufficiently extensive to cover these expenses.

REFERENCES

http://www.cabi.org/isc/datasheet/303802.

Rosca I., 2003. Entomologie agricola speciala. Ed. Didactica si Pedagogica, R. A., Bucuresti, 368 p.

Rosca I., Istrate Rada, 2009. Tratat de Entomologie (Agricultura, Horticultura, Silvicultura). Ed. ALPHA MDN, 699 p.

Rosca I. et al., 2011. Tratat de Entomologie Generala si Speciala, Ed. ALPHA MDN, 1055 p.

Anderman R., 2000. Hemp leaf tea discourages potato bugs. Eco-Farm & Garden, Winter, p. 29.

Kuepper G., 2003. Colorado Potato Beetle: Organic control options. www.attra.ncat.org. p 6.

Grossman J., 1989. Herbal folklore tested. Common Sense Pest Control, Spring, p. 4.

Barbara E., Bradley F.M., 1992. The Organic Gardener's Handbook of Natural Insect and Disease Control. Rodale Press, Emmaus, PA, p. 471.

Scott I.M., Jensen H., Scott J.G., Isman M.B., Arnason J.T., Philogène B.J., 2003. Botanical insecticides for controlling agricultural pests: piperamides and the Colorado Potato Beetle *Leptinotarsa decemlineata* say (*Coleoptera*: *Chrysomelidae*). Arch Insect Biochem Physiol, 54 (4): 212-25.

Williams G., Williams P., 1986. Oak extracts inhibit Colorado potato beetle feeding. HortIdeas, August, p. 86.

Williams G., Williams P., 1988. Leptine vs. Colorado potato beetles. HortIdeas. February.

http://hobbygradina.ro/2011/04/28/ combaterea-gandacului-de-Colorado-prin-metode-bio.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON PEST EVOLUTION TO *PLATANUS* SPP. FROM NURSERIES

Irina NEACSU, Ioan ROSCA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: ioanrosca_usamv@yahoo.com

Abstract

In recent years, in Bucharest and in other urban centres in our country began to be placed Platanus spp. trees. In the area of Bucharest, in the year 2014 was an extension of two dangerous Platanus' pests [The sycamore lace bug (Corythucha ciliata Say, 1832 - Hemiptera: Tingidae) and leaf-mining moth (Phyllonorycter platani Staudinger, 1870 - Lepidoptera: Gracilariidae)]. Research has followed the evolution of these pests in the nursery from Bolintin Deal and identifies other potential pests that have the potential to attack the Platanus spp. Phyllonorycter platani species has been reported in Europe in 1964, in Padova, Italy, and Romania by Kis, in 1990. The greatest danger of this pest is the association brought two fungi Ceratocystis fimbriata Ellis and Halsti. form platani J. M. Walter and Apiognomonia (Gnomonia) veneta Sacc. and Speg. that through synergy with pests can cause decline and death of trees. The two pests have, in addition to their herbivorous character, a negative impact on the visitors of the parks or streets both from the point of view of aesthetics and hygiene and much more sycamore lace bug can be an agent of insect-caused dermatosis considered subjects who visit or live near wooded areas or trees which are infested. In order to carry out effective and well timed control methods, bio monitoring studies of the pests are necessary. The biology, ecology and the vulnerable life periods of the pests were studied. It was noted intensity and frequency of infested leaves, calculating the degree of attack, these indicators are variable, depending on the pest life cycle or the period studied. For Corythucha ciliata recorded population was between the 2 and 8 exemplars/leaf attacked, while for Phyllonorycter platani attack was between 441 and 549 leaves attacked, regarding the number of mine / leaf between 1 and 10 and ranges of attacked leaf surface is between 1.4 and 5.5/attacked leave. Are presented other pests identified in the nursery. It is discussed also the possibility that other important quarantine of Platanus spp. pests to appear in Romania.

Key words*: evolution of Platanus pests in nursery.*

INTRODUCTION

Today many researches were done in European countries on the spread of the main pests of plane (*Platanus* spp.) and on their influence on the decline of this genus. Of the primary pests which have been detected, has spread throughout almost all Mediterranean countries; so also has the insect *Corythucha ciliata*, which causes yellowing of the foliage. On trees declining under the interaction of these pests, secondary pests, agents of bark necrosis and, above all, of wood decay, are often detected (Anselmi et al., 1994). *Corythucha ciliata* (Say), the sycamore lace bug, is originally from North American and feeds on different species of sycamore trees. The bugs generally lives on the undersides of the leaves, stiking and sucking, causing a chlorotic foliage and trees may be defoliated in late summer. Several consecutive years of severe lace bug damage, combined with other stress factors, may kill the trees (Barnard and Dixon, 1983). Heavy infestations are more common in urban areas than in natural settings. Damage is' more severe during dry weather (Filer et al., 1977). The sycamore lace bug was discovered, for the first time, in Europe in 1964 in Padova, Italy. The sycamore lace bug is associated as vectors with two fungi, *Ceratocystis fimbriata* Ellis and Halst. forma *platani* J.M. Walter and *Apiognomonia* (=Gnomonia) *veneta* Sacc. and Spreg., which, in combination with the lace bug, cause decline and death of the trees (Maceljski, 1986). During the past century an outbreak of the leaf mining moth *Phyllonorycter platani* (Sůaudinger, 1870) was observed in Europe. This species is a leaf mining conductor of various species of Platanus trees, in Europe, which is frequently planted in town alleys, cities, castle parks etc. The first indications of the spread of this species were observed at the beginning of the century, but its massive course has been started approximately in the middle of it (Šefrová, 2001). *Phyllonorycter platani* Stdgr., has been recorded in Romania for the first time at Bucharest in 1970 (Drăghia, 1970; Rákosy et al., 2003) or in 1996 by Sandru after Ureche Camelia (Ureche, 2006) Larvae of pest, develop mines large and very distinctive, with several mines often on one leaf in leaves.

MATERIALS AND METHODS

Identification of the pests was done in nursery "Bolintin Deal" at the north of Giurgiu district, 18 km away from Bucharest, near Bucharest-Pitesti highway, in a small company in the field of ornamental plants nursery, its geographical coordinates are 44° 27' 33" North, 25° 49' 16" East. The climate is continental, with very hot summers, and not very important quantities of precipitation which fall as showers, and cold winters with strong blizzards and frequent worm periods. The average rainfall is 650-700 mm / in most rainy month from the year is June (maximum of 24 hours was 103.2 mm at 21.VII.1978). There are years when rainfall was doubled, and years when rainfall decreases, appearing drought and rainfall is 250-300 mm, annual average temperature for this area was 10.2°C average temperature of January was -2.3°C, and the average temperature in July was 23.7°C, (thermal amplitude was 21.4°C). In 2007 the business was started by importing plants from Italy, Holland and France. Experience has taught them that imported plants that have started their life cycle in a certain climate, have lower rooting rates and the plants develop slower. Thus, in 2009 the owners decided to produce their own plants in Romania. The first author started the business by cultivating her first 2000 sq. m. with plants in the field. Now company is growing and at present the production covers over 2 ha plants, (1 ha of container fields). The extremely vast assortment of plants, about 50 species are grown, ranges from deciduous tree to conifers, climbers, roses, topiary, coming in various sizes from small and medium up to unique specimens (*Platanus acerifolia*, *Thuja occidentalis* "Smaragd", *Picea pungens* "Glauca globossa", *Acer platanoides*, roses, *Prunus cerasifera* "Nigra", *Juniperus* spp. etc.). Harmful insect species were noted according to usual methods. Because we done our observation in nursery, number of leaves of *Platanus* trees was considered as average 45. It was taken into consideration 4 batch of Platanus trees (761 trees). Samples were collected in the field, and more detailed processing was carried out in laboratory conditions. Species of insect pests were determined in the laboratory. Microscopic techniques were used to determine of some species. Finally, the found species were classified systematically.

RESULTS AND DISCUSSIONS

Continuing our researches (Balanescu and Rosca, 2014), we surveyed the evolution of main pest of *Platanus* spp.. The Platanus species have few specialized phytophagous pests. During our observations, in 2014, it were registered on *Platanus acerifolia* the following pests: *Corythucha ciliata* Say, 1832 (Sycamore lace bug), order Hemiptera, family Tingidae; *Phyllonorycter platani* (Sycamore leaf-miner pest) Staudinger, 1870, order Lepidoptera family Gracilariidae; *Acalyptris platani* Müller-Rutz, 1934, order Lepidoptera, family Nepticulidae; possible *Epirrita autumnata* Borkhausen, 1794 (autumnal moth) order Lepidoptera, family Geometridae; probably *Acleris forsskaleana* Linnaeus 1758 (Maple Leaftier Moth) Lepidoptera, Tortricidae; *Fagocyba cruenta* Herrich-Schäffer, 1838, order Homoptera, family Cicadellidae and *Drepanosiphum platanoidis (= platanoides*) (Common Sycamore Aphid) order Homoptera, family Drepanosiphidae.

Corythucha ciliata Say, 1832 (Sycamore lace bug) (Figure 1), it was observed from August, but it's attack was no heavy. From 761 trees, in 18 August, only 5 (1.31%) were attacked with 6 leaves with pest colonies, in 29 August, 9 (1.18%) with 19 leaves with pest colonies, in 18 September, 48 (6.31%) with 122 leaves with pest and in 16 October, 47 (6.18%) with 144 leaves with pest colonies. Maximum number of adults and nymphs/leaf was 45. The sycamore lace bug is the only lace bug listed as feeding on *P. occidentalis* according to the world host list for lace bugs (Drake and Ruhoff, 1965). Adults are whitish in color (body is brown to black in color) and about 3 mm in length. For practical purposes, the association with the host plant should be diagnostic for this species (http://entnemdept.ufl.edu/). The sycamore lace bug feeds on the undersides of leaves, causing desiccation of tissue, first near the veins, and subsequently affecting the entire leaf, which may drop prematurely. The most detailed life history information on sycamore lace bug can be found in Wade (Wade, 1917). According to Wade's observations in Oklahoma, mating pairs of sycamore lace bugs initiate colonies by laying eggs along leaf veins, especially near the forks. One to several pairs occupy a newly colonized leaf. Sycamore lace bugs overwinter as adults, either under loose bark of the trees, or in nearby cracks and crevices. They are extremely cold tolerant, withstanding temperatures as low as -23.3°C. According to Wade (1917), the flying wings of adults are very delicate, and thus, these insects rarely fly very far, however, Maceljski (1986) writes that adults "are very mobile and are good fliers. Supported by wind they can fly over many kilometers", both authors surmise that the majority of long distance distribution occurs as a result of human activity. First generation adults appear in June and second generation appears around July/August (http://fera.co.uk/plantClinic/). Adults survive the winter under peeling bark of the sycamore tree.

Figure 1. Sycamore lace bug (*Corythucha ciliata*), adults, larvae and frass

Adults become active in the spring when sycamore leaves begin to develop. The nymphs are wingless, smaller and darker than the adults, their body has spines. Adults and nymphs feed on the undersides of leaves, around the feeding sites, the leaf tissue turns yellow (Figure 2).

Figure 2. Feeding sites, early indicators of Sycamore lace bug activity

Damage to trees is typically not serious, but heavy infestations can reduce growth.In Romania the pest was first recorded in 1990 when Kis collected it at Craiova, after that it has recorded in 2010, at Sibiu (Tatu and Tăuşan, 2011).

Phyllonorycter platani Staudinger, 1870 (Sycamore leaf-miner pest), (Figure 3), it was observed on 30 August as initial attack with small larvae in leaves mines (Figure 4), which become large and very distinctive, with several mines often appearing on one leaf in October (Figure 5). The moths fly in late April to May and in August. Wingspan (distance from one wingtip to the other wingtip) is 8-10 mm. The pupae overwinter in mines in fallen leaves and there are 3 adult flights a year in Netherland (Frankenhuyzen, 1983) or two generations in late April to May and in August, in London (http://ukmoths.org.uk/). Pest attack was no heavy. In 18 August and 16 October from 761 trees 222 (29.17%) were attacked by pest, from these 41.38% had only 1 leaf attacked with one mine, 6.9% with two mines, 17.24% with three mines and 34.48% with five mines. The pest larvae of moths is colourless and transparant have a head capsule and chewing mouthparts with opposable mandibles, six thoracic legs and abdominal legs. In leaf mine, larvae made two types of frass: small, light brown granules scattered throughout the mine, and larger blackish brown grains in an elongate clump. The light spots are windows the larva has eaten in the palissade parenchyma, the roof of the mine. The pupa is found inside a white cocoon (Pitkin et al., 2011).

Figure 3. Sycamore leaf-miner pest (*Phyllonorycter platani*), adult

Figure 4. Sycamore leaf-miner pest initial attack on upper leaf surface

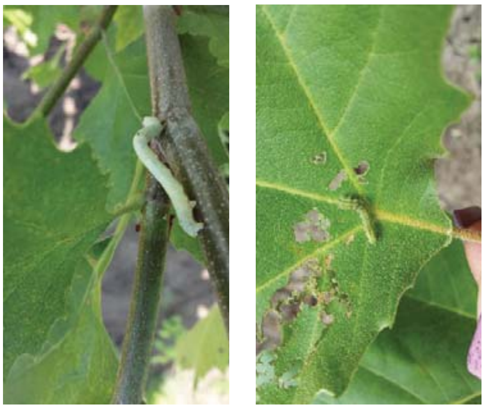
Figure 5. Sycamore leaf-miner pest attack as large mines on underside leaf surface

Figure 6. Sycamore leaf-miner pest attack as large mines on underside leaf surface

Acalyptris platani (Müller-Rutz, 1934), Lepidoptera, Nepticulidae observed in France, Greece, Italy, Switzerland, Slovenia, Croatia and Bulgaria, it seems to be present, for the first time recorded in Romania (this is the conclusion only after larvae attack (Figure 7), but its presence has to be confirmed in the future, taking into consideration that the species was registered in Romania (Laštůvka and Laštůvka, 1997). The second specialized lepidopteran leaf miner in Europe is *Acalyptris platani* (MtillerRutz, 1934). This species reaches the limits of central Europe only in Switzerland, it is known also from southwestern Croatia, northern Italy and southern France (Pitkin et al., 2011).

Figure 7. *Acalyptris platani* leaf attack

Defoliators (Figure 8), during 2014, in nursery, there were registered a heavy attack of two species of defoliators. From 761 trees, from 16 August till 16 October, only 24.7% of trees were attacked by defoliators. It was impossible to rear larvae till adults or to identify species or larvae. One of them is a geometrid the other one is tortricid probably *Acleris forsskaleana* Linnaeus 1758 (Maple Leaftier Moth) Lepidoptera, Tortricidae.



A B

Figure 8. Defoliators' larvae.
A - Geometridae; B - Tortricidae

Fagocyba cruenta Herrich-Schäffer, 1838, Homoptera, Cicadellidae, adult 3.5-4 mm length (Figure 9), appear from June to October in the nursery, till now, in Romania pest was noted on *Acer pseudoplatanus* (http://www.faunaeur.org/;http://www.commanster.eu/). Extremely variable in colour, with the head and pronotum varying from pale to grey-brown or chestnut brown. This is one of the typical colourations, with the clavus and apices of the forewings suffused greyish. The species can be abundant on some trees, but most notably beech, which hosts few other leafhoppers. There is a similar species, *F. carri*, which occurs locally on oak, and can only be reliably distinguished by microscopic examination.

Figure 9. *Fagocyba cruenta*, adult

Drepanosiphum platanoidis (*=platanoides*) Schrank, 1801 (Common Sycamore Aphid) was present on Platanus trees (Figure 10). Alate aphids have yellow-brown head and thorax with darker brown markings, and a pale green abdomen. Those that develop early or late in the year have cross-bars present (see first picture below), but these are never restricted to abdominal tergites 4-5. Alates that devevelop in mid-summer are much paler and have no cross bars (second picture below). The antennae are brown and the siphunculi are pale with a brown tip. The forewing has no black spot at the tip nor one at the outer end of the pterostigma; the pterostigma is defined by two longitudinal brown stripes. The body length is 3.2-4.3 mm. The aphid lives on the undersides of leaves of sycamore (*Acer pseudoplatanus*). It is also recorded from many other *Acer* spp., as well as a wide variety of other trees which are apparently only visited on a casual basis. Sexual forms occur in September-November. It is a cosmopolitan species which is common on sycamores wherever they are grown (http://influentialpoints.com/).

Figure 10. *Drepanosiphum platanoidis* Schrank, 1801 larvae

CONCLUSIONS

- The Platanus species have few specialized phytophagous pests.
- During our observations, in 2014, it were registered on *Platanus acerifolia* the following pests: *Corythucha ciliata*; *Phyllonorycter platani*; *Acalyptris platani*; possible *Epirrita autumnata*; probably *Acleris forsskalean*; *Fagocyba cruenta* and *Drepanosiphum platanoidis*.
- *Corythucha ciliata*, it was observed from August, but it's attack was no heavy, from 761 trees, in 18 August, only 5 (1.31%) were attacked with 6 leaves with pest colonies, in 29 August, 9 (1.18%) with 19 leaves with pest colonies, in 18 September, 48 (6.31%) with 122 leaves with pest and in 16 October, 47 (6.18%) with 144 leaves with pest colonies.
- *Phyllonorycter platani* pest attack was no heavy. In 18 August and 16 October from 761 trees 222 (29.17%) were attacked by pest, from these 41.38% had only 1 leaf attacked with one mine, 6.9% with two mines, 17.24% with three mines and 34.48% with five mines.

REFERENCES

Anselmi et al., 1994. Plane decline in European and Mediterranean countries: associated pests and their

interactions. EPPO Bulletin Vol. 24, Issue 1, p. 159-171.
Barnard E.L., Dixon W.N., 1983. Insects and diseases: Important problems of Florida's forest and shade tree resources. Florida Department of Agriculture and Consumer Services, Gainesville, FL. Bulletin No. 196-A. 120 p.
Filer et al., 1977. Sycamore pests: A guide to major insects, diseases, and air pollution. USDA Forest Service, Atlanta, GA. 36 p.
Maceljski M., 1986. Current status of Corythuca [sic] ciliata in Europe. Bulletin OEPP/EPPO Bulletin 16: 621-624.
Šefrová H., 2001. *Phyllonorycter platani* (Staudinger)-a review of its dispersal history in Europe (Lepidoptera, Gracillariidae). Acta Universitatis Agricultures et Silviculturae Mendelianae Brunensis Sborník Mendelovy Zemědělské a Lesnické Univerzity v Brně, Ročník IL, Císlo 5, p. 71-75.
Drăghia I., 1970. Nouvelles contributions à la connaissance des insectes mineurs de Bucarest et de ses environs. Trav. Mus. Hist. nat. „Grigore Antipa". Bucarest. 10: 235-240.
Rákosy et al., 2003. Catalogul Lepidopterelor României/ Verzeichnis der Schmetterlinge Rumäniens. Soc. Lepid. Rom. Cluj-Napoca. Tipar Romsver, Cluj-Napoca, 447 p.
Ureche C., 2006. Invasive leaf miner insects in Romania. IUFRO Working Proceedings of the Workshop 2006, Gmunden/Austria.
Balanescu I., Rosca I., 2014. Platanul se raspandeste in orase si parcuri. Atentie la daunatori. Sanatatea Plantelor, 197, nr. 10, p. 24.
Drake C.J., Ruhoff F.A., 1965. Lacebugs of the World: A Catalog (Hemiptera: Tingidae). Smithsonian Institution, Washington, D.C. United States National Museum Bulletin 213. 634 p.
http://entnemdept.ufl.edu/
Wade O., 1917. The sycamore lace-bug (*Corythucha ciliata*, Say). Oklahoma Agricultural Experiment Station Bulletin No. 116, 16 p.
http://fera.co.uk/plantClinic/
Tatu Al., Tăuşan I., 2011. *Corythucha ciliata* (Say, 1832) (Hemiptera: Tingidae) – Second record for the lace bug fauna of Romania Brukenthal. Acta Musei, VI. 3: 453-458.
Frankenhuyzen A. van, 1983. *Phyllonorycter platani* (Staudinger, 1870) (Lep. Gracillariidae), a leaf-miner on Platanus in the Netherlands. Entomologische Berichten, Vol. 43, No. 2, p. 19-25.
http://ukmoths.org.uk/
Pitkin B. et al., 2011. The leaf and stem mines of British flies and other insects. (Coleoptera, Diptera, Hymenoptera, Lepidoptera) http://www.ukflymines.co.uk/-viewed on 13/02/2015.
Laštůvka A., Laštůvka Z., 1997. Nepticulidae Mitteleuropas. Ein illustrierter Begleiter (Lepidoptera). Konvoj, Bmo, 230 s.
http://www.faunaeur.org/
http://www.commanster.eu/
http://influentialpoints.com/

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DETERMINATION OF WEEDS IN RICE FIELDS OF SOUTH EASTERN ANATOLIA REGION OF TURKEY

Cumali ÖZASLAN

Dicle University, Faculty of Agriculture, Plant Protection Department, 21280 Diyarbakır, Turkey

Corresponding author email: cumali.ozaslan@dicle.edu.tr

Abstract

This study was conducted in 2012 to determine the most prevalent and challenging weeds in the rice fields of Southeastern Anatolia, Turkey. Rice production in the region differs from the other regions as conservational tillage practices are being opted in the region in contrast to conventional tillage practices in the other regions of the country. As a result of the survey total 70 different weedy species belonging to 22 families were observed. The incidence and frequency of all the weedy species observed was calculated and families were ranked according to incidence and frequency. Poaceae, Asteraceae and Cyperaceae were the most prevalent families having 12, 12 and 8 species while the rest 19 families were represented with 1-4 species. This survey gives the current prevalence of weedy species in the rice fields, and the information being presented in this article will help in devising management options for the troublesome weeds in the region.

Key words: *rice, South Eastern Anatolia Region, weeds, survey.*

INTRODUCTION

Rice (*Oryza sativa* L.) has the largest cultivated acreage after wheat and ranks third regarding total production after wheat and maize in the world. Despite of its low protein content this crop is rich of essential amino acids. For that reason, it is most widely used in human nutrition following wheat (Elçi et al., 1994). Rice cultivation was firstly practiced in South India and spread to China in 3000 BC and to Java in 1000 BC. It was introduced to Europe during the expedition of Alexander the Great into Asia in 300 BC. It is assumed that this crop entered to Turkey from the South about 500 years ago (Kün, 1985). About 91% of world rice production is consumed by Asian countries (Finnasi, 1979). According to statistical data during 2010, rice was cultivated on 99,000 ha with total production of 860,000 tonnes and average yield 8,690 kg ha^{-1}. In south eastern Anatolia the rice acreage was about 5915 ha (4.7% of total), production was 30675 tonnes with average yield of 5190 kg ha^{-1} (Anonim, 2015). Şanlıurfa and Diyarbakır provinces contributed the 98% of total rice production in the region during 2010. Total rice acreage was 3345 and 2438 ha with average production of 1788 and 1235 tonnes in Şanlıurfa and Diyarbakır provinces respectively (Anonim, 2015).

Euphrates and Tigris rivers constitute the main fresh water resources and the Karacadağ elevation zone receives the most of snowfall in the region. Irrigation water is obtained from the snowmelt waters in March and April. This is why irrigation water temperature in rice fields is low and the way of rice cultivation in the region is called as cold water rice cultivation.

As a local rice variety, Karacadağ rice is especially cultivated in Diyarbakır (Karacadağ basin along with Çınar, Hazro, Çermik and Kocaköy districts), Şanlıurfa (Siverek and Viranşehir districts), Mardin (Derik district), Siirt and Adıyaman provinces. Karacadağ rice genotype receives the intensive demand from the local farming community. Rice cultivation is, in general, performed to be pan-style irrigation system in Turkey. However, in Karacadağ elevation zone flood irrigation system is used in crop production. The reason for this is that the land is not suitable for tillage due to the presence of stones in the soil. Karacadağ rice is special for the region and takes its name from the inactive volcanic mountain Karacadağ where it is intensely cultivated. Karacadağ elevation zone has a thin soil layer formed by deposition of volcanic blow outs with a high organic matter content (5%). Sowing is done keeping the seed rate of 160-180 kg ha^{-1}. Seed is broadcasted from mid-

April to late May and flood irrigation method is opted to fulfil the moisture requirements of the crop. Embankments are constructed over regular intervals in the rice fields to allow only the irrigation water to stay in the fields and avoid run off. Commercial fertilizer are rarely used while, the herbicide application has recently been inducted in the rice production system of the region. In the past, the crop was manually harvested, sundried for several weeks and then threshed but nowadays mechanical harvesting with combine harvester is being practiced in plain areas (Anonim, 2014). Due to the difference in cultivation and tillage practices, prevalent and troublesome weeds show great variation throughout the region. Without optimum weed control, achieving optimum yield is virtually impossible in rice. Rice yield ad quality is linearly affected by weeds. Due to the highlighted reasons, an effective weed control is inevitable to eliminate the yield and quality losses posed by weeds. To develop the effective weed control, determination of the prevalent and troublesome weeds is the core step. Rice is the only cereal germinating in submerged/waterlogged conditions and it grows using the dissolved oxygen in irrigation water. Since the competitive ability of the weeds is fairly high, rice crop cannot compete with weeds and they under develop with a dwarf and low tillering, low and poor quality yield.

This study was conducted to determine the prevalence and frequency of troublesome weed species in the rice fields of south eastern Anatolia.

MATERIALS AND METHODS

Survey studies were conducted in 2012 to determine the problematic weed species in rice production fields of south eastern Anatolia region of Turkey. In total 56 fields were surveyed in Diyarbakır (Karacadağ basin along with Çınar, Hazro, Çermik and Kocaköy districts), Şanlıurfa (Siverek and Viranşehir districts), Mardin (Derik district), Siirt and Adıyaman provinces where rice crop is widely cultivated. In field surveys, a 0.25 m^2 quadrate (50 cm × 50 cm) was used. To avoid the biasness in the survey data, 5 quadrates were randomly thrown in different parts of the field under survey in diagonal fashion. In order to avoid border effects quadrates sampling was started at least 15 m inside from the border of the fields alongside an imaginary diagonal line. Individual weeds in the quadrates were counted according to their genus & species in order to calculate arithmetic means, and their incidence and frequency rates m^{-2} (Odum, 1971). Additionally, individuals outside the quadrates were recorded (Uluğ et al., 1993). Unknown species in the fields were collected according to technical requirements, numbered, pressed and taken to laboratory for identification. Species identification of the weeds determined in the region was mainly accomplished according to Davis (1965-1988). Specie identifications were approved by Prof. Dr. A. Selçuk Ertekin Department of Biology, Faculty of Science Dicle University, Diyarbakır Turkey. The formulas used in the calculations were given below.

Intensity (plant m^{-2}) = Y / n

Incidence (%) = (M / n) × 100

Y = Number of individuals of a species within the quadrate.

M = Number of quadrates a plant species occurred.

n = Total number of quadrates thrown.

RESULTS AND DISCUSSIONS

As a result of survey, 70 different species of 22 families were determined, of which one was fern (pteridophyta), 20 were monocotyledonous and 49 were dicotyledonous. The most common families in the surveyed rice fields were *Poaceae* (12 species), *Asteraceae* (12 species) and *Cyperaceae* (8 species). The rest 19 families were represented by 1-4 numbers of species (Table 1).

Incidence (%) and frequency of the weeds (weed m^{-2}) determined in the Karacadağ rice fields exhibited huge variations (Table 2). It is obvious from Table 2 that 15, 14, 9, 8 and 13 weeds in Diyarbakır, Şanlıurfa, Mardin, Adıyama and Siirt provinces respectively were present in more than 50% of rice fields (frequency more than 50%) surveyed. The numbers of weed species of with frequency more than 1% are 4 in Diyarbakır and Şanlıurfa, 3 in Siirt, 2 in Adıyaman and 1 in Mardin. The number of weeds determined in more than 50% of the rice fields over the whole region was 12 and four weed species with frequency more than 1%.

Table 1. Family and species for the weeds determined in the surveyed fields of local Karacadağ rice genotype

FAMILY	No. of species	FAMILY	No. of species
PTERIDOPHYTA			
Equisetaceae	1	*Euphorbiaceae*	1
MONOCOTYLEDONEAE		*Fabaceae*	4
Cyperaceae	8	*Guttiferae*	1
Poaceae	12	*Lamiaceae*	3
DICOTYLEDONEAE		*Lythraceae*	1
Alismataceae	1	*Malvaceae*	3
Amaranthaceae	2	*Onagraceae*	2
Apiaceae	2	*Plantaginaceae*	2
Asteraceae (Compositae)	12	*Polygonaceae*	4
Boraginaceae	1	*Portulacaceae*	1
Chenopodiaceae	1	*Scrophulariaceae*	3
Convolvulaceae	2	*Solanaceae*	3
Total	**42**		**28**
General Total			**70**

Weed species with more than 50% frequency of the total surveyed area in Diyarbakır were *Amaranthus retroflexus*, *Lactuca serriole, Xanthium strumarium*, *Cyperus glomeratus*, *C. longus*, *Lythrum hyssopifolia*, *Cynodon dactylon*, *Echinochloa crus-galli*, *Eragrostis collina*, *Poa nemoralis*, *Sorghum halepense*, *Polygonum persicaria*, *Veronica anagallis-aquatica* subsp. *lysimachioides*, *Physalis angulata* ve *Physalis philadelphica.* Weeds species with frequency more than 1% were *A. retroflexus*, *X. strumarium*, *L. hyssopifolia* and *E. crus-galli*

Weed species found in more than 50% of the total surveyed area in Şanlıurfa were *A. retroflexus*, *L. serriole*, *X. strumarium*, *C. glomeratus*, *C. longus*, *Scirpoides holoschoenus*, *Mentha longifolia*, *L. hyssopifolia*, *C. dactylon*, *E. crus-galli*, *P. nemoralis*, *P. persicaria*, *P. angulata* ve *P. philadelphica.* Weeds species having weeds more than one per unit area in Şanlıurfa were *A. retroflexus*, *X. strumarium*, *L. hyssopifolia* and *E. crus-galli.*

Weed species found in more than 50% of the total surveyed area in Mardin were *X. strumarium*, *Cyperus fuscus*, *C. glomeratus*, *C. longus*, *L. hyssopifolia*, *E. crus-galli*, *S. halepense*, *P. angulata* and *P. philadelphica*. Weeds species having more than one individual per unit area in Mardin was only *E. crus-galli*.

Weed species found in more than 50% of the total surveyed area in Adıyaman were *X. strumarium*, *C. glomeratus*, *L. hyssopifolia*, *E. crus-galli*, *Echinochloa oryzicola*, *S. halepense*, *Polygonum lapathifolium* ve *P. philadelphica*. Weeds species having more than one individual per unit area in Adıyaman were *X. strumarium* and *L. hyssopifolia*.

Weed species found in more than 50% of the total surveyed area in Siirt were *Alisma plantago-aquatica*, *X. strumarium*, *Cyperus difformis*, *C. glomeratus*, *C. longus*, *M. longifolia*, *L. hyssopifolia*, *Epilobium parviflorum*, *E. crus-galli*, *E. oryzicola*, *Phragmites austrialis*, *S. halepense*, *P. lapathifolium* and *P. persicaria*. Weeds species having more than one individual per unit area in Siirt were *Bidens cernua*, *L. hyssopifolia* and *E. crus-galli*.

Weed species found in more than 50% of the total surveyed area in south eastern Anatolia were *A. retroflexus*, *X. strumarium*, *C. glomeratus*, *C. longus*, *M. longifolia*, *L. hyssopifolia, C. dactylon*, *E. crus-galli*, *S. halepense*, *P. persicaria*, *Physalis angulata* ve *Physalis philadelphica*. Weeds species representing more than one individual per unit area in South Eastern Anatolia were *A. retroflexus*, *X. strumarium*, *L. hyssopifolia* and *E. crus-galli*.

Table 2. Incidence and frequency of the weeds present in growing areas of local Karacadağ rice genotype district wise and the region as whole (%, weed m^{-2})

WEED SPECIES	Survey Area in South Eastern Anatolia Region											
	Diyarbakır		Şanlıurfa		Mardin		Adıyaman		Siirt		Total	
	%	Plant m^{-2}	%	Plant m^{-2}	%	Plant m^{-2}	%	Plant m^{-2}	%	Plant m^{-2}	%	Plant m^{-2}
Fam: *ALISMATACEAE*												
Alisma plantago-aquatica L.	-	-	-	-	-	-	-	-	45	0.5	9	0.1
Fam: *AMARANTHACEAE*												
Amaranthus retroflexus L.	85	1.6	92	1.8	25	0.5	29	0.8	35	0.9	53.2	1.12
Amaranthus albus L.	36	0.4	29	0.2	38	0.4	12	0.1	-	-	23	0.22
Fam: *APIACEAE*												
Eryngium campestre L.	24	0.3	43	0.6	26	0.2	16	0.1	15	0.1	24.8	0.26
Eryngium creticum Lam.	13	0.1	20	0.3	-	-	-	-	-	-		
Fam: *ASTERACEAE* (*Compositae*)												
Anthemis sp.	36	0.2	42	0.3	42	0.2	22	0.1	25	0.1	33.4	0.18
Artemisia vulgaris L.	25	0.1	-	-	-	-	36	0.1	23	0.1	16.8	0.06
Bidens cernua L.	22	0.4	27	0.3	-	-	36	0.8	88	1.5	34.6	0.6
Cichorium intybus L.	23	0.1	33	0.1	16	0.1	-	-	-	-	14.4	0.06
Conyza canadensis (L.) Cron.	36	0.2	44	0.4	-	-	18	0.1	14	0.1	22.4	0.1
Lactuca aculeata Boiss.	34	0.1	-	-	-	-	-	-	12	0.1	9.2	0.04
Lactuca saligna L.	22	0.1	26	0.2	18	0.1	-	-	-	-	13.2	0.08
Lactuca serriole L.	66	0.4	55	0.5	30	0.1	24	0.2	33	0.2	41.6	0.28
Notabasis syriaca (L.) Cass.	10	0.1	14	0.1	-	-	-	-	-	-	4.8	0.04
Sonchus sp. (eşek marulu)	19	0.1	36	0.1	22	0.1	15	0.1	-	-	18.4	0.08
Xanthium spinosum L.	-	-	29	0.1	-	-	-	-	-	-	5.8	0.02
Xanthium strumarium L.	70	1.4	76	1.2	73	0.8	66	1.1	48	0.6	66.6	1.02
Fam: *BORAGINACEAE*												
Heliotropeum europaeum L.	-	-	32	0.1	-	-	-	-	-	-	6.4	0.02
Fam: *CHENOPODIACEAE*												
Chenopodium album L.	-	-	-	-	-	-	18	0.1	14	0.1	6.4	0.04
Fam: *CONVOLVULACEAE*												
Convolvulus arvensis L.	23	0.3	33	0.1	19	0.1	30	0.2	43	0.4	29.6	0.22
Convolvulus galaticus Roston. Ex Choisy	36	0.1	43	0.2	-	-	-	-	-	-	15.8	0.06
Fam: *CYPERACEAE*												
Carex sp.	25	0.2	38	0.3	-	-	-	-	-	-	12.6	0.1
Cyperus difformis L.	38	0.3	46	0.4	42	0.3	47	0.4	50	0.4	44.6	0.36
Cyperus fuscus L.	29	0.2	34	0.3	50	0.2	36	0.2	46	0.3	39	0.24
Cyperus glomeratus L.	68	0.6	72	0.8	65	0.5	56	0.4	61	0.5	64.4	0.56
Cyperus longus L.	55	0.5	63	0.7	50	0.2	48	0.3	36	0.2	50.4	0.38
Cyperus rotundus L.	27	0.1	29	0.1	-	-	-	-	-	-	11.2	0.04
Cyperus serotinus Rottb.	23	0.2	36	0.3	23	0.1	33	0.2	36	0.2	30.2	0.2
Scirpoides holoschoenus (L.) Sojak.	42	0.1	55	0.1	39	0.1	28	0.1	33	0.1	39.4	0.1
Fam: *EQUISETACEAE*												
Equisetum sp.	18	0.1	26	0.1	-	-	-	-	23	0.2	13.4	0.08
Fam: *EUPHORBIACEAE*												
Chrozophora tinctoria (L.) Rafin.	27	0.2	28	0.3	27	0.1	22	0.3	-	-	20.8	0.18
Fam: *FABACEAE*												
Trifolium arvense L.	24	0.1	29	0.1	30	0.1	14	0.1	12	0.1	21.8	0.1
Trifolium haussknechtii var. *haussknechtii* Boiss.	26	0.1	31	0.1	-	-	12	0.1	14	0.1	16.6	0.08
Trifolium resupinatum L.	22	0.1	24	0.1	-	-	-	-	-	-	9.2	0.04
Vicia sativa L.	36	0.1	32	0.2	46	0.2	42	0.3	26	0.2	36.4	0.2
Fam: *GUTTIFERAE*												
Hypericum triquetrifolium Turra.	-	-	21	0.1	32	0.1	32	0.2	28	0.1	22.6	0.1
Fam: *LAMIACEAE*												
Mentha longifolia (L.) Hudson	46	0.3	66	0.5	44	0.2	42	0.2	55	0.3	50.6	0.3
Mentha spicata L.	33	0.2	36	0.2	-	-	-	-	-	-		
Marrubium sp.	-	-	-	-	-	-	16	0.1	24	0.1	8	0.04
Fam: *LYTHRACEAE*												
Lythrum hyssopifolia L.	85	1.4	92	1.6	75	0.9	85	1.2	88	1.8	85	1.38
Fam: MALVACEAE												
Alcea setosa (Boiss.) Alef.	26	0.1	36	0.1	-	-	-	-	-	-	12.4	0.04
Hibuscus trionum L.	35	0.1	25	0.1	34	0.1	35	0.1	25	0.1	30.8	0.1
Malva sp.	38	0.1	24	0.1	26	0.1	22	0.1	18	0.1	25.6	0.1
Fam: *ONAGRACEAE*												
Epilobium parviflorum Schreber	-	-	-	-	-	-	43	0.6	56	0.4	19.8	0.2
Epilobium hirsutum L.	42	0.2	38	0.2	-	-	-	-	-	-	16	0.08
Fam: *PLANTAGINACEAE*												
Plantago lanceolata L.	34	0.1	19	0.1	33	0.1	18	0.1	38	0.2	28.4	0.12
Plantago major L.	49	0.2	18	0.1	28	0.1	33	0.2	45	0.2	34.6	0.4
Fam: *POACEAE*												
Agrostis capillaris L.	36	0.1	33	0.1	22	0.1	36	0.1	29	0.1	31.2	0.1
Cynodon dactylon (L.) Pers.	76	0.6	68	0.3	45	0.4	42	0.2	25	0.7	51.2	0.44
Digitaria sanguinalis (L.) Scop.	46	0.2	35	0.2	21	0.1	16	0.1	27	0.2	29	0.16
Echinochloa colonum (L.) Link.	36	0.1	26	0.1	-	-	-	-	-	-	12.4	0.04
Echinochloa crus-galli (L.) P.B.	95	1.4	96	1.6	82	1.1	73	0.8	85	1.2	86.2	1.22
Echinochloa oryzicola Vasing	49	0.1	28	0.1	32	0.1	66	0.4	73	0.7	49.6	0.28
Eragrostis collina Trin.	64	0.3	42	0.2	26	0.1	22	0.2	33	0.1	37.4	0.18
Phragmites austrialis (Cav.) Trin. ex Steudel	-	-	-	-	-	-	-	-	76	0.3	15.2	0.06
Poa nemoralis L.	72	0.1	54	0.1	36	0.1	25	0.1	42	0.1	45.8	0.1
Polypogon monspeliensis (L.) Desf.	-	-	-	-	46	0.1	-	-	39	0.1	17	0.04
Setaria viridis (L.) P. Beauv.	-	-	36	0.1	-	-	-	-	28	0.1	7.2	0.04
Sorghum halepense (L.) Pers.	69	0.5	67	0.6	51	0.4	62	0.6	73	0.8	64.4	0.58
Fam: *POLYGONACEAE*												
Polygonum aviculare L.	36	0.2	19	0.1	28	0.1	25	0.2	17	0.1	25	0.14
Polygonum lapathifolium L.	29	0.1	44	0.3	36	0.1	56	0.3	75	0.8	48	0.32
Polygonum persicaria L.	71	0.3	72	0.4	44	0.2	49	0.4	62	0.5	59.6	0.36
Rumex crispus L.	42	0.1	41	0.1	26	0.1	-	-	-	-	21.8	0.06
Fam: *PORTULACACEAE*												
Portulaca oleracea L.	29	0.1	17	0.1	22	0.1	17	0.1	26	0.1	22.2	0.1
Fam: *SCROPHULARIACEAE*												
Veronica anagallis-aquatica subsp. *lysimachioides* (Guss) Sch.	56	0.3	46	0.4	24	0.1	23	0.1	-	-	29.8	0.18
Veronica anagallis-aquatica subsp. *oxycarpa* (Boiss) Elenevskyi	32	0.1	17	0.1	24	0.1	-	-	-	-	14.6	0.06
Veronica lysimachioides (Boiss.) M.A.	29	0.1	36	0.2	-	-	-	-	-	-	13	0.06
Fam: *SOLANACEAE*												
Physalis angulata L.	68	0.6	76	0.7	65	0.4	45	0.2	32	0.2	57.2	0.42
Physalis philadelphica Lam.	75	0.9	82	0.9	76	0.5	66	0.3	46	0.3	69	0.58
Solanum nigrum L.	36	0.2	23	0.1	18	0.1	24	0.1	23	0.1	24.8	0.12

CONCLUSIONS

According to the results weed species found in more than 50% of the total Karacadağ rice growing area and the species having plants more than one per unit area in South Eastern Anatolia were *Alisma plantago-aquatica*, *Amaranthus retroflexus*, *Bidens cernua, Cynodon dactylon*, *Cyperus difformis*, *Cyperus fuscus*, *Cyperus glomeratus*, *Cyperus longus*, *Echinochloa crus-galli*, *Echinochloa oryzicola*, *Epilobium parviflorum*, *Eragrostis collina*, *Lactuca serriole*, *Lythrum hyssopifolia*, *Mentha longifolia*, *Phragmites austrialis*, *Physalis angulata*, *Physalis philadelphica*, *Poa nemoralis*, *Polygonum lapathifolium*, *Polygonum persicaria*, *Sorghum halepense*, *Veronica anagallis-aquatica* subsp. *lysimachioides* and *Xanthium strumarium*. In a study conducted in Uzunköprü district of Edirne province *Diplachne fusca*, *Echinochloa crus-galli*, *Cyperus rotundus, Echinochloa oryzoides*, *Paspalum paspalodes*, *Ammania baccifera*, *Lindernia dubia* and *Scirpus maritimus* were reported to be the most frequent weed species (Uzun and Demirkan, 2013). Also, in another study conducted in the rice fields of Marmara region *Cyperus* spp., *Scirpus* spp. and *Alisma plantago-aquatica* were determined to be the dominant weed species (Özdemir, 1992). Moreover, in a study conducted in south eastern Anatolia 32 years ago 14 weed species were determined and reported that *E. crus-galli*, *E. oryzicola*, *E. macrocarpa*, *E. colonum*, *Cyperus difformis* and *Cyperus fuscus* were the most important weeds of the rice fields in the region (Uzun, 1983). In other studies these weeds were also reported to be important weeds (Işık et al., 2000; Damar, 2006; Chang, 1970). In addition, it was claimed that yield loss in rice varied between 40-66% due to to the incidence of *E. crus-galli* in rice (Smith et al., 1977). The small numbers of weeds determined in this survey were similar to the already determined weeds in rice fields during different studies. However, there were number of weeds observed during the survey which were different to the previously observed weeds. Obviously there are a number of reasons for that but probably the most important reason is the differences in soil and climate of the regions, farming systems and amount of herbicides applied. It can be inferred from the results that *A. retroflexus*, *X. strumarium*, *L. hyssopifolia*, *E. crus-galli* come first regarding the frequency rates as *E. crus-galli*, *L. hyssopifolia*, *A. retroflexus* and *X. strumarium* come first in line in terms of incidence. In addition to the other weeds these four species must be taken under control because of their intensive seed production potential, longer viability in the soil seed bank and serious yield losses in cultivated crops.

In addition to the weed competition with crop plans, presence of weed seeds in the rice at the time of harvest decrease its commercial value. Moreover, the use of this seeds contaminated with weed seeds for raising next crop creates the weed problem even in the fields which were weed free earlier. Due to the reason, prevention of the infestations is of pivotal importance in rice farming. Moreover, harvesting and threshing cost for the infested rice fields increase as the weed infestation becomes intense in the rice fields. Total global rice production is approximately 680 million tonnes, with around 90% grown in Asia (FAO, 2009). Rice production is challenged by multiple pests, with weeds reducing global rice production by around 10% (Oerke, 2006). Knowing the rice weed species and density in order to take control of weed species is important. Due to the continuously changing climate, rapid changes are being observed in weedy plants' distribution and abundance. The dramatic changes in temperature and CO_2 are predicted to heavily infect the density of weedy plants. In order to keep the weeds under control in changing climat scenario, knowing their density and prevalence is of key importance. The changing climate can equally affect the weed communities in rice fields.

As a result of the ever increasing world population, demand for food and quality is rising. Therefore, to maintain the quality of the rice; weeds problem must be sorted out on priority basis. The weed scientists must determine the important weeds for different crops particularly rice in the above addressed region and devise effective management strategies.

ACKNOWLEDGEMENTS

The study has been supported by Dicle University Research Projects Coordinator (DUBAP 12ZF71).

REFERENCES

Anonim, 2015. Türkiye İstatistik Kurumu (TÜİK). http://tuikapp.tuik.gov.tr/bitkiselapp/bitkisel.zul (14.04.2015).

Anonim, 2014. Kalkınma merkezi derneği mikro bölge kalkınma modeli için bir araştırma. Karacadağ kırsal alanında sek törel gelişim planı. Kalkınma Merkezi. Turgut Özal Cad. 343. Sk. Balek Apt. B/Blok Kat:1 No:5 Bağlar/Diyarbakır.

Chang T.T., 1970. Rice. In Genetic Resources in Plants. Their Exploration and Conservation. (eds O.H. Frankel and E. Bennett), IBP Handbook, Blackwell, Oxford and Edinburgh, no. 11, p. 267-272.

Damar İ., 2006. Edirne İli Çeltik Alanlarında Bulunan Yabancı Ot Türleri ve Yoğunluklarının Belirlenmesi, Yüksek Lisans Tezi, Edirne.

Davis P.H., 1965-1988. Flora of Turkey and the East Aegean Island. At the University Press. Edinburg, Vol. 1-10.

Elçi Ş., Geçit H., Kolsarıcı Ö., 1994. Tarla Bitkileri Ders Kitabı, Ankara Üniversitesi, Tarla Bitkileri Bölümü, Ankara.

Food and Agriculture Organisation (FAO), 2009. FAOSTAT Database, FAO, Rome.

Işık D., Mennan H., Ecevit O., 2000. Samsun İli Çeltik Ekim Alanlarında Görülen Yabancı Ot Türlerinin Belirlenmesi. OMÜ Zir. Fak. Dergisi, 15 (3), 98-104.

Kün E., 1985. Sıcak _klim Tahılları, A.Ü Ziraat Fakültesi Yayınları yayın No:953, Ankara. [3] (Finnasi, 1979).

Finnasi A., 1979. Rice and Food for Development. Fiat Trattori Edution, Torino, İtaly.

Odum E.P., 1971. Fundamentals of Ecology, 3rd Edition, Saunders, Philadelphia. 574 p.

Oerke E.C., 2006. Crop losses to pest. J. Agric. Sci., 144: 31-43.

Özdemir C., 1992. Marmara Bölgesinde çeltikte sorun olan yabancıotlara karşı ilaç denemesi. Zir. Müc. Araş. Yıl., 20-21: 219-219.

Smith R.J.Jr., Flinchum W.T., Seaman D.E., 1977. Weed control inU.S. rice production. U.S. Dep. Agric. Handb. 457. U.S. Gov. Printing Office, Washington, DC. 78 p.

Uluğ E., Kadıoğlu İ., Üremiş İ., 1993. Türkiye'nin Yabancı Otları ve Bazı Özellikleri. T.C. Tarım ve Köy İşleri Bakanlığı, Zirai Mücadele Araştırma Enstitüsü Müd., Yayın, Adana, No 78.

Uzun K., Demirkan H., 2013. Determination of Weeds in Rice Region of Edirne-Uzunköprü and Researches on Chemical Control of Those Weeds. The Journal of Turkish Phytopathology, Bornova / İzmir, Volume 42, Number 1-3, p. 1-11.

Uzun A., 1983. Güneydoğu Anadolu Bölgesindeki Çeltik Alanlarındaki Bazı Darıcan (*Echinochloa* spp.) ve bazı tek yıllık Topalak (*Cyperus* spp.) Türleri Üzerinde Araştırmalar, Doktora çalışması, Diyarbakır Zirai Mücadele Araştırma İstasyonu.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

A NEW HOST *Myagrum perfoliatum* L. RECORD FOR *Melanobaris dalmatina* (H. BRISOUT, 1870) (COLEOPTERA: CURCULIONIDAE) FROM TURKEY

Cumali ÖZASLAN, Halil BOLU

Dicle University, Faculty of Agriculture, Plant Protection Department, 21280 Diyarbakır, Turkey

Corresponding author e-mail: cumali.ozaslan@dicle.edu.tr

Abstract

This study was conducted to determine the natural enemies associated with Bird's-eye cress (Myagrum perfoliatum L.), an important weed in wheat and lentil fields in the Diyarbakır Province (Turkey) in 2012. Infected bird's-eye cress samples were collected from wheat and lentil growing areas and were taken to the laboratory to culture. Melanobaris dalmatina adults were obtained from the cultured bird's-eye cress samples. This is the first record of M. dalmatina for Diyarbakır province and the second record for Turkey. Though few weeds have been reported as a host of *M. dalmatina*, this is the first record of *M. perfoliatum* as a host of the *M. dalmatina* in the world.

Key words: *Melanobaris dalmatina*, *Myagrum perfoliatum*, biological control, Diyarbakır, new host Turkey.

INTRODUCTION

Insects can control weeds by feeding on seeds, flowers, leaves, stems, roots, or combinations of these, or by transmitting plant pathogens. There are some very tough weeds on the prairies. They compete with valuable crop and forage plants and threaten many native plant species. Many of these weeds have been very expensive and difficult, if not impossible, to control with more traditional methods. In some instances, the chemicals used for control are non-selective compounds, which will also damage non-target plants and may leach out of sandy or gravelly soils, or compounds that give top growth control only. In addition, because of leaching, chemicals cannot be used on weeds that grow close to bodies of water.

Biological control covers two key concepts: the deliberate use of a weed's "natural enemies" to suppress its population and the use of these live organisms to maintain this lower population density. A weed's natural enemies may be arthropods (insects, mites and their relatives), bacteria or fungi. These "control agents" feed upon or cause disease in the weed, thereby limiting its growth, reproduction and spread.

Weeds have traditionally been considered totally unwanted plants that reduce yields by directly competing with crops or by harboring insect pests and plant diseases. Certain weeds, however, can be regarded as important components of agroecosystems, which can complement existing insect pest management systems. Outbreaks of some insect pests are more likely to occur in weed-free than in weed-diversified crop systems. Moreover, crop fields with a dense weed cover and high diversity usually have more beneficial insects than do weed-free fields. Plants commonly considered weeds in many situations are considered desirable wild plants in this case.

Worldwide, the *Curculionidae* (Weevils) is one of the largest families of the order Coleoptera, including many species on various host plants and represented by 4600 genera and 51000 species (Alonso-Zarazaga and Lyal, 1999; Oberprieler et al., 2007). This family is abundant and rich in species also in the fauna of Turkey.

This variation is due to biology of the weevils. They are not specialized for a specific plant species even for a definite part in a given plant. Any of the plant species may also host for a number of weevils at the same time. For example, as some weevils may feed on stems, others may damage roots, flowers, fruits and leaves. Also, life periods of the weevils on the same plant species may be different. This fact is of great importance regarding the biological control of the weed.

MATERIALS AND METHODS

This study was conducted in the wheat and lentil growing areas of the Department of Plant

Protection, Faculty of Agriculture, Dicle University, Diyarbakir, Turkey (latitude 37°53 N, longitude 40°16 E, altitude 680 m above sea level). Infected bird's-eye cress samples were collected from wheat and lentil growing areas and were taken to the laboratory to culture. Larvae of the *Melanobaris dalmatina* were collected from *Myagrum perfoliatum* during 16-17 May 2012, and were brought to the laboratory for rearing.

The larvae were reared in boxes containing peach branches from the same field at a temperature of 26±1°C, relative humidity of 65±5%, and illumination of 3500 lux for 16 hours per day. The boxes were checked daily. Host plant was placed in separate petri dishes containing moistened cotton until the adults weevils emerged.

Host plant was sent for confirmation of identification to Prof. Dr. A. Selçuk Ertekin and *Melanobaris dalmatina* identification were done by Prof Dr. Osman Sert.

RESULTS AND DISCUSSIONS

This root-mining weevil is recorded from bird's-eye cress (Figures 1, 2, and 3) (*Myagrum perfoliatum*) in Turkey. As a result of this study, we obtained 49 adults of *Melanobaris dalmatina* (Figure 4) from one host plant *M. perfoliatum.*

***Melanobaris dalmatina* (H. Brisout, 1870)**
Order: *Coleoptera*
Family: *Curculionidae*
General Distribution: Recorded in Austria, Croatia, French mainland, Italian mainland, Poland, Russia Central, Russia South, Ukraine, Near East (Asian Turkey, Caucasian Russian republics, Georgia, Armenia, Azerbaidjan, Lebanon, Syria, Israel, Jordan, Sinai Peninsula (Egypt), Arabian peninsula, Iran, Iraq) (Anonymous, 2015).
Distribution in Turkey: In Turkey *M. dalmatina* was recorded for the first time in 1975 at Kula, Manisa, in western Turkey (Lodos et al., 1978). After forty years the *M. dalmatina* was recorded in the Diyarbakır Province in southeastern Turkey at a relatively high population level. It seems that the area of distribution of *M. dalmatina* have been extended to East.

Figure 1. *Myagrum perfoliatum* L

Figure 2. *Myagrum perfoliatum* L.

Figure 3. *Myagrum perfoliatum* L.

Figure 4. *Melanobaris dalmatina*, adults

Host plant: *Myagrum perfoliatum* new record for *Melanobaris dalmatina.*

Recorded host pest: *Melanobaris* sp. *near semistriata* (Col., Curculionidae) In no-choice tests conducted with 16 test plant species, larvae were found in eight species (*Barbarea orthoceras*, *Erysimum asperum*, *Lepidium densiflorum*, *L. lasiocarpum*, *L. oblongum*, *Reseda lutea*, *Schoenocrambe linifolia* and *Stanleya pinnata*) apart from the control, *L. draba.* Larval survival on test plants was much lower than on *L. draba* and in most cases none of the larvae were able to complete development. Under single-choice conditions, *L. draba* was always preferred. Detailed results will be presented in the Annual Report (Anonymous, 2008).

First of all, there is a need for more comprehensive studies attempting to determine the distribution area and host plants of *M. dalmatina* in the region. These studies will reveal whether *M. dalmatina* can be used as a biological control agent of *M. perfoliatum* or not.

ACKNOWLEDGMENTS

The authors thank Prof. Dr. A. Selçuk Ertekin from the Dicle University, Faculty of Science, Department of Biology Diyarbakır / Turkey, for identification of the host plant and Prof. Dr. Osman Sert, Hacettepe University, Faculty of Science, Department of Biology Ankara/Turkey for the identification of the *Melanobaris dalmatina.*

REFERENCES

Alonso-Zarazaga M.A., Lyal C.H.C., 1999. A world catalogue of families and genera of *Curculionoidea* (Insecta: Coleoptera) (Excepting Scolytidae and Platypodidae). Barcelona, Entomopraxis: 315 p.

Oberprieler R.G, Marvaldi A.E, Anderson R.S., 2007. Weevils, weevils, weevils everywhere. Zootaxa 1668: 520 p.

Anonymous, 2015, http://www.faunaeur.org/distribution_table.php (Last update, 20.01.2015).

Lodos N., Önder F., Pehlivan E., Atalay R., 1978. Ege ve Marmara Bölgesinin Zararlı Böcek Faunasının Tespiti üzerine çalış-malar. Zirai Mücadele ve Zirai Karantina Genel Müdürlüğü, Ankara, 301 p.

Anonymous, 2008. Weed Biological Control. Quarterly Report 30 September 2008.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

A NEW HOST *Lasioptera eryngii* (VALLOT, 1829) (DIPTERA: CECIDOMYIIDAE) RECORD FOR *Pseudotorymus sapphyrinus* (HYMENOPTERA: TORYMIDAE) FROM TURKEY[*]

Cumali ÖZASLAN[1*], Halil BOLU[1], Marcela SKUHRAVÁ[2]

[1]Dicle University, Faculty of Agriculture, Plant Protection Department, 21280 Diyarbakır, Turkey
[2]Czech Zoological Society, Vinicna 7, 128 00 Praha 2, Czech Republic
[*]Abstract of this work was published in the XIVth İnternational Symposium on Biological Control of Weeds, 2 - 7 March 2014, South Africa.

Corresponding author e-mail: cumali.ozaslan@dicle.edu.tr

Abstract

This study was conducted in 2012 to determine the gall midges associated with field eryngo (Eryngium campestre L.), an important weed in cereal and leguminous fields in the Şanlıurfa province (Turkey). Infected common eryngo samples were collected from cereal and legume growing areas and were taken to the laboratory to culture. Lasioptera eryngii adults were obtained from the cultured common eryngo samples. This is the first record of L. eryngii for Şanlıurfa province and the second record for Turkey. As a result of our study it was determined that L. eryngii suppressed the development and distribution of E. campestre, an important weed of the crops. It inhibits the growth and development of generative parts of this host plant and prevents its spread to the surroundings areas. This fact is of great importance regarding the biological control of the weed. Pseudotorymus sapphyrinus (Hymenoptera: Torymidae) was reared from galls of L. eryngii on E. campestre. It is a new host of this parasitoid and the second record of occurrence of P. sapphyrinus from Turkey.

Key words: *Eryngium campestre, Lasioptera eryngii, Pseudotorymus sapphyrinus, Turkey.*

INTRODUCTION

Cereal and Leguminous cultivation is of great economic importance in Turkey. Approximately 50% of the agricultural land in Turkey is occupied by cereals, 33% of which is wheat. Approximately 79% of red lentil production in Turkey is obtained from the South Eastern region (Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt, Şanlıurfa and Şırnak) (Anonymous, 2010).

In a study carried out to determine the prevalence and intensity of weeds in production areas of wheat in Diyarbakır the prevalence of *Eryngium campestre* 19.40% was identified at an intensity of 0.062 plant/m^2 (Özaslan, 2011).

Gall midges (Cecidomyiidae) are one of the largest families in the order Diptera including many species inducing galls on various host plants. At present this family contains 6,203 known species in 736 genera (Gagné and Jaschhof, 2014). The present recorded gall midge fauna of Turkey includes 71 species belonging to 38 genera and associated with 59 host plant species (Skuhravá, 2005). A few gall midge species are zoophagous and mycophagous. Larvae usually induce galls on various organs of host plants but larvae of some species develop on plant organs without making galls. They are usually host-specific for a definite plant species, even for a definite part in a given plant.

Galls of *Lasioptera eryngii* on *Eryngium campestre* were recorded for the first time at Taşlıçiftlik, Tokat, in northern Turkey, in June 2003 by H. Cam (Skuhravá et al., 2005). We recorded galls of *Lasioptera eryngii* in large amounts in the province Şanlıurfa in southeastern Turkey in 2012.

First of all, there is a need for more comprehensive studies to determine the distribution area and host plants of *L. eryngii* in the region. These studies will reveal whether *L. eryngii* can be used as a biological control agent of *Eryngium campestre* or not.

MATERIALS AND METHODS

Samples of *Eryngium campestre* including galls were collected from cereal and leguminous growing areas in the Şanlıurfa province (Turkey) during 2012. Each sample was put into a plastic bag and taken to the laboratory for examination. Galls were kept in rearing cages until adult emergence. Specimens were taken from both wild and cultivated plants during irregular surveys carried out in the spring and summer seasons of the one-year study.

Host plants were sent for confirmation of identification to Prof. Dr. A. Selçuk Ertekin and parasitoids reared from the galls of *Lasioptera eryngii* were sent for identification to Prof. Dr. Miktat Doğanlar.

RESULTS AND DISCUSSIONS

During 2012 we obtained 51 adults of *Lasioptera eryngii* from one host plant, and also 15 adult parasitoids.

Material examined

19♀♀, 32♂♂ (reared on 19.V.2012, Ö. Cumali, from galls on *Eryngium campestre*; all mounted on microscope slides, deposited in the collection of Marcela Skuhravá, Praha, Czech Republic.) Şanlıurfa (37°13'N, 38°57'E at altitude of about 570 m).

Life cycle

Lasioptera eryngii produced two generations per year. Adults of *L. eryngii* emerged in the middle of May from galls, where they had hibernated as fully-grown larvae. Females searched for host plants and laid several eggs on young stems of *Eryngium.* Larvae hatched from eggs after several days, penetrated in plant tissue, started to suck plant liquid and induced galls. Larvae caused plurilocular swellings on stems, leaf petioles and main leaf veins of *Eryngium campestre* (Figure 1).

Figure 1. Galls of *Lasioptera eryngii* on stem of *Eryngium campestre* in the field in Şanlıurfa province in southeastern Turkey

The inner walls of the gall chambers were covered with fungal mycelium. Larvae pupate in galls and moved from inside of the gall to the surface where they changed into pupae. After several days pupae broke opening and adults flew from galls. Pupal exuviae remained in opening of galls (Figure 2).

Figure 2. Pupal exuviae (white) and orange larvae of *Lasioptera eryngii* (in cross section of the gall) protruding from openings on the gall

Females started to search for host plants and laid eggs on young parts of host plants. Larvae quickly developed, pupate in galls and adults emerged in July and August. Female started to search for suitable plants and the life cycle was repeated (Figure 3).

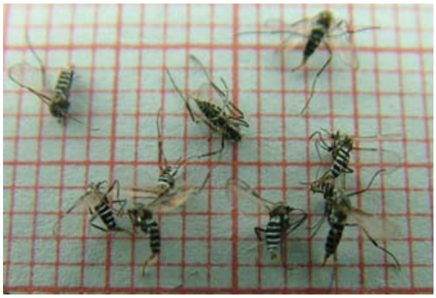


Figure 3. Females and males of *L. eryngii* reared from the gall. Small square – 1 mm

Larvae hibernate in the galls and pupate there in the spring of the following year.

Adult

The body is 3-4 mm long, dark coloured, abdomen with yellow and black bands. Black bands are formed of many very small black scales. Female antennae consist of 2+15 to 2+16 flagellomeres, male antennae of 2+11 to 2+14 flagellomeres. Females have ovipositors of characteristic shape, with a lateral group of strong setae and a group of strong, hooked setae on dark field dorsally and apical oblique lamella (Figure 4).

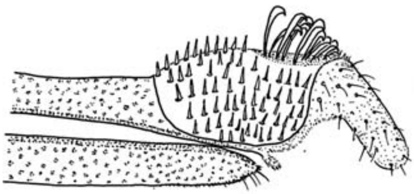


Figure 4. Ovipositor of the female of *L. eryngii* with groups of strong setae

Larva

Full-grown larvae are 3.4-3.5 mm long and orange coloured, with dark brown sternal spatula on the ventral side of the body. It is strongly sclerotized and has a bilobed anterior part.

Gall

Stem swellings are usually large, from 3.5 to 5 cm long and 1.5 cm broad, including many chambers, up to 30. The galls on leaf petioles and inflorescence stalks are usually smaller and include only a few chambers. Only one larva develops in each chamber.

Host plants

In the Şanlıurfa Province (Turkey) the galls of *L. eryngii* were recorded only on *Eryngium campestre* var. *campestre* (L.) Hudson. In Europe the galls were recorded also on other species of *Eryngium*, viz. *E. amethystinum* L., *E. maritimum* L. *E. tricuspidatum* L. and *E. dilatatum* Lam. (Möhn, 1966-1971).

Distribution

Lasioptera eryngii is a sub-Mediterranean and Mediterranean species. It occurs in many countries of central and southern Europe, in Africa (Algeria) and in Asia (Turkey) (Figure 5).

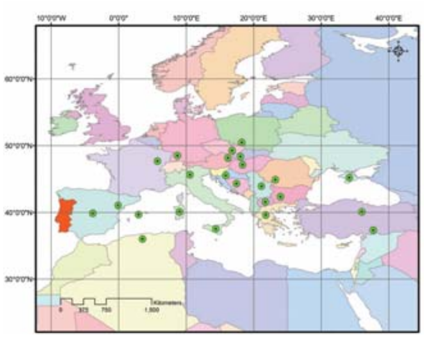


Figure 5. Distribution of *Lasioptera eryngii* in countries of Europe, Asia and North Africa

Its host plant, *Eryngium campestre*, is widely distributed in southern Europe including the Atlantic coast and coast of North Africa up to the Caspian Sea. The distribution of *L. eryngii* is smaller. Galls occur abundantly in southern Europe and markedly less frequently in the north (Skuhravá, 1986; Skuhravá, 1987). In the Czech Republic situated in central Europe *L. eryngii* is rare and therefore included on the red list of endangered species (Skuhravá, 2005).

In Turkey the galls of *L. eryngii* were recorded for the first time in 2003 at Taşlıçiftlik, Tokat, in northern Turkey. After nine years the galls were recorded in the Şanlıurfa Province in southeastern Turkey at a relatively high population level. It seems that the area of distribution of *L. eryngii* have been extended to East.

Parasitoids

Several species of parasitic Hymenoptera have been reared from galls of *Lasioptera eryngii* in Europe. Fulmek (Fulmek, 1968) summarized scattered data on parasitoids and gave a list of 10 species obtained from galls of *L. eryngii.* Skuhravá & Thuróczy (Skuhravá and Thuróczy, 2007) reared the specimens of the genus *Torymus* from galls. In Turkey we reared *Pseudotorymus sapphyrinus* from galls.

New record host

In Turkey several adults of *Pseudotorymus sapphyrinus* (Hymenoptera: Chalcidoidea: Torymidae) have been reared from galls of *Lasioptera eryngii*. Graham & Gijswijt (Graham and Gijswijt, 1998) indicated that *P. sapphyrinus* is a parasitoid in galls of *Biorrhiza pallida* (Olivier) (Hymenoptera: Cynipidae) on *Quercus* sp. and consider it as a common species in Europe. Gencer (Gencer, 2003) reared adults of *P. sapphyrinus* from galls of *Diplolepis mayeri* Schld. (Hymenoptera: Cynipidae) on *Rosa* sp. and recorded it from a new host and for first time from Turkey.

We reared *P. sapphyrinus* from galls of *Lasioptera eryngii* on *Eryngium campestre*. It is a new host of this parasitoid and the second record of occurrence of *P. sapphyrinus* in Turkey.

CONCLUSIONS

Possibility of using *Lasioptera eryngii* seems to be suitable object for biological control of *Eryngium campestre.* It has two generations per year and each female is able to lay large quantity of eggs. Its galls are large, each gall includes many larvae that develop into adults in a relative short time. Forming galls on stems inhibits the growth and development of generative parts of this host plant and prevents its spread to the surroundings areas. This fact is of great importance regarding the biological control of this weed.

ACKNOWLEDGMENTS

The authors thank Prof. Dr. A. Selçuk Ertekin from the Department of Biology, Art & Science Faculty, Dicle University, Diyarbakir, Turkey, for identification of the host plant and Prof. Dr. Miktat Doğanlar, Mustafa Kemal University, Faculty of Agriculture, Department of Plant Protection, Hatay, Turkey, for the identification of the parasitoid.

REFERENCES

Anonymous, 2010. Türkiye İstatistik Kurumu, Bitkisel Üretim İstatistikleri, (TUIK). http://www.tuik.gov.tr/bitkiselapp/bitkisel.zul (Uptaded: 15.02.2014).

Fulmek L., 1968. Parasitinsekten der Insektengallen Europas. Beiträge zur Entomologie, 18: 719-952.

Gagné R.J., Jaschhof M., 2014. A Catalog of the Cecidomyiidae (Diptera) of the World. 3rd Edition. Digital version 2, p. 493.

Graham M.W.R. de Vere, Gijswijt M.J., 1998. Revision of the European species of *Torymus* Dalman (Hymenoptera: Torymidae). Zoologische Verhandelingen, 317: 3-202.

Gencer L., 2003. The chalcidoid parasitoids of *Diplolepis mayri* Schld. (Hymenoptera: Cynipidae), a pest of *Rosa canina* L. in Sivas province. Türkiye Entomoloji Dergisi, 27(2):109.

Möhn E., 1966-1971. Cecidomyiidae (= Itonididae). Pp.: 1-248. In: Lindner E.: *Die Fliegen der palaearktischen Region*. Stuttgart: E. Schweizerbartische Verlagsbuchhandlung: 269:1-48, 273: 49-96, 274: 97-160, 277: 161-200, 288: 201-248. Stuttgart: E. Schweizerbartische Verlagsbuchhandlung.

Özaslan C., 2011. Diyarbakir İli Buğday ve Pamuk Ekim Alanlarında Sorun Olan Yabancı Otlar İle Üzerindeki Fungal Etmenlerin Tespiti ve Bio-Etkinlik Potansiyellerinin Araştırılması, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü, Bitki Koruma Anabilim Dalı, Doktora Tezi, 229 s., Konya.

Skuhravá M., 2005. Cecidomyiidae (Bejlomorkovití), p. 255-258. In: Farkač J., Král D. & Škorpík M. (eds): Červený seznam ohrožených druhů České republiky. Bezobratlí. Red list of threatened species in the Czech Republic. Invertebrates. Agentura ochrany přírody a krajiny ČR, Praha, 760 p. (in Czech).

Skuhravá M., Bayram S., Cam H., Tezcan S., Can P., 2005. Gall midges (Cecidomyiidae, Diptera) of Turkey. Türkiye Entomoloji Dergisi, 29 (1): 17-34.

Skuhravá M., 1986. Family: Cecidomyiidae, p. 72-297. In: Soós Á. & Papp L. (editors): Catalogue of Palaearctic Diptera, Vol. 4. Hungarian Academy of Sciences, Budapest, Akadémiai Kiadó and Elsevier, Amsterdam, p. 441.

Skuhravá M., 1987. Analysis of areas of distribution of some Palaearctic gall midge species (Cecidomyiidae, Diptera). Cecidologia Internationale 8: 1-48.

Skuhravá M., Thuróczy C., 2007. Parasitic Hymenoptera reared from galls of Cecidomyiidae (Diptera) in Europe. Acta Zool. Univ. Comen., 47: 203-221 (pdf).

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE INFLUENCE OF PLOIDY LEVEL ON SOME BIOCHEMICAL CHARACTERISTICS OF MAIZE GRAINS WITH *OPAQUE-2* ENDOSPERM

Andrei PALII[1], Grigorii BATÎRU[1], Alexandru ROTARI[2], Eugen ROTARI[2], Galina COMAROV[1]

[1] State Agrarian University of Moldova, 44 Mirceşti str., 2049, Chisinau, Republic of Moldova
[2] Institute of Phytotechny "Porumbeni", 4834, Paşcani, District Criuleni, Republic of Moldova

Corresponding author email: g.batiru@uasm.md

Abstract

Maize is an important souse of vegetable protein. However, maize grains contain low protein and the protein is of poor quality, due to deficiencies in essential amino acids like lysine and tryptophan. Conventional breeding methods have been used to overcome this problem, yet, the only possible solution is the use of specific genes. Two of them are opaque2 and floury2, which have been extensively used in breeding maize for protein quality. Difficulties regarding pleiotropic effects of the genes on some important cultural characteristics, determine to find new ways of using these genes. This paper aims to present the results of biochemical analysis of diploid and tetraploid maize grains that contain the opaque-2 (o2) gene. Experiments were conducted at the Department of Plant Biology of the State Agrarian University of Moldova and at the Institute of Phytotechny "Porumbeni" in 2013. The research involved two special maize hybrids approved in Moldova and their tetraploid forms obtained by colchicine treatment. Biochemical analysis of diploid and tetraploid o2 grain was performed by infrared spectroscopy and traditional methods. As a result of the study it was revealed that tetraploid grains show higher protein content and a decrease in starch and fat. Lysine content was almost similar in the two types of grains. As hexaploid endosperm cells of the tetraploid grains are bigger in volume than triploid endosperm cells of the diploid grains, it was concluded that lysine content per cell is double in tetraploid grains.

***Key words**: diploid, opaque-2(o2), protein, tetraploid, Zea mays L.*

INTRODUCTION

Maize plays an important role in agriculture and the global economy providing vegetable protein. However, the maize grains contain relatively low protein (10%), with low quality due to the limitation in such essential amino acids as lysine and tryptophan (Palii, 1989; Vasal, 2001; Shewry, 2007). The biological value of maize protein is approximately 32% of casein protein quality (FAO, 1992).

It is known that protein content of maize can be increased by applying traditional methods like selection (Dudley, Lambert, 2004), polyploidy (Ellis et al., 1946; Rotary et al, 1970; Hatefov and Novoselov, 2011), mutagenesis (Blyandur, 1974) and distant hybridization (Borovsky et al., 1973), however, this increase is usually not accompanied by improved quality. The issue of protein quality of maize grain took a great turn after the discovery of the biochemical effects of spontaneous recessive mutations *opaque2* (*o2*) and *floury2* (*fl2*) that determine a floury endosperm texture and cause an increase in the content of lysine and tryptophan (Mertz et al., 1964; Nelson et al., 1965). However, pleiotropic effects of genes on certain cultural traits of maize (floury endosperm that cause kernel damage by mechanical harvest, high moisture of grains at harvest that increased pathogen attack, reduced yield etc.) reduced the interest in these forms. In this context, finding new ways to exploit these mutations are an essential objective in genetics and improvement of maize.

At the State Agrarian University of Moldova, research are carried out that aim at studying the possibility of using genomic (polyploidy) and genetic (mutation recessive *o2*) variability to improve the quality of maize grain. In this paper we present the results on some biochemical characteristics of diploid and tetraploid grains of maize that contains the *o2* gene.

MATERIALS AND METHODS

The research was conducted at the Department of Plant Biology of the State Agrarian University of Moldova and at the Institute of Phytotechny “Porumbeni” in 2013. The biological stock used consisted of two simple hybrid maize Chişiniovschi 307 PL and Chişiniovschi 401 L (Figure 1) approved for cultivation in the Republic of Moldova. Both genotypes contain the *o2* gene that determines an essential increase in lysine and tryptophan in grain protein. The Chisiniovschi 401L also contains modifier genes that change the physical structure of the floury endosperm in mosaic, partly glassy.

Figure 1. Diploid and tetraploid maize ears of Chisiniovschi 307 PL (A) and Chisiniovschi 401 L (B) hybrids

The material was provided by the laboratory of genetic and improvement of maize from the State Agrarian University of Moldova. Tetraploid forms of these hybrids were obtained earlier by the conventional colchicine methods as described (Palii and Batîru, 2011).
Biochemical analysis of diploid and tetraploid *o2* grain was performed by infrared spectroscopy method (Krishchenko, 1997). Also it was used classic methods (Rotari, 1993). These analyzes were performed in the laboratory of biochemistry of the Institute of Phytotechny "Porumbeni".

RESULTS AND DISCUSSIONS

The results of biochemical analysis have shown that tetraploid o2 grains are characterized by higher protein content as compared with diploid grains (Table 1). These data confirm the information in the literature that supports higher protein content in grains of tetraploid maize (Ellis et al., 1946; Khadzhinov and Shcherbak, 1974; Hatefov and Novoselov, 2011).
It has to be mentioned that protein content in table 1 represents the average value of the tetraploid populations studied. An important fact is that the range of protein content in different ears was highly variable. The highest protein content obtained approached 15%. This increase shows possibilities to make selection for protein content at tetraploid level.

Table 1. Biochemical characteristics of diploid and tetraploid grains of maize with *o2* endosperm, 2013 (% dw)

Indici	Chisiniovschi 307 PL		Chisiniovschi 401 L	
	2x	4x	2x	4x
Protein	11.79	12.10	11.55	12.31
Starch	71.95	68.71	71.88	70.16
Lipids	4.98	3.88	4.70	3.51
Cellulose	4.02	4.03	4.13	4.18
Lysine	0.49	0.55	0.49	0.48
Lysine/protein	4.16	4.46	4.24	3.90

In the same time, it was noted by other researchers that protein content can be higher in grains if seed set is low (Rotary et al., 1970). In tetraploid maize, seed set is a very big problem especially for newly created tetraploids. In our research the ears were abundantly pollinated so that seed set could be as high as possible.
In this way well filled ears were used for biochemical analysis which assured a more relevant data for protein content.
Along with the increase in protein, starch content was reduced, compared to diploid grains. The same downward trend was found for lipid content.

From the literature it is known the ploidy level in maize is usually accompanied by a reduced fat content, which some research put on the cumulative action of the genes (Ellis et al., 1946).
The amount of cellulose in diploid and tetraploid grains was almost similar for both genotypes, a fact that has been mentioned in other sources (Ellis et al., 1946).
As it was mentioned above, the main biochemical effect of the *opaque2* gene is increasing lysine content in protein. Thus the most important was to determine whether doubling of chromosome number would at least increase the lysine if not double, because it is known that in diploid maize grain the *o2* gene showed dosage effect (Bates, 1966).
The obtained results for lysine content showed no significant differences among genotypes. If, however, taken into account the higher level of protein in tetraploids, then lysine gets higher for tetraploid Chisiniovschi 307 PL, and lower for Chisiniovschi 401L. Similar results were obtained in other crops, such as barley, where tetraploids showed similar lysine content as diploids (Tiwary et al., 1980).
Our results, in fact show, that the opaque2 gene lacks dosage effect as a result of genome doubling and thus, gene copies. However, certain factors need to be considered to better understand the mechanism of expression. First of all, it is necessary to mention that tetraploid cells are twice as big in volume as diploid ones (Kondorosi et al., 2000). Studies have shown, also that endosperm cells of tetraploid maize are even triple in volume compared with those of diploid grains (Randolph, Hand, 1938). The fact that polyploid cells are larger makes them fewer per unit mass. To confirm this hypothesis, Birchler and Newton (1981) determined the total hydrolysable DNA of diploid and tetraploid forms of maize and found that the amount of DNA in mg dry weight was almost similar in all forms. This means that if a gene has an additive effect, by comparison, biochemical analyzes of the two forms with different ploidy will show almost similar data. In this way, usually gene expression in polyploids is evaluated per cell.
In the present study, quite similar lysine content in *o2* maize grain at both diploid and tetraploid levels can be considered additive, i.e. double the level of lysine per cell of tetraploid maize forms.

CONCLUSIONS

The results of biochemical analysis of diploid and tetraploid maize grains that contain the *opaque2* gene revealed that tetraploid grains show higher protein content and a decrease in starch and fat. Lysine content was almost similar in the two types of grains. As hexaploid endosperm cells of the tetraploid grains are bigger in volume than triploid endosperm cells of the diploid grains, it was concluded that lysine content per cell is double in tetraploid grains.

REFERENCES

Bates L., 1966. Amino acid analysis. Proc. of the high lysine corn conference. Washington, 1966, p. 55-65.

Birchler J.A., Newton K.J., 1981. Modulation of protein levels in chromosomal dosage series of maize: the biochemical basis of aneuploid syndromes. In: Genetics, vol.99, no 2, p. 247-266.

Borovsky M.I., Rotary A.I., Karayvanov G.P., 1973. On the biochemistry of diploid and tetraploid hybrids of corn with Teosinte and Tripsacum. In: Biochemical studies in maize breeding. Kishinev Shtiintsa, p.174-186 (in russian).

Blyandur O.V., 1974. Chemical mutagenesis in inbred corn. Chishinau: Shtiinta, 212 p. (in russian).

Dudley J.W., Lambert R.J., 2004. 100 Generations of selection for oil and protein in corn. In: Plant Breed Rev, vol.24, p. 79-110.

Ellis G.H., Randolph L.F., Matrone G., 1946. A comparison of the chemical composition of diploid and tetraploid corn. In: Journ Agric Research, vol.72, no 3, p.123-130.

FAO, 1992. Maize in human nutrition. In: FAO food and Nutrition Series, no 25, Rome, 160 p.

Hatefov E.B., Novoselov S.N., 2011. Biochemical composition of tetraploid grain of sweet corn. In: The Bulletin of the Russian Academy of Agricultural Sciences, no 4, p. 40-42 (in Russian).

Khadzhinov M.I., Shcherbak V.S., 1974. Polyploidy in maize. Theoretical and practical problems of polyploidy. Moscow: Science, p. 27-42 (in russian).

Kondorosi E., Roudier F., Gendreau E., 2000. Plant cell-size control: growing by ploidy? In: Curr Opin Plant Biol, vol.3, p. 488-492.

Krishchenko V.P., 1997. The near infrared spectroscopy. Moscow, JSC "Interagroteh" 638 p. (in russian).

Mertz E.T., Bates L.S., Nelson O.E., 1964. Mutant genes that chages protein composition and increases lysine content of maize endosperm. In: Science, vol. 145, p. 279-280.

Nelson O.E., Mertz E.T., Bates L.S., 1965. Second mutant gene affecting the amino acid pattern of maize endosperm proteins. In: Science, vol.150, p. 1469-1470.

Palii A., 1989. Genetic aspects of improving the quality of maize grain. Chishinev: Shtiintsa, 175 p. (in russian).

Palii A., Batîru G., 2011. Obținerea experimentală a formelor tetraploide de porumb opaque-2. În: Ameliorarea porumbului şi utilizarea androsterilității citoplasmatice în producerea de semințe, Materialele conf. intern. cons. m. cor.al AŞM Tihon Cealîc - 90 ani de la naştere, Chişinău, p. 88-97.

Randolph L.F., Hand D.B., 1938. Increase in vitamin A activity of corn caused by doubling of chromosomes. In: Science, vol.87, p. 442-443.

Rotari A.I., 1993. Metodele genetico-biochimice a ameliorării porumbului la calitate. Autoref. tezei de doctor hab. în științe biologice. Chişinău, 48 p.

Rotary A.I. et al., 1970. The biochemical and morphological characteristics of pollen and seeds of experimentally obtained tetraploid maize. In: Cytology and Genetics, v.4, no 1, p. 15-23 (in russian).

Shewry P., 2007. Improving protein content and composition of cereal grain. In: J Cereal Sci, vol.46, p. 239-250.

Tiwari S.P., Pai R.A., Bansal H.C., 1980. Effect of autopolyploidy on quantity and quality of protein in barley. Theor. Appl. Genet., no 56, p.133-136.

Vasal S.K., 2001. High quality protein corn. In: Specialty corns, Arnel R. Hallauer, 2nd ed. CRC Press, p. 93-137.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DURUM WHEAT QUALITY AS AFFECTED BY GENOTYPE AND NITROGEN

Galia PANAYOTOVA[1], Svetla KOSTADINOVA[2], Neli VALKOVA[3]

[1]Trakia University, Faculty of Agriculture, 6000 Stara Zagora, Bulgaria
[2]Agrarian University, [2]Faculty of Agronomy, Mendeleev 12, 4000 Plovdiv, Bulgaria
[3]Field Crops Institute, 6200 Chirpan, G. Dimitrov 2, Bulgaria

Corresponding author: galia_panayotova@abv.bg

Abstract

The quality properties of seven Bulgarian durum wheat genotypes (Progress, Vazhod, Victoria, Predel, Deana, Zvezdica and Elbrus) under influence of nitrogen fertilization (0, 60, 120 and 180 kg.ha^{-1}) during 2011-2013 were studied. The analysis of the results showed that the test weight of grain reached maximum value of 81.38 kg, and 1000 kernel weight - 55.04 g average for a period under the agroecological conditions of Institute of Field Crops – Chirpan, Bulgaria on the soil type Pellic Vertisols. The cultivar Progress has the highest test weight and 1000 grains weight. Average for the studied varieties vitreousness, concentration of protein and wet and dry gluten content in the grain increased respectively to 72.36 %, 15.49 %, 33.37 % and 12.60 % with increasing the nitrogen levels to N_{180}. New varieties Predel and Zvezdica have a tendency to a higher concentration of crude protein and gluten in grain, regardless of the year conditions.

Key words: *durum wheat, variety, nitrogen, quality, vitreousness, crude protein, gluten.*

INTRODUCTION

Durum wheat (*Tr. Durum* Desf.) takes up approximately 8% of the world's wheat production. In the last years Bulgaria has increased its grain growing from this crop and has increased the consumption of durum wheat products. The biology of durum wheat and the need to increase the productivity and quality require application of optimal fertilization rates complied with the region and field specifics. Most research on wheat fertilization refers mainly to common wheat and only a limited number of them are on durum wheat, though not to the present-day most widespread intensive varieties.
The productivity and quality of field crops, including durum wheat, varies to a wide range in dependence of a number of factors: agroecological conditions, genetic potential of the cultivar, crop-rotation, soil fertility, applied fertilization, cultivation technology, etc. (Delchev and Panayotova, 2010; Lalev et al., 2000; Moral, 2003; Panayotova, 1999, 2001; Panayotova and Kostadinova, 2011; Petrova, 2009). Weather conditions in the years and applied fertilizers exert great influence on the grain yield and quality of durum wheat (Abad et al., 2004; Ammes et al., 2003; Koleva-Lizama and Panayotova, 2002; Panayotova and Dechev, 1997). In order to obtain normal durum wheat yield are necessary a number of conditions, which directly or indirectly influence the growth and development in different vegetation periods. The differences between the biological requirements of the plants at a certain stage of their development and the conditions they are grown under, give rise to unfavourable stress situations.
Optimizing the mineral nutrition is one of the most important conventions for a favorable growth, production and quality of the plants, for ensuring their need of nutrient elements, for increasing the soil richness. The fertilization of durum wheat grown after cotton should be complied with the fact that a significant part of the nitrogen for cotton is not utilized by it, but remains in the soil. The two cultures are successfully developed in crop-rotation and when fertilized actively participate in the nutrient utilization (Panayotova, 1999).
A number of studies (Panayotova and Yanev, 2001; Pacucci et al., 2004) establish fertilization efficiency for varieties with different genetic endowments in different soil fertility. Panayotova (2001) appoints a genotype specific in relation with grain yield depending on the nutrition level. It is generally

acknowledged that the varieties vary in their responsiveness to nitrogen accumulation in the vegetative parts.

In breeding rarely takes into account the specifics of output forms in terms of mineral nutrition and are predicted possible results. So in recent years, agrochemical assessment of varieties and hybrids are emerging as a component in modern selection (Johnson, 2004; Sylvester-Bradley and Kindred, 2009).

Grain quality is the most important criterion in the breeding of durum wheat to produce high-quality pasta. Experimental data indicate that the new genotypes combine high productivity with good quality. The problems for genetically transmitted and improved grain quality under different varieties of durum wheat are the subject of extensive scientific work (May et al., 2008; Mariani, 1995; Panayotova and Gorbanov, 1999; Panayotova and Valkova, 2010; Rharrabti et al., 2003; Uppal et al., 2002).

Many studies have been conducted to examine the effects of N fertilizers and preceding crops on cereal grain yield. Some authors (Carcea, 2003; Bauer et al., 1987; Kostadinova, 2000) reported that the increasing N rate and rich soil fertility enhanced the content of grain protein and N in the straw. The responsiveness of different cultivars to N accumulated in the vegetative plant parts was established (May et al., 2008; Panayotova, 2010).

The aim of this study was to investigate the influence of nitrogen fertilization on grain quality of new Bulgarian durum wheat varieties.

MATERIALS AND METHODS

The experiment was established in 2011-2013 at the field of the Cotton and Durum Wheat Research Institute, Chirpan, Bulgaria under rainfed conditions. Split-plot randomised design with yield plot 10 m^2 in four replications was used. The cropping pattern is winter durum wheat (*Tr. durum* Desf.) – cotton.

The influence of nitrogen rates 0, 60, 120 and 180 kg/ha on the durum wheat varieties Progress, Vazhod, Victoria, Predel, Deana, Zvezdica and Elbrus were studied. The unfertilized Progress variety was accepted for control.

The nitrogen as ammonium nitrate (34% N) for durum wheat was applied by hand two times: one third - at sowing, and the rest as a top dressing at the end of wheat tillering stage (Feekes stage 4-5).

The seeds were sown on October 25-30, and for each genotype the sowing rate was 450 germinated seeds per m^2. Weeds were controlled between the tillering and shoot elongation stages with herbicides. There were no pathogens and pests above the threshold of harm during the durum wheat vegetation period in the three growing years and chemical spraying was not carried out. The harvest with plot combine occurred on July10-15.

The main quality parameters of grain were studied: test weight (kg/hl) - determined with libra; 1000 kernel weight (g) – by weighting two samples with 500 kernels; total vitreousness (%) - by cutting with pharinotom of Heinsdorf; the content of crude protein - by Kjeldahl standard method after combustion with sulfuric acid and derived according to: Protein, %= N (% DM) x 5.7; and wet and dry gluten (%) - with Gluten washing apparatus and by drying.

Information about the individual effect and interaction between the genotypes and nitrogen fertilization for each studied parameter was obtained by analysis of variance (ANOVA) and LSD test for evaluation of significant differences.

In regard with the meteorological conditions on grain quality unfavorable influence had the high temperatures during the period April to June in the three years and heavy precipitation in May-June in 2012 and 2013. During the winter period are not counted critical negative temperatures and no frostbite of crop.

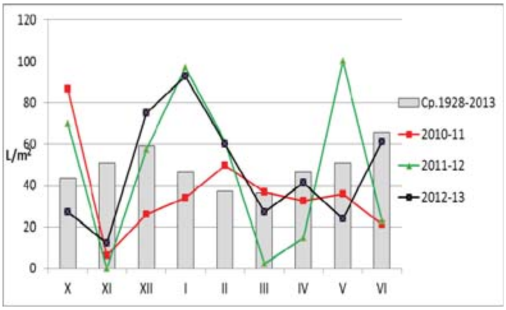


Figure 1. The average air temperatures during the vegetation period of durum wheat, 2011-2013

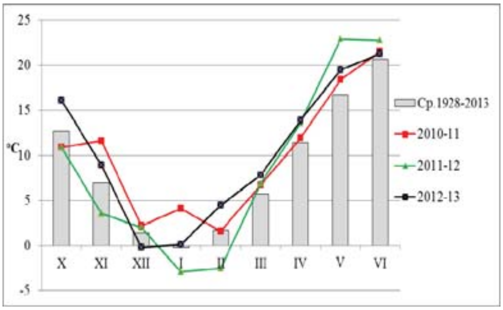


Figure 2. Sum of rainfall during the vegetation of durum wheat, 2011-2013

Soil samples from two replications were collected before durum wheat seeding and after harvest to a depth of 0.40 m. The soil in the field was *Pellic Vertisols* (FAO). It was with high humidity capacity and small water-permeability, defined by the sand-clay composition. The test field was with bulk weight of the plough soil layer - 1.2 g/m^3 and specific gravity - 2.45. The sorbcium capacity was 35-50 mequ/100 g soil. The soil was of slightly acid soil reaction, with total N – average 0.110 %, middle supplied with mineral nitrogen, low supplied with available phosphates and well provided with available potassium (Table 1).

Table 1. Soil properties in 0-40 cm soil layer of *Pellic Vertisols*, Chirpan

Depth (cm)	pH	Mineral N (mg/kg)			P_2O_5 (mg/ 100g)	K_2O (mg/ 100g)
		NH_4-N	NO_3-N	N_{min}		
0-20	6.3	25.80	15.40	41.20	3.2	19.8
20-40	6.5	20.02	10.01	30.03	2.8	17.8

RESULTS AND DISCUSSIONS

The test weight is an indirect classification parameter, normally in direct correlation with flour output, criterion for the health state of durum wheat. The test weight of durum wheat grain in 2011-2013 low depends on genotype and nitrogen level. At different levels of fertilization significant difference was found only in 2013, and the highest test weight was recorded at the rate of N_{180} – 78.66 kg, and it was lowest in N_0 - 77.47 kg. In the previous two years between the values no proven differences and at different levels of nitrogen fertilization were 81.24-81.57 kg in 2011 and 78.43-79.16 kg in 2012 (Table 2). Average values for the period demonstrated tend to increase to N_{120} - 79.66 kg, but differences with the other nitrogen levels were unessential. With the highest value were Progress and Victoria - 80.10 kg and 79.93 kg, and the Deana occurred the lowest test weight - an average of 78.66 kg. The differences were proven in three years. In 2011 the test weight of Progress was highest - 82.45 kg. In 2011, under the influence of favorable combination of temperature and precipitation the test weight had higher values - average 81.38 kg, with 3 and 4% more than in 2012 and 2013. This years were characterized by high temperatures at the end of May and the beginning of June and with lower humidity when formed grain.

The 1000 kernel weight of varieties unsignificant depends on the level of nitrogen fertilization (Table 3). There were no proven differences between the N levels in 2011 and 2012. The greatest weight of 1000 kernel average of the three years was formed at fertilization with N_{60} - 54.34 g, and the smallest in N_{180} - 53.22 g, but the difference between the levels of fertilization was unproven. Significant differences were observed regarding the influence of varieties, such as Progress proven exceeded all other genotypes, reaching a large weight of 1000 grains - 57.29 g, while Deiana is lowest - 51.20 g (with 11.9 % under control Progress). Proven differences between varieties had in each of the examined years. The weight of 1000 grains was greatest in 2012 - 55.04 g under the influence of rainfall in the amount of 100.2 L / m^2 in May and good humidity of wheat in flowering, and it was the lowest in 2013 - 52.33 g due to drought during ear formation-flowering.

The total vitreousness average for the period was low (Table 4). The values increased with increasing nitrogen rates. The vitreousness was highest at the rate of N_{180} - average 72.36% and proven exceed all other nitrogen levels. Positive changes were established in all years of study. Only vitreousness at higher rate N_{180} (72.36% on average) comes close to the quality standard. Vitreousness increased with the amount of nitrogen during the three years. In 2011 the highest value - 72.49% at N_{180} proven exceed other N levels, and the lowest value is at N_0 - 53.37%. No difference between the control and the low level of fertilization N_{60}. In 2012 the vitreousness at N_{180} reached 73.26%

and was higher than all other values, and at N_0 was lowest - 63.14%. Vitreousness was highest in 2012 - 67.88% (by 8 to 17% more than other two years) due to the drought in June. Rainfall during the pouring of grain in 2013 were the main reason for the decreased the grain vitreousness. Cultivar Predel was distinguished by the highest vitreousness - average 66.88%, followed by Progress - 65.37%, and at Vazhod was lowest, but differences between varieties was unsignifican.

Table 2. Test weight for durum wheat genotypes at nitrogen fertilization (kg), 2011-2013

Factors	2011	2012.	2013	Average	
				kg	%
A. Fertilization					
N_0	81.24 ns	79.16 ns	77.47 b	79.29 ns	100.0
N_{60}	81.41	78.88	78.40 ab	79.56	100.3
N_{120}	81.57	78.88	78.54 ab	79.66	100.5
N_{180}	81.27	78.43	78.66 a	79.45	100.2
Б. Genotype					
Progress	82.45 a	78.91 a	78.95 ab	80.10 a	100.0
Vazhod	81.03 bc	79.28 a	77.80 cd	79.37 b	99.1
Victoria	81.58 b	79.14 a	79.08 ab	79.93 a	99.8
Predel	81.18 bc	78.69 a	78.33 bc	79.40 b	99.1
Deana	81.28 b	77.78 b	76.94 d	78.66 c	98.2
Zvezdica	80.63 c	79.03 a	79.40 a	79.68 ab	99.5
Elbrus	81.50 b	79.04 a	77.39 cd	79.31 b	99.0
B. Year	81.38 a	78.84 b	78.27 c	79.49	-

Table 3. Weight of 1000 grains (g) in the durum wheat varieties depending on the nitrogen fertilization

Factors	2011	2012	2013	Average	
				g	%
A. Fertilization					
N_0	53.70 ns	55.35 ns	50.86 b	53.30 ns	100.0
N_{60}	54.30	55.14	53.57 a	54.34	101.9
N_{120}	53.12	54.89	52.41 ab	53.47	100.3
N_{180}	52.41	54.77	52.49 ab	53.22	99.8
Б. Genotype					
Progress	55.76 a	61.55 a	54.56 a	57.29 a	100.0
Vazhod	54.15 ab	54.21 c	53.22 ab	53.86 bc	94.0
Victoria	53.85 b	55.35 c	51.71 ab	53.64 bc	93.6
Predel	51.16 c	52.40 d	50.86 b	51.47 de	89.8
Deana	50.52 c	52.65 d	50.44 b	51.20 e	88.9
Zvezdica	53.51 b	59.15 b	52.06 ab	54.91 b	95.8
Elbrus	54.73 ab	49.95 e	53.50 ab	52.73 cd	92.0
B. Year	53.38 b	55.04 a	52.33 b	53.58	-

Table 4. Vitreousness (%) of durum wheat varieties depending on nitrogen fertilization

Factors	2011 г.	2012 г.	2013 г.	Средно
A.Fertilization				
N_0	53.37 c	63.14 c	42.09 d	52.87 d
N_{60}	57.83 c	66.71 bc	53.14 c	59.23 c
N_{120}	66.80 b	68.40 b	65.09 b	66.76 b
N_{180}	72.49 a	73.26 a	71.34 a	72.36 a
Б. Genotype				
Progress	63.75 ns	70.95 ns	61.40 ns	65.37 ns
Vazhod	57.58	64.60	52.80	58.33
Victoria	66.13	69.05	59.45	64.88
Predel	68.50	70.50	61.65	66.88
Deana	59.68	67.65	54.25	60.53
Zvezdica	63.63	67.75	63.50	64.96
Elbrus	59.10	64.65	52.35	58.70
B. Year	62.62 b	67.88 a	57.91 b	62.80

At growing of durum wheat without fertilization was formed grain with protein content of 12.44%. With increasing fertilization to N_{180} content reached 15.49 % (Table 5). This proved exceed the checks and N_{60} and the requirements of the purchasing organizations and guarantee high biological value of the grain. The difference between N180 and N_{120} was not proven. The data confirmed that nitrogen fertilization is crucial to the concentration of protein in the grain. In each of the years the protein content rising along with the increasing of nitrogen rate.

Table 5. Content of crude protein (%) in the grain of durum wheat varieties depending on nitrogen fertilization

Factors	2011	2012	2013	Average
A.Fertilization				
N_0	12.99 b	11.78 b	12.54 b	12.44 b
N_{60}	13.04 b	12.33 b	12.85 b	12.74 b
N_{120}	15.32 a	14.08 a	14.64 a	14.68 a
N_{180}	16.03 a	14.90 a	15.54 a	15.49 a
Б. Genotype				
Progress	14.32 ns	13.20 ns	13.78 ns	13.77 ns
Vazhod	13.31	12.44	12.97	12.90
Victoria	14.41	13.32	13.91	13.88
Predel	15.31	13.80	14.51	14.54
Deana	13.64	12.78	13.36	13.26
Zvezdica	14.93	14.11	14.71	14.58
Elbrus	14.49	13.26	14.00	13.92
B. Year	14.35 a	13.27 b	13.89 ab	13.84

There were no evidence of differences between the control and the low rate of N_{60}, as well as between N_{120} and high rate of N_{180}. The values of the index were proven higher at N_{120} and N_{180}, compared to N_0 and N_{60} during the whole period of study. In 2011 the protein content of the grain was in the range from 12.99 to 16.03%, in 2012 was 11.78 to 14.90% and in 2013 was 12.54 to 15.54%. The average concentration of crude protein was highest in variety Zvezdica - 14.58%, and the lowest in Vazhod - 12.90%, but the difference between varieties is not proven. In 2011 the highest values were recorded in the Predel - 15.31%, and the lowest were in Vazhod - 13.31%. In 2012 and 2013 with the highest crude protein content in grain were variety Zvezdica, respectively 14.11 and 14.71%, while the lower the Vazhod - 12.44 and 12.97%.

The yield of protein in the grain increased with increasing nitrogen fertilization to N_{180}, reaching the highest average of 718 kg/ha, but the differences with N_{120} were unsignificant. The study shows that moderate N_{120} and high N_{180} rates manifest a strong influence on the yield of protein and as regards of this indicator were the most effective (Table 6). The relative yield of protein increased by 14; 51 and 53% with increasing of the nitrogen rates, which shows the strong influence of nitrogen on the yield of grain protein. In 2011 and 2013, the yields of grain protein increased with increasing nitrogen rate to N_{120}, respectively 862 and 723 kg/ha, but the difference was not proven. In 2012 this indicator increased with the increasing of nitrogen rate to N_{180} and was within 364-636 kg/ha. Between durum wheat cultivars during the period there were no significant differences in the average yield of protein. Progress was characterized with low average yield of grain protein - 534 kg/ha. New varieties Elbrus and Zvezdica were distinguished by the highest average values reached 675 and 630 kg/ha, with 26 and 18% over the standard Progress. Variety Predel also realized high yield grain protein - 628 kg/ha. At the interaction nitrogen rates x cultivar regarding the yield of grain protein with the highest average values of seven varieties differs Elbrus, fertilized with N_{120} - 823 kg/ha and N_{180} - 785 kg/ha, exceeding average for the period with 92 and 83% Progress without nitrogen. Lowest was protein yield of variety Vazhod grown without fertilization - 399 kg/ha, followed by Progress at N_0 - 429 kg/ha.

Table 6. Yield of protein in the grain (kg/ha) depending on the variety and nitrogen fertilization

Factors	2011	2012	2013	Average	
				kg/ha	%
A.Fertilization					
N_0	536 c	364 c	510 b	470 b	100
N_6	613 b	414 c	576 b	534 b	114
N_{12}	862 a	542 b	723 a	709 a	151
N_{18}	833 a	636 a	684 a	718 a	153
Б. Genotype					
Progress	684 ns	451 ns	468 ns	534 ns	100
Vazhod	678	429	577	561	105
Victoria	741	459	659	619	116
Predel	757	458	671	628	118
Deana	653	534	629	606	113
Zvezdica	695	535	661	630	118
Elbrus	768	558	699	675	126
B. Year	711	489	623	608	-

The content of wet and dry gluten increased with an increase in nitrogen rate in each of the years (Table 7). The standard requirement for the content of wet gluten in durum wheat grains is over 28% and for dry gluten - over 10%. Average for study period values at fertilization variants of wet (from 29.26 to 33.37%) and dry (from 10.60 to 12.60%) gluten comply with the standard of quality with only exception of unfertilized control. Average for the study in all varieties and levels of fertilization, the gluten content in 2012 reached 35.23% for wet and 13.07% for dry and exceed the remaining two years, where the precipitation in June were the cause of most low values of the index in 2013 - 23.22% and 8.33% wet and dry.The variety has no significant impact on the indicator. Average for the period with the lowest values was variety Elbrus - 28.28% and 10.16% wet and dry gluten, and the highest was Vazhod - 31.50% for wet and Victoria - 11.75% for dry gluten, but there is no evidence of differences between the values for the varieties.

CONCLUSIONS

The optimal fertilization rate out of those tested for realization of high-yield grain is 12 kg N/da. Application of higher nitrogen rates decreases the test weight and 1000-kernel weight. Grain vitreousness and wet and dry gluten increase with the increase of the nitrogen rate up to N_{180}.

The Progress standard manifested the highest test weight - an average of 80.10 kg and bigger grain - 57.29 g, high vitreousness and best suitability for production of hulled wheat.

The Predel variety manifested high vitreousness, crude protein content, wet and dry gluten and suitability for production of healthy wholesome foods.

Table 7. Concentration of wet and dry gluten (%) in the grain of durum wheat under nitrogen fertilization

Factors	Wet gluten, %				Average dry gluten, %
	2011	2012	2013	Average	
A. Fertilization					
N_0	29.96 c	31.66 c	18.64 c	26.75 d	9.47 d
N_6	31.16 bc	35.11 b	21.50 c	29.26 c	10.60 c
N_{12}	32.87 ab	36.37 ab	24.81 b	31.35 b	11.59 b
N_{18}	34.41 a	37.77 a	27.91 a	33.37 a	12.60 a
Б. Genotype					
Progress	30.33 b	36.28 ns	22.48 ns	29.69 ns	10.53 ns
Vazhod	34.68 a	37.18	22.65	31.50	11.63
Victoria	33.15 ab	35.68	23.45	30.76	11.75
Predel	31.68 ab	33.85	22.60	29.38	10.79
Deana	33.13 ab	33.88	23.78	30.26	11.21
Zvezdica	31.93 ab	35.13	27.18	31.41	11.39
Elbrus	29.83 b	34.63	20.40	28.28	10.16
B. Year	32.10 b	35.23 a	23.22 c	-	-

ACKNOWLEDGEMENTS

This study is a part and was financed of project 1P/14 "Genotype specific of new varieties of cotton and durum wheat to the level of mineral nutrition in the region of Central South Bulgaria".

REFERENCES

Abad A., Lloveras J., Michelena A., 2004. Nitrogen fertilization and foliar urea effects on durum wheat yield and quality and on residual soil nitrate in irrigated Mediterranean conditions. Field Crops Research. VL, 87: 257-269.

Ammes N, Clark P., Dexter J., Woods J., Schols F., Marchylo B., 2003. Effect on N on quality of protein and streng of gluten. Cereal Chemistry, ¾, 80: 203-211.

Bauer A., Frank A., Black A., 1987. Aerial parts of hard red spring wheat. II. Nitrogen and phosphorus concentration and content by plant development stage. Agron. J., 79: 852-858.

Carcea, M., 2003. The quality of durum wheat in Italy. Sementi Elette. VL, 49, 14-15.

Delchev, G., Panayotova G., 2010. Application of some agrotechnical factors for increasing grain yield and quality of durum wheat in Bulgaria. Сборник научных докладов XIII Международной научно-практической конференции "Аграрная наука – сельскохозяйственному производству Монголии, Казахстана и Сибири", Улаанбаатар, 6-7 июня 2010 г. Рос. акад. с.-х. наук. Сиб. регион. отд-ние – Новосибирск, p. 222-227.

Johnson A., 2004. Agricultural nutrients and climate change, Crop nutrients and the environment, Progress Knowledge, Canada, p. 02-211.

Koleva-Lizama I, Panayotova G., 2002. Effects of weather conditions on the durum wheat development stages. Plant science, v. 39, p. 125-128.

Kostadinova S., 2000. Response of winter common wheat (*Triticum aestivum* L.) to the level of nitrogen nutrition, Ph.D. Thesis, Sofia.

Lalev Tsh., Delchev Gr., Panayotova G., Nikolov G., Saldzhiev I., Yanev Sh., Deneva M., 2000. Achievements of the scientific research on the durum wheat's agrotechnology and technology of growing. Plant Science, 37: 682-687.

Mariani B., 1995. Durum wheat quality evaluation, influence of genotype and environment. Cereal Chemistry, 72: 194-197.

May W., Fernandez M., Holzapfel C., Lafond G., 2008. Influence of Phosphorus, Nitrogen, and Potassium Chloride. Placement and Rate on Durum Wheat Yield and Quality. Agronomy Journal, Vol. 100, Issue 4, p. 1179.

Moral, 2003. Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters. Field Crops Research, Vol. 80, Issue 2, p. 133-140.

Pacucci G., Troccoli C., Leoni B., 2004. Response of durum wheat genotypes to previous crop and N fertilization under Mediterranean conditions. Proc. 4th Intern. Crop Science Congress, Brisbane, Australia, 26 Sep. - 1 Oct. 2004.

Panayotova G., 1999. Nutrition of durum wheat (*Tr. durum* Desf.) cultivated with cotton in crop rotation. Ph.D. Thesis; Sofia.

Panayotova G., 2001. Response of Durum Wheat Genotypes to Nitrogenous Fertilizers. Plant Science, 5-6: 203-207.

Panayotova G., 2010. Effect of Soil Fertility and Direct Nitrogen Fertilization on the Durum Wheat Varieties in the Conditions of Central Southern Bulgaria. Proceedings 12th International Symposium "Materials, Methods & Technologies", June 11-15, 2010, Sunny Beach, Bulgaria, vol. 4, part 1, p. 281-293.

Panayotova G., Dechev D., 1997. Stability of the 1000 kernel weight of durum wheat at different nitrogenous fertilization rates and agrometeorological conditions. Soil Science, Agrochemistry and Ecology, 6, 38-40.

Panayotova G., Gorbanov S., 1999. Influence of the fertilization on the properties of durum wheat grain and pasta products. Bulgarian J. of Agr. Science, 5: 425-430.

Panayotova G., Kostadinova S., 2011. Response of new durum wheat varieties to the level of nitrogen nutrition. II. Quality parameters of grain. Field Crops Studies, Volume VII – 2: 363-376.

Panayotova G., Yanev Sh., 2001. Response of Durum Wheat Genotypes to Nitrogen Fertilization. Animal Science, 6: 109-111.

Petrova, I., 2009. Criteria and indices for durum wheat technological quality, Agricultural Science, No. 3: 23-32.

Rharrabti Y. Villegasb D., Royo C., Martos-Núñeza V. et al., 2003. Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters, Field Crops Research, v. 80, 2, 20, p. 133-140.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SEED GERMINATION OF *Betonica bulgarica* Deg. et Neic UNDER THE INFLUENCE OF DIFFERENT TREATMENTS AND SEED QUALITY

Galia PANAYOTOVA, Neli GROZEVA, Mima TODOROVA, Marya GERDZHIKOVA

Trakia University, Faculty of Agriculture, Student campus, 6000 Stara Zagora, Bulgaria

Corresponding author e-mail: galia_panayotova@abv.bg

Abstract

Betonica bulgarica Degen & Nejceff is a Bulgarian endemic species protected under the Biological Diversity Act and included in the Red Data Book of the Republic of Bulgaria, vol.1. Plants and fungi in the category "endangered". The aim of this research was to study seeds germination of endemic species Betonica bulgarica Deg. et Neic, as well as 1000 seeds weight of four natural habitats from the Nature Park Sinite Kamani, Bulgaria. Harvested seeds from plants in the Sinite Kamani Nature Park were collected by means of insulators to assist the natural reproduction of the populations. The seed germination was studied in petri dishes after different temperature treatments - in a laboratory at 15°C, in a thermostat at 20°C and 25°C, at a temperature of 5°C, treated with water at 35°C, and direct sowing in the soil without any treatment. It was found that B. bulgarica is characterized by a prolonged period of germination and emergence. The best results were achieved after direct sowing in soil - 35.0%, followed by seeds placed for germination in laboratory conditions at 15°C - 25.0 %. Treatments of stratification and hot water at 35°C did not give good results for seed germination. The 1000-seed weight of four populations was an average of 0.971 g, from 0.840 to 1.055 g.

Key words: *Betonica bulgarica Deg. et Neic., seed germination, germination rate, weight of 1000 seeds.*

INTRODUCTION

The Nature Park Sinite Kamani is located in the Eastern Balkan Mountains on the southern slopes of the Sliven Balkan. The specific climate and lay conditions of the nature park at altitude between 290 and 1180 m determine the great diversity of flora. In the park, over an area of 11 308 hectares are established 1060 species of high plants from 430 genera and 96 families (Stoeva et al., 2002; Grozeva et al., 2004). 42 endemic species are protected by Biological Diversity Act of Bulgaria (2002) (Petrova et al., 2009, 2011; Tashev et al., 2010; Tashev, 2011).

The *Betonica bulgarica* Degen & Nejceff (Bulgarian Betony) from family *Lamiaceae* is a Bulgarian endemic species protected under the Biological Diversity Act (2002) and is included in the Red Book of Bulgaria, vol.1. Plants and fungi under the category „endangered" (Genova, 2011). It is known with localities in Stara planina (Middle and Eastern) and the Thracian plain (Koeva, 1970; Genova, 2011). According to Genova (2011) the species has good regeneration ability and area is 0.3-0.5 ha. It occurs on open grassy places within the forest and in the subalpine zone. No harvesting is allowed by its natural habitats. Populations involved in the composition of herbaceous communities with relatively small abundance.

For the first time *Betonica bulgarica* is reported for Eastern Stara planina by Grozeva et al. (2004) on the territory of Natural park Sinite kamani in Ablanovo area. According to data by the authors the population is small in number. In Bulgarian scientific herbaria (SOM, SOA, SO) there is one herbarium specimen of *Betonica bulgarica* from Eastern Stara planina, Natural park Sinite kamani - a meadow in the area of Karandila (SOM 167749, 19.07.2010, A. Petrova). The species was first described by the Hungarian botanist A. v. Degen and Ivan Neychev in 1906. Grozeva at al. (2004) has been reported for the first time the species for the Nature Park Sinite Kamani in Eastern Stara Planina. There are no clinical human trials supporting the use of Betony for any indication. *B. bulgarica* is a perennial herbaceous plant to the family *Lamiaceae*. Stem is 30 to 60 cm, covered with bristles facing down. The leaves are ovate extended, heart-shaped at the base, along the edge acute serrated. The fruits are brown grass nuts, triangular, elongated, 4 mm long, 2 mm wide, the outside almost flat, the edges with narrow wings, which at the top edge goes into irregularly toothed membranous appendage. Blooms in May-June, the seeds ripen in July-August. The species is reproduce by seeds and vegetatively (Velchev et al., 1992; Flora of the People's Republic of Bulgaria, 1989).

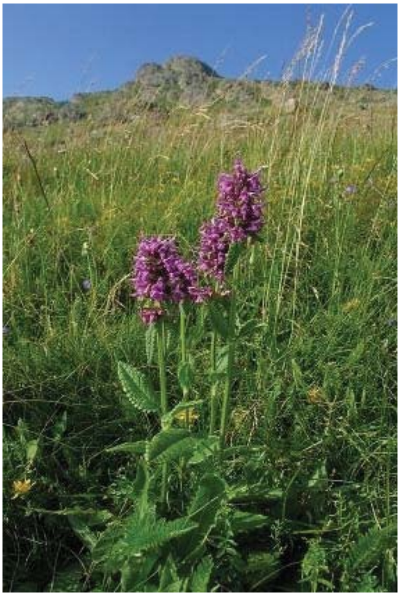


Figure 1. View of *B. Bulgarica*

Numerous procedures for data analysis of seed germination responses are scattered throughout the literature. The methods reviewed include the percent germination, germination index, coefficient of velocity, median response time, probit analysis, curve-fitting of cumulative germination, heat sums, survival analysis with life tables, logistic regression, proportional hazards regression and accelerated failure time analysis (Scott et al., 1984).

Detailed information on the different stages in the reproductive cycle of endemic, threatened and at the same time medicinal species may contribute to improved understanding of the phenomenon of endemism and at the same time assist conservation management decisions for the species under study (Navarro et al., 2003).

Each species has particular requirements for seed germination and germination requirements for native species are often unknown, particularly for rare or endemic species of which material is more difficult to obtain (Navarro et al., 2003; Cerabolini et al., 2004).

According to Escriba et al. (2004) the seed germination is a critical phase in the reproductive cycle, of great importance for species fitness and the variation in germination percentage and has been interpreted as an adaptation to ecological conditions. Temperature and light are the most important factors influencing the induction of seed germination (Baskin and Baskin, 1998). Senel et al. (2007) reported that the optimum temperature for seed germination of medical plants disturbed in Turkey - *S. dicroantha*, *V. bithynicum* and *V. wiedemannianum* was 20°C and darkness.

Emel et al. (2007) reported that the optimum temperature for seed germination of *S. dicroantha, V. bithynicum* and *V. wiedemannianum* was 20°C and darkness. The seeds of *V. bithynicum* and *V. wiedemannianum* incubated in darkness showed higher germination percentages than the seeds incubated with a 16:8 h photoperiod or continuous light, but the effect of application of darkness, photoperiod (16:8 h) or continuous light on the germination percentage of the seeds of *S. dicroantha* was not significant. In the case of *S. dicroantha,* seed weight significantly affected germination percentage, but not significant in the case of *V. bithynicum* and *V. wiedemannianum*. Exogenous GA_3 (20, 100, 200 mg L^{-1}) was comletely prevented germination the seeds of these species.

Yücel and Yılmaz (2009) reported that germination of *Salvia cyanescens* seeds was promoted by cold-wet process at -5ºC; low concentrations of NaCl and KNO_3 (0.5-1%) brought up high germination percentage, but higher concentrations inhibited the germination comparing with no treatment. Herranz et al. (1998) did not find a clear relationship between heat-shock germination response and post-fire regeneration strategy. This work supports that endemics species have germination more sensitive to fire than widely distributed ones.

According to Patanè et al. (2009) the increase in incubation temperature to 35°C determined a faster germination of Sorghum seed than at 25°C, despite the lower final germination percentage. With the lowering of temperature to 15°C germination percentage significantly declined. At 10°C seeds failed to germinate due to depressive effect of low temperature. Seed priming enhanced germination and shortened the delay in germination time due to the increase in saline stress, at suboptimal temperatures only.

Dušek et al. (2010) reported that the 1000-seed weight of *Salvia officinalis* varied from 0.594 g (in 2005) to 1.3142 g (in 2004) and an average weight is 1.0510 g.

Thanos and Doussi (1995) recorded that 60 to 70% of the seeds of Sideritis syriaca ssp. syriaca germinated only in the dark at a warmer temperature range (20 to 25°C). At 30°C, only 40 % seeds germinated. There was no increase in the germination ratio of Sideritis seeds treated with hot water. No literature could be found concerning the hot water treatment.

Kozhuharova (2009) established that after treatment with gibberellic acid seeds of *Sideritis scardica* (Mountain tea) and *Sideritis recta* have good germination percentage and stratification does not manifest as an effective method.

B. bulgarica is close with *B. officinalis* L. (Stachys Betony), used as a medicine plant. According to Bown (2002) *B. officinalis* L. prefers a light moist neutral to acid soil in sun or light shade, rich heavy soils, hardy to at least -25°C. This herb is best sown at 41F/ 5°C to germinate in 30-90 days. Seed - sow spring in a cold frame and very easy, the plant can be successfully divided at almost any time of the year.

Betonica bulgarica Deg. et Neic of the territory of the Nature Park Sinite Kamani has not yet been the subject of special study. So far the species has not been studied in relation to seed germination and rate of germination for use ex situ conservation.

The aim of this research was to study seeds germination of endemic species *Betonica bulgarica* Deg. et Neic, as well as 1000 seeds weight of four natural habitats from the Nature Park Sinite Kamani, Bulgaria.

MATERIALS AND METHODS

To assist the natural reproduction of the populations of *Betonica bulgarica* using isolators are harvested seeds from ripe fruits of the plants. From preliminary expeditions in the Nature Park Sinite Kamani - Sliven were established populations of *B. bulgarica* in locality Ablanovo (N 42°42.628; E 26°17.251). Average altitude is 542 m above sea level.

Inflorescences capsules with placed isolators were collected in the month of September 2013 from natural populations, without the risk of reducing their reproduction. Collection was made after obtaining permission from the Ministry of Environment and Water of Bulgaia for the use of the exception from art. 40 of the Biodiversity Act, namely the collection of material of the protected plant species *Betonica bulgarica*. All the activities are in accordance with the Protected Areas Act (PAA), the Biological Diversity Act (BDA) and Ordinance № 8.

The study was conducted at the research laboratory of the Faculty of Agriculture at Trakia University - Stara. Zagora. The seeds were hulled, cleaned, inspected by microscopic technique for their physiological condition and stored in paper bags in the dark at room temperature. Sprouting seeds and damage by diseases and pests were not established.

For establishing seed germination and rate of germination were tested the following factors:

1. Germinate under laboratory conditions at 15°C;
2. Germinate in a thermostat at 20°C and humidity of 95% at 8 hours light and 16 hours dark;
3. Germinate in a thermostat at 25°C and humidity of 95% at 8 hours light and 16 hours dark;
4. Germinated after treatment with a temperature of 5°C for 7 days in a refrigerator, and then the seeds were placed at 18-20°C under room conditions;
5. Germinate after immersion of the seeds in water at 35°C;
6. Direct sowing in soil taken from natural habitats.

For the first five tested factors seeds were placed in Petri dishes between distilled water moistened filter paper. Twenty replicates of 25 seeds each were used. A periodic checking of germination was carried out. Radicule emergence was the criterion used for scoring a seed as germinated.

For establish seed weight four replication of 1000 seeds from four populations (Ablanovo, Slancheva poliana, Gorna Lift Stancia,

Microiazovir) were chosen at randomly and was weighed with a precision balance.
The data of each studied parameter was analyzed using Analyses of variance (ANOVA) and Principal component analyses (PCA).

RESULTS AND DISCUSSIONS

The results of our studies indicated that *B. bulgarica* was characterized with a prolonged period of seed germination (Table 1). The exceptionally low percentage of seed germination was established in all studies influences. The start of germination was observed 15 days after the placement of the seeds.
The highest percentage of germinated seeds was established in direct sowing in soil - 35.0%, followed by seeds placed for germination in laboratory conditions at 15°C - 25.0%. By increasing the temperature to 20°C seed germination was reduced to 19.2%, and at 25°C (a temperature which is favorable for a number of other cultures) after 37 days were not reported sprouted plants. Treatments by stratification and hot water at 35°C does not give good results on seed germination. When tested at 7-day low temperature 5°C germination was 1%, and under the effect of hot water at 35°C - 15.0%. Estrelles et al. (2004) also reported that at 35°C were not germinated seeds of Sideritis spinulosa, both at continuous and at varying temperatures 35/15°C, wherein germination was 35% at 25/15°C and 33% at 35/15°C under changing temperature conditions and at light. The results of our studies indicate that the germination is not increased by different types of treatment in comparison to direct sowing in soil taken from natural habitats.
The rate of germination of seeds varied and no permanent tendencies of increasing were observed. When placing on 27 January 2014 seeds for germination in a thermostat at 20°C and 95% humidity, the highest rate of germination was after 50-60 days (Table 2).
The mass of 1000 seeds is an indication of size of the seeds, for the opportunity all together to germinate and grow at accelerated rates. The seed weight is an important factor for successful germination (Kambizi et al., 2006; Malcolm et al., 2003; Perez-Garcia et al., 2006).

Table 1. Germination of seeds from *Betonica bulgarica* Deg. et Neic. under the influence of different temperatures

Treatment	Seeds for germination, total number	Sprouted seeds, number	Germination, %	Date of setting	Last date of sampling	Days of germination
1. 15°C	100	25	25	31.01	18.02	18
2. 20°C	100	19	19	27.01	11.04	74
3. 25°C	100	0	0	27.01	05.03	37
4. 5°C	100	1	1	18.02	09.04	50
5. 35°C	100	15	15	28.02	31.03	31
6. In soil	100	35	35	18.02	11.04	52
Total	600	95	15.8			43.7

Figure 2. Seeds in Petri dishes for germination

Figure 3. Germinated seeds of *Betonica bulgarica*

The 1000 seeds weight of *Betonica bulgarica* from harvest 2013 was on average 0.971 g, with variation in populations from 0.841 to 1.055 g (Table 3 and Figure 4). The plants by area Gorna Lift Stancia were characterized with the biggest seeds - 1.055 g, and with the lowest size were from the area Microiazovir. It was found that the variation within populations is much stronger (69.848%) than among the four populations (30.152%). The values are significantly different at $p < 0.05$ (Table 4). Figure 5 shows that with regard to the weight of 1000 seeds mostly (27%) were the cases within the range 0.9-1.0 g, followed by 23% in the range of 0.8-0.9 g. Single seeds have a lower weight of 0.7 g and greater than 1.2 g.

Principle Component analyses for establishing the power and contribution of the population of *Betonica bulgarica* regarding weight of 1000 seeds demonstrate that for principle components could be defined which have effect above 1. The seeds from population Slancheva poliana are the most important because this parameter is positive for first and second factors (Figure 6). Seeds from populations Gorna Lift Stancia and Microiazovir are the other parameters with the significant effect in PC 2. Fourth parameter (Ablanovo) have not substantial effect and contribution to the seed weight. Integrated PC analyses for the effect and contribution of the parameters to the seed weight demonstrated that the parameters could be separate in three groups as follows:

- first – seeds from Slancheva poliana - positive for F1 and F2;
- second – seeds from Gorna Lift Stancia and Microiazovir – negative for F1, positive for F2;
- third – seeds from Ablanovo - negative for F1 and F2.

Table 2. Rate of germination of seeds in a thermostat at 20°C

Date of sampling	Number of sprouted seeds	Date of sampling	Number of sprouted seeds
04.03	3	25.03	2
07.03	3	27.03	8
13.03	3	28.03	1
17.03	16	31.03	16
18.03	3	02.04	2
19.03	1	07.04	7
20.03	7	09.04	4
21.03	31	11.04	1
24.03	7		

Table 3. 1000 seeds weight of *Betonica bulgarica* from four populations

	1000 Seed mass, g
Ablanovo	1.001a
Slanch poliana	0.987a
Gorna Lift Stancia	1.055a
Microiazovir	0.841
All Grps	**0.971**
N	40
Std.Dev.	0.147
Variance	0.021
Std.Err.	0.023
Minimum	0.715
Maximum	1.430
Variation of 1000 seeds weight, g	
Between population (SSb)	30.152
Within population (SSv)	69.848

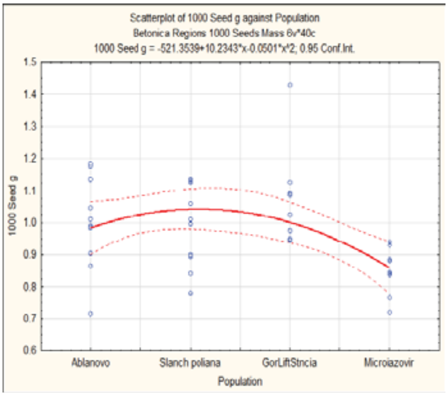


Figure 4. Scatterplot of 1000 seeds weight (g) for four populations of *Betonica bulgaric*

Table 4. Analysis of variance for 1000 seeds weight of four populations of *Betonica bulgarica*

	SS – Effect	df	MS	SS - Error	df – Error	MS - Error	F	P		
1000 Seed, g	37.346	3	12.449	2802.47	8482	0.330	37.678	0	SSb%	SSw%
Error	2802.47								1.32	98.68
Total	2839.82									

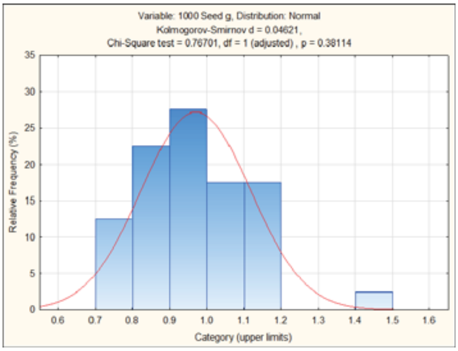


Figure 5. Frequency of weight of 1000 seeds, %

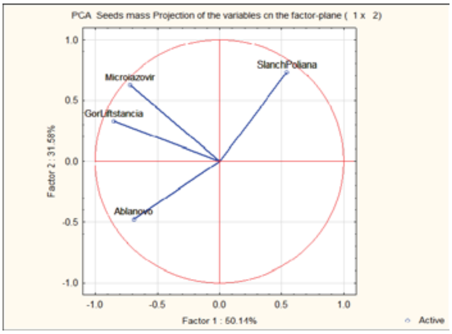


Figure 6. PCA for the distribution of population of *Betonica bulgarica* regarding weight of 1000 seeds

CONCLUSIONS

It was found that *B. bulgarica* is characterized by a prolonged period of germination and emergence. The best results were achieved after direct sowing in soil - 35.0%, followed by seeds placed for germination in laboratory conditions at 15°C - 25.0%. Treatments of stratification and hot water at 35°C did not give good results for seed germination. The 1000-seed weight of four populations were an average of 0.971 g, from 0.840 to 1.055 g.

ACKNOWLEDGEMENTS

This study is a part of project Restoration of habitats and preservation of biodiversity in Natire park Sinite kamani and was financed from Project 2P/14 "Complex population study of species of the genus Suaeda (Sueda) in Bulgaria".

REFERENCES

Baskin C., Baskin J., 1998. Seeds Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press, San Diego, 666 p.

Bown D., 2002. New Encyclopedia of Herbs & Their Uses, The Herb Society of America. Dorling Kindersley Publishers Ltd, 424 p.

Biological Diversity Act, Republic of Bulgaria, 2002. State Gazette No. 77/9.08.2002 (Bg).

Cerabolini B., Andreis R., Ceriani R., Pierce S. and Raimondi B., 2004. Seed germination and conservation of endangered species from the Italian Alps: *Phsoplexis comosa* and *Primula glascescens.* Biol. Conserv., 117: 351-356.

Dušek K., Dušková E., Smékalová K., 2010. *Betonica officinalis* L. in the Czech Republic. II. Seed production and quality and variability of total polyphenols content. Herba polonica, Vol. 56 No. 3, p. 15-23.

Emel D., Ozdener Y., Incedere D., 2007. Effect of Temperature, Light, Seed Weight and GA_3 on the Germination of Verbascum bithynicum, Verbascum wiedemannianum and Salvia dicroantha. Pakistan Journal of Biological Sciences, 10 (7), 1118-1121.

Escriba M., Laguna E., Guara M., 2004. Seed germination trends of endemic vascular plants in the Valencian community (Spain). 4th European Conference on the conservation of wild plants, Planta Europa IV Proceedings, 17-20th September 2004, Valencia (Spain).

Estrelles E., Albert F., Navarro A., Prieto J., Ibars A., 2004. Germination behaviour of Labiatae SW distributed in the Iberian Peninsula. 4th European Conference on the conservation of wild plants, Planta Europa IV Proceedings, 17-20th September 2004, Valencia (Spain).

Flora of the People's Republic of Bulgaria, vol IX, 1989. Published by BAS. Editor C. Velchev (Bg).

Genova E. 2011. Betonica bulgarica Deg. et Neic. In: Peev D (ed.), Red Data Book of the Republic of Bulgaria, vol. 1. Plants & Fungi, http://e-ecodb.bas.bg/rdb/en/vol1/Betbulga.html (12.01.2014).

Grozeva N., Georgieva M., Vulkova M., 2004. Flowering plants and ferns. In: Stoeva, M. (ed.), Biological diversity of Sinite Kamani Nature Park. Kontrast - Bogomilovo, Stara Zagora, p. 9-112 (Bg).

Kambizi, L., Adebola P.O., Afolayan A.J., 2006. Effects of temperature, pre-chilling and light on seed germination of *Withania somnifera*; A high value medicinal plant. South African J. Bot., 72: 11-14.

Koeva Y., 1970. Genus Betonica. In: Jordanov D (ed.), Flora Reipublicae Bulgaricae, vol 9, Editio Acad. „Prof. Marin Drinov", Serdicae, p. 412-416 (Bg).

Kozuharova E., 2009. New Ex Situ Collection of Rare and Threatened Medicinal Plants in the Pirin Mts. (Bg). Ecology, 18, 72, p. 32-44.

Malcolm P., Holford P., McglassonW., Newman S., 2003. Temperature and seed weight affect the germination of peach rootstock seeds and the growth of rootstock seedlings. Sci. Hortic., 98, p. 247-256.

Navarro L., Guition J., 2003. Seed germination and seedling surviv of two threatened endemic species of the northwest Iberian Peninsula. Biol. Conserv., 109: 313-320.

Herranz J., Ferrandis P., Martinez-Sanchez J., 1998. Influence of heat on seed germination of seven Mediterranean Leguminosae species. Plant Ecol., 136: 95-103.

Patanè C., Cavallaro V., Cosentino S., 2009. Germination and radicle growth in unprimed and primed seeds of sweet sorghum as affected by reduced water potential in NaCl at different temperatures. Industrial Crops and Products, Vol. 30, Issue 1, p. 1-8.

Perez-Garcia, F. and M.E. Gonzalez-Benito, 2006. Seed germination of five *Helianthemum* species: Effect of temperature and presowing treatments. J. Arid Environ., 65: 688-693.

Petrova A., Trifonov G., Venkova D., Ivanova M., 2009. Records 51-74. In: Vladimirov V & al. (comps). New floristic records in the Balkans: 10. Phytol. Balcan., 15 (1): 128-132.

Petrova A., Getova N., Grozeva N., Venkova D., 2011. Reports 73–93. In: Vladimirov, V. & al. (comps). New floristic records in the Balkans: 17. Phytol. Balcan., 17 (3): 361-384.

Scott S., Jones R., Williams W., 1984. Review of Data Analysis Methods for Seed Germination. Crop Science, Vol. 24, 6, p. 1192-1199.

Senel E., Ozdener Y., Incedere D., 2007. Effect of temperature, light, seed weight and GA3 on the germination of *Verbascum bithynicum*, *Verbascum wiedemannianum* and *Salvia dicroantha*. Pakistan Journal of Biological Sciences, 10 (7), p. 1118-1121.

Stoeva M. et al. 2002. Management Plan of Nature Park Sinite Kanani, Sliven, 124

Thanos C., Doussi M., 1995. Ecophysiology of seed germination in endemic Labiates of Crete. Israel J. Plant Sci., 43: 227-237.

Tashev A., Aleksandrova A., Dochshev D., 2010. New record of Quercus coccifera L. in Bulgaria. Gora, 8, p. 16-18 (Bg).

Tashev A., 2011. Reports 108-113. In: Vladimirov V & al. (comps). New floristic records in the Balkans: 17. Phytol. Balcan., 17(3): 361-384.

Velchev V., Kozuharov S., Ancev M., 1992. Atlas of the Endemic Plants in Bulgaria, Sofia. Publishing House of the Bulgarian Academy of Science, p. 204.

Yücel E., Yılmaz G., 2009. Effects of different alkaline metal salts (NaCL, KNO_3), acid concentrations (H_2SO_4) and growth regulator (GA3) on the germination of *Salvia cyanescens* Boiss. & Bal. Seeds. G.U. J. Sci., 22(3): 123-127.

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Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESPONSES OF ACID PHOSPHATASE ACTIVITY ON THE ROOT SURFACE AND RHIZOSPHERIC SOIL OF SOYBEAN PLANTS TO PHOSPHORUS FERTILIZATION AND RHIZOBACTERIA APPLICATION UNDER LOW WATER SUPPLY

Vladimir ROTARU

Institute of Genetics, Physiology and Plant Protection, 20 Padurii Str. MD 2002, Chisinau, Republic of Moldova

Corresponding author email: rotaruvlad@yahoo.com

Abstract

Plant growth-promoting rhizobacteria (PGPR) are known to influence plant nutrition and growth by various direct or indirect mechanisms. Acid phosphatases (APase) produced by the roots of plants and microorganisms plays an important role in inorganic phosphate (Pi) acquisition. The present study was undertaken to evaluate the effects of phosphorus (P) and rhizobacteria suspension of Pseudomonas fluorecens and Azotobacter chroococcum application on root surface and soil rhizosphere acid phosphatase activities of two soybean (Glycine max. L. Merr.) cultivars. The pot experiment was conducted in a greenhouse under controlled soil moisture conditions and plants were cultivated on soil-sand mixture. Bacterial and phosphorus fertilization plants were subjected at flowering stage to temporally drought conditions (35% WHC) for 12 days. Both soybean cultivars Zodiac and Horboveanca supplied with rhizobacteria showed significantly (p <0.05) higher root surface acid phosphatase activity than no treated plants irrespective of the soil water regime. But the activity of acid phosphatase in rhizothere soil under Zodiac was higher than under Horboveanca. Experimental results revealed a significant positive association between acid phosphatase activity in soil and roots with PGPR application, indicating the role of these enzymes in P nutrition of soybean. These results indicate that the application of rhizobacteria consortium pseudomonas fluorescens and azotobacter chroococcum plays an important role in modulation of root surface acid phosphatase activity of soybean and these could have a beneficial impact on P acquisition by possibly mobilizing organic P, but their beneficial effect must be tested under field conditions.

Key words: *Glycine max., acid phosphatase, phosphorus, rhizobacteria, drought.*

INTRODUCTION

Phosphate deficiency is considered to be one of the major environmental factors affecting plant growth, metabolism and productivity (Schachtman et al., 1998; Hammond et al., 2004; Li et al., 2008). It was well demonstrated that plants are able to utilize only a small portion of phosphoric fertilizers that are applied, as much of it is rapidly converted into insoluble complexes in soil (Rodríguez and Fraga, 1999; Cisse and Amar, 2000). Organic P comprises 30-80% of total P in most agricultural soils.

Among the mechanisms that contribute to the increase of Pi availability in soil are the exudations of organic acids or enzymes (like acid phosphatases) into the rhizosphere, as well as symbiosis with microorganisms (George et al., 2005; Tran et al., 2010; Duff et al., 1994; Tarafdar and Marschner, 1995; Gilbert et al., 1999).

Acid phosphatases (orthophosphoric monoester phosphohydrolyzes; EC 3.1.3.2, APases) belong to a broad group of enzymes that catalyze the hydrolysis of different phosphor-monoesters at low pH (Duff et al., 1994; Yadav and Tarafdar, 2001). The production of extracellular APases and secretion from roots rely on the environmental conditions, the physiological state of the plant, age or root type and architecture (Yadav and Tarafdar, 2001). It is well known that acid phosphatases, which catalyze the hydrolysis of organic phosphate compounds, are present in the rhizosphere of most plants (Shen et al., 2005; Tarafdar and Jungk, 1987). The use of PGPR has an important role in improving plant nutrition, particularly on soils of low fertility (Richardson et al., 2001). However, there is scarce information regarding the mechanisms of microorganisms that contribute to improve the availability of phosphates for plants.

Soybean has an important role in sustainable agriculture development and it is an essential source of vegetable protein and oils in the world. However, its production is largely limited by the phosphorus deficiency in many regions, in particular in the Republic of Moldova (Andries, 2011). The effects of PGPR on crops have been studied typically under normal water soil conditions. Actually these two major environmental constraints: phosphorus deficiency and low moisture of soil coexist in field conditions. Therefore, the objective of this study was to compare two soybean cultivars (differing in productivity and response to P fertilization) in terms of acid phosphatase activities on root surface and rhizosphere soil under fertilization with P or PGPR in relation to soil moisture regime. The identification of differences among acid phosphatase activities might be useful for selection of soybean varieties more tolerant to unfavorable environmental conditions.

MATERIALS AND METHODS

A pot experiment was conducted under controlled soil moisture regime. Two soybean (*Glycine max* L. Merr) cultivars were used in this investigation, namely Zodiac and Horboveanca differing in potential productivity. The soil was carbonated chernoziom with pH 8 and low available phosphate (1.8 mg/100g soil). The soil was sieved and then mixed with sand at the ratio 3:1. Ten kilograms of soil was put into each plastic pot. Macro- and micronutrients were thoroughly mixed with soil. The P levels (added as $Ca(H_2PO_4)_2$ were 0, 20 and 100 mg P/kg soil-sand mixture. The suspension of bacteria strains *Pseudomonas fluorecens and Azotobacter chroococcum* was applied by spraying the soil with bacteria suspension and then thoroughly homogenate.

Before the sowing the soybean seeds were treated with bacteria *bradyrhizobium japonicun*. The two water treatments were at 70% of water holding capacity (WHC) as control and at 35% WHC for 12 days as drought. The water deficit was initiated at the flowering stage. Soil moisture at the desired level was adjusted by watering the pot to the designated weight. Plants were harvested at the end of the drought period. The APase activity on root surface was analyzed using the modified method of Tang H. and co-workers (Tang et al., 2013). The soil adhering to roots was collected and then analyzed for acid phosphatase activity (Zhang et al., 2010). The enzyme activity was measured in µmol p-nitrophenol released from p-nitrophenylphosphate solution in 1 g soil within 1 h (µmol p-nitrophenol g^{-1} h^{-1}). Analysis of variance was performed with the GLM general Linear Model procedure of SPSS version 8.

RESULTS AND DISCUSSIONS

Root growth and its exudates are important for acquisition of P that is immobile in soil. Phosphatases released by plant roots or soil microorganisms can mineralize organic P (Tarafdar and Claassen, 1988), thus increasing P availability. Experimental results revealed a large variation in phosphatases activity upon application of bacteria suspension *pseudomonas fluorecens and azotobacter chroococcum* regardless of soil moisture levels. Likewise, the response of root surface APase activity of soybean to phosphoric fertilizer varied with genotypes as well as soil moisture levels. The root surface APase activity was significantly higher in Horboveanca than in Zodiac in all treatments under well watered conditions (Figure 1). The root surface APase activity of Zodiac after application of suspension bacteria *pseudomonas fluorecens and azotobacter chroococcum* was about 30% higher than that at unfertilized plants under normal water conditions (Figure 1). In Horboveanca, only APase activity on the root surface increased with P application under low water supply (Figure 2). Our experimental results are consistent with the study demonstrating that inoculation of *Aspergillus* strains improved P uptake by plants and availability of phosphates in soil (Tarafdar et al., 1996).

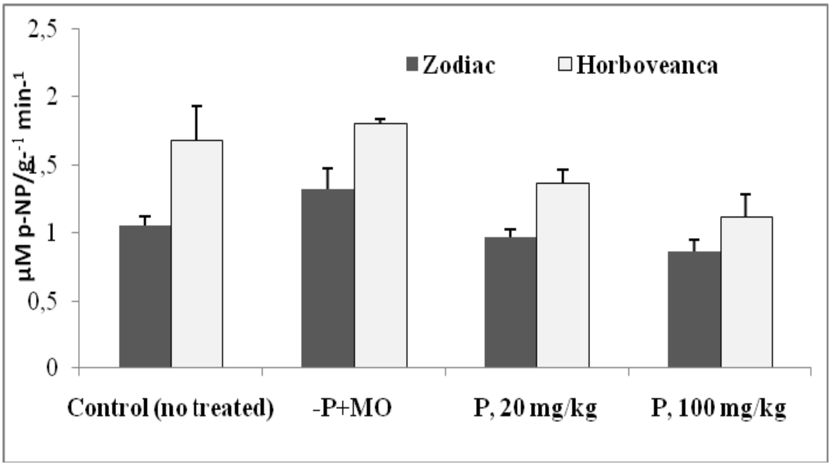


Figure 1. Effects of P fertilization and microorganisms (MO) application on the root surface acid phosphatases activity of two soybean cultivars grown under normal soil moisture conditions (70% WHC). Each value represents the mean of three replicates ± S.E.

Our data also showed that APase activity decreased under P fertilization only for Zodiac (Figure 2), which was consistent with the result of Gaume and researchers (Gaume et al., 2001). The use of PGPR increased significantly the APase activity on the root surface in P-efficient cultivar Zodiac, under optimal moisture regime. While in P-inefficient cultivar Horboveanca the APase activity increased but to a lesser extent (8.5% in Horboveanca, compared to 20.5% in Zodiac). This may be attributed to the increased growth of plant roots (Tarafdar et al., 1996), which in turn stimulated the proliferation of soil microorganisms in the rhizosphere.

Furthermore, the administration of biofertilizers had beneficial impact on root surface acid phosphatases activities of both cultivars subjected to water deficit conditions.

We can conclude that the biofertilizers administration had positive impact on root surface acid phosphatase activities of both cultivars. Under drought condition, the application of PGPR increased the root surface acid phosphatase activity by 13%. Therefore, drought reduced the beneficial influence of the rhizobacteria.

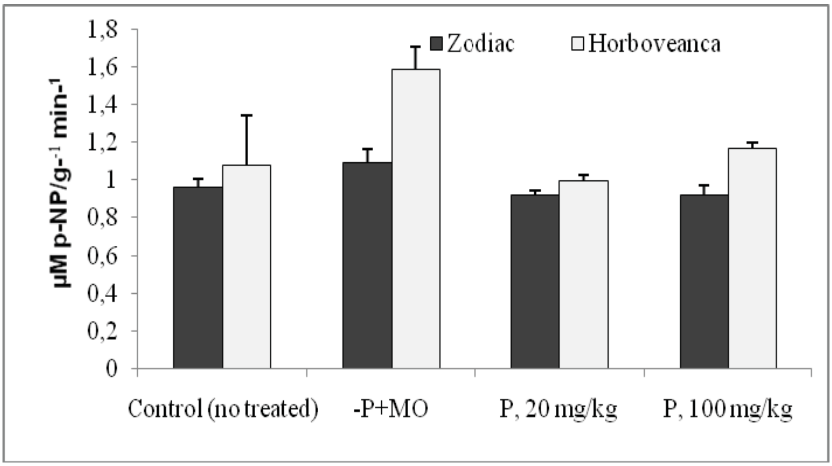


Figure 2. Effects of P fertilization and microorganisms (MO) application on the root surface acid phosphatases activity of two soybean cultivars grown under suboptimal water regime (35% WHC). Each value represents the mean of three replicates ± S.E.

Increased APase in roots of Zodiac may help hydrolyze the organic P pool in soil, and therefore enhance the availability of phosphates. Our results are consistent with others where a positive relationship has been reported between root APase activity and P uptake from organic P in bean (Helal, 1990) and barley (Asmar et al., 1995).

Mineral phosphorus fertilization and the application of PGPR showed also effects on phosphatase activities in the rhizosphere soil (Figures 3 and 4). The positive influence of microorganisms was observed on rhizosphere soil acid phosphatase activity and this parameter increased from 0.69 µM (no treated plants) to 1.08 µM/g/h for Zodiac under normal soil moisture regime.

The mineral fertilizer didn't have significant effect on rhizosphere soil acid phosphatase activity under Horboveanca when plants were subjected to drought. Very small changes in soil acid phosphatase activity were observed under sensitive soybean cultivar Horboveanca regardless of soil moisture regime. However, there was a pronounced effect after the rhizobacteria application in soil with Zodiac under normal water conditions. In such environment the rhizosphere acid phosphatase activity increased by 36% over the control treatment without fertilization. Probably, these changes in the rhizosphere could consequently affect plant nutrition. The study of Marschner et al. (2007) has shown that in low-phosphorus conditions, P uptake of wheat was in significant positive correlation with rhizosphere acid phosphatase activity. It is necessary to note, in our study, the lack of significant changes of pH in the rhizosphere soil was observed, which indicated that soybean cultivars Zodiac and Horboveanca do not respond to phosphate starvation *via* increase of protons or organic acids exudation from the roots, at least in our experimental conditions (data not shown). Tang et al (2007), also, demonstrated that soybean did not excrete protons in the rhizosphere.

Thus in the current study there were not significant changes of pH in water suspension of soil in relation to phosphorus and bacteria application. Likewise, the acidification of rhizosphere was not observed by Gaume et al. (Gaume et al., 2001) in corn plants. Hence, a significant increase of phosphatase activities in soil was observed after the PGPR.

Stronger impacts of PGPR in the unfertilized soil might be caused by the P deficiency in the soil since the phosphatase secretion is induced by low P supply (Helal and Dressler, 1989).

Compared to the untreated soils, the addition of phosphorus and biofertilizers improved P nutrition of both soybean cultivars regardless of soil moisture levels (data not shown). Therefore, increased secreted APases can contribute to enhancing the P uptake and utilization under P limited conditions.

The trend in soil enzyme activity was similar between two genotypes, but acid phosphatase activity in soil under P-efficient genotype Zodiac was significantly higher than that of P-inefficient Horboveanca genotype ($p<0.05$; Figure 4).

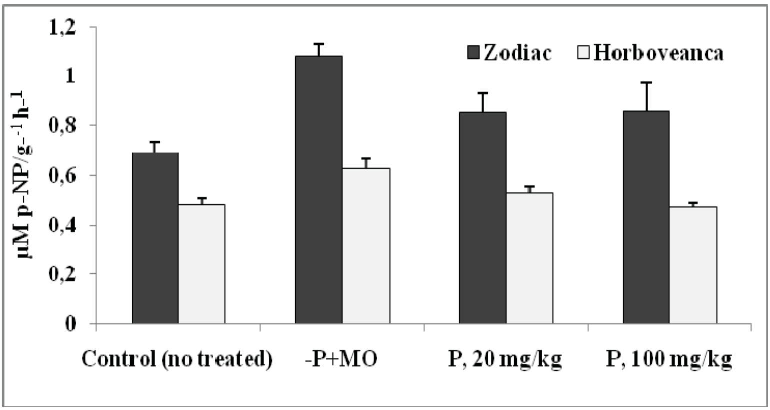


Figure 3. Acid phosphatase activities (µmol p-nitrophenol g–1 h–1) in rhizospheric soil of two soybean cultivars grown under P and rhizobacteria application in normal soil moisture conditions (70% WHC). Data are means ± S.E. of three replicates

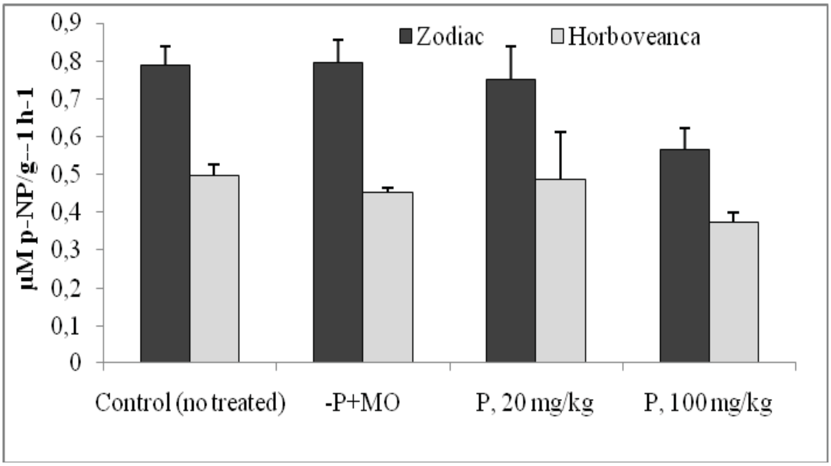


Figure 4. Acid phosphatase activities (µmol p-nitrophenol g–1 h–1) in rhizosphere soil after phosphorus fertilization and application of PGPR of two soybean cultivars under low water supply (35% WHC). Data are means ± S.E. of three replicates

CONCLUSIONS

The present results demonstrate that the application of the rhizobacteria consortium *pseudomonas fluorecens and azotobacter chroococcum* increased the acid phosphatase activity on surface roots and in the soil rhizosphere of soybean. However, the effect of PGPR was determined by soybean cultivar. The APase activity levels were significantly affected by the soil moisture regime and genotypes. Furthermore, field evaluation is necessary to confirm soil enzymes activities in soil and P nutrition of soybean to assess practical utility of these bacteria.

ACKNOWLEDGEMENTS

This research work was carried out with the support of the Supreme Council and Technology Development of Moldavian Academy of Sciences.

REFERENCES

Andries S., 2011. Agrochimia elementelor nutritive. Fertilitatea şi ecologia solurilor. Ch., Pontos, 232 p.

Asmar F., Gahoonia T., Nielsen N., 1995. Barley genotypes differ in activity of soluble extracellular phosphatase and depletion of organic phosphorous in the rhizosphere soil. Plant Soil 172: 117-122.

Chen Y.P., Rekha P.D., Arun A.B., Shen F.T., Lai W.A., Young C.C., 2006. Phosphate solubilizing bacteria from subtropical soil and their tricalcium phosphate solubilizing abilities. Appl. Soil Ecol. 34: 33-41.

Cisse L., Amar B., 2000. The importance of Phosphatic Fertilizer for Increased Crop Production in Developing Countries. Proceedings of the AFA 6th International Annual Conference, Cairo, 31 January-2 February, p. 1-7

Duff S.G., Sarath G., Plaxton W.C., 1994. The role of acid phosphatases in plant phosphorus metabolism. Physiologia Plantarum 90: 791-800.

Gaume A.F., Mächler C.D., Leòn L., Frossard E., 2001. Low-P tolerance by maize genotypes: significance of root growth, and organic acids and acid phosphatase root exudation. Plant Soil 228: 253-264.

George T.S., Gregory P.J., Hocking P.J., Richardson A.E., 2008. Variation in root associated phosphatase activities in wheat contributes to the utilization of organic P substrates *in-vitro*, but does not explain differences in the P-nutrition when grown in soils. Environmental and Experimental Botany 64: 239-249.

Gilbert G.A., Knight J.D., Vance C.P., Allan D.L., 1999. Acid phosphatase activity in phosphorus-deficient white lupin roots. Plant Cell Environ. 22: 801-810.

Hammond J.P., Broadley M.R., White P.J., 2004. Genetic responses to phosphorus deficiency**.** Ann Bot., 94: 323-332

Helal H.M., 1990. Varietal differences in root phosphatases activity as related to the utilization of organic phosphates. Plant Soil, 123: 161-163.

Helal H.M., Dressler A., 1989. Mobilization and turnover of soil phosphorus in the rhizosphere. Z. Pflanzenernahr. Bodenk. 152: 175-180.

Hunter D.A., McManus M.T., 1999. Comparison of acid phosphatases in two genotypes of white clover with different responses to applied phosphate. J. Plant Nutr. 22: 679-692.

Li H.G., Shen J.B., Zhang F.S., Tang C.X., Lambers H., 2008. Is there a critical level of shoot phosphorus concentration for cluster-root formation in Lupinus albus? Functional Plant Biology 35: 328-336.

Marschner P., Solaiman Z., Rengel Z., 2007. Brassica genotypes differ in growth, phosphorus uptake and rhizosphere properties under P limiting conditions. Soil Biol. Biochem. 39: 87-89.

Richardson A.E., Hadobas P.A., Hayes J.E., 2001a. Extracellular secretion of *Aspergillus* phytase from *Arabidopsis* roots enables plants to obtain phosphorus from phytate. The Plant Journal 25: 641-649.

Richardson A.E., Hadobas P.A., Hayes J.E., O'Hara C.P., Simpson R.J., 2001. Utilization of P by pasture plants supplied with myo-inositol hexaphosphate is enhanced by the presence of soil microorganisms. Plant Soil 229: 47-56.

Rodríguez H., Fraga R., 1999. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotechnology Advances 17: 319-339.

Schachtman D.l., Reid P.R.J., Ayling S.M., 1998. Phosphorus Uptake by Plants: From Soil to Cell**.** Plant Physiol. 116: 447-453.

Shen J.B., Li H.G., Neumann G., Zhang F.S., 2005. Nutrient uptake, cluster root formation and exudation of protons and citrate in *Lupinus albus* as affected by localized supply of phosphorus in a split-root system. Plant Sci., 168: 837-845.

Tang H., Shen J., Zhang F., Rengel Z., 2013. Interactive effects of phosphorus deficiency and exogenous auxin on root morphological and physiological traits in white lupin (*Lupinus albus* L.). Science China Life Sciences. 56 (4): 313-323.

Tarafdar J.C., Claassen N., 1988. Organic phosphorus compounds as a phosphorus source for higher plants through the activity of phosphatases produced by plant roots and microorganisms. Biol. Fertil. Soil, 5: 308-312.

Tarafdar J., C, Jungk A., 1987. Phosphatase activity in the rhizosphere and its relation to the depletion of soil organic phosphorus. Biology and Fertility of Soils 3, p. 199-204.

Tarafdar J.C., Rao A.V., 1996. Contribution of Aspergillus strains to acquisition of phosphorus by wheat (*Tritcum aestivum* L.) and chickpea (*Cicer arietinum* Linn.) grown in a loamy sand soil. Appl Soil Ecol 3: 109-114.

Tran H.T., Hurley B.A., Plaxtona W.C., 2010. Feeding hungry plants: the role of purple acid phosphatases in phosphate nutrition. Plant Sci., doi:10.1016/j.plantsci.2010.

Yadav R.S., Tarafdar J.C., 2001. Influence of Organic and Inorganic Phosphorous Supply on the Maximum Secretion of Acid Phosphatase by Plants. Biology and Fertility of Soils, 34 (3): 140-143.

Zhang H., Huang Yu, XiangSheng Y.E., FangSen Xu., 2010. Analysis of the contribution of acid phosphatase to P efficiency in *Brassica napus* under low phosphorus conditions. Science China Life Sciences 53(6): 709-71.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DETERMINATION OF OPTIMUM ROW-SPACING AND PLANT DENSITY IN GOLDASHT SAFFLOWER VARIETY

Mohammad SHARRIF MOGHADDASI[1], A.H. OMIDI[2]

[1]Islamic Azad University/Savehbranch, felestin esq. 39137-366, Saveh, Iran
[2]Seed and Plant Improvement Institute (SPII), Karaj, Iran

Corresponding author email: memo1340@yahoo.com

Abstract

In this study optimum row-spacing and plant density of new safflower cultivar, Goldasht were evaluated during a two-year period (2007-2009) in Saveh University in Iran. The experimental design was set up as strip-plot in a randomized complete block with four replication Rows were arranged at varying spaces of 25, 30, 50, 60 cm while the plants were adopted horizontally at 5, 10 and 15 cm. In this way, plants density ranged from 111111 to 800000 plant/ha. Combined analysis of two years, demonstrated that a significant effect on the seed and oil yields due to a decrease in row spacing from 50-25 cm and inter-row spacing from 15 to 5 cm. This decrease in row spacing from 50 to 25 cm and inter-row spacing from 15 to 5 cm could also increase 100SW from 27 gr to 31 gr, and seed and oil yields from 1010 and 361 kg/ha to 1399 and 422 kg/ha respectively. Moreover, an increase in plant spacing from 50 to 25 cm and inter-row spacing from 15 to 5 cm caused decreasing in the number of head/plant from 15 to 5, number of branches from 19 to 9. Correlation among the traits showed that the grain yield is significantly correlated with oil yield, number of heads and number of secondary branches. It can be concluded that the higher number of heads per plot caused more seed yield, comparing with high number of heads per plant.

***Key words**: safflower, row spacing, plant density, variety.*

INTRODUCTION

Safflower, *Carthamus tinctorius* L., is a member of the family Compositae or Asteraceae, cultivated mainly for its seed, which is used as edible oil and as birdseed (Ashri, 1976). Traditionally, the crop was grown for its flowers, used for coloring and flavoring foods and making dyes, especially before cheaper aniline dyes became available, and in medicines. Safflower is a highly branched, herbaceous, thistle-like annual or winter annual, usually with many long sharp spines on the leaves (Li and Mündel, 1996).

Plants are 30-150 cm tall with globular flower heads (head) and, commonly, brilliant yellow, orange or red flowers. Achenes are smooth, four-sided and generally lack pappus.

The plant has a strong taproot which enables it to thrive in dry climates. Depending on condition varieties grow from about 0.75 to 1.5 m tall. Some have spiny, others do not.

In China, safflower is grown almost exclusively for its flowers, which are used in treatment of many illnesses as well as in tonic tea. Safflower has a bitter herbal taste, but the Institute of Botany of the Chinese Academy of Sciences in Beijing has developed a non bitter, sweet-smelling tea which contains amino acids, minerals and vitamins B1, B2, B12, C and E. Safflower preparations should be stored in light-resistant containers (Weiss, 1971).

India is the biggest safflower producing country, following by the USA and Mexico (Li and Mündel, 1996). Safflower has tolerance to drought and is suitable for growing in dry and marginal areas.

Safflower has been cultivated in Iran for centuries on limited areas for dye extraction from its florets. Its importance as an oil seed crop has only been realized since 1970 in Iran (Ahmadi and Omidi, 1997). Iran is one of the richest germplasm sources of safflower. For instance, out of the 2042 safflower genotypes deposited at the Western Regional Plant Introduction Station, Pullman, WA, USA, 199 are from Iran (De Haro et al., 1991).

Safflower is being grown in over 60 countries but India is contributing about 50% of production. In Iran the area safflower cropped area has increased over the last few years reaching about 7500 ha in 2001 whereas in 1997 it was 200-300 ha (Omidi, 2001).

The recommended range of planting density for spring and winter types is from 200 to 400 thousand plants per hectare; this will vary depending on germination rate, soil type and availability of irrigation (Omidi et al., 2009).

Omidi (2000) concluded that in winter safflower type seed number per head, head number per plant showed a decrease against increasing of plant density from 111 thousand to 800 thousand plants per hectare.

Salera (1996) conducted an experiment on safflower cultivars for best plant density in 25, 30, 50 and 60 cm. Results showed a remarkable rise in the seed yield against plant density which rose from 25 to 75 cm.

Uslu (1997) had run an experiment on two safflower over 3 varying plant rows spacing of 20, 40 and 60 cm. His conclusion revealed that the highest seed yield was belonging to 20 cm row space.

Evaluating yield components and their interrelationships and detecting suitable selection indexes is also very important in safflower breeding programme,

Omidi (1994) reported that the number of seeds per head is associated with the increase of seed yield in safflower. Uslu et al. (1994) concluded that selection for number of head per plant was effective for the improvement of the yield. Consentino et al. (1980) showed that the number of head per plant and seeds per head were significantly and positively correlated.

Yazdi-Samadi and Abd-Mishani (1989) grouped all 1618 Iranian and American safflower genotypes into 5 clusters according to their similarities and reported that the of lines from USA and Iran and other eastern countries were classified into same cluster, as they had similar genetic base.

Zongwen Zhang (2001) in a classification of 89 accessions of safflower reported that accessions from India possessed high diversity and accessions from Turkey were closely related to those from the other Middle East countries.

Bagawan and Ravikumar (2001) studied 10 safflower populations from F2 and M2 generation and reported that the number of head per plant is the most important character contributing to grain yield per plant and the number of head recorded the highest positive correlation with grain yield.

Johnson et al. (2001) indicated that grain yield was positively correlated with seed weight, and plant height.

Thus this study was planned to evaluate determination of optimum row-spacing and plant density for safflower varieties.

MATERIALS AND METHODS

This experiment was carried out over a two - year period in Saveh University at 48°26’’ and 32°16’’ with an altitude of 1000 m above sea level. Based on meteorological statistics, the annual rainfall is 350 mm, mean annual air temperature are +35^{o}C, maximum and minimum absolute annual temperature are +35^{o}C and -9^{o}C respectively. The pilot farm indicated a silty clay loam texture, the table 1 shows to the soil farm trial characters.

The experiment was conducted in four replications using statistical strip plots. The vertical plots were arranged in rows at 25, 30, 50 and 60 cm and plant intervals of 5, 10 and 15 cm. Table 2 shows the various densities in different cultivation patterns. Each plot was composed of four lines of 10m long. The new safflower variety Goldasht was planted in October 2008. After emergence, manual thinning was used to obtain normal density. For the experiment, 70 kg/ha of P_2O_5 as ammonium phosphate and 25 kg/ha of nitrogen as urea were supplied prior to sowing and 30 kg/ha of nitrogen as urea at the start of stem elongation. Weeds were controlled by manual weeding before stem elongation. Irrigation was applied at 7 stages:

- after emergence;
- stem elongation;
- bud formation;
- beginning of flowering;
- 50% of flowering;
- finishing of flowering;
- seed filling.

Data on yield per plant and yield components and other agronomic traits were recorded on plants randomly selected from the two middle rows. The harvesting areas for determination of seed yield, after deletion of the plot sides, were from two middle rows. The data for each experiment were analysed by MSTATC software for comparison of the mean values by the Duncan test at the 1% level.

Table 1. Soil farm trial characters at two depths

Soil depth Cm	N %	p %	K %	PH	EC Ds/cm	Soil Texture
0-30	0.77	14.1	111	7.1	2.2	Silty clay Loam,
30-60	0.70	11.3	99	7	3.1	Silty Loam

Table 2. Plant numbers per square meter at different row spacing and plant distances

Plant distance (cm) Row spacing (cm)	5	10	15
25	800	400	266
30	666	333	222
50	400	200	133
60	333	166	111

RESULTS AND DISCUSSIONS

In this investigation the impact of plant density over 12 growing patterns, ranging from 111111 up to 800000 plants per unit area were monitored on the seed and oil yields and their components. After homogeneity test for error variances, combined analysis of variance was performed. F test of different sources of variation revealed that the effect of row space x year, plant distance x year and row space x plant distance x year interaction were not significant. Analysis of the grain and oil yields and some traits showed significant difference for the main effects of row space, plant distance and row space x plant distance (Table 3).

There were significantly different results values between plant heights on the rows spacing treatments but, as well as plant distance being increased, plant height became decreased, it means that inter-plant competition was decreased.

The results of Yield and yield components comparison for different row spacing and densities are shown in table 4 and 5. The highest plant height belong to 25x5 cm, because in this situation, relative humidity is high and there is no direct sun shine, and also there is desirable temperature, they cause to Auxin reduction especially in some parts of stem in shadow, Auxin as a class of plant growth substance that have an essential role in coordination of many growth and behavioral processes in the plant life cycle.

Also, the results showed that, by spacing the rows more widely from 25 to 60 cm, and by distancing the plants from 5 to 15 cm led to increase in number of head from 13 to 20 cm and 11 to 14.5 respectively.

The average head number per plant in interaction effects between row spacing with plant distance was also significant and revealed that widening distance between the plants, which caused competition decrease among the variety, also increased the head number of plant. The greatest number of plant heads was recorded as 19 in 60x15 cm pattern. Whereas the least, recorded as 8 was detected in 5x25 cm pattern. The seed number of the head as another component of yield was effected by the plant distance applied. Although no significance was identified between the seed number of the heads at varying plant spacing. The significant interaction effects of row and plant spacing were indicated that in increasing plant distance each row spacing would increase the seed content of the head. The least quantity of the head seeds at 10 was seen in its highest density in 25x5 cm pattern, while the greatest content was reported equal to 16 in the 60x15 cm growing arrangement.

Significantly effect of the number of branches trait was observed in different row spacing. The highest number of plant branches was recorded as 19 in 60 cm. Study of plant row spacing and plant distance interaction showed the highest number of branches (21) was belonging to 60x15 cm pattern. High plant density produced more biomass compared to low plant density. The thousand seed weight was also affected by the above spacing, so that the greatest weight was yielded at 60 cm wide. The mean seed weight interaction effects significant different. The range of thousand seed weight in the treatments was 37 to 42 grams. It is because of high Net photosynthetic rates, in this case, the leaves and seeds work as source and sink respectively. The highest seed and oil yields were obtained at the highest plant density .The 25 and 5 cm row and plant spacing possibly due to excessive competition, and the row and plant spacing of 60 and 15 cm, for their lower plant density per unit area, demonstrated less yield. Also, the planting density of 800000 plants per unit area resulted in the highest seed yield. Having the higher the all treatments at a 25 cm row spacing, as well as with the preferred 5 cm, plant distance for all row spacing, a growing pattern of 25x5 cm is

therefore recommended .The pattern is available easily, by planting two lines in 50 cm row spacing, prepared by seed planter.
It can be concluded that the higher number of heads per plot caused more seed yield, comparing with high number of heads per plant.
The relationship between seed yield and row spacing, plant distance and plant density represented a linear character and followed the equation y=-9.79 x +1692.5, y=-4.99. x +1324.5 and y=0.0007 x +1040.5 respectively, which means a falling trend of seed yield against row spacing, plant distance and plant density. According to the above equations, the highest seed yield was obtained in the highest plant population. The planting density of 111111 to 800000 plants per unit area resulted in the highest seed yield (Figures 1-3).
The results of phenotypic correlations showed that the grain yield is significantly correlated with oil yield (0.84), biomass (0.71) coefficient and number of head per plant (0.97).

Table 3. Mean squares for yield and yield component

S.OV	df	ms							
		Seed yield (kg/ha)	Oil yield (kg/ha)	Head per plant	Seed per head	Thousand Grain weight	Number of branches	Biomass (kg/ha)	Height (cm)
Year	1	13380.22 ns	7440 ns	221.88 ns	847.87 ns	724.1 ns	933.5 ns	144506 ns	9855.8 ns
E1	6	8920.33	3270.32	401.77	422.8	499.8	577.8	111158.1	7039
R.S	3	18960.66**	5611.47**	398.38**	998.11**	395.88**	407.11**	104409.1**	5877.46**
Rs×Y	3	964.33 ns	3981.01 ns	100.06 ns	411.40 ns	222.2 ns	99.77 ns	9999.8 ns	1510.5 ns
E2	18	2106.33	561.42	36.88	155.8	88.79	37.3	9494.33	839.8
P.d	2	8222.0. ns	1165.78 ns	81.2 ns	101.63 ns	108.68 ns	99.68 ns	13254.88 ns	1741.6 ns
P.d×Y	2	1478.66 ns	1121 ns	88.87 ns	107.11 ns	111.2 ns	88.87 ns	25688.2 ns	1054.10 ns
E3	12	7475.33	604.21	31.4	95.11	88.8	58.99	17839.8	1456.55
R.S×Pb	6	27084.77**	2599.77**	774.568**	2010.02**	477.47**	659.7**	132547.8**	9984.98**
R.S×Pb×Y	6	4129.33 ns	911.33 ns	99.90 ns	233.11 ns	100.2 ns	147.17 ns	98.74.9 ns	990.8 ns
E4	36	2608.88	256.66	59.61	313.48	53.11	99.55	12801.57	1426.14

Table 4. Yield and yield components comparison for different row spacing and densities

Treatment		Seed yield (kg/ha)	Oil yield (kg/ha)	Head per pant	Seed per head	Thousand Grain weight	Number of branches	Biomass (kg/ha)	Height (cm)
Row spacing	25	1477 a	315 a	13 a	11.3 b	42.6 a	13.3 a	6530 a	147 a
	30	1362 ab	295 b	13 a	12.3 b	39.6 b	15.6 b	6110 ab	131 a
	50	1210 b	266 b	12.3 a	12.3 b	38 b	15.3 b	5629 b	126 a
	60	1036 c	234 b	20.6 b	15.3 a	37.6 b	19 b	4710 c	117 b
Plant distance	5	1351 a	300 a	11 a	12 a	39.5 a	13.75 a	5893 a	128 a
	10	1252 a	271 a	13.5 a	13.5 a	38.75 a	12.75 a	5653 a	127 a
	15	1211 a	262 a	14.75 a	13 a	38.7 a	16 a	5688 a	127 a

Means followed by similar letters in each column for each main row or plant distance are not significantly different at the 1% level

Table 5. Yield and yield components comparison for different row spacing and densities

Row spacing (cm)	Plant distance (cm)	Seed yield (kg/ha)	Oil yield (kg/ha)	Head per plant	Seed per head	Thousand Grain weight	Number of branches	Biomass (kg/ha)	Height (cm)
25	5	1605 a	353 a	8 b	10b	42 a	11 b	7295 a	139 a
	10	1421 a	298 a	15 a	13a	40 a	18 a	6178 a	135 a
	15	1407 a	295 a	9 b	11b	40 a	11 b	6117 a	139 a
30	5	1390 a	319 a	9 b	11b	40 a	11 b	5791 b	121 b
	10	1376 a	275 a	17 a	14a	39 a	20 a	6254 a	119 b
	15	1320 b	290 a	13 a	12a	40 a	16 a	6258 a	117 b
50	5	1300 b	286 a	13 a	12a	38 b	16 a	5652 b	128 a
	10	1212 b	278 a	11 a	12a	38 b	14 a	5637 b	138 a
	15	1120 b	235 b	13 a	13a	38 b	16 a	5600 b	135 a
60	5	1112 b	244 b	14 a	15a	38 b	17 a	4833 c	115 b
	10	1000 b	230 b	16 a	15a	38 b	19 a	4545 c	119 b
	15	998 b	229 b	19 a	16a	37 b	21 a	4752 c	120 b

Means followed by similar letters in each column for each main row or plant distance are not significantly different at the 1% level

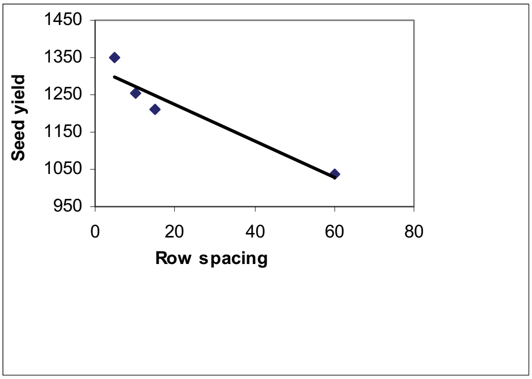


Figure 1. The relation between row spacing and seed yield which follows the linear equation: of y=-9.79 x +1692.5 representing yield decrease yield decrease against row space increase

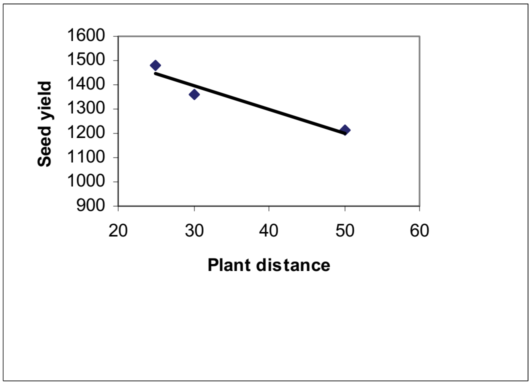


Figure 2. The relation between plant distance and seed yield which follows the linear equation: of y=-4.99. x +1324.5 representing yield decrease yield decrease against plant distance increase

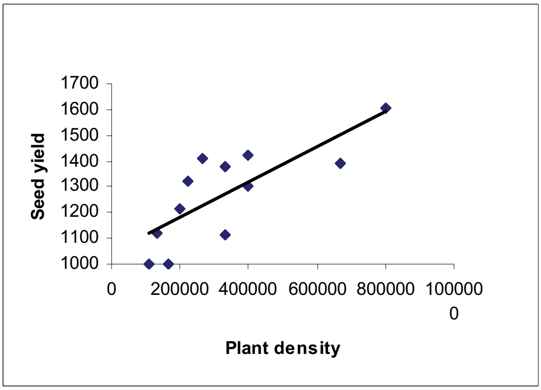


Figure 3. The relation between plant density and seed yield which follows the linear equation: of y=0.0007 x +1040.5 representing yield decrease yield decrease against plant distance increase

REFERENCES

Abel G.H., 1976. Relationships and uses of yield components in safflower breeding. Agronomy Journal, 68: 442-447.

Ahmadi M.R., Omidi A.H., 1997. Evaluation of 25 safflower (*Carthamus tinctorius* L.) genotypes for their morpho-agronomic characters. IV International Safflower Conference. Italy, p .218-221.

Ashri A., Zimmer E., Urie L., Ghaner A., 1976. Evaluation of the world collection of safflower for yield and yield components and their relationship. Crop. Sci., 14: 799-802.

Bagavan I., Ravikumar R.L., 2001. Strong undesirable linkages between seed yield and oil components - A problem in safflower improvement. Proceeding of the Vth International Safflower Conference, USA, July 23-27, p. 103-107.

De Haro A., Del Rio M., Lopez J.C., Garcia M.A., Palomares M.J., Fernandez Martinez J., 1997. Evaluation of the world collection of safflower for oil quality and other seed characters. Sesame Safflower Newsl., 6: 94-99.

Johnson R.C., Ghorpadeand P.B., Bradley V.C., 2001. Evaluation of the USDA core safflower collection for seven quantitative traits. V International Safflower Conf.USA, p. 143-149.

Li D., Mundel H., 1996. Safflower: (*Carthamus tinctorius* L.), Promoting the conservation and use of underutilized and neglected crops. 7.IPGCPR, Catersleben/ IPGRI, Rome, Italy, 83 p.

Omidi A.H., 1994. Evaluation of safflower genotypes for yield and yield components. Second Iranian Congress on Crop Production and Breeding, Karaj-Iran.

Omidi A.H., 2000. A review of agro-breeding safflower researches in Iran and the world. Zeitoon 142: 14-19.

Omidi Tabrizi A.H., 2001. Correlation between traits and path analysis for grain and oil yield in spring safflower. Proceeding of the Vth International Safflower Conference, USA, July 23-27, p. 95-98.

Omidi A.H., Khazaei H., Hongbo S., 2009. Variation for Some Important Agronomic Traits in 100 Spring Safflower (*Carthamus tinctorius* L.) Genotypes. American-Eurasian J. Agric. & Environ. Sci., 5 (6): 791-795.

Salerea E., 1997. Yield and quality of safflower growth and different plant population and row spacing. Field Crop Abs. 50 (6).

Singh M., 1991. Genotypic and phenotypic correlation in plant traits. Computer Service. ICARDA, Aleppo, Syria, 279 p.

Uslu N., Akin A., Basi M., 1997. Weed and row spacing effects on some agronomic characters of safflower spring planted. IV International Safflower Conf. Italy, p. 128-132.

Weiss E.A., 1983. Oilseed Crops. Chapter 6, Safflower, Longman Group Limited, Longman House, London, UK, p. 216-281.

YazdiSamadi B., Abd-mishani C., 1989. Cluster analysis in safflower. Second International Safflower Conference INDIA, 9-13 Jan., p.119-126.

Zongwen Z., 2001. Genetic diversity and classification of safflower (*Carthamus tinctorius* L.) germplasm by Isozyme. V International Safflower Conf. USA, p.157-163.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE CONTENT OF TOTAL PHENOLS, FLAVONOIDS AND ANTIOXIDANT ACTIVITY IN ROSEHIP FROM THE SPONTANEOUS FLORA FROM SOUTH ROMANIA

Rodica SOARE[1], Cristina BĂBEANU[2], Dorina BONEA[1], Ovidiu PĂNIȚĂ[1]

[1]University of Craiova, Faculty of Agriculture and Horticulture, Libertatii Street, no 19, 200583, Craiova, Dolj, Romania
[2]University of Craiova, Faculty of Mathematics and Natural Sciences, Department of Chemistry, A.I. Cuza Street, no 13, Craiova, Dolj 200585, Romania

Corresponding author email: soarerodi@yahoo.com

Abstract

Rosa canina L. is a shrub native to Europe, northwest Africa and western Asia with various uses in naturopathy, nutrition, as a decorative plant or in breeding as rootstocks etc. Although in Romania, Rosehip grows in abundance in wild flora, few know about the valuable biochemical properties that it has and the antioxidant potential of this species. At present, a priority in the human diet, both nationally and internationally, is to identify natural sources of antioxidants. In this study, it was analyzed the content of total polyphenols, flavonoids and antioxidant activity of Rosehips genotypes from the spontaneous flora of Oltenia (Romania). The total phenolic content was determined according to the Folin-Ciocalteu method, the antioxidant activity by DPPH radical (2,2 1 picrilhidrazil diphenyl) and flavonoids by colorimetric method. Polyphenol content was between 35.43-48.07 mg GAE/g, antioxidant activity varied between 99.3 and 363.64 µmTE/100 g sp., and the content in flavonoid was between 211.8-672.67 mg/100g. The best results for total polyphenol content and antioxidant activity was observed in Group I which comprises three genotypes (G6, G9, G11), considered as prospects for the improvement of this species.

***Key words**: natural antioxidants, Oltenia, Rosa canina.*

INTRODUCTION

The interest in finding new, cheap and reliable sources of natural antioxidants which could replace synthetic antioxidants used in food or therapeutic products has increased lately. The most used synthetic antioxidants are butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Their use in food products is limited or restricted due to their toxicity and carcinogenicity (Iqbal et al., 2005).
The human body needs antioxidants in order to fight free radicals in the body. Natural antioxidants are often sourced from plants, spices and teas recommended for the daily diet. Current needs in natural food and pharmaceutical products require more thorough knowledge of the biochemical composition of non-agricultural plant species i.e. rosehips (Roman et al., 2013).
A number of scientific studies have shown that *Rosa canina* berries are rich sources of vitamin C, vitamin A, vitamins B1 and B2, vitamin P, nicotinic acid, vitamin K, hydrolysable tannins, citric and malic acid, peptine, volatile oils, fat oil, proanthocyanidins, anthocyanins, flavonoids, carotenoids, mineral substances, traces of vanillin, alpha and beta tocopherol (vitamin E), lecithin, sugars, etc. (Aptin et al., 2013; Barros et al., 2011; Chrubasik et al., 2008; Demir and Ozcan, 2001; Fecka, 2009; İlbay et al., 2013; Nowak, 2006), having anti-inflammatory properties (Hamidi et al., 2015; Roman et al., 2013; Warholm et al., 2003) also antioxidant (Ghazghazi et al., 2010; Koca et al., 2009), anti-mutagenic (Karakaya and Kavas, 1999) and antibacterial ones (Montazeri et al., 2011). Researchers have shown that the use of *Rosa canina* L. as a remedy in traditional folk medicine comes from its high content of phenolic compounds and minerals (İlbay et al., 2013).
The genus *Rosa*, with over 100 species, is part of *Rosacea* family and it is found in Europe, Northwest Africa and Western Asia (Netoiu et al., 2008). The *Rosa canina* species and its inter-taxa were identified in the 60 plant communities and it is characterized by a big abundance-dominance and high constancy.

The underwoods edified by *Prunus spinosa* and *Crataegus monogyna* are highly encountered in the hilly floor and with reduced frequency in the lower mountain sub-floor (Niculescu, 2006).
Phenolic compounds can be classified into a number of subgroups including phenolic acids, flavonoids, isoflavonoids, lignans, stilbenes, and complex phenolic polymers. In terms of structure, phenolic compounds consist of an aromatic ring, bearing one or more hydroxyl substitutes, and range from simple to high polymerised phenolic molecules compounds. Lately, a rich diet in polyphenols has been associated with reducing the risk for cardiovascular disease, cancer and other diseases. These compounds have antioxidant, anti-inflammatory and anti-carcinogenic properties. According to Pandey and Rizvi (2009), polyphenols and flavonoids are antioxidants which provide a significant protection of the humane body against the development of some chronic diseases including cancer, diabetes, neurodegenerative and cardiovascular problems.
In Romania, *Rosa canina* species biodiversity has recently begun to be studied, in regions of different heights. Thus, in Transylvania research has been carried out at 440 to 1250 m high (Brasovan et al., 2011; Roman et al., 2013), in the northern and northeastern region of Romania, at 400-1060 m high (Ghiorghita et al., 2012; Ropciuc et al., 2011; Rosu et al., 2011) and in Oltenia at 110-600 m high (Soare et al., 2014a and b).
The purpose of this study was to continue the research begun in Oltenia in order to get a valuable selection of *Rosa canina* genotypes, as potential sources of natural antioxidants.

MATERIALS AND METHODS

The biological material consisted of average samples of *Rosa canina* berries harvested from the indigenous flora of the southern Romania, in Dolj county, i.e. genotypes G1-Poiana Mare, G2-Craiova, G3-Teslui, G4-Filiasi, G5-Carcea and from Valcea County, i.e. genotypes: G6-Mateesti, G7-Tetoiu, G8-Lapusata, G9-Balcesti, G10-Horezu, G11 and G12 - Slătioara. Harvesting was carried at 110-600 m, in the fall of 2014 in full ripening. These areas are characterized by temperate continental climate with dry summers and annual average temperatures of 10-11.5°C (in Dolj County) but also with cool summers without any sudden changes in temperature or humidity, with an annual average temperature of 10.3°C (Valcea County).
In order to achieve the objectives, the content of total polyphenols, flavonoids and antioxidant activity content has been analyzed.

Chemicals and Reagent
The used Methanol for the extraction was from Sigma-Aldrich. Gallic acid, 1.1-diphenyl-2-picrylhydrazyl, Ghydroxy - 2,5,7,8 - tetramethylchromon 2-carboxylic acid (Trolox) were obtained from Sigma-Aldrich, Germany and Quercetin was purchased from Carl Roth. Folin-Ciocalteu reagent was obtained from Merck, Germany. All the other used chemicals were of analytical grade.

Sample preparation
Extracts for the determination of total phenolic content, total flavonoid content and antioxidant activity were prepared into 80% aqueous methanol (1:10 w/v) at 24°C for 16 h. The resulting slurries were centrifuged at 4000g for 5 min and the supernatants were collected. In addition, for the determination of phenolic compounds was prepared an aqueous extract (1g:50 mL dH_2O) at 7°C, 60 minutes.
Determination of total phenolic content (TPC): Phenolic compounds were determined colorimetric by using the Folin-Ciocalteu method (Singleton et al., 1999) based on the oxidation of phenolic groups with phosphomolybdic and phosphotungstic acids. 2 mL Folin-Ciocalteu's phenol reagent (1:10) and 1.5 mL 7.5% w/v Na_2CO_3 were added to 0.5 mL sample extract. The mixture was allowed to stand at room temperature in the dark for 60 min and then the absorbance was recorded at 765 nm using a Thermo Scientific Evolution 600 UV-Vis spectrophotometer. The total phenolic content (TPC) was calculated using a standard curve prepared

using gallic acid and expressed as mg of gallic acid equivalents (GAE)/1 g dry weight.

Determination of total flavonoids content: was quantitatively determined by using colorimetric methods at 500 nm with chromogenic system of $NaNO_2$-Al $(NO_3)_3$-NaOH according to Abeysinghe et al. (2007). 0.5 ml of the sample extract was transferred into a 10ml volumetric flask. Furthermore, a 0.6 mL of 5% sodium nitrite ($NaNO_2$) was added and the mixture was shaken and left for 6 min. Secondly, 0.5 mL of 10% $Al(NO_3)_3$ was added to the volumetric flask, shaken, and was left to stand for 6 min. Finally, 3.0 mL of the 4.3% NaOH was added to the volumetric flask. Subsequently, water was added up to the scale. The mixture was then shaken and left to stand for 15 min before determination.

The total flavonoid concentration in methanol extract was calculated from quercetin (Q) calibration curve and expressed as quercetin equivalents (Q)/100g .

DPPH (2.2-diphenyl-1-picrylhydrazyl) radical scavenging assay: The capacity of sample extracts to reduce the radical 2.2-diphenyl-1-picrylhydrazyl was assessed using the method of Babbar et al. (2014) with some modification. A 0.075 mM (final concentration) DPPH solution in methanol was mixed with sample extracts and vortexed thoroughly. The absorbance of the mixtures at ambient temperature was recorded for 20 min at 2 min intervals. The absorbance of the remaining DPPH radicals was measured at 519 nm. The normal color of DPPH will turn into yellow when its singlet electron is paired with a hydrogen atom coming from a potential antioxidant. A blank reagent was used to study stability of DPPH over the test time. The scavenging activity of extracts was evaluated as a percentage of DPPH discoloration using the formula: $\% \text{ scavenging} = [A0-(A1–AS)]/ A0]100$, where A0 is the absorbance of DPPH alone, A1 is the absorbance of DPPH + extract and AS is the absorbance of the extract only. The Trolox calibration curve was plotted as a function of the percentage of DPPH radical scavenging activity. The final results were expressed as micromoles of Trolox equivalents (TE)/100g. (μmol TE/g fw). All determinations were performed in triplicate, and all results were calculated as mean.

The results were interpreted statistically by analyzing the variance and PCA (Principal Component Analysis). Different letters on columns refer to significant differences between genotypes at 5% level according to LSD.

RESULTS AND DISCUSSIONS

Phenolic compounds are an important group of biologically active substances present in the berries of *Rosa canina*, including tannins, flavonoids, phenolic acids and anthocyanins (Demir and Özcan, 2001; Ercisli, 2007). Türkben et al. (2010) identified different genotypes of *Rosa canina* with different concentrations of phenolic acids (ellagic acid, ferulic acid, caffeic acid, p-coumaric acid, p-hydroxybenzoic acid, protocatechuic acid), ascorbic acid and flavonols (quercetin, kaempferol, myricetin, (+) - catechin). Pogacnik-Ulrich (2011) found that the total phenolics (TP) antioxidant capacity (AOC) and vitamin C content of rosehips vary according to the area and harvesting season. Thus, during the ripening in late autumn the concentration of vitamin C decreases, while the TP and AOC increase.

In the present study, the total polyphenol content in aqueous extract, varied for the *Rosa canina* genotypes between 35.43 mg GAE/1g to 48.07 mg GAE/1g d.w. (Table 1). In the case of the variance analysis of the content of phenols, it was calculated with a significant difference of 3.53 mg/1g for a significance threshold of 5%. In this way, the genotypes G 11 and G12 have the highest medium values, differing significantly from all the other genotypes except the genotype G10. Genotype G10 gets significant difference compared to genotypes G1-G7 and genotypes G1 and G2 have significant negative differences in comparison with all the other genotypes, a significant difference being needed between the two of them.

In another study carried out in Romania by Roman et al. (2013) for the rosehips harvested in different areas and heights (ranged from 275 m to 1250 m ranged) a total amount of polyphenols content varying from 575 mg/100g frozen pulp to 326 mg/100 g frozen pulp was reported.

There are many studies that confirm the presence of phenolic compounds in the berries of *Rosa canina* in specialized literature, Thus, Ilbay et al. (2013) found a 48.59±0.29 mg content GAE/g DM extract. The total content of phenols reported by Denev et al. (2013) in the berries of *Rosa canina* was of 1934.3 ± 4.3 GAE/100 g and by Montazeri et al. (2011) was of 424.6 ± 1.8 mg GAE/g extract.

Yilmaz and Ercilsi (2011) after studying four taxa of Rosa (*Rosa pisiformis, Rosa canina, Rosa villosa i Rosa dumalis subsp. antalyensis*) have found a total content of phenols from 78 to la102 mg GAE/g DW. Also, Aptin et al. (2013) reported total phenol content of rosehips harvested in North of Iran, by 26.54 mg gallic acid/ml .

The chemical composition of rosehips is influenced by the interaction of several factors: genotype, height, climatic conditions, harvesting time, etc., all these explaining the data differences reported within the scientific studies. Some authors have found that the interaction between the habitat and the harvesting period influences the amount of antioxidant, vitamin C and flavonoids. In Rudbar-Kushk valley at 50% maturity, in Eshkevarat-Rudsar at full maturity and in Eshkevarat-Rudsar at 50% maturity, i.e. there have been obtained the highest value of antioxidant, vitamin C and flavonoid contents, but the influence of habitat on harvesting time was not significant for anthocyanin and total phenol content (Rahimabadi et al., 2013).

The results in terms of content in flavonoids, for the studied genotypes are presented in Table 1, it ranged between 211.8 in G2 and 672.6 mg 100 in G9.

As it concerns the variance analysis, a significant difference of 51.70 mg/100 g for a 5% significance threshold was calculated. The best ranked was genotype G9 which had significant differences in comparison with all the other genotypes, followed by genotype G10 which had positive differences distinctly significant compared to all genotypes, except genotype G9 where there is a negative difference. Between genotypes G11, G7 and G8 there were no significant differences; between the mentioned ones and those ranked higher or lower there have been significant positive or negative differences, as it was the case. For genotypes G1 and G2 there were significant negative differences in comparison with all other genotypes classified higher compared to these two genotypes, mentioning that there was no significant difference between these two.

Our results are similar to those obtained by Yoo et al. (2008) who reports a flavonoid content of 400 mg catechin/100 g fw for *Rosa rubiginosa* and Barros et al. (2011) in a study carried out to get a chemical analysis of *Rosa canina* berries at different stages of maturity, reports a content of flavonoids of 9.8 mg/1 g extract for the ripened rosehips and extraction progress of 43.19%.

Demir et al. (2014) reports a flavonoids content of 9.48 mg rutin/g dry weight for *Rosa canina* berries in a study of five different rosehips species grown in Turkey. Furthermore, our results are higher than those reported by Roman et al. (2013) (101.3 mg/100 g to 163.3 mg/100 g frozen pulp), while the lowest concentration in flavonoids was reported by Adamczak et al. (2012), who found a medium content in flavonoid of 41 mg/100 g dw in the rosehips harvested in different parts of Poland.

Knowing the variation of the antioxidant and antibacterial activity is very important in choosing the plant material that can be used in food production, health industry and future breeding programs (Yilmaz and Ercisli, 2011). Montazeri et al. (2011), after the in vitro study in order to know the variation of the antibacterial and antioxidant activity of different extracts of *Rosa canina* berries harvested in Iran, it is suggested a possible use of the *Rosa canina* methanol extract as a source of natural antioxidant and antimicrobial agents. The antioxidant activity of *Rosa canina* studied berries varied from 99.3 to 363.44 μmol TE/1g f.w. In the case of the variance analysis, a significant difference of 48.13 µmol TE/1g sp (DPPH) has been calculated for a significant threshold of 5%. Thus, G1 has a significant positive difference compared to all other genotypes for this significance threshold. Genotypes G11 and G3 are characterized by significant differences compared to the last two genotypes classified, whilst the last genotype classified has significant negative differences compared to all other genotypes (Table 1).

In the study carried out by Roman et al. (2013) on rosehip berries from Transylvania (Romania), the antioxidant activity varied from. 63.35 µM TE/100g frozen pulp to 127.8 µM TE/100g frozen pulp. By Denev et al, (2013) in the *Rosa canina* berries originating in Bulgaria, the antioxidant activity was of 201.14 µmol $TE.g^{-1}$. Moreover, Montazeri et al. (2011) identified high activity of DPPH indicated by the methanol extract of 11.58 µg/ml, found in the berries harvested from Kandeloos village, Noshahr Mountains, Mazandaran province, Iran, and Yilmaz and Ercisli (2011) identified an antioxidant activity of 91.4% for the *Rosa canina* berries, which were samples from Erzurum in Eastern Anatolia, a region in Turkey. Duda-Chodak et al. (2011) in a study evaluating the antioxidant activity in fifteen popular herbal products reports the lowest ability to scavenge the ABTS radical for the *Rosa canina* berries of 20.6 mg TE/1g dry weight (82.4 (µM TE/1g dw) and Egea et al. (2010) report an antioxidant activity of 416.64 (µM TE/1g fw) for the *Rosa canina* berries and Demir et al. (2014) report an antioxidant activity of 35.51 µM TE/g dry weight.

Table 1. The analysis of variance and the calculation of the significant differences for the chemical compounds analyzed

Genotype	Total phenolic content (mgGAE/1g) Mean	Antioxidant activity µmol TE/100g (DPPH) Mean	Total flavonoid content (mgQ/100g) Mean
G1	35.43d	363.64a	206.13g
G10	45.71ab	188.8cd	593.51b
G11	47.85a	242.54b	534.13c
G12	48.07a	99.3e	302.26ef
G2	36.43d	232.5bc	211.8g
G3	40.5c	246.42b	279.62f
G4	40.71c	236.67bc	387.09d
G5	42.14c	149.01d	344.68de
G6	42.14c	206.15bc	378.6d
G7	42.14c	218.62bc	522.82c
G8	42.86bc	224.5bc	500.2c
G9	43.50bc	222.24bc	672.67a
Average	42.29	219.198	411.1258
Standard error	8.70	1621.84	1871.82
Standard deviation	1.70	23.25	24.98
LSD 5%	3.53	48.13	51.70

Means followed by the same letter in each column are not significantly different according to LSD Test at 5 % level.

Dog rose is a major source of acids, phenolic compounds (Aptin et al., 2013), flavonoids, anthocyanins and ascorbic acid (Ercisli, 2007; Chrubasik et al., 2008).

In order to identify sources of valuable genes, with the purpose of the establishment of some plantations the analysis of the main components was also performed.

From Table 2 one can see that out of the three factors analyzed the first two of them influence the total variance with a percent of 82.555%, these two factors being the content of phenol in aqueous extract mg/1g) in a percent of 48.674% and the antioxidant activity µmol TE/100g (DPPH) in a percent of 33.881%. The other factor analyzed i.e the flavonoid content (mgQ/100 g) influenced the variance by 17.445%.

Table 2. Eigen values and component score coefficients

Component	Initial Eigen values			Component Score Coefficient Matrix	
	Total	% of Variance	Cumulative %	1	2
Total phenolic content (mgGAE/1g)	1.460	48.674	48.674	0.619	0.202
Antioxidant activity µmol TE/100g sp	1.016	33.881	82.555	0.565	-0.219
Total flavonoid content (mgQ/100g)	0.523	17.445	100.000	0.012	0.930

The graph in Figure 1 was carried out for the first two components, namely the content of total phenolic compounds (mg/1g) (PCA 1) and antioxidant activity µmol TE/100g (PCA 2). Thus, in this graph one can see that we can identify four groups with the following characteristics:

- Group I has 3 genotypes with high values both for the for the total phenolic content and for antioxidant activity (both positive components).
- Group II has 4 genotypes with high values for the total phenolic content extract and low ones for the antioxidant activity.
- Group III has 2 genotypes with low values (negative) for both components.
- Group IV has 3 genotypes and has high values for the antioxidant activity and low values for the total phenolic content.

Principal Component Analysis was applied by Atoosa Danyaei et al., 2012 for 37 *Rosa damascena* genotypes, also by Marjorie Mercure and Anne Bruneau, 2008) for 11 morphological types used in the study of natural hybridization between *Rosa blanda* and *Rosa rugosa* to show the share of each within the total variation.

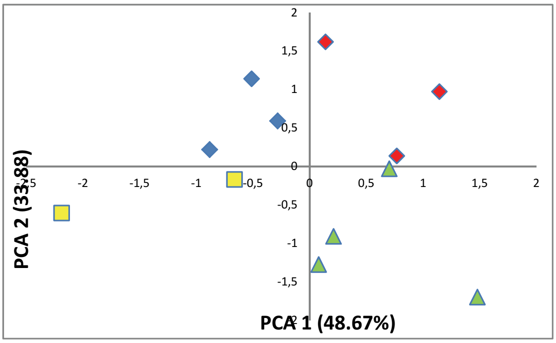


Figure 1. Plot of the first two principal components (PCA1 and PCA2). Eigenvalues for each two principal component are listed in parentheses.

CONCLUSIONS

Based on the results obtained in terms of the content of the active compounds of the *Rosa canina* berries harvested in different areas of Oltenia region a high variation was found.

After the PCA analysis, the best results in terms of total polyphenol content and antioxidant activity were observed in Group I which is formed of three genotypes: G6, G9, G11, which are thought as a chance for the improvement of this species. The three genotypes are to be found in Valcea County at a 360-600 m height. These genotypes are possible sources of natural antioxidants.

ACKNOWLEDGMENTS

This work was partially supported by the Grant number 13C/27.01/2014 awarded in the internal grant competition of the University of Craiova.

REFERENCES

Abeysinghe D.C., Li X., Sun C., Zhang W., Zhou C., 2007. Bioactive compounds and antioxidant capacities in different edible tissues of citrus fruit of four species. Food Chemistry 104(4): 1338-1344.

Adamczak A.A., Buchwald W., Zieliński J., Mielcarek S., 2012. Flavonoid and organic acid content in rose hips (*Rosa canina* L., sect. caninae dc. em. christ.) Acta Biologica Cracoviensia, Series Botanica 54(1): 105-112.

Aptin R., Asadian G., Tavana A., Taghavi M., 2013. Evaluation of biochemical compounds *Rosa cannia* L. in North of Iran (Ramsar and Tonekabon Heights). Academic Journals, Vol. 7(45): 3319-3324.

Babbar N., Oberoi H.S., Sandhu S.K., Bhargav V.K., 2014. Influence of different solvents in extraction of phenolic compounds from vegetable residues and their evaluation as natural sources of antioxidants. J Food Sci Technol, 51 (10): 2568-2575.

Barros L., Carvalho A.M., Ferreira C.F.R.I., 2011. Exotic fruits as a source of important phytochemicals: Improving the traditional use of *Rosa canina* fruits in Portugal. Food Research International, Vol. 44 (7): 2233-2236.

Brasovan A., Mândroc V., Câmpean R., Petean I., Codrea V., Arghir G., 2011. Calcium And Magnesium content in brier (*Rosa Canina* L.) fruits at the "Campul lui Neag" Sterile coal Dump (Hunedoara County, Romania). Analele Universității din Oradea - Fascicula Biologie Tom. XVIII (1): 5-9

Chrubasik C., Roufogalis B.D., Müller-Ladner U., Chrubasik S., 2008. A systematic review on the *Rosa canina* effect and efficacy profiles. Phytother Res, 22(6): 725-733.

Danyaei A., Seyed R.T.A., Mousavi A., Matinizadeh M., Jafari A.A., Mirjani L., 2012. Genetic variation and relationships between morphological and phonological traits of Damask rose (*Rosa damascena* Mill.) genotypes across 8 environments in Iran. Annals of Biological Research, 3 (10): 4918-4925

Demir F., Ozcan M., 2001. Chemical and technological properties of rose (*Rosa canina* L.) fruits grown wild in Turkey. Journal Food Engineering, 47: 333-336.

Demir N., Yildiz O., Alpaslan M., Hayaloglu A.A., 2014. Evaluation of volatiles, phenolic compounds and antioxidant activities of rose hip (*Rosa* L.) fruits in Turkey. LWT - Food Science and Technology, 57: 126-133.

Denev P., Lojek A., Ciz M., Kratchanov M., 2013. Antioxidant activity and polyphenol content of Bulgarian fruits. Bulgarian Journal of Agricultural Science, 19 (1): 22-27.

Duda-Chodak A., Tarko T., Rus M., 2011. Antioxidant activity and total polyphenol content of selected herbal medicinal products used in Poland. Herba Polonica, 57(1): 48-61.

Egea I., Sanchez-Bel P., Romajaro F., Pretel M.T., 2010. Replace synthetic additives in functional foods as a natural antioxidant. Plants Foods Hum Nutr, 65: 121-129.

Ercisli S., 2007. Chemical composition of fruits in some rose (*Rosa* spp.) species. Food Chemistry, 104 (4): 1379-1384.

Fattahi S., Jamei R., Hosseini S.S., 2012. Antioxidant and antiradicalic activity of Rosa canina and *Rosa pimpinellifolia* fruits from West Azerbaijan. Iranian J Plant Physiol, 2(4): 523-529.

Fecka I., 2009. Qualitative and quantitative determination of hydrolysable tannins and other polyphenols in herbal products from meadowsweet and dog rose. Phytochem Anal., 20(3): 177-90.

Ghazghazi H., Miguel M.G., Hasnaoui B., Sebei H., Ksontini M., Figueiredo A.C., Pedro L.G., Barroso J.G., 2010. Phenols, essential oils and carotenoids of *Rosa canina* from Tunisia and their antioxidant activities. African Journal of Biotechnology, Vol. 9(18): 2709-2716.

Ghiorghiță G., Antohe N., Rați I.V., Maftei D.E., 2012. The study of some parameters of *Rosa canina* L. genotypes from different native populations and from the same population. Analele Științifice ale Universității „Al. I. Cuza" Iași, Biologie vegetală, 58 (1): 19-27.

Hamidi S., Vaez H., Asgharian P., 2015. *Rosa canina* as an adjunctive treatment of asthma: A hypothesis. Advances in Bioscience & Clinical Medicine, Vol. 3 (1): 48-52.

İlbay Z., Şahin S., Kırbaşlar Ş.I., 2013. Investigation of Polyhenolic Content of Rose Hip (*Rosa canina* L.) Tea Extracts: A Comparative Study. Foods, 2: 43-52.

Iqbal S., Bhanger M., Anwar F., 2005. Antioxidant properties and components of some commercially available varieties of rice bran in Pakistan. Food Chem., 93(2): 265-272.

Karakaya S., Kavas A., 1999. Antimutagenic activities of some foods. Journal of the Science of Food and Agriculture, 79: 237-242.

Koca I., Ustun N.S, Koyuncu T., 2009. Effect of Drying Conditions on Antioxidant Properties of Rosehip Fruits. Asian Journal of Chemistry, 21 (2): 1061-1068.

Mercure M., Bruneau A., 2008. Hybridization between the escaped *Rosa rugosa* (*Rosaceae*) and native *R. blanda* in Eastern North America. American Journal of Botany, 95(5): 597-607.

Montazeri N., Baher E., Mirzajani F., Barami Z., Yousefian S., 2011. Phytochemical contents and biological activities of *Rosa canina* fruit from Iran. Journal of Medicinal Plants Research, Vol. 5(18): 4584-4589.

Netoiu C., Visoiu D., Bădele O., 2008. Dendrologie. Editura Eurobit Timisoara, 235 p.

Niculescu, M., 2006. Flora and vegetation in the upper basin of the Luncavat River, Ph.D. thesis, "Babes-Bolyai" University of Cluj-Napoca, 347 p.

Nowak R. 2006a. Comparative study of phenolic acids in pseudofruits of some species of roses. Acta Pol Pharm, 63: 281-288.

Pandey K.B., Rizvi S.I., 2009. Plant polyphenols as dietary antioxidants in human health and disease. Journal Oxid Med Cell Longev, 2(5): 270-278.

Pogačnik L., Ulrih P.N., 2011. Influence of environmental factors on antioxidants content in rose hips. Bulletin of the Transilvania University of Braşov Series VI: Medical Sciences, 4 (53): 103-110.

Rahimabadi E.B., Sedaghathoor S., Qasemnejad M., 2013. Study on phytochemical and horticultural traits of dog rose (*Rosa canina*) in natural habitat. International Journal of Biosciences, 3 (12): 145-152.

Roman I., Stanila A., Stanila S., 2013. Bioactive compounds and antioxidant activity of *Rosa canina* L. biotypes from spontaneous flora of Transylvania. Chemistry Central Journal, 7(1): 73

Ropciuc S., Cenuşă R., Căpriță R., Crețescu I., 2011. Study on the Ascorbic Acid Content of rose Hip fruit Depending on Stationary Conditions. Scientific Papers: Animal Science and Biotechnologies, 44 (2): 129-132.

Rosu C.M., Manzu C., Zenovia O., Oprea L.A., Ciornea E., Zamfirache M.M., 2011. Several Fruit Characteristics of *Rosa* sp. Genotypes from the Northeastern Region of Romania. Not Bot Horti Agrobo, 39(2): 203-208

Singleton V.L., Orthofer R., Lamuela-Raventos R.M., Lester P., 1999. Analysis of total polyphenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Method enzymol, 299:152-178.

Soare R., Iancu P., Soare M., Bonea D., Mandrila G., Păniță O., 2014(a). Morphological And Biochemical issues to some *Rosa Canina* L. populations from the spontaneous flora from south-west Romania. 14th GeoConference on Nano, Bio and Green-Tehchnologies for a sustainable future. Conference proceedings, Vol 1: 435-442.

Soare R, Niculescu M., Panita O., Bonea D., Iancu P., 2014 (b). The biodiversity study of some *Rosa canina* L. gneotypes from Oltenia area. Annals of the University of Craiova- Agriculture, Montanology, Cadastre Series, Vol 44 (1): 257-261.

Yilmaz S.O., Ercisli S., 2011. Antibacterial and antioxidant activity of fruits of some rose species from Turkey. Romanian Biotechnological Letters, Vol. 16, No. 4, p. 6407-6411.

Türkben C., Vildan U., Bige İ., Işıl Ç., 2010. Effects of different maturity periods and processes on nutritional components of rosehip (*Rosa canina* L.). Journal of Food, Agriculture & Environment, 8 (1): 26-30.

Warholm O., Skaar S., Hedman E., Molmen H.M., Eik L., 2003. The effects of a standardized herbal remedy made from a subtype of *Rosa canina* in patients with osteoarthritis: a double-blind, randomized, placebo-controlled clinical trial. Current Therapeutic Research, 64: 21-31.

Yilmaz S.O., Ercisli S., 2011. Antibacterial and antioxidant activity of fruits of some rose species from Turkey. Romanian Biotechnological Letters, Vol. 16 (4): 6407-6411.

Yoo K.M, Lee C.H, Lee H., Moon B., Lee C.Y., 2008. Relative antioxidant and cytoprotective activities of common herbs. Food Chem, 106: 929-936.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SPIKE MORPHOLOGY AND VARIATION IN SPIKE PARAMETERS IN SPECIES *TRITICUM* × *SAVOVII* H.P.ST.

Hristo P. STOYANOV[1,2]

[1]Technical University – Varna, 1, Studentska str., 9000, Varna, Bulgaria
[2]M-AGRO EOOD, 5, Parvi Mai str., 9350, Stozher, Dobrich region, Bulgaria

Corresponding author email: hpstoyanov@abv.bg

Abstract

Modern agricultural production and the growing demand for qualitative grain inputs, suggest dynamic and constantly development of new technologies and varieties of cereals in order to meet the market requirements. Therefore breeders faced a number of difficulties, since combining quantitative with qualitative parameters of yield being a difficult and lengthy process. Wide hybridization allows valuable plant materials that incorporate such features such as high protein content, resistance to diseases and pests, tolerance to abiotic stress and etc, to be obtained. The species Triticum ×savovii (2n=6x=42, $A^uA^uBBA^bA^b$) is amphidiploid obtained as a result of interspecific hybridization, which combines the genomes of the species Triticum polonicum (2n=4x=28, A^uA^uBB) and Triticum boeoticum (2n=2x=14, A^bA^b). Since both are characterized by very valuable qualities, they represent significant interest for the breeding of the wheat species. In order to determine its eligibility to participate in the hybridization programs as starting breeding material, the morphological parameters of the spikes and grains of species Triticum ×savovii were studied within 2 years. Moderate to significant variation in the indicators related to the weight of spike and the weight and the number of grains in a spike was settled. Less is the reported variation in the length of the spike but not for the indicators associated therewith. There were no significant variations in the weight of 1000 grains, which highlights the comparative uniformity of the resulting production of studied amphidiploid. There are, however, some differences between productivity associated with growing conditions (factor "economic year"), which suggests differences in some of the climatic factors. However, the species indicates stability and flexibility in relation to the morphological characteristics of the formed spikes, which together with its other characteristics (resistance to diseases), makes it valuable for inclusion in the breeding programs of the wheat species.

Key words: *amphidiploid, spike morphology, Triticum ×savovii, variation.*

INTRODUCTION

Agricultural production of the modern stage of its development and the ever increasing global demand for more quality grain raw materials sets numerous problems about the crops yield (von Braun, 2007). It is therefore necessary to be rapidly set up agricultural technologies and new varieties which should meet the global needs for food and feed (Crosson and Anderson, 1992). Notwithstanding this dinamics, in the developed countries is necessary to maintain a certain level of agrodiversity being able to satisfy the various industrial requirements. Therefore, it is not sufficient to grow limited number of crop plants, but it is necessary plant species from other geographical areas to be introduced, as well as new species with varying characteristics to be created using classical breeding methods (Atanasov, 2013). Thus, plant production could be enriched, but also the sources of the initial breeding material of the existing crops will increase.

Wide hybridization is a method of classical breeding, whereby phylogenetically distant species are crossed to create intergeneric and interspecific hybrid and amphidiploid forms (Stoyanov et al., 2010). Its significance is quite diversified because by this method could both create new species and resynthesize existing ones based on their phylogenetic origin, but also to transfer valuable genes carrying different types of resistance and tolerance to biotic and abiotic stress factors into the crops (Stoyanov, 2013a). The wide hybridization has great importance in cereals and especially in wheat species. There are numerous amphidiploid forms in tribus *Triticae*, and transfer of many resistance genes in common winter wheat (Stoyanov, 2013a; Spetsov et al., 2008; Spetsov et al., 2009). Although wide hybridization is associated with many difficulties related to species incompatibility at preembryonic, embryonic and postembryonic level, modern biotechnological methods could be effectively used to overcome them (Stoyanov, 2013).

Triticum ×savovii (2n = 6x = 42, $A^uA^uBBA^bA^b$) is an amphidiploid, first described by Spetsov and Savov (1992) and as a separate species of the genus *Triticum* by Stoyanov (2014). The species originated from a cross between the species *Triticum polonicum* (2n = 4x = 28, A^uA^uBB) and *Triticum boeoticum* (2n = 2x = 14, A^bA^b) uniting their genomes. It strongly likened the spike morphology of *Triticum polonicum*, but grains are smaller and slightly shriveled. The species is highly resistant to powdery mildew, brown rust and septoria leaf blight (Stoyanov, 2014a). Its treshability is considerably more difficult than *Triticum polonicum*, due to its hard glumes and lemmas and paleas.

The importance of this species for the breeding programs of wheat species is significant, because it combines hexaploid level with valuable genome of *Triticum boeoticum*. Therefore it is necessary to be examined in details in relation to its features. It is important to be evaluated by morphological, physiological, ecological, phytopathological, entomological point of view, and to be outpointed to what extent is able to meet the requirements as initial material in modern dynamic breeding (Stoyanov, 2014b). The determination of many valuable features would allow its possible introduction as a cultivated plant species.

The main purpose of this study is a morphological analysis of spikes of the species *Triticum × savovii*, originating from different economic years to be made, and the impact of the environment on various studied parameters to be assessed in order to determine the suitability of the species to be involved as a initial material in breeding programs of different wheat species.

MATERIALS AND METHODS

An accession of the wheat species *Triticum × savovii* is used, originating from the collection of Dobrudzha Agricultural Institute - General Toshevo. 15 numbers of seeds of the accession were sown in a scheme with row spacing 30 cm and 5 cm inside the rows. Sowing is carried out in 2012/2013 and 2013/2014 economic year respectively on 11.11.2012 and 06.11.2013, under field conditions in the area of Stozher, Dobrich region.

Harvesting is carried out in full maturity phase in the economic years 2012/2013 and 2013/2014 respectively on 20.07.2013 and 16.07.2014. Of each sample were randomly selected 20 fully mature spikes free of diseases and pests. An assessment of the morphology of spikes of each sample is made by 6 quantitative: length of spike (LS), length of spike with awns (LSA), weight of spike (WS), number of spikelets in a spike (NSS), weight of the grains in a spike (WGS), number of grains in a spike (NGS) and 6 index parameters: awness index (AI) - ratio between LSA and LS, weight distribution along the length of spike (WDLS) - ratio between WS and LS, number of spikelets to the length of spike (NSLS) - ratio between NSS and LS, average weight of a spikelet (AWS) – ratio between WS and NSS, mass of 1000 grains (M1000) – set by a standart methodology, grain index (GI) - ratio between WGS and WS, productivity distribution along the length of spike (PDLS) - ratio between WGS and LS, number of grains along the length of spike (NGLS) - ratio between NGS and LS, average productivity of a spikelet (APS) - ratio between WGS and NSS, average number of grains in a spikelet (ANGS) - ratio between NGS and NSS, weight of straw in the spike (WSS) - difference between WS and WGS.

To neutralize the influence of the factor "year" in order to establish biometrical relations in the amphidiploid, are calculated six specific weight indeces as a corrected value of the weight of 1000 grains (according to Stoyanov, 2015a) - a specific index eliminating the factor influence (SEFI) - ratio between M1000 and WSS; SEFI2 - ration between M1000 and the product between WSS and NSS; SEFI3 - ratio between M1000 and NSS; SEFI4 - ratio between M1000 and the product of AI and NSS; SEFI5 - ratio between M1000 and AI; SEFI6 - ratio between M1000 and NSLS. An additional indicator - specific index eliminating the year influence (SEYI) - a product between the ratio of WGS and NGS with LS is established. The corrective parameters are determined based on the hypothesis that the year did not affect the number of formed spikelets, largely on the weight of the vegetative part of the spike and to the awness index. SEYI additional indicator is based on the hypothesis that the indicators WGS, NGS and LS are in the biological equilibrium regardless of environmental conditions.

Data of the average daily temperatures during the period 01.10.2012 - 06.30.2013 and 10.01.2013 - 30.06.2014, and the amount of precipitation in the same periods are summarized. The temperature and rainfall data were obtained from measurements with automatic meteorological station LaCrosse. Measurements were taken twice daily in 07:00 and 19:00. The data were averaged in two periods (vegetative - 01.10 - 31.03; and reproductive - 01.04 - 30.06) and total. (Abbreviations: AVT - average vegetation temperature; AVFT - average vegetative-formation temperature; ARFT - average reproductive-formation temperature; TVT - total vegetation precipitation; TVFP - total vegetative-formation precipitation; TRFP - total reproductive-formation precipitation).

The data obtained is averaged and also the standard deviation (SD) is calculated, by years and total. The total variation coefficient (VC) is calculated. A correlation analysis between all recorded parameters and climatic characteristics is made. One-way ANOVA for considering the effects of the year on amphidiploid is conducted. It has been used a method of adding a third medium component representing the data of morphological parameters, averaged for the two study periods – average year (AY). It is reported the significance of the results. In order to summarize the data and for variational analysis was used software Microsoft Excel 2003 and for ANOVA and correlation analysis - IBM SPSS Statistics 19.

RESULTS AND DISCUSSIONS

Data about the studied morphological parameters are presented in Table 1. From the table could be monitored the slight variations in indicators NSS, LS, LSA, AI, NSLS and M1000 and the high variations in WS, WGS and NGS, and the index parameters associated with WGS and M1000. The slight variation in the first six listed indicators is due to the similar external morphology of the spikes and grains (Figure 1, 2, 3, 4), which is emphasized by the uniform genetic background of the studied plants. In the second group of indicators, high variation is caused by the uneven seedset and filling the grain of spikes in different periods, which is indicative of the influence of environmental factors on them. Lack of stability of yield components is a typical sign of the most wide hybrids and amphidiploids, especially in different growing conditions. Similar data have been reported in other amphidiploid wheat species, synthetic hexaploid wheats and intergeneric hybrids and amphidiploids (Spetsov and Savov, 1992; Spetsov et al., 2008; Spetsov et al., 2009; Niskidashvili, 1984; Stoyanov et al., 2012; Lalkova et al., 2004). There is high variability within the plant of the studied accession in the second year of cultivation, indicating differences in the size and seedset of the spikes caused by deteriorating environmental conditions. Firstly this could be due to the difference in nutrition of the additional tillers and secondly - in inhomogeneity of the plant population.

The difference in the environmental conditions could be monitored from the data presented in Table 2. There are, too large differences in the average temperatures and precipitation in the two studied periods. 2013/2014 economic year is characterized by very low temperatures during the period 01.04 - 30.06, compared with the previous year, which allows the presence of variation in plant development. Lower temperature during this period, in combination with higher rainfall are firstly a prerequisite for low fertility and secondly to the delay in the physiological processes of the grain filling. This would lead to an increase in the variation in some of the weight parameters as the amphidiploid plants are characterized by a high degree of instability in the yield of the spikes (Stoyanov, 2014d) obtained by the additional tillers. In combination with higher temperatures during the period 01.10-31.03 in 2013/2014, the present conditions are reason for higher tillering. This together with the slower physiological processes into the reproductive period, leading to instability in the seedset of the the main spike due to the distribution of the nutrients to more tillers (Stoyanov, 2013c). This thesis is underlined by higher variability of the indicators NSS, LS, WS, WGS and NGS in the economic 2013/2014 (Table 1).

Figure 1. Spikes of *Triticum ×savovii* of 2012/2013 economic year

Figure 2. Seeds of *Triticum ×savovii* of 2012/2013 economic year

The data from the conducted one-way ANOVA are presented in Table 3. The factor "year", which generally refers to the environmental conditions, enables to follow the reaction of a particular genotype, depending on the specific characteristics in the growing period. Usually these factors in wheat species are associated with a very strong influence on weight parameters. Various studies in other cereals (Tsenov et al., 2006; Rachovska and Uhr, 2010; Reeves et al., 1999; Georgieva et al., 2004) emphasize its widespread impact on parameters such as M1000, WS, WGS, NGS, LS. However, the degree of impact of growing conditions is directly related to the specific genotype (Stoyanov, 2013b).

Figure 3. Spikes of *Triticum ×savovii* of 2013/2014 economic year

Figure 4. Seeds of *Triticum ×savovii* of 2013/2014 economic year

The factor "year" has no impact on the index NSS in the studied accession. Despite of the wide variation in the economic 2013/2014, there are no significant differences between the studied periods. This allows to assert that the environmental conditions do not affect the spike formation in the phase stem extension (Stoyanov, 2014b). This is emphasized by the uniform values of AVFT and TVFP in both years of cultivation. Complete lack of correlation between the meteorological parameters and the NSS confirms moreover the absence of influence of growing conditions.

The indicators LS and LSA are too variative parameters that could be strongly influenced by environmental conditions. Similar dependences have been reported about amphidiploid accessions, and for different wheat species (Tsenov et al., 2004; Tsenov et al., 2006; Rachovska and Uhr, 2010; Reeves et al., 1999; Georgieva et al., 2004; Stoyanov, 2013b; Stoyanov, 2014b; Stoyanov, 2014c; Stoyanov, 2014d; Stoyanov, 2015). The significant influence of environmental conditions is indicative of the differences in values between the two study periods, since their formation is related to the period 01.04-30.06, which for the two economic years differ as in precipitation but also in the average temperatures.

The weight of the spike and the weight of grains in a spike like LS and LSA are highly varying parameters, but they form their values rather dynamic (Rachovska and Uhr, 2010; Asif et al., 1999; Fischer and HilleRisLambers, 1978; Fonseca and Patterson, 1968; Grieve et al., 1992; Kashif and Khaliq, 2004; Leilah and Al-Khateeb, 2005). The presence of highly significant differences between the two periods is indicative of highly deteriorated environmental conditions due to intense rainfall in June 2014, coinciding with the phase of grain filling. Lack of enough intensive photosynthesis, because of less light in daylight hours and reduced temperatures suggest impaired nutrients flow and hence lower and highly variable values of WS and WGS.

Similar is the impact on the indicator NGS (Siddique et al., 1989). Rainfall in May 2014 is a prerequisite for reducing the degree of cross-pollination between plants of the accession and to increase self-pollination. As the studied amphidiploid like triticale has a hybrid character, it could be presumed that a certain low level of sterility is a result of abnormalities in the meiosis. Therefore NGS performed much higher values in the 2012/2013 economic year.

Particularly strong and significant is the influence on the indicator M1000. Although during every year, this indicator could be characterized by moderate to high variability, there are observed significant differences for different periods. Since the M1000 is a specific ratio of the number of formed grains in weight units of a particular spike (Stoyanov, 2013b), it could be seek the simultaneous influence of the year on the parameters WGS and NGS. The presence of high significance implies an accumulation of a number of factors, and different mechanism of formation of the two parameters. Similar significance levels of M1000 are reported from many authors and researches in wheat (Rachovska and Uhr, 2010; Asif et al., 1999; Fischer and HilleRisLambers, 1978; Fonseca and Patterson, 1968; Grieve et al., 1992; Kashif and Khaliq, 2004; Leilah and Al-Khateeb, 2005).

The meanings of the index parameters NSLS, WDLS, AWS, NGLS, PDLS, APS, ANGS, GI and WSS followed a similar trend with the M1000. This is because these parameters are specific ratios of features that are largely influenced by the environmental conditions (Stoyanov, 2014b; Stoyanov, 2013b). Due to the fact that on their components affect environmental conditions, but with different intensities and at different times, its influence is accumulated in this kind of parameters. Less is only the impact on the indicator NSLS as one of its compmnens is not affected by environmental conditions, and the other to a lesser extent. Similar should be the trend in the indicators AWS, APS and ANGS, but they are influenced by the strong meanings of WS, WGS and NGS.

The values of the index indicators should have a sustainable character, as they represent specific biological ratios into the plant biology (Stoyanov, 2014c). In spite of the fact that in amphidiploids amongst the cereals there are typical unstable values of the correlations between the components of the yield in progressive generations (Stoyanov et al., 2010), they are retained to a certain levels. However, deteriorating environmental conditions during the 2013/2014 economic year have an impact on such dependencies. This indicates the presence of particular genetic mechanisms that violate biological ratios in order to preserve the reproduction of the species (Ayala and Kiger, 1987). For this reason, regardless of the environmental conditions it should be a relation between certain parameters which is not affected by the growing period because the genotype for both periods remained unchanged. This is important in breeding work, since it allows to distinguish the effect of genotype from the environmental influence and thus is associated with resistance of a genotype in relation to the reproduction to a variety of factor effects.

Such kind of ratios represents the indicator AI. Regardless of the period of the study, its variation remains relatively moderately low, even in economic 2012/2013. Lack of significant values to growing conditions, assumes that the length of the awns is strictly in relation to the length of the spike. This is because LS and LSA are formed by the action of the same conditions and environmental factors (Stoyanov, 2013b).

The parameters, SEFI, SEFI2, SEFI3, SEFI4, SEFI5 and SEFI6 in the studied plants give an idea of the strong intensity of the influence of the factor "year" on the formation of the components of yield. Although they are specific corrective indicators of M1000 and its corrective components NSS is not affected by environmental conditions for the studied genotype, the presence of high significance for SEFI SEFI2, SEFI3, SEFI4 and SEFI5 is indicative of the presence of various factors of the environmental conditions, which form the values of the components of a particular coefficient. In SEFI and SEFI2 is observed effect like to the index parameters, because WSS participates as a component, which is significant affected by the environmental conditions, since its values are related to the intensity of the vegetative growth of the spikes.

SEFI6 unlike other corrective parameters is characterized by a lack of significance regarding the influence of environmental conditions. This is likely due to the involvement of LS as an element of NSLS and also NSS. However, since NSS operates through the genotypic factors, it could not eliminate the importance of a formation factor of the environmental conditions. Therefore, it is calculated specific additional parameter SEYI. It includes the effect of three highly variative parameters – WGS, NGS and LS. Lack of significance in relation to the factor "year" proves the existence of biological ratio in the studied amphidiploid, which excludes specific variability due to the hybrid nature of the plant species. The operation of LS exhibit that the environment has a effect on it throughout whole reproductive-forming period - 01.04-30.06 while on NGS is (relatively) from 01-31.05 and for WGS - 01-30.06.

The dependencies and the impact of the environmental conditions on the index and corrective parameters are confirmed by the values of correlation coefficients (Table 4).

Regardless of the low values of the parameters of the studied accession of the species *Triticum ×savovii*, due to deteriorating environmental conditions in the economic 2013/2014, the studied plants are distinguished by biometrically and biologically stable genotype and could be effectively used as an initial material in breeding programs of different wheat species.

CONCLUSIONS

Based on the results mentioned above the following conclusions could be made:

1. The parameters NSS, LS, LSA, NSLS, AI and M1000 are distinguished by low to moderate variability due to the similar morphology because of the identical genotype of the studied accession.
2. The parameters WS, WGS, NGS are characterized by high levels of variation due to uneven seedset and due to the impact of growing conditions in different periods.
3. All studied morphological quantitative parameters with the exception of NSS and index parameters excluding AI are influenced reliable and significant in relation to the factor "year", based on the conducted ANOVA.
4. All index parameters correlate high and significantly with the climate indicators, which highlights the importance of growing conditions in the formation of the spike morphology.
5. The corrective parameters SEFI, SEFI2, SEFI3, SEFI4 and SEFI5 do not eliminate the influence of environmental conditions, while SEFI5 and SEYI are not affected significantly, emphasizing the presence of biological ratios in the species *Triticum ×savovii*, determining its stable genotype, which makes it suitable for use as initial material in breeding programs for the wheat species.

Table 1. Data of the morphological analysis of spikes of the species *Triticum* ×*savovii*

Parameter	Year	AV	SD	VC	Parameter	Year	AV	SD	VC
NSS	2012/2013	14.35	1.93	13.43	NGLS	2012/2013	0.451	0.101	22.40
	2013/2014	14.45	3.28	22.73		2013/2014	0.221	0.082	37.12
	AY	14.40	1.89	13.12		AY	0.329	0.071	21.53
	AV	14.40	2.41	16.75		AV	0.333	0.127	38.00
LS	2012/2013	90.75	12.01	13.23	PDLS	2012/2013	0.026	0.008	32.38
	2013/2014	106.05	16.40	15.46		2013/2014	0.009	0.004	49.69
	AY	98.40	11.34	11.52		AY	0.015	0.005	34.20
	AV	98.40	14.63	14.87		AV	0.017	0.009	55.60
LSA	2012/2013	174.15	16.94	9.73	APS	2012/2013	0.158	0.030	19.20
	2013/2014	190.15	16.21	8.52		2013/2014	0.068	0.027	39.52
	AY	182.15	11.87	6.52		AY	0.112	0.023	20.40
	AV	182.15	16.30	8.95		AV	0.113	0.045	40.28
WS	2012/2013	3.02	0.71	23.57	ANGS	2012/2013	2.83	0.46	16.12
	2013/2014	2.03	0.67	32.82		2013/2014	1.63	0.58	35.66
	AY	2.53	0.54	21.25		AY	2.23	0.41	18.20
	AV	2.53	0.75	29.72		AV	2.23	0.69	30.86
WGS	2012/2013	2.28	0.57	25.08	WSS	2012/2013	0.74	0.17	23.64
	2013/2014	0.98	0.44	44.81		2013/2014	1.05	0.38	36.65
	AY	1.64	0.38	23.49		AY	0.90	0.23	26.15
	AV	1.63	0.71	43.35		AV	0.89	0.30	33.89
NGS	2012/2013	40.70	9.18	22.56	SEFI	2012/2013	79.84	18.67	23.38
	2013/2014	23.65	9.94	42.02		2013/2014	44.42	16.96	38.17
	AY	32.18	7.56	23.48		AY	60.35	15.12	25.05
	AV	32.18	11.25	34.97		AV	61.54	22.18	36.04
AI	2012/2013	1.94	0.28	14.16	SEFI2	2012/2013	5.83	2.28	39.04
	2013/2014	1.82	0.24	13.23		2013/2014	3.49	2.14	61.40
	AY	1.87	0.17	9.37		AY	4.37	1.64	37.58
	AV	1.88	0.24	12.56		AV	4.57	2.23	48.81
NSLS	2012/2013	0.161	0.031	19.44	SEFI3	2012/2013	4.00	0.84	21.03
	2013/2014	0.137	0.019	14.12		2013/2014	3.02	0.91	30.23
	AY	0.148	0.015	10.05		AY	3.59	0.59	16.53
	AV	0.148	0.025	16.55		AV	3.54	0.88	24.88
WDLS	2012/2013	0.034	0.009	27.86	SEFI4	2012/2013	2.10	0.54	25.83
	2013/2014	0.019	0.004	23.54		2013/2014	1.66	0.44	26.65
	AY	0.025	0.005	20.52		AY	1.93	0.32	16.58
	AV	0.026	0.009	34.40		AV	1.90	0.47	24.96
AWS	2012/2013	0.210	0.036	17.27	SEFI5	2012/2013	29.36	4.84	16.48
	2013/2014	0.139	0.029	21.12		2013/2014	23.21	5.93	25.56
	AY	0.175	0.025	14.54		AY	27.44	3.21	11.70
	AV	0.175	0.042	24.05		AV	26.67	5.38	20.16
M1000	2012/2013	56.12	6.19	11.03	SEFI6	2012/2013	363.98	93.13	25.59
	2013/2014	41.38	8.32	20.12		2013/2014	313.89	82.80	26.38
	AY	50.83	4.24	8.35		AY	351.03	57.62	16.41
	AV	49.44	8.84	17.89		AV	342.97	80.80	23.56
GI	2012/2013	0.75	0.04	5.38	SEYI	2012/2013	5.11	0.95	18.51
	2013/2014	0.47	0.12	26.36		2013/2014	4.43	1.21	27.27
	AY	0.65	0.06	9.54		AY	5.01	0.74	14.75
	AV	0.62	0.14	22.96		AV	4.85	1.01	20.88

AV – average value; SD – standard deviation; VC – variation coefficient; AY – average year

Table 2. Temperature and precipitation data for the studied period

Months	AMT, ºC			TMP, mm		
	2012/2013	2013/2014	AY	2012/2013	2013/2014	AY
October	16.1	12.1	14.1	73.5	79	76.25
November	9.2	9.5	9.4	41	29	35
December	0.9	1.8	1.4	142	10	76
January	1.2	2.6	1.9	47	153	100
February	3.6	4.7	4.2	34.5	19	26.75
March	6.2	8.7	7.5	31	56	43.5
April	13.4	11.5	12.5	39.5	39	39.25
May	19.7	15.6	17.7	20.5	120	70.25
June	20.9	19.2	20.1	60	234	147
AVT	10.1	9.5	9.8	-	-	-
AVFT	6.2	6.6	6.4	-	-	-
ARFT	18.0	15.4	16.7	-	-	-
TVP	-	-	-	489	739	614
TVFP	-	-	-	369	346	358
TRFP	-	-	-	120	393	257

AMT – average monthly temperature; TMP – total monthly precipitation; AY – average year; AVT – average vegetation temperature; AVFT – average vegetative-formation temperature; ARFT – average reproductive-formation temperature; TVT – total vegetation precipitation; TVFP – total vegetative-formation precipitation; TRFP – total reproductive-formation precipitation

Table 3. ANOVA of the morphological parameters

Paramater	Sum of Squares	degrees of freedom	Mean Square	F	Significance
NSS	0.100	2	0.050	0.008	0.992
LS	2340.900	2	1170.450	6.482	0.003
LSA	2560.000	2	1280.000	5.560	0.006
WS	9.712	2	4.856	11.749	0.000
WGS	16.874	2	8.437	37.802	0.000
NGS	2907.025	2	1453.513	18.155	0.000
AI	0.154	2	0.077	1.407	0.253
NSLS	0.006	2	0.003	5.535	0.006
WDLS	0.002	2	0.001	23.872	0.000
AWS	0.050	2	0.025	26.766	0.000
M1000	2229.744	2	1114.872	26.638	0.000
GI	0.813	2	0.406	58.478	0.000
NGLS	0.530	2	0.265	36.300	0.000
PDLS	0.003	2	0.001	36.559	0.000
APS	0.080	2	0.040	55.666	0.000
ANGS	14.412	2	7.206	30.531	0.000
WSS	0.983	2	0.491	6.326	0.003
SEFI	12586.393	2	6293.196	21.834	0.000
SEFI2	55.782	2	27.891	6.704	0.002
SEFI3	9.735	2	4.868	7.705	0.001
SEFI4	1.979	2	0.990	5.020	0.010
SEFI5	396.306	2	198.153	8.629	0.001
SEFI6	27039.159	2	13519.579	2.152	0.126
SEYI	5.386	2	2.693	2.790	0.070

Table 4. Correlation analysis between morphological parameters and climatic data

Parameter	AVT	AVFT	ARFT	TVP	TVFP	TRFP
NSS[1]	-.017	.017	-.017	.017	-.017	.017
LS[2]	-.430**	.430**	-.430**	.430**	-.430**	.430**
LSA	-.404**	.404**	-.404**	.404**	-.404**	.404**
WS[3]	.540**	-.540**	.540**	-.540**	.540**	-.540**
WGS	.755**	-.755**	.755**	-.755**	.755**	-.755**
NGS	.624**	-.624**	.624**	-.624**	.624**	-.624**
AI	.214	-.214	.214	-.214	.213	-.214
NSLS	.403**	-.403**	.403**	-.403**	.402**	-.403**
WDLS	.672**	-.672**	.672**	-.672**	.670**	-.672**
AWS	.696**	-.696**	.696**	-.696**	.696**	-.696**
GI	.812**	-.812**	.812**	-.812**	.815**	-.812**
NGLS	.748**	-.748**	.748**	-.748**	.747**	-.748**
M1000	.686**	-.686**	.686**	-.686**	.689**	-.686**
PDLS	.740**	-.740**	.740**	-.740**	.737**	-.741**
APS	.813**	-.813**	.813**	-.813**	.813**	-.813**
ANGS	.719**	-.719**	.719**	-.719**	.719**	-.719**
WSS	-.426**	.426**	-.426**	.426**	-.426**	.426**
SEFI	.658**	-.658**	.658**	-.658**	.656**	-.658**
SEFI2	.432**	-.432**	.432**	-.432**	.430**	-.432**
SEFI3	.459**	-.459**	.459**	-.459**	.460**	-.459**
SEFI4	.383**	-.383**	.383**	-.383**	.384**	-.383**
SEFI5	.471**	-.471**	.471**	-.471**	.474**	-.471**
SEFI6	.255*	-.255*	.255*	-.255*	.257*	-.255*
SEYI	.276*	-.276*	.276*	-.276*	.279*	-.276*

*- the data is significant at level of p<0.05; **- the data is significant at level of p<0.01; 1 (in *italic*) – parameters not influenced by environmental conditions; 2 (normal) – parameter influenced by environmental condition in moderate or very low level; 3 (**bolded**) – parameters influenced by environmental conditions in a high level.

REFERENCES

Asif M., Khaliq I., Chowdhry M.A., Salam A., 1999. Genetic Mechanism For Some Spike Characteristics and Grain Yield In Bread Wheat. Pakistan Journal of Biological Sciences, 2(3): 948-951

Atanasov A., 2013. Sustainable agriculture in the climate change area, Scientific Conference with international participation: Innovations and Agriculture Development in Bulgaria, Trakia University - Stara Zagora (in press).

Ayala F.J., Kiger J.A., 1987. Modern genetics. Zemizdat. Sofia (Bg).

Crosson P., Anderson J.R., 1992. Resources and global food prospects: supply and demand for cereals to 2030. World Bank Technical Paper, 184: 1-138.

Fischer R.A., HilleRisLambers D., 1978. Effect of environment and cultivar on source limitation to grain weight in wheat. Australian Journal of Agricultural Research, 29(3): 443-458

Fonseca S., Patterson F.L., 1968. Yield Component Heritabilities and Interrelationships in Winter Wheat (*Triticum aestivum* L.). Crop Science, 8-5: 614-617

Grieve C.M., Lesch S.M., Francois L.E., Maas E.V., 1992. Analysis of Main-Spike Yield Components in Salt-Stressed Wheat. Crop science, 32-3: 697-703

Georgieva Hr., Tsankova D., Samodova A., 2004. Biological and economical properties of some prospective common winter wheat varieties. FCS 1(1): 51-56 (Bg)

Kashif M., Khaliq I., 2004. Heritability, Correlation and Path Coefficient Analysis for Some Metric Traits in Wheat. International Journal of Agriculture and Biology, 6-1: 138-142

Lalkova L.I., Arbuzova V.S., Efremova T.T., Popova O.M., 2004. Resistance to fungal diseases in hybrid progeny from crosses between wheat variety Saratovskaya 29 and the amphidiploid *Triticum timopheevii*/*Triticum tauschii*. Rusian Journal of Genetics, 40(9): 1046-1050.

Leilah A.A., Al-Khateeb S.A., 2005. Statistical analysis of wheat yield under drought conditions. Journal of Arid Environments, 61-3: 483-496

Naskidashvili P.P., 1984. Wheat wide hybridization. Kolos. Moscow (Ru).

Rachovska G., Uhr Z.L., 2010. Inheritance of quantitative characteristics associated with productivity of F1 hybrids winter common wheat, FCS 6(3): 361-367 (Bg).

Reeves T., Rajaram S., van Ginkel M., Trethowan R., Braun H.-J., Cassaday K., 1999. New Wheats for a Secure, Sustainable Future. Mexico, D.F.: CIMMYT, p. 28.

Rehman M., Hansen J.L., Zemetra R.S., 2006. Hybrids and Amphiploids of *Aegilops cylindrica* with *Triticum aestivum* L.; Production Morphology and Fertility. Pakistan Journal of Biological sciences, 9(8): 1563-1566.

Siddique K.H.M., Kirby E.J.M., Perry M.W., 1989. Ear: Stem ratio in old and modern wheat varieties; relationship with improvement in number of grains per ear and yield. Field Crops Research, 21-1: 59-78.

Spetsov P., Savov M., 1992. A review on amphidiploids in the *Triticeae*, obtained in Bulgaria during 1950-1990. Wheat Information Service, 75: 1-6.

Spetsov P., Belchev I., Plamenov D., 2008. Breeding of synthetic wheats: Crossability and production of hybrids with participation of Aegilops tauschii. Proceedings of Technical university-Varna, I, p. 71-76 (Bg).

Spetsov P., Plamenov D., Belchev I., 2009. Breeding of synthetic wheats: analysis of amphidiploid plants obtained with *Aegilops tauschii* Coss. Field crops studies, V-2: 207-216 (Bg).

Stoyanov H., Spetsov P., Plamenov D., 2010. Origin of common wheat (*Triticum aestivum* L.) and analysis of synthetic wheat forms as sources of genetic diversity. Proceedings of University of Ruse, 49(1.1): 55-60 (Bg).

Stoyanov H., Koleva M., Plamenov D., Spetsov P., 2012. Influence of wheat genome in hybrids with participation of *Aegilops cylindrica* Host. Field Crops Studies VIII-1: 41-52 (Bg).

Stoyanov H., 2013a. Status of remote hybrids in the Poaceae: problems and prospects. Agricultural science and technology, 5(1): 3-12.

Stoyanov H., 2013b. Correlation between the spike characteristics in common winter wheat varieties (*Triticum aestivum* L.). Scientific works of the Institute of Agriculture - Karnobat, 2(1): 95-104 (Bg).

Stoyanov H., 2013c. Study on the productive tillering in *Abyssinian teff* (*Eragrostis tef* (Zucc.) Trotter), under the conditions of Southern Dobrudja. Scientific works of the Institute of Agriculture - Karnobat, 2(1): 49-56 (Bg).

Stoyanov H., 2014a. New amphidiploid wheat species (nothosp. nov.) as a result of artificial hybridisation. Scientific Papers. Series A. Agronomy, LVII: 331-338.

Stoyanov H., 2014b. Morphological analysis of spikes and grouping of accessions of *Triticum turgidum* ssp. *dicoccon*. Agricultural science and technology, 6(2): 124-133.

Stoyanov H., 2014c. Similarity of spike properties of tetraploid wheat species of section *Dicoccoides* (2n=4x=28, AABB). Field Crop Studies (in press).

Stoyanov H., 2014d. Analysis and assessment of amphidiploids of Triticum-Aegilops group as a source of genetic diversity. Bulgarian Journal of Agricultural Science, 20 (Supplement 1), p. 173-178

Stoyanov H., 2015. Effect of black (stem) rust (*Puccinia graminis* f.sp. *tritici*) attack to the spike characteristics in Polish wheat (*Triticum polonicum* L.). Agricultural Science and Technology (in press).

Tsenov N., Gubatov T., Peeva V., 2006. Study on the genotype x environment interaction in winter wheat varieties II. Grain yield, FCS 3(2): 167-175 (Bg).

von Braun J., 2007. The world food situation: New Driving Forces and Required Actions. International Food Policy Research Institute, Washington, D.C., USA (Bg).

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE EFFECTS OF PLANT DENSITY AND EYE NUMBER PER SEED PIECE ON POTATO (*Solanum tuberosum* L.) TUBER YIELD

Arif ŞANLI, Tahsin KARADOĞAN, Sabri ERBAŞ, Bekir TOSUN

Süleyman Demirel University, Faculty of Agriculture, Field Crops Department, 32260 Isparta, Turkey

Corresponding author e-mail: arifsanli@sdu.edu.tr

Abstract

This study was carried out to determine effects of plant density and number of eyes per seed pieces on yield and tuber size of potato (Solanum tuberosum L. cv Agria) in Turkey during 2011 and 2012 crop seasons. Treatments were arranged as a split plot design with plant density (distance on rows 20, 25 and 30 cm) as main plots, eyes number (2, 4 and 6 eyes) per seed piece as sub plots. Total tuber yield, yield of Grade C (45-35 mm) and Grade D (35-25 mm) sized tubers significantly increased with the increasing planting density. Number of tubers per plant, average tuber weight, tuber yield per plant and yield of Grade A (>60 mm) sized tubers significantly decreased with the increasing of plant density. With the increasing number of eyes in seed pieces, while tuber number per plant and yield of Grade C and Grade D sized tubers increased, average tuber weight decreased. The highest total tuber yield (40.6 t/ha) and Grade B (13.0 t/ha) and Grade C (15.3 t/ha) were obtained in the distance of rows at 20 cm and four eyes cut seed tubers. In conclusion, with the increase of the planting density and eyes number in seed piece, we noticed some decline in marketability and an increase the yield of seed tubers.

Key words: *eye number, plant density, potato, tuber yield.*

INTRODUCTION

Potato is an important vegetable crop in Turkey and covers around 125,000 hectares with a production of 3.95 mil tons (Anonymous, 2013). 320 thousand tones seed potatoes are needed to plant production area in Turkey annually. In Turkey, like other developing countries, seed potato production is the main limiting factor. The cost of seed represents the greatest proportion of the total production costs that can account for 30 to 50% of the total production expenses depending on the country or region (Kabir et al., 2004; Karim et al., 2010). For this reason, the larger seed tubers are usually cut into pieces to get maximum number of seed, thus minimizing the seed cost. But it is not clear that how many eyes are to be kept in each cut tuber piece to obtain a higher yield (Kabir et al., 2004).

When potatoes are grown for seed, cultural practices need to be used in order to maximize the production of seed size tubers and decrease the yield of large tubers. Tuber number is positively correlated with stem number and tuber size at harvest is inversely proportional to the number of tubers per hill (Lynch and Rowberry, 1977; Iritani et al., 1983). However, tuber number may be manipulated by altering stem and tuber number through changes in seed piece size and physiological age of seed tuber. Higher plant density or larger seed pieces effectively reduce overall tuber size (Iritani et al., 1983). However, increasing seed pieces per hectare or seed piece size also increases costs.

There are strong relationships between tuber yield and stem density (Jarvis, 1977) and between tuber yields distribution in different size grades and stem density (Wurr, 1974). Thus control over stem numbers is a fundamental requirement if growers are to control tuber size aiming to produce seed, table or ware potatoes. The density of the potato crop consists of two components. The first component is the number of plants generally referred to as plant density and the second is the number of stems per plant (Wiersema, 1987). The number of eyes determines stem number per seed piece (Nielson et al., 1989). The number of eyes and stems produced per seed piece increased as cut seed piece increased (Nielson et al., 1989). Each stem from a single eye can be regarded as an independent production unit. Thus a sufficient number of strong stems should develop per seed tuber. However, as much as higher stem density results in greater yield, it also affects the size of tubers. Growth is limited when competition among stems is high. At higher stem density, the tubers produced remained smaller than at lower stem density, while the percentage of large tubers decreased (Gulluoglu and Arioglu, 2009).

Seed spacing have been reported to influence yield, tuber size distribution, tuber, stem density and net returns of potato cultivars (Love and Thompson-Johns, 1999; Zamil et al., 2010). As stem density increased, fewer tubers were produced and this was due to a reduced multiplication rate which was defined as number of tubers produced per seed tuber (Fleisher et al., 2011). This effect is due to increased inter-plant competition for water, light and nutrients. It is therefore, essential to understand how individual plants interact with each other and the environment and to possibly come up with the ideal crop density levels to optimize yields. Increasing the planting density may lead to a decrease in the average weight of the tuber, and to an increase the outcome of the amount and weight of the tubers per unit area (Gasimova et al., 2010; Mahmoodabad et al., 2010; Somarin et al., 2010). According to Zamil et al. (2010) when the nutrition area of potato plants decreases, the number of stems and tubers reduces tubers weight per one plant. The primary purpose of the current study was to study the influence of eye number per seed piece and plant density on the growth and yield of the potato in order to achieve maximum production of seed tubers.

MATERIALS AND METHODS

Field experiments were conducted at the research farms of Suleyman Demirel University, in Isparta province (Lakes Region, 37º45' N, 30º33' E, altitude 1035 m) during 2011 and 2012 crop seasons, using the cv. Agria. The soil of the experimental field was loam, low in organic matter (1.5%) and alkaline (pH 8.1). Nutrient content of the experimental area was determined for the entire location and it was divided two parts and each part was used to grow potato during first and second year of the study, separately. Total nitrogen content of the entire location was 0.21% (micro Kjelhdal method), extractable P and K contents were 19.8 mg/kg (Olsen method) and 179 mg/kg, respectively. Total precipitation between April to October was 226 mm and 201 mm for the first and second years of the experiment, respectively. For the same period, the long term average rain fall was 188 mm. Average daily temperature was 19.7°C and 18.8°C, for 2011 and 2012 crop seasons, respectively. Long term average daily temperature between April and October was 18.1°C.

The experiment was established as split plot design with three replications. In-row spacing (population density) was assigned to the main plots and eye number per seed piece was assigned to the sub plots. Population density involved at three levels; 20 cm, 25 cm and 30 cm. Cut seed tubers containing 2 eyes (15 g/piece), 4 eyes (30 g/piece) and 6 eyes (50 g/piece) were used as eyes number treatments. Each plot consisted of 4 rows having 6 m length. Potatoes were planted at three intra-row spacing of 20, 25 and 30 cm, while the inter row spacing was kept constant at 70 cm. All the seeds were planted by hand on 16 April in 2011 and 22 April in 2012. Basal fertilizer (20%N-20%P-20%K) was applied at the rate of 500 kg/ha prior to planting. Additional fertilization of ammonium sulphate (AS) was applied at 4 and 8 weeks after emergence at a rate of 200 kg/ha. Cultivation, hilling up and hand weeding were conducted as necessary. Irrigation was performed with sprinkler irrigation system when available soil moisture dropped below 50% in soil. Tubers were harvested at the second half of September for each growing year and yield and yield components were determined from middle row of each plot.

Data was subjected to the analysis of variance (ANOVA) procedure with SAS statistical program (SAS, 2009). Means were separated using Duncan's multiple range tests at the 0.05 significance level. Results were averaged over 2 years and analysis was performed on those results.

RESULTS AND DISCUSSIONS

According ANOVA results, differences between years and year interactions were not statistically significant for all studied traits.

Tuber Number per Plant

Intra-row spacing and eye number per seed piece significantly (P>0.01) influenced the number of potato tubers per plant (Table 1). Tuber number per plant increased with the increased eye number in cut seed tubers. Tuber number was found maximum (7.8 tuber/plant) in 6-eyed cut seed piece and minimum (4 tuber/plant) in the cut seed tubers containing 2 eyes (Table 2). Also, increase in in-row spacing led to significant increase in tuber number, the highest and the lowest tuber number was obtained at 30 cm and at 20 cm, respectively (Table 2). The combined effect of in-row spacing and eye number in cut seed tuber produced significant (P>0.05) variation in tuber number. The number of tubers per plant significantly increased in 6-eyed cut seed piece with increasing in-row spacing, while 2-eyed cut seed piece had the similar tuber number with the increasing in-row spacing (Table 2). Tuber production per plant are directly correlated with number of main stems per plant and significantly affected by inter-plant and intra-plant competition (Moorby, 1967; Bussan et al., 2007). Increasing plant density and decrease in the inter plant distances lead to decrease in the number of tuber per plant. It was could be due to per share of the light and food are reduced resulting in increased competition within plant. Many authors previously reported that tuber number per plant increased with the increasing distance between the in-rows of plants (Jones and Alben, 1989; Gulluoglu and Arioglu; Samarin et al., 2010; Tahmorespour et al. 2013; Ayupov et al., 2014). Several stems develop from individual seed tubers depending on size and physiological age of seed tubers (Gulluoglu and Arioglu, 2009). Cut seed tubers containing more eyes produced more stems. Since each stem is an independent production unit, an increase in their number will consequently translate to more tubers per plant. Similar results were reported by Wiersema (1987) and Shayanowako et al. (2014).

Table 1. Results of Analyses Variance (ANOVA) for the traits measured in the study

Source of variance	df	Tuber number per plant	Average tuber weight	Grade A	Grade B	Grade C	Grade D	Tuber yield per plant	Total tuber yield
Year (Y)	1	ns	ns	ns	ns	ns	ns	ns	ns
Rep (Year)	4	ns	ns	*	ns	ns	*	ns	ns
Distance in-rows (D)	2	**	**	**	**	**	**	**	**
Y x D	2	ns	ns	ns	ns	ns	ns	ns	ns
Rep x D (Y)	8	ns	ns	ns	ns	ns	ns	ns	ns
Eye number (E)	2	**	**	**	**	**	**	**	**
Y x E	2	ns	ns	ns	ns	ns	ns	ns	ns
D x E	4	*	**	**	**	**	*	**	**
Y x D x E	4	ns	ns	ns	ns	ns	ns	ns	ns
Error	24								
CV%		5.9	8.1	5.9	8.4	9.0	9.8	4.7	4.4

df, degrees of freedom ; ns, non-significant; * P<0.05; ** P<0.01

Average tuber weight

Average tuber weight was significantly (P>0.01) affected by both in-row spacing and eye number per seed piece and in-row spacing x eye number per seed piece interaction effect (Table 1). The lowest mean tuber weight was obtained from the closest in-row spacing (20 cm) and mean tuber weight values tended to increase with widening in-row spacing (Table 2). Average tuber weight decreased with increased eye number per seed piece. As plants planted containing 2-eyed tubers exhibited the highest tuber weight compared to those planted containing 4 or 6-eyed tubers (Table 2). The highest (171 g) and the lowest (76 g) average tuber weight was obtained from 4-eyed cut seed tubers at 30 cm in-row spacing and 4 and 6-eyed cut seed tubers at 20 cm in-row spacing (Table 2).

The competition between and within the plants increased with plant density increase (Karafyllidis et al., 1997) and this situation leads to decreased availability of nutrients for each plant and consequently, results in decline of mean tuber weight. Similarly, many researches stated that the crop established at closest planting produced larger but fewer tubers than that established at wider planting (Somarin et al., 2010; Masarirambi et al., 2012; Tahmorespour et al., 2013). Dehdar Masjedlo, (2002) reported that increasing plant density (decreasing distance between the rows of plants) increased tuber yield, number of main stems and the average number of tubers/m^2 but the average tuber weight was reduced. Individual tuber weight was found to be higher when tubers with fewer eyes per piece were used. It is possible that seed pieces having fewer eyes produced less number of stems and tubers per plant resulting in increased individual tuber weight. These finding are in agreement with observation by Shakh et al. (2001) who reported decreased average tuber weight with increased eye number per cut seed piece.

Tuber Size Grading

The effects of in-row spacing and eye number per seed piece and their interactions on tuber size grading was significantly (P>0.01) important (Table 1). While the Grade A tuber yield increased with the increase in in-row spacing, Grade C and Grade D tuber yield decreased. With the increasing eye number per seed peace, Grade C and D tuber yields significantly increased (Table 2). Mean yield of Grade A was higher in 4-eyed cut seed tuber (9.54 t/ha) than the cut seed tubers containing 2 or 6 eyes. Grade B tuber yield was lower in 2-eyed cut seed tuber (8.57 t/ha) (Table 2). The highest yield of Grade A tuber was obtained at 30 cm in-row spacing in 4 and 6-eyed (11.98 t/ha and 12.40 t/ha, respectively) cut seed tuber, while Grade B, Grade C and Grade D tuber yields had the highest at 20 cm in-row spacing with 4-eyed (12.95 t/ha), 4 and 6-eyed (15.23 t/ha and 14.13 t/ha, respectively) and 6-eyed (7.43 t/ha) cut seed tubers, respectively (Table 2).

The proportion of larger tuber was the highest at the wider spacing and the non-marketable yield increased with increasing stem density. This could be a result of greater competition for water, nutrients and sunlight during tuber bulking at closer in-row spacing resulting in fewer assimilates available for each individual tuber. By increasing planting density, the portion of small tubers increases, the portion of large ones declines, and the yield of seed fractions increases (Marin, 1986; Trusov, 1990). Our results confirm works of Wiersema (1987), Rex (1990) and Love and Thompson-Johns (1999) who reported a reduction in total marketability of tubers as plant population increased. Similarly, Allen (1992) reported that as plant density increased the weight and size of tubers produced per plant is reduced. The number of eyes determine stem and tuber number per seed pieces because each stem from a single eye can be regarded as an independent production unit (Nielson et al., 1989). However, higher stem density results in greater yield; it also affects size of tubers. Growth is limited when competition among stems is high. Thus, the grade of produced tubers by per plant also depends on planting density. At higher stem density, the tubers produced remained smaller than at the lowest stem density, while the percentage of large tubers decreased (Gulluoglu and Arioglu, 2009). The desired size of the potato depends on the intended use. For seed production, diameter of 25-60 mm tubers is preferred. The highest yield of Grade C and Grade D (more valuable for seed production) were obtained at 4 or 6-eyed cut seed tubers planted in closest in-row spacing, while larger tubers (Grade A) were higher at wider planting space. Plants established from large seeds produced smaller but numerous tubers whereas those established from small to medium sized seed produced few but large tubers as previously reported (Wurret al., 1993; Love and Thompson-Johns, 1999; Khan et al., 2010).

Tuber Yield per Plant

In-row spacing and eye number per cut seed tuber significantly (P>0.01) affected tuber yield per plant (Table 1). Mean tuber yield per plant increased with increasing in-row spacing and it was determined 512 g, 618 g and 737 g at 20, 25 and 30 cm in-row spacing, respectively (Table 2). Mean tuber yield per plant significantly (P>0.001) increased as eye number per cut seed pieces increased from containing 2-eyed tuber to 6-eyed tuber (Table 2).

Table 2. Effects of different in-row spacing and eye number in cut seed piece on measured traits

Eyes number	Distance in-rows (cm)				Distance in-rows (cm)			
	Number of tubers per plant				Average tuber weight (g)			
	20	25	30	Mean	20	25	30	Mean
2	5.5e	5.5e	5.6e	5.5c	81.7cd	97.8ab	103.0a	93.9a
4	7.4d	7.6cd	7.9bc	7.6b	75.7d	85.3c	97.3ab	86.1b
6	7.9bc	8.1b	8.8a	8.3a	66.7e	81.0cd	96.0b	81.2c
Mean	6.9b	7.1b	7.4a		74.5c	88.1b	98.6a	
Eyes number	Grade A yield (t/ha)				Grade B yield (t/ha)			
	20	25	30	Mean	20	25	30	Mean
2	7.3e	9.3d	10.3bc	9.0b	9.9e	9.0e	6.8f	8.6b
4	6.3f	10.4b	12.0a	9.5a	13.0a	12.0b	10.9cd	12.0a
6	4.8g	9.6cd	12.4a	8.9b	11.0cd	11.9bc	11.6bc	11.5a
Mean	6.1c	9.8b	11.6a		11.3a	11.0a	9.8b	
Eyes number	Grade C yield (t/ha)				Grade D yield (t/ha)			
	20	25	30	Mean	20	25	30	Mean
2	10.3b	6.9d	3.3f	6.8c	4.8d	3.8e	2.6g	3.7c
4	15.2a	8.4c	5.1e	9.6b	6.1b	4.8d	3.4f	4.8b
6	14.1a	10.3b	6.4d	10.3a	7.4a	5.5c	4.2e	5.7a
Mean	13.2a	8.5b	4.9c		6.1a	4.7b	3.4c	
Eyes number	Tuber yield per plant (g/plant)				Total tuber yield (t/ha)			
	20	25	30	Mean	20	25	30	Mean
2	455f	528e	572d	518c	32.3d	28.8e	22.9f	28.0b
4	547de	653c	782b	660b	40.6a	35.6bc	31.4d	35.9a
6	534e	672c	858a	688a	37.3b	37.2b	34.8c	36.4a
Mean	512c	618b	737a		36.7a	33.9b	29.7c	

Numbers with the same letters in each column, have no significant differences to each other

The interaction of in-row spacing and eye number per cut seed tuber also significantly affected to tuber yield per plant. The highest (858 g) and the lowest (455 g) tuber yield per plant were observed at 30 cm in-row spacing with 6-eyed cut seed tuber and at 20 cm in-row spacing with 2-eyed cut seed tuber, respect-tively. Tuber yield per plant decreased at 6-eyed cut seed tuber at 20 cm in-row spacing while increased at the 30 cm in-row spacing compared to tubers containing fewer eyes (Table 2).

Since higher number of tuber per plant and the highest average tuber weight were obtained from 30 cm in-row spacing, this treatment also gave higher tuber yield per plant. Increasing in tuber yield per plant in wider planting could be due to the availability of adequate space for root and tuber expansion and less competition for light, water and nutrients. Bremer and Taba (1966) and Allen and Wurr (1992) reported that planting density affects on tuber yield per plant significantly and with increasing distance between the rows, tubers yield per plant increases. Additionally, Ayupov et al. (2014) stated that increased density is reduced tuber yield per plant. Cut seed tubers containing more eyes were larger in size and larger seed tubers have a greater amount of reserve material than smaller seed tubers (Love and Thompson-Johns, 1999; Kabir et al., 2004). This resulted in higher relative growth rates of tubers with more eyes than those with fewer eyes. Similarly, Strange and Blackmore, (1990) and Shakh (2001) showed that tuber yield per plant increased as increasing the eye number per cut seed piece.

Total Tuber Yield

Total tuber yield was significantly (P>0.01) affected by in-row spacing and eye number per cut seed tuber (Table 1). As the planting density increased there was a corresponding increase in yield. Mean total tuber yield was higher at closest in-row spacing (36.70 t/ha) than wider in-row spacing (29.71 t/ha) (Table 2). Total tuber yield increased with increasing eye number per cut seed tuber, but differences between 4 and 6-eyed tubers were not statistically significant. There was a significant (P>0.01) interaction between in-row spacing and eye number per cut seed pieces (Table 1). Planting of 4-eyed cut seed tubers at closest in-row spacing gave the highest (40.55 t/ha) total tuber yield (Table 2). The lowest total tuber yield (22.94 t/ha) was obtained from 2-eyed cut seed tubers at 30 cm in-row spacing (Table 2). Differences between 6-eyed cut seed tuber planting at 20 and 25 cm in-row spacing and 4-eyed cut seed tuber planting at 25 cm in-row spacing was not significant in terms of total tuber yield (Table 2).

Major yield components such as number of tuber per plant, mean tuber weight and tuber yield per plant significantly decreased as planting distances became closer in this study due to increased inter-plant competition. Increase in number of tuber per hectare with increasing plant density and eye number per cut seed tuber may result in increase in tuber yield per unit area. Tuber yield per hectare reduced at wider in-row spacing due to reduction of hill number per unit area. Similarly, with the increased plant density, yield was decreased in each plant but increased per unit area (Asl Gorgani and Damavand, 1996; Alvin et al., 2007; Bussan et al., 2007; Tahmorespour et al., 2013). Additionally, Love and Thompson-Johns (1999) showed that the highest total yield occurred at the closest spacing, and then declined as spacing widened. Based on the increased eye number per cut seed tuber, the increase of tuber number and tuber yield per plant also caused increased of total tuber yield.However, total tuber yield of 6-eyed cut seed tubers planting at 20 cm in-row spacing was lower than that of 4-eyed cut seed tubers planting at the same spacing.

CONCLUSIONS

Seed potato tuber yield increase is a function of the number of tubers and their relative increase in size. The results obtained indicate that planting at narrow in-row spacing with 4 or 6-eyed cut seed tuber increase total and seed potato production as they contribute high seed potato yield. Seed (mother) tubers are used for seed potato production and are usually cut before planting because the cost of seed tuber is very high in Turkey. In order to maximize seed yield performance in potatoes, it is recommended that 4-eyed cut seed pieces should be planted at 20 cm in-row space.

REFERENCES

Allen E.J., Wurr D.C.E., 1992. Plant density. In PM Harris (ed) The Potato Crop, The scientific basis for improvement, Chapman & Hall, UK, p. 293-333.

Alvin J.B., Mitchell P.D., Copas M.E., Drilias M.J., 2007.Evaluation of the Effect of Density on Potato Yield and Tuber Size Distribution. Crop Sci., 47:2462-2472.

Anonymous, 2013.FAOSTAT, 2013, http://faostat3.fao.org/browse/Q/QC/E.

AslGorgani R., Damavandi V., 1996. Effects of cultivar and plant density on yield components and yield of Potato. Journal of Agriculture, 14(3): 41-50.

Ayupov Y., Apushev A., Zamalieva F.F., Gabdulov M., 2014. The effect of planting density on the crop yield, the structure and the quality of middle-early variety of potato in the west Kazakhstan. Life Science Journal, 11(8): 545-548.

Bussan A.J., Mitchell P.D., Copas M.E., Drilias M.J., 2007. Evaluation of the effect of density on potato yield and tuber size distribution. Crop Sci., 47: 2462-2472.

DehdarMasjedlo B., 2002. The final report of the survey before germination density on six commercial potato varieties Ardabil Agricultural Research Center.

Gasimova N.V., Mingaliev S.K., Laptev V.R., 2010. Yield and quality of potato tubers of different early ripeness groups depending on the growing technology methods in Middle Urals. Agricultural Gazette of the Urals, 5(71): 41-44.

Gulluoglu L., Arioglu H., 2009. Effects of seed size and in-row spacing on growth and yield of early potato in a Mediterranean-type environment in Turkey. African J. Agric. Res., 4: 535-541.

Iritani W.M., Weller L.D., Knowles N.R., 1983. Relationships between stem number, tuber set and yield of Russet Burbank potatoes. Am. Potato J. 60: 423-431.

Jarvis R.H., 1977. An assessment of the value of different sizes of seed potatoes of maincrop varieties. Experimental Husbandry 32: 102-114.

Jones J.L., Alben E.J., 1989. Effects date of planting on plant emergence, leaf growth and yield in contrasting potato varieties. Journal of Agricultural Science, Cambridge 101: 81-85.

Kabir M.H., Alam M.K., Hossain M.A., Hossain M.M., Hossain M.J., 2004. Yield performance of whole-tuber and cut-piece planting of potato. Trop. Sci., 44: 16-19

Karafyllidis D.I., Georgakis D.N., Stavropoulos N.I., Nianiou E.X., Vezyroglou I.A., 1997. Effect of

planting density and size of potato seed-minitubers on their yielding capacity.Acta Hort. (ISHS), 462: 943-950.
Karim M.R., Hanif M.M., Shahidullah S.M., Rahman A.H.M.A., Akanda A.M., Khair A., 2010. Virus free seed potato production through sprout cutting technique under net-house. African J. Biotech., 9: 5852-5858.
Khan S.A., RahmanJamro M.M., Arain M.Y., 2010. Determination of suitable planting geometry for different true potato tuberlet grades. Pakistan J. Agric. Res., 23: 42-45.
Love S.L., Thompson-Johns A., 1999. Seed piece spacing influences yield, tuber size distribution, stem and tuber density, and net returns of three processing potato cultivars. Hort. Sci., 34: 629-633.
Lynch D.R., Rowberry R.G., 1977. Population studies with Russet Burbank II. The effect of fertilization and plant density on growth, development and yield. Am. Potato J. 54: 57-71.
Mahmoodabad Z.R., Jamaati-e-Somarin S.H., Khayatnezhad M., Gholamin R., 2010. Quantitative and qualitative yield of potato tuber by used of nitrogen fertilizer and plant density. American-Eurasian J. Agric. Environ. Sci., 9(3): 310-318.
Marin G.S., 1986. Features of intensive technology of cultivation of potatoes.Intensive cultivation of crops in the Mari ASSR. Yoshkar-Ola: Map. book. Publishing House, p. 314-339.
Masarirambi M.T., Mandisodza F.C., Mashingaidze A.B., Bhebhe E., 2012. Influence of plant population and seed tuber size on growth and yield components of potato (*Solanum tuberosum*). Int. J. Agric. Biol., 14: 545–549
Moorby J., 1967. Inter-stem and inter-tuber competition in potatoes. Eur. Potato J. 10: 189-205.
Nielson M., Iritani W.M., Weiler L.D., 1989. Potato seed productivity: factors influencing eye number per seed piece subsequent performance. Am. J. Potato. Res., 66(3): 151-160.
Rex B.L., 1990. Effects of seed piece population on the yield and processing quality of Russet Burbank potatoes. Am. J. Potato. Res. 67(8): 473-489.
SAS Institute, 1999. INC SAS/STAT user's guide release 7.0. Cary NC USA.
Shakh M.N.U., Awal M.A., Ahmed U., Baten M.A., 2001. Effect of eyes number in cut seed tuber and different levels of nitrogen on growth, yield and grading of tuber size in potato (*Solanum tuberosum* L.). Pakistan Journal of Biological Sciences, 4(10): 1184-1187.
Shayanowaka A., Mangini R., Mtaita T., Upenyu M., 2014. Effect of stem density on growth, yield and quality of potato variety amethyst. African Journal of Agricultural Research, 9(17): 1391-1397.
Somarin S.J., Mahmoodabad R.Z., Yari A., 2010. Response of Agronomical, Physiological, Apparent Recovery Nitrogen Use Efficiency and Yield of Potato Tuber (*Solanum tuberosum* L.), to Nitrogen and Plant Density. American-Eurasian J. Agric. & Environ. Sci., 9 (1): 16-21
Strange P.C., Blackmore K.W., 1990. Effect of whole seed tubers, cut seed and within row spacing on potato (cv Sebago) tuber yield. Aust. J. Exp. Agric. 30: 427-431.
Tahmorespour M.A., Vishkai M.N.S., Soleymani A., 2013. Effect of Plant Density, Date and Depth of Cultivation on Yield and Yield Components of Potato Planting in the Chabahar. International Journal of Agronomy and Plant Production, 4 (8): 1890-1897.
Trusov M.F., 1990. Optimal rate of planting. Potatoes and Vegetables, 2: 11-13.
Wiersema S.G., 1987. Effect of stem density on potato production.Technical information Bulletin.
Wurr D.C.E., 1974. Some effects of seed size and spacing on the yield and grading of two maincrop potato varieties. I. Final yield and its relationship to plant population. J. Agric. Sci. Camb, 82: 37-45.
Wurr D.C.E., Fellows J.R., Allen E.J., 1993. An approach to determining optimum tuber planting densities in early potato varieties. J. Agric. Sci. (Cambridge), 120: 63-70.
Zamil M.F., Rahman M.M,.Rabbani M.G., Khatun T., 2010. Combined effect of nitrogen and plant spacing on the growth and yield of potato with economic performance. Bangladesh research publications journal, 3(3): 1062-1070.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH REGARDING THE INFLUENCE OF SEED SIZE ON ROOT NODULE FORMATION CAPACITY IN COMMON BIRD'S-FOOT-TREFOIL (*Lotus corniculatus* L.)

Ilie TOTH, Carmen DRAGOMIR, Dorin CAMEN, Anca SALA, Florin NECIU, Neculai DRAGOMIR

Banat's University of Agricultural Sciences and Veterinary Medicine
"King Michael I of Romania" from Timişoara, Calea Aradului nr.119, Timişoara, Romania

Corresponding author email: dragomir_ne@yahoo.com

Abstract

In the process of biological fixation of atmospheric nitrogen, root nodule growth and development in legumes is the result of the symbiosis relationship between these plant species and nitrogen fixing bacteria. In this respect, research points out the effect of common bird's-foot-trefoil (Lotus corniculatus L.) seed size on root nodule formation capacity in the presence of nitrogen fixing bacterium Mesorhyzobium loti. Our results show that there is a direct relationship between seed size and dimensional features of root nodules in common bird's-foot-trefoil (number of nodules/plant, and weight of nodules).

***Key words**: Lotus corniculatus L., root nodule formation capacity, nitrogen fixing bacteria, seed size.*

INTRODUCTION

Bird's-foot-trefoil (*Lotus corniculatus* L.) is a grassland legume species with a high degree of rusticity due to both its ecological plasticity and specific biological features (Ross et al., 1985). The germination capacity of (*Lotus corniculatus* L. is influenced by physical factors and by seed size (Toth, 2013).
The efficiency of the relationship of symbiosis between the plants of bird's-foot-trefoil and specific bacteria of *Mesorhyzobium meliloti* is strongly influenced by natural conditions, by the diversity of existing bacterial strains in the soil and by some morpho-physiological features of the species (Jarvis et al., 1982; Monza et al., 1992; Irisarry et al., 1996; Baraibar et al., 1999; Rebah et al., 2002; Sotelo et al., 2011).
In this paper, the authors present the results of research carried out on the influence of seed size on root nodule formation in bird's-foot-trefoil.

MATERIALS AND METHODS

Research was carried out in 2014, in a vegetation house, using as biological material seeds of the Nico cultivar of *Lotus corniculatus* L. Before sowing, the seeds from the crop of 2013 were grouped into five size groups depending on seed diameter: a1 - very small seeds (Ø=0.50-1.00 mm), a2 - small seeds (Ø=1.01-1.25 mm), a3 - medium-size seeds (Ø=1.26-1.40 mm), a4 - large seeds (Ø=1.41-1.50 mm) and a5 - very large seeds (Ø> 1.51 mm). We sowed from each seed group several seeds in vegetation vases and after sprouting we preserved only ten plants per vase that were studied individually during the vegetation period.
During the vegetation period, we made in each plant quantitative measurements regarding the plant growth and development: height, ramification, sprouting, and weight.
The nodule formation capacity was determined at the beginning of the blooming period in ten plants per group. After 12 h of immersion, we removed the soil using a mild flow of water and the nodules were sampled from the root system and collected in Petri dishes on a substratum of porous paper to absorb the water and then weighed with a digital laboratory balance, BP 221 S (Sartorius, Germany), with a measuring accuracy of 0.1 mg.
In order to facilitate the measurements of the number and size of nodules, they were photographed with a digital camera and the

images were processed using the Image J software (Schneider et al., 2012) (File - Open; Process - Enhance contrast / Subtract Background; Image - Adjust - Colour Threshold; Analyze - Analyze Particles).
The nodules on each plant were grouped into three size groups - small, medium and large – using Microsoft Excel (Home - Sort & Filter).
The data thus obtained (number, weight and size of nodules) were processed statistically with variance analysis and the Duncan Test. In order to point out relationships between seed size and nodule formation capacity, the authors also carried out a study of the correlations between size-related features of seeds and nodules.
Nodule observations and measurements were also evaluated through the nodule index calculus (Rebah et al., 2002) with the formula:

$$\text{Nodule index} = AxBxC \leq 18,$$

where:

- A- nodule size (1- small, 2- medium, 3- large);
- B- nodule colour (1- white, 2- pink);
- C- nodule number (1- few, 2- medium, 3- many).

RESULTS AND DISCUSSIONS

The biological features in plants and the natural conditions during fructification and harvesting of bird's-foot-trefoil seeds influence strongly seed size and weight. This feature can affect, in a certain measure, the vigour of new bird's-foot-trefoil plants, including the nodule formation capacity, which depends on the nitrogen nutrition rate (from the symbiosis process with nitrogen fixing bacteria) (Sotelo et al., 2011).
Data obtained and presented in Table 1 show that the number of nodules/plant reached values between 135 and 386 depending on seed size, with seed weight ranking between 22-212 mg/plant. The largest number of nodules (386/plant) and the largest weight of nodules (212 mg/plant) were in the medium-size seed group (Ø=1.51-1.60 mm) (191 nodules/plant). At the extreme limits of seed size groups (<1.25 and >1.51 mm), the size values of the nodules were smaller and insignificant statistically. Likewise, the efficiency of nodules established through the measurement of the nodule index is larger (12) in the large size group (ranging between 1.26 and 1.60 mm).

Table 1. Influence of *Lotus corniculatus* L. seed size on nodule formation capacity. Size groups are: a1 – very small seeds (Ø=0.5-1.0 mm), a2 – small seeds (Ø=1.01-1.25 mm), a3 – medium seeds (Ø=1.26-1.40 mm), a4 – large seeds (Ø=1.41-1.50 mm), a5 – very large seeds (Ø=1.51-1.60 mm)

Seed size groups	Nodule number per plant	Nodule weight (mg/ plant)	Nodule efficiency			
			A	B	C	Nodule index (AxBxC)
a1	150	22	1	2	2	4
a2	135	35	1	2	2	4
a3	386***	212***	2	2	3	12
a4	191***	135***	3	2	2	12
a5	135	43	3	2	2	12
DL 5%	17.03	27.35	-	-	-	-

According to the experimental protocol, the nodules were grouped, in their turn, into three size groups – small, medium, and large. Thus, in the very small seed group, the share of nodules per size groups was as follows: 50% small nodules, 48% medium nodules and only 2% large nodules. In the larger seed groups, the share of large nodules increases to 16-20% and the share of small and medium nodules decreases (Table 2).

Table 2. Influence of *Lotus corniculatus* L. seed size on nodule size. Size groups are: a1 – very small seeds (Ø=0.5-1.0 mm), a2 – small seeds (Ø=1.01-1.25 mm), a3 – medium seeds (Ø=1.26-1.40 mm), a4 – large seeds (Ø=1.41-1.50 mm), a5 – very large seeds (Ø=1.51-1.60 mm)

Seed size groups	Small nodules (%)	Medium nodules (%)	Large nodules (%)
a1	50	48	2
a2	59*	31°°°	10**
a3	44	36°°°	20***
a4	54	30°°°	16***
a5	74	35°°°	18***
DL 5%	7.65	5.43	4.44

As shown in Table 3, there is a relationship between seed size and weight, and the nodule formation capacity in bird's-foot-trefoil.
From this perspective, the authors noted a close correlation between both seed size and medium-size nodule share (r=0.94*) and seed size and nodule number (r=45) and nodule weight (r=0.59). As for seed weight (MMB), the higher values of correlation coefficients were in the correlations with the number of nodules (r=0.69) with nodule weights (r=0.82) and with the share of medium-size nodules (r=0.87).

Table 3. Correlation coefficients between *Lotus corniculatus* L. seed size and weight and nodule formation capacity

Specification	Nodule number	Nodule weight	Large nodules	Medium nodules	Small nodules
Seed size (Ø)	0.45	0.59	0.65	0.94*	0.43
Seed weight (MMB)	0.69	0.82	0.42	0.87	0.22

CONCLUSIONS

In general, bird's-foot-trefoil seed size correlates with the nodule formation capacity expressed as the number and size of the nodules.
In plants obtained from very small, and small seeds, the share of large nodules was of only 2-10% compared to plants stemming from the large seeds with 16-20% large nodules.
There is a stronger correlation between seed size and weight and the share of medium-size nodules (r= 0.94 and 0.87).

ACKNOWLEDGEMENTS

This paper is published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

REFERENCES

Baraibar A., Frioni L., Guedes M.E., Ljungren H., 1999. Symbiotic effectivenes and ecologial characterization of indigenous *Rhizobium loti* population in Uruguay. Psq. Agrop. Bras. Brasilia, 34: 1011-1017.
Irisarri P., Milnitzky F., Monza J., Bedmar E.J., 1996. Characterization of rhizobia nodulating *Lotus subbiflorus* from Uruguayan soils. Plant and Soil, 180: 39-47.
Jarvis B.D.W., Pankhurst C.E., Patel J.J., 1982. *Rhizobium loti*, a new species of legume root nodule bacteria. Int. J. Syst. Bacteriol., 32: 378-380.
Monza J., Fabiano E., Arias A., 1992. Characterization indigenous population of rhizobia nodulating *Lotus corniculatus* L., Soil Biol. Biochem., 24: 241-247.
Rebah F.B., Prevost D., Tyagi R.D., 2002. Growth of alfalfa in sludge-amended soils and inoculated with rhizobia produced in sludge. Journal of Environmental Quality., 31: 1339-1348.
Ross M.D., Jones W.T., 1985. The origin of *Lotus corniculatus* L., Theor. Appl. Genet., 71: 284-288.
Schneider C.A., Rasband W.S., Eliceiri K.W., 2012. NIH Image to ImageJ: 25 years of image analysis, Nature Methods 9: 671-675.
Sotelo M., Irisarri P., Lorite M.J., Casaretto E., Rebuffo M., Sanjuan J., Monza J., 2011. Diversity of rhizobia nodulating *Lotus corniculatus* L. grown in norythern and southern of Uruguay, Applied Soil Ecology, 49: 197-207.
Toth I., 2013. Studii privind influența factorilor fizici asupra speciei *Lotus corniculatus* L., PhD Thesis, Victor Babeş University of Medicine and Pharmacy Timişoara, Romania.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH ON CHOOSING THE OPTIMAL DOSAGE OF HERBICIDES CEREDIN SUPER (300 g/l 2.4-D + 100 g/l Dicamba) AND ASTRAL 40 SC (Nicosulfuron 40 g/l) APPLIED TO CONTROL WEEDS IN MAIZE CROP

Daniela TRIFAN[1], Marcel BULARDA[1,2]

[1]Agricultural Research and Development Station of Braila, Km. 9 Vizirului Rood, 810008, Braila County, Romania
[2]"Dunarea de Jos" University of Galati, Engineering and Agriculture Faculty of Braila, 29 Calarasilor Str., Braila, 810017, Romania

Corresponding author email: dtrifan2015@gmail.com

Abstract

Studies have been conducted for two consecutive years, 2013 and 2014 respectively, in the climatic conditions of Braila Plain. The experience was monofactorial, including six variants in three repetitions, placed on the Latin rectangle method, experimental plot measuring 12.6 square meters and a total area measuring 300sqm. Graduation experimental factor were: V1 (Ceredin Super 0.8 l/ha + Astral 40 SC 0.8 l/ha); V2 (Ceredin Super 1 l/ha + Astral 40 SC 1 l/ha); V3 (Ceredin Super 1.2 l/ha + Astral 40 SC 1.2 l/ha); V4 (Ceredin Super 1.5 l/ha + Astral 40 SC 1.5 l/ha); V5 (untreated) and V6 (hand weeding). Hybrid corn used was PR39D34. Particular sensitivity to weed corn manifested predominantly untreated variant, noticing increasing weed from 89 plants/sqm in 2013 and 92 plants/sqm in 2014, in phase 4-6 leaves of corn, 165 plants/2013 sqm and 169 plants/sqm in 2014, at the end of the vegetation period of maize. Compared to hand weeding were revealed statistically significant two variants, namely V3 (Ceredin Super 1.2 l/ha + Astral 40 SC 1.2 l/ha) and V2 (Ceredin Super 1 l/ha + Astral 40 About 1 l/ha), with an average of weed 81 and 77% in 2013 and 80 and 74% in 2014 compared to control 88% manual weeding. Also, we determined the elements of productivity and yield obtained from each experimental variant compared with untreated variant, and was established correlations between doses of fertilizer and values of productivity elements.

Key words*: maize, weeds control, herbicides doses.*

INTRODUCTION

Maize is very sensitive to weeds, on the one hand because it develops slowly in the first 4-6 weeks and on the other hand because density of plants per square meter is lower than in other cultures. The weed competition can lead to significant loss of harvest, unless the time comes for weed control.

The most effective weed control is with herbicides, but herbicides dose varies depending on the degree of weeds and climatic conditions. Single factor experiment was represented by testing four different doses of herbicides and Astral Super CEREDIN as follows: V1 (CEREDIN Super 0.8 l/ha + Astral 40 SC 0.8 l/ha); V2 (CEREDIN Super 1 l/ha + Astral 40 SC 1 l/ha); V3 (CEREDIN Super 1.2 l/ha + Astral 40 SC 1.2 l/ha); V4 (CEREDIN Super 1.5 l/ha + Astral 40 SC 1.5 l/ha); V5 (hand weeding). Hybrid corn was used PR39D34.

In control of weeds, the main objective has always been throughout the period of vegetation removal of weed competition by reducing pest infestations below the threshold of the consumption of water and nutrients by weeds, ultimately contributing to obtaining high yields and quality appropriate to the level of the biological potential of maize hybrids (Şarpe, 1987; Bârlea & Segărceanu, 1985).

MATERIALS AND METHODS

Experience placement was performed by the method Latin rectangle in three repetitions, experimental plot the surface of 17.5 m^2 (3.5 m x 5 m), 1m wide alleys are the total area of experience being 447 m^2 (Figure 1).

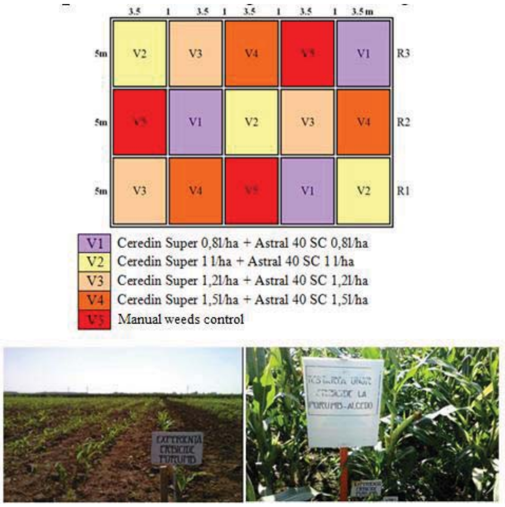


Figure 1. Scheme of experience with different doses of the herbicide for corn and images of experimental field

We determined the degree of weed before treatment, 30 days, 45 days and at harvest each experimental variant. Biometric measurements were made at harvest and were determined yield and production obtained. The results were statistically processed by the method variance (Anova) and correlation method (Trifan & Bularda, 2014).

RESULTS AND DISCUSSIONS

The degree of weed herbicide was raised before, in both experimental years, the 15 weed species occurring in the experience: *Fumaria officinalis, Chenopodium album, Echinochloa crus-galli, Amaranthus retroflexus, Setaria glauca, Cirsium arvense, Galinsoga parviflora, Convolvulus arvensis, Sonchus arvensis, Polygonum lapathyfolium, Sorghum halepense, Agropyron repens, Xanthium strumarium, Atriplex patula* and *Chenopodium polyspermum* and their average percentage is shown in Figure 2. Particular sensitivity to weed corn manifested predominantly untreated variant, noticing increasing weed average from 89 plants / m in phase 4-6 leaves of corn, 165 plants / m at the end of the vegetation period of maize (Figure 3). The yield was between 82.6% and values 89.5%, the highest value being obtained yield variant V3 (CEREDIN Super 1.2 l/ha + Astral 40 SC 1.2 l/ha), followed in order decreasing the variants V4 (CEREDIN Super 1.5 l/ha + Astral 40 SC 1.5 l/ha) and V6 (manual weeds control) (Figure 4).

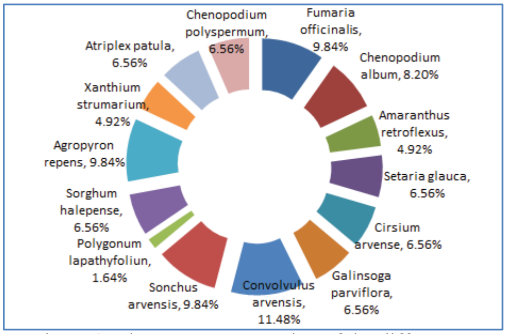


Figure 2. The average proportion of the different species of weeds, in the experience of herbicides in corn, phase of 4-6 leaves of maize (A-2013 B - 2014)

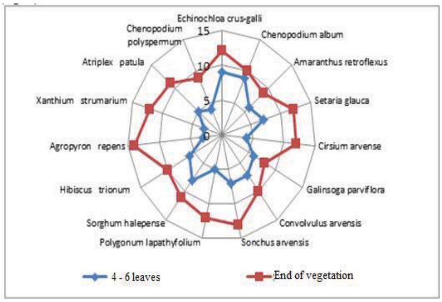


Figure 3. The graph of weeds in untreated variant

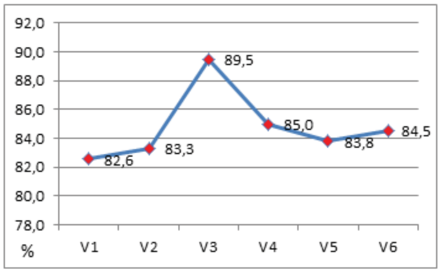


Figure 4. The graph values yield for each experimental variant

Analysis of correlations established between doses of herbicides applied to production and productivity elements values were very significant positive and highlighted in the graphs in Figures 5 and 6.

Explanation of these correlations derived from the corn weed problem, which harms both the ill-fated competition for space nutrition and for being gazed agents of pests and pathogens, which can reduce production quantity and quality of corn.

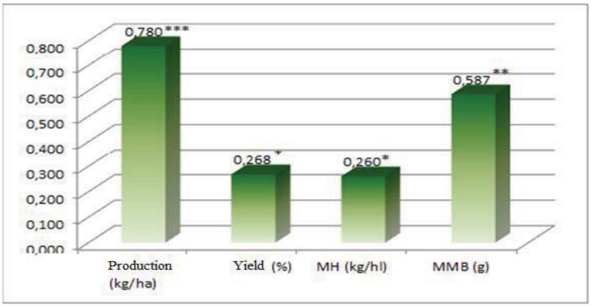


Figure 5. Graph correlations established between doses of herbicides applied and productivity elements

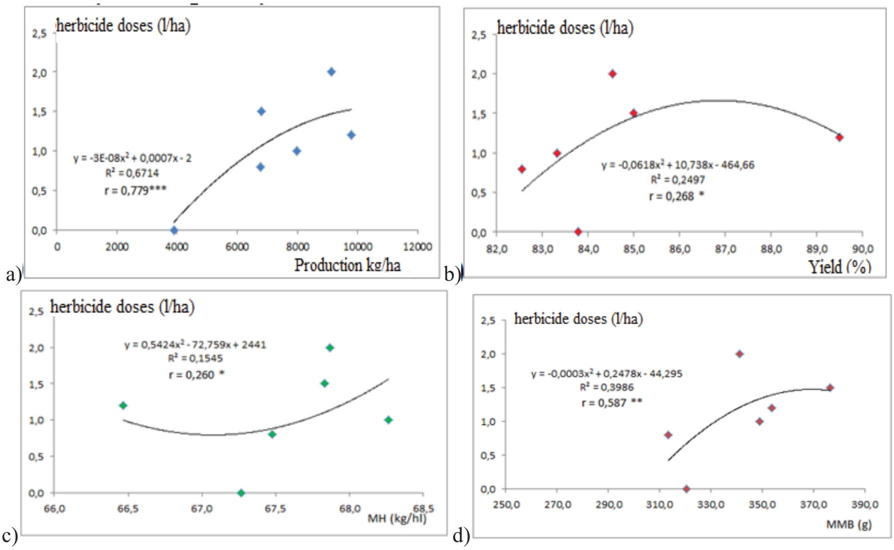


Figure 6. Graphs correlation between doses of herbicides applied to maize production indices (a), the yield of production (b) hectolitre mass (c), thousand grain weight (d)

Compared to alternative weed control by hand hoeing, were found statistically significant two variants, namely V3 (CEREDIN Super 1.2 l/ha + Astral 40 SC 1.2 l/ha) and V4 (CEREDIN Super 1.5 l/ha + Astral 40 About 1.5 l/ha), with an average degree of weed in end vegetation 85 and 90%, compared with the control hand weeding 94% (Figure 7).

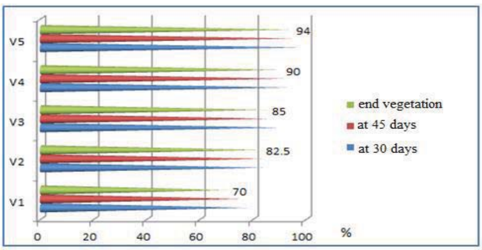


Figure 7. The average degree of weed control

At harvest, and production indices were determined from the number of cobs per plot (17.5 square meters), the mass of the samples taken, the average weight of the cob, the mass of grains per cob, the mass of the rachis, the number of rows/cob, the number of seeds/row, thousand grain weight (MMB), hectolitre mass (MH), yield at STAS humidity.

The average number of cobs/variant was highest in manual hoeing version (V5), followed in descending order of V3 variants (doses of 1.2 l/ha) and V4 (doses of 1.5 l/ha) (Figure 8).

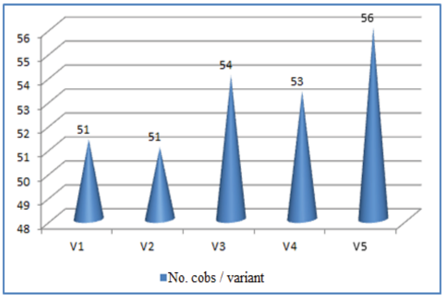


Figure 8. The graph of the average number of cobs / experimental variant (17.5 m^2)

The average weight of the corn cob harvest was the highest in version V4 (dose of 1.5 l/ha), followed by variant V5 (manual weeds control) and V3 version (dose of 1.2 l/ha) (Figure 9).

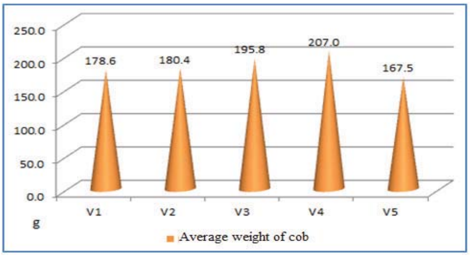


Figure 9. The graph of the average weight values of the ear recorded at harvest

The lowest average number of kernels/row was recorded in variant V1, and the average number of rows/ear lowest was recorded in variant V4. The highest average number of grains per cob was recorded in variant V3, followed in descending order of variants V1 and V5 (Figure 10).

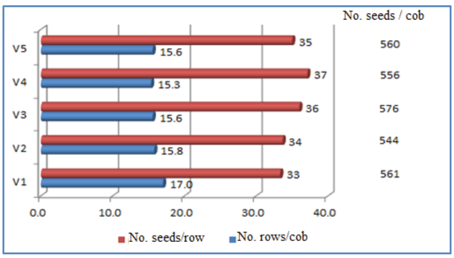


Figure 10. The graph determinations on the number of rows per ear, number of kernels per row and the number of grains per cob variants

Hectolitre mass determinations have shown that manual hoeing variant (witness experience) hectolitre mass was lowest (74.8 kg/hl), followed in ascending order of V3 variants (dose of 1.2 l/ha), V4 (the dose of 1.5 l/ha), V1 (dose of 0.8 l/ha) and V2 (the dose of 1 l/ha) (Figure 11).

Highest production yield, calculated at standard humidity was recorded at hand weeds control variant, followed in descending order by herbicide version 0.8 l/ha and then 1.5 l/ha herbicides version (Figure 13).

Regarding thousand grain weight, the best results were obtained from manual hoeing version (V5), followed in descending order by V4 version (1.5 l/ha) and variant V1 (1 l/ha) (Figure 12).

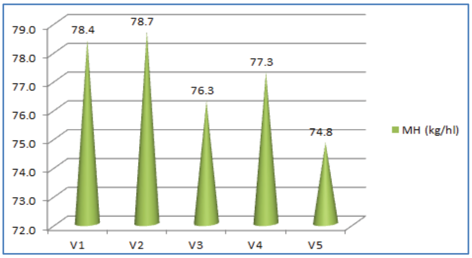


Figure 11. The graph of hectolitre mass average in experimental variants

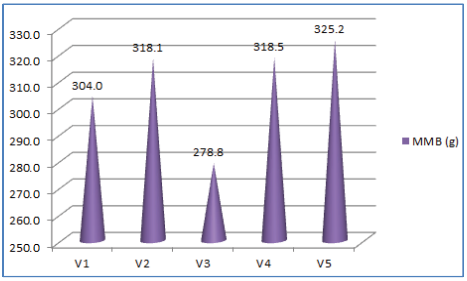


Figure 12. The graph of MMB (thousand seed weight) of experimental variants

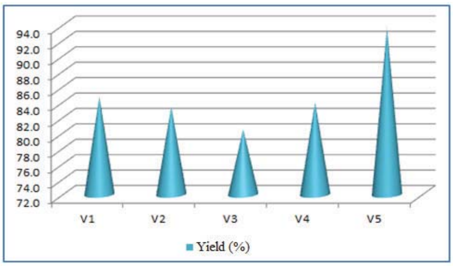


Figure 13. The graph yield of maize production in the experience of herbicides in crop year 2013-2014

Average grain yields, calculated at 15.5% humidity STAS for maize, the experience obtained values ranged from 4807 kg/ha and 5788 kg/ha and yield differences between experimental variants compared to the control manual weeding were significantly herbicides version only positive at 1.5 l/ha, followed by a dose of 1.2 l/ha, which means that a higher dose of herbicide was more economically efficient than manual weed control (Figure 14).

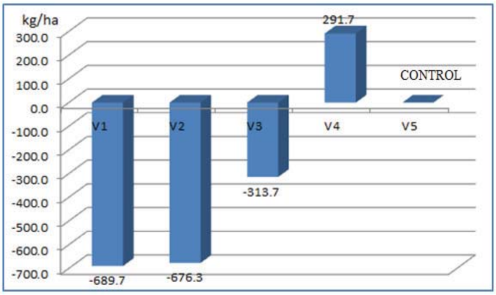


Figure 14. Differences of corn production in herbicides experience, compared to manual weed control

CONCLUSIONS

It can be concluded that the application of a herbicide in higher dose is more effective compared to manual weeding, but the dilution of herbicide must to be correctly calculated, in correlation with the state of soil moisture and air, so as not to produce toxicity in plants to the crop being treated.

REFERENCES

Bârlea V., Segărceanu O., 1985. Cercetări privind eficacitatea erbicidelor în combaterea buruienilor din cultura de porumb şi sfeclă de zahăr. Analele INCDA Fundulea -Volum omagial, p. 176-189.

Şarpe N., 1987. Combaterea integrată a buruienilor din culturile agricole. Editura Ceres, Bucureşti.

Trifan D., Bularda M., 2014. Importance of using graphical and statistical computing programs in agricultural research - Proceedings of the 10th International Scientific Conference "eLearning and Software for Education" Bucharest, April 24-25, 2014, Volume 3, Editura Universitatii Nationale de Aparare "Carol I", p. 411-416.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

STUDIES REGARDING EFFICIENCY OF BIOLOGICAL FERTILIZATION WITH ALGAFIX ON WINTER RAPE AND SPRING BARLEY PRODUCTION

Daniela TRIFAN[1], Marcel BULARDA[1,2]

[1]Agricultural Research and Development Station of Braila, Km. 9 Vizirului Rood, 810008, Braila County, Romania
[2]"Dunarea de Jos" University of Galati, Engineering and Agriculture Faculty of Braila, 29 Calarasilor Str., 810017, Braila County, Romania

Corresponding author email: dtrifan2015@gmail.com

Abstract

Foliar microbiological fertilizer Algafix is represented by a mixture of living green algae species Scenedesmus obtisausculus who are able to assimilate different hormones and antioxidants that are transmitted through the leaves of the plant, stimulating growth and resistance to biotic and abiotic stress, and having an important influence for increased production. This paper presents an experience of establishing optimal Algafix dosage of winter rape and spring barley, with four graduations or doses of 1.5 l/ha, 2 l/ha, 2.5 l/ha and 3 l/ha, which were compared with the control - untreated variant. We watched both morphological and physiological differences on the characteristics of plants in the experimental variants, and production quality indexes obtained, and the correlations established between doses of biofertilizers and measured parameters. In the same time, we studied how the doses of biofertilizers influence the water and mineral elements root absorption by plants grown in the two species, as well as economic efficiency calculation. Compared with untreated control, all variants have obtained positive differences, most production being registered variant V4 (dose of 2.5 l/ha), both in winter rape and spring barley cultures.

Key words: *microbiological fertilizers, spring barley, rape.*

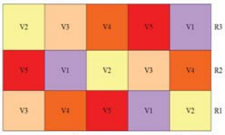
INTRODUCTION

Currently, put increasing emphasis on the transition to a sustainable organic agriculture, especially when the products are used directly in human nutrition. On the other hand, it is very important to avoid environmental pollution, to use less fertilizers and gradually to proceed with both biological products for crop fertilization and for phytosanitarytreats (Leopa, 2013). Also, farmers can easily use the remaining waste for composting farm and obtain organic fertilizer, using various design patterns, depending on the size of farms (Trifan, 2013; Anghelache, 2012). Rape culture is autumn consuming nutrients, increase production is directly proportional to the applied fertilizers. Due to the short period of vegetation, spring barley is not pretentious for fertilization using the residual effect of previous crop, apply fertilizers. To see how to behave crop to biological fertilizer treatments compared with chemical fertilization was achieved with various doses of biofertilizers experience. Algafix is a foliar fertilizer microbiological green alga of the genus Scenedesmus living in water suspension obtained by photofermentation technology, macro and trace elements, plant hormones culture removed from algae. Fractional application of chemical fertilizers provide plant supply throughout the growing season, enabling increased production of grains and based by algae fertilizer application, ensure soil nutrient absorption increase in the critical stages of plant nutrition (Trifan, 2014).

MATERIALS AND METHODS

Experience with chemical and biological fertilization (with Algafix) winter rape has been set according to the method in Latin rectangle in three repetitions (Figure 1).

Each experimental plot has an area of 17.5 m^2 (5m x 3.5m) paths had a width of 1 m, and the whole experience was a total area of 446.5 m^2.



Variant	Tratment	Dose / variant 17,5m²	Water for solution preparation
V1	Without tratment	-	-
V2	Algafix 1.5 l / ha	2.625ml	525ml
V3	Algafix 2 l/ha	3.5ml	700ml
V4	Algafix 2.5 l/ha	4.375ml	875ml
V5	Algafix 3 l/ha	5.25ml	1050ml

Figure 1. Scheme of experience with chemical and biological fertilization on winter rape in the agricultural year 2013-2014

Biometric measurements were performed: plant size, the diameter of the stem, no. branches / plant, average length of capsule, no. a capsule / plant, no. seeds / capsule, MMB, MH, average production (Figure 2). For statistical interpretation by analysis of variance (ANOVA and Correlation) was used at harvest, the results compared with the average of experience (Trifan, 2014).

Figure 2. Images from the biometric measurements to rapeseed plants in different stages of vegetation, from the experience with different doses of Algafix

RESULTS AND DISCUSSIONS

Average height of rape plants - was between 168 and 183 cm values (Figure 3 a), while the package stem diameter was between 1.4 and 2 cm, the lowest being the untreated variant, and the highest value was recorded in variant V3 (treated with Algafix 21 / ha). It turned out that the variants treated with high doses tend Algafix thickening of the stem at the expense of increase in plant height (Figure 4 a).

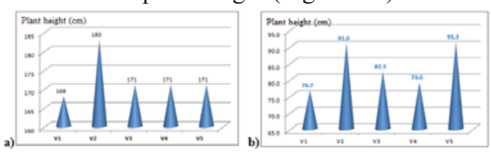


Figure3. The graph for the average size of the plants of oilseed rape (a) and barley (b)

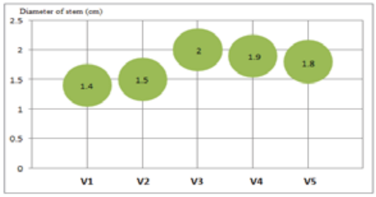


Figure 4. The graph for the stem diameter of rape in experience with Algafix different doses

Number of branches per plant for rape crops - was higher in variant V3 (2 l/ha) - 14 branches/pl., V4 and V5 variants followed by 10 branches/pl., while the average length of capsule had higher values V4 variant (2.5 l/ha) 7.5 cm, followed by variant V3 (2 l/ha), with a length of 6.7 cm (Figure 5).

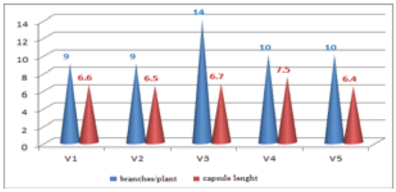


Figure 5. The graph for the average number of branches per plant and average capsule length of rape

For spring barley, the average length of the ear was equal to variants V3, V4 and V5 (11.3 cm), followed by V2 (10.2 cm), with a difference of 2.5 cm and 1.4 cm, respectively (Figure 6).

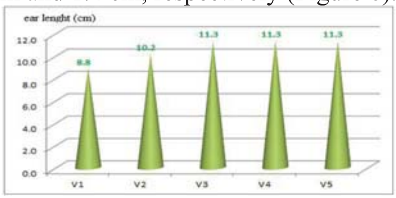


Figure 6. Graph the average values of ear length in spring barley experience with different doses of Algafix fertilization

Number of capsules/plant - was between 252 capsules/plant in untreated variant and 417 capsules/plant in variant V3 (Algafix 2 l/ha), followed by V5 (Algafix 3 l/ha) with 323 capsules/plant and 321 capsules/plant in V4 (Algafix 2.5 l/ha) (Figure 7).

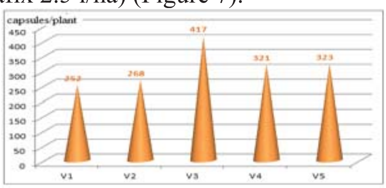


Figure 7. The graph for the average number of a capsules/plant in rape experience

No. seeds/capsule for rape was most increased in variant V4 (Algafix 2.5l/ha) with a value of 30seeds /capsule, representing an increase of 15.38% compared to untreated variant (Fig. 8a), and no. seeds/ear for spring barley was highest in variant V4 (32 seeds/ear), followed by variants V5 and V2 (27 seeds/ear) and V3 (26 seeds/ear) (Figure 8 b).

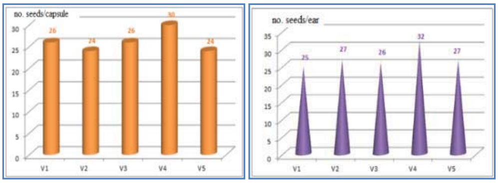
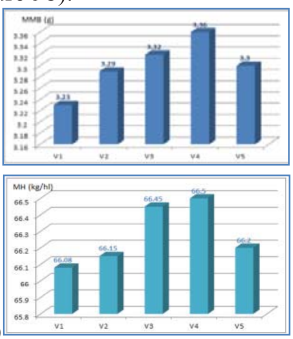


Figure 8. The graph for the average number of seeds per capsule for rape and per ear for spring barley

The mass of a thousand grains for rape, superior to untreated control values were obtained in all variants fertilized with Algafix, the highest value of this element of productivity is obtained V4 version (2.5 l/ha) - 3.36 g, followed by variant V3 (2l/ha) - 3.32 g, V5(3l/ha) - 3.3 g and V2 (1.5 l/ha) - 3.29 g (Figure 9a). The higher values of hectolitre mass in rape experience were obtained by variant V4 (2.5 l/ha) - 66.5 kg/hl, followed by V3 (2 l/ha) - 66.45 kg/hl and V5 (3 l/ha) 66.2 kg/hl (Figure 9b).

a)

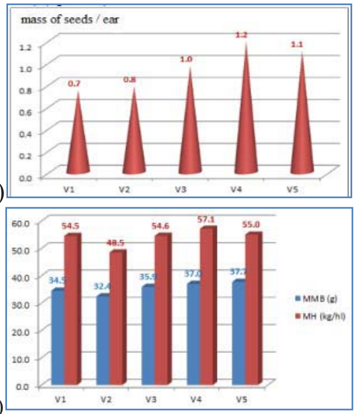


b)

Figure 9. The graph of a thousand grains mass values (MMB) and hectolitre mass (MH) in rape

The mass of grains per ear in spring barley had the highest value compared to the untreated control variant V4 - Algafix 2.5 l/ha (1.2 g), followed by V5 - Algafix 3 l/ha (1.1 g) and V3 (Algafix 2 l/ha) (Figure 10 a). Mass of thousand mass and hectolitre mass in spring barley were differed significantly only variants V4 (Algafix 2.5 l/ha), followed in descending order of variants V5 (Algafix 3 l/ha) and V3 (Algafix 2 l/ha) (Figure 10b).

a)



b)

Figure 10. Graphs for the average weight of grain in the ear and the MMB and MH in spring barley experience

Average yield of rape (recalculated at 8% moisture STAS) shows that influence of fertilization was observed most in variant V3 (dose of 2 l/ha), with an increase of 31%, followed by V4 (dose 2.5 l/ha) with an increase of 30% and V5 (dose of 3 l/ha), with an increase of 3% compared to control represented by experience average (Figure 11).

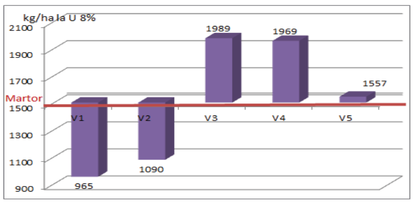


Figure 11. The graph of the average production for winter rape in Algafix experience

The highest average yields per hectare in spring barley experience were obtained on application Algafix dose of 2.5 l/ha (V4), with 60% more than average experience, followed in descending order by version V5 (3 l/ha), which obtained a production increase of 15% and V3 version (2 l/ha), with an increase of 1.18% (Figure 12).

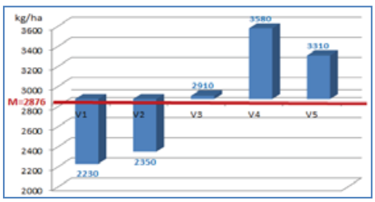


Figure 12. Graph the average production experience with Algafix in spring barley in crop year 2013-2014

Correlations established between Algafix doses and values of MMB, MH and average yield were significantly influenced by increasing the dose of biofertilizers Algafix, while ear length, number of grains per ear and ear weight had a negative correlation with increasing Algafix doses.

Therefore, we can say that by increasing the dose of Algafix can positively influence the grain dry matter accumulation, leading to increased MMB, MH and average production per hectare (Figure 13).

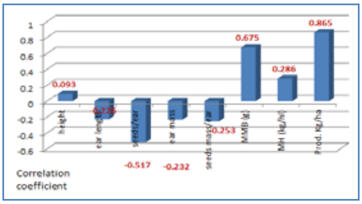


Figure 13. Graph correlations established between Algafix doses and productivity indices

Between increasing dose of Algafix and average production was a very significant positive correlation with a coefficient of 0.865 (Figure 14) and between increasing dose of Algafix and MMB and MH (Figure 15).

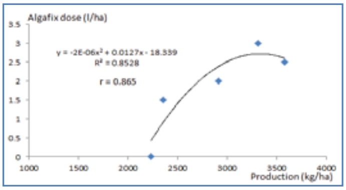


Figure 14. Graph of correlation between Algafix doses and average production

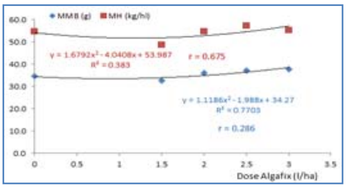


Figure 15. Graph of correlation between Algafix doses and thousand seeds mass, and hectolitre mass

Calculation of economic efficiency on Algafix doses applied in autumn rape culture revealed that the highest profit was achieved in variant V3 (Algafix 2 l/ha), followed by variant V4 (2.5 l/ha) and V5 (3 l/ha).

In spring barley, the highest profit per hectare was obtained from version V4 (2.5 l/ha), followed in descending order by version V5 (3l/ha) and V3 (2l/ha) (fig. 16).

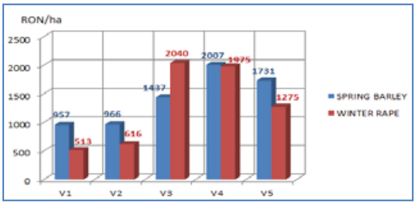


Figure 16. Profit per hectare calculated for each experimental variant of winter rape and spring barley

CONCLUSIONS

Algafix microbiological fertilizer used for winter rape and spring barley make a significant production by increasing of thousand grain weight and hectolitre mass.

Algafix doses recommended for these crops are 2.5l/ha and 2l/ha, which can increase the profit per hectare from two to four times compared to unfertilized variant.

ACKNOWLEDGEMENTS

This research work was carried out with the support of S.C. AGRO BIOFORCE S.R.L.

REFERENCES

Anghelache D., 2012. Clamshell bucket - digital modeling method – http://www.cmu-edu.eu/anale/anale/2012-vol18/Volumul_18.pdf pag. 85.

Leopa A., Trifan D., 2013. Quantification of Atmospheric Pollution by Qualitative Analysis of Precipitation as Snow, The Annals of „Dunărea de Jos" University of Galați, p. 197-203, ://www.fimm.ugal.ro/new/index.php/annals/archive

Trifan D., Burtea C., Bularda M., Vişinescu I., 2013. Study on the biotech utilization of waste crops to improve anthropical degraded soils - Rational Use of Natural Resources, Faculty of Alecu Russo Balti State University, Moldova.

Trifan D., Bularda M., 2014, Importance of using graphical and statistical computing programs in agricultural research - eLearning and Software for Education Journal, vol. III, p. 411-416. http://proceedings.elseconference.eu/index.php?r=site/index&year=2014&index=papers&vol=15&paper=42c4e0f01b9ffc71d68072728fcea4ab

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DRY MASS AND PHOSPHORUS TRANSLOCATION IN BARLEY IN DEPENDENCE OF SOURCE-SINK RATIO

Nedialka YORDANOVA, Lyubena KUZMANOVA, Svetla KOSTADINOVA

Agricultural University – Plovdiv, 12 Mendelleev str., 4000 Plovdiv, Bulgaria

Corresponding author email: yordanova.ne@abv.bg

Abstract

The changes in reutilization of vegetative dry mass of barley were studied in dependence of source-sink ratio as a result of the reduction of spike by half. A malting barley variety Krami was investigated in conditions of long-term fertilizer trial at the experimental field of Department of Agrochemistry and Soil Science of Agricultural University – Plovdiv on soil type Molic fluvisol. It was found that in anthesis the vegetative dry mass was higher than the dry mass of the growing spike, and its share of biomass was 31.0% for the first year of study and 31.9%, respectively for the second. The amount of phosphorus in the developing spike was 40.4% and 44.6%, respectively in 2013 and 2014. The reduction of the spike had a low influence on the accumulated straw dry mass but significantly reduced that of the grain, and therefrom the yield harvest index. As a result of the reduction of spike, the amount of phosphorus in grain was highly increased in both experimental years. As opposed to grain, the changes in the content of straw phosphorus in plants with and without reduced spikes, were less developed. Barley accumulated significant amounts of net dry mass after anthesis, and a gain of dry mass and phosphorus was established after that phase during the two years of study with high values in 2014-up to 67.3% for barley without reduced spikes. A higher efficiency of phosphorus reutilization was established in 2013-61.9%. The barley productivity decreased as a result of the spike reduction with a significant lowering of yield in 2014. A lower productivity was reported in the second year of study as a result of unfavourable weather conditions during the year.

***Key words**: barley – sourse-sink ratio.*

INTRODUCTION

During the growth cycle yield is mainly limited by the source strength, the sink capacity or colimited by both (Borrás et al., 2004; Dordas, 2009). Many factors can affect the source–sink relations during the different growth phases including genotype, temperature, rainfall and fertilization (Mohammadi and Amri, 2008; Miralles and Slafer, 2007). Nitrogen and phosphorus are the main nutrients that affect the assimilate production and distribution and affecting directly or indirectly the source–sink relation (Arduini et al., 2006; Muchow, 1988). The most active acceptor for assimilates in anthesis and after this phase is grain. Improving the productivity of grain is a major scientific and application priority). The changed acceptor in wheat showed that the grain size is limited only by the acceptor under favorable growing conditions (Cartelle et al., 2006; Borrás et al., 2004; Slafer & Savin, 1994; Jenner et al., 1991). Under no irrigation the grain mass often increased as a result of reduction of the acceptor (Blum et al., 1988), which can be interpreted as a result of a (donor) source limitation of the grain growth. In Bulgaria barley is grown under non-irrigated fields where stressful conditions during grain filling can limit productivity and increase the dependence of the yield of spare assimilates. A better understanding of the relationship between vegetative and grain reserves in this culture is important for establishing physiological and agrochemical characteristics suitable for adaptation to adverse external effects, mainly related to climate changes such as frequent droughts and other external factors that lead to the modification of grain yield (Borras et al., 2004). The aim of present study was to examine the effect of changed sourse-sink ratio on accumulation and reutilization of dry mass and phosphorus in barley plants.

MATERIALS AND METHODS

The experiment was carried out in conditions of long-term fertilizer trial in rotation with maize. The barley variety Krami was investigated. The soil type was Molic fluvisoil.

The area of experimental plots was 20 m^2 and each variant were examined in four replications. A moderate mineral fertilization was applied in rate 80 kg $N.ha^{-1}$. In heading/anthesis of barley the aboveground plant parts were analyzed. The samples were divided into leaves, stems and growing spikes. They were dried, weighed, ground and later analyzed for primary nutrients nitrogen, phosphorus and potassium. At the same time in anthesis the spikes of barley from four plots were reduced by 50% (removing the top one-half) and they were marked. At maturity the plants from area of plots (subplots) with halved spikes and plots with no reduced spikes were taken for analysis. The samples were separated into grains and leaves, stems and chaffs. They were weighed and dried to constant weight at 60°C. An aliquot part of dry plant samples was mineralized with concentrated H_2SO_4 catalyzed by H_2O_2 and the content of phosphorus was defined (method of Egner-Rheem).

The parameters referring to dry mass and phosphorus accumulation, translocation and remobilization within the wheat and barley plants were calculated as follows according to different authors (Dordas, 2009; Abeledo et al., 2008; Przulj and Momcilovic, 2001a,b; Papakosta and Gagianas, 1991; Cox et al., 1986, 1985a,b):

1. Dry mass translocation ($kg.ha^{-1}$) = dry mass at anthesis –dry massof straw at maturity. Straw included leaves, culm and chaff.
2. Dry mass translocation efficiency (%) = (dry mass translocation/dry mass at anthesis) x 100.
3. Contribution of pre-anthesis assimilates to the grain (%) CAVG = (dry mass translocation/grain yield) x 100.
4. Harvest index (HI) = grain yield/total aboveground biomass at maturity.
5. Phosphorus translocation (kg $N.ha^{-1}$) = P_2O_5 content at anthesis– P_2O_5 content of straw at maturity.
6. Phosphorus translocation efficiency (%) = (P_2O_5 translocation/P_2O_5 content at anthesis) x 100
7. Phosphorus harvest index (PHI) = grain P_2O_5 at maturity/total P_2O_5 content of aboveground biomass at maturity.

RESULTS AND DISCUSSIONS

Dry mass of vegetative plant parts (leaves and stems) in anthesis was higher, than dry mass of the growing spikes in anthesis (Table 1). The total accumulated aboveground dry mass of barley was 3854 $kg.ha^{-1}$ and 5120 $kg.ha^{-1}$, respectively for 2013 and 2014. The part of aboveground dry biomass in anthesis was 31.0% for the first year of study and 31.9%-for the second one. The content of phosphorus (Table 2) in aboveground plant parts was higher in 2013-31.4 kg $P_2O_5.ha^{-1}$ compared with 2014-20.4 kg $P_2O_5.ha^{-1}$. The amount of phosphorus distributed to the growing spikes was 40.4% for the first experimental year 44.6 kg $P_2O_5.ha^{-1}$, respectively for the second.

Table 1. Aboveground dry mass ($kg.ha^{-1}$) and spike/dry mass ratio in anthesis

Crop	Growing spikes	Leaves and stems	Dry mass in anthesis	Spikes/Dry mass
2013	1589	3531	5120	0.310
2014	1228	2626	3854	0.319

Table 2. Phosphorus content of aboveground plant parts (kg $P_2O_5.ha^{-1}$) in anthesis and ratio of P_2O_5 spike to aboveground dry mass P_2O_5

Crop	P_2O_5 of growing spikes	P_2O_5 of leaves and stems	P_2O_5 in anthesis	P_2O_5 of spikes/P_2O_5 in anthesis
2013	12.7	18.7	31.4	0.404
2014	9.1	11.3	20.4	0.446

The accumulation of dry mass and its distribution between the different plant parts in maturity is presented in Table 3. In anthesis dry mass of vegetative plant parts was higher than dry mass of the growing spikes. At maturity dry mass of grain in plants with reduced spikes was lower in both years of the study - 25.6% in 2013 and 41% - in 2014. The amount of straw yield formed was hardly affected by the reduction of the spike. Therefore, the reduction of the sink (grain acceptor) did not influence the dry weight of straw (leaves, culm and chaff). As expected the spikes halving decreased the grain yield and hence the yield harvest index, which was lower in plants with reduced spikes and was 16% for both experimental years.

Table 3. Productivity of barley (kg.ha^{-1})

Parameters	2013 Barley	2013 Barley with reduced spike	2014 Barley	2014 Barley with reduced spike
Grain	4502	3350	3357	1982
Straw	3738	3970	3628	2944
Grain+Straw	8240	7320	6985	4926
HI	0.546	0.458	0.481	0.402

Spikes reduction resulted in most significant diminishing of the amount of grain phosphorus-with 55.6% for 2013 and 64.9% for 2014 (Table 4). Unlike grain phosphorus, changes in the phosphorus content of straw in plants with and without halved spikes were less demonstrated. The distribution of the total accumulated phosphorus of plants in maturity, expressed by phosphorus harvest index, indicated that the proportion of phosphorus in the grain was diminished due to the spikes reduction. This was expected as the total phosphorus content in the grain was lower in halved spikes plants. The phosphorus harvest index for 2013 was 0.716 and 0.551 in barley with or without changes in acceptor, while in 2014 values were respectively 0.660 and 0.490.

Table 4. Phosphorus content of barley at maturity (kg P_2O_5.ha^{-1})

Parameters	2013 Barley	2013 Barley with reduced spike	2014 Barley	2014 Barley with reduced spike
Grain phosphorus	30.2	13.4	22.5	7.9
Straw phosphorus	12.0	10.9	11.6	8.2
Phosphorus of grain+straw	42.2	24.3	34.1	16.1
PHI	0.716	0.551	0.660	0.490
PHI/HI	1.311	1.203	1.372	1.218

Distribution of biomass is determined by the number and activity of the acceptor and the number of grains is closely related to the presence of assimilates in anthesis (Wardlaw, 1990). Under non-irrigated conditions, it is important to increase to maximum extent translocation (reutilization) of dry mass as it can provide a higher yield. Proper selection of varieties in addition to the cultivation of crops could increase the efficiency of reutilization of dry mass (Cox et al., 1985). The results of the trial showed that barley accumulated significant amounts of net mass after anthesis, as in both experimental years was established a gain of dry mass (Table 5). The translocated pre-anthesis biomass changed in range from 1150 to 1382 kg.ha^{-1} in 2013 and from 1910 to 2260 kg.ha^{-1} in 2014, as the efficiency of reutilization was higher in the first year of study. Barley plants with reduced spikes reutilized least pre-anthesis dry biomass in the grain.

The accumulated phosphorus, its reutilization and its part of pre-anthesis phosphorus were presented in Table 6. The results demonstrated that the barley accumulated a large amount of phosphorus after anthesis in plants without reduction of the sink - 10.7 kg P_2O_5.ha^{-1} in 2013 and 13.7 kg P_2O_5.ha^{-1} and 13.7 kg P_2O_5.ha^{-1} in 2014, as in both years of study was observed a loss of phosphorus in the variants with reduced spikes, which was significantly expressed in 2013. It was established a gain of phosphorus after anthesis and more significant values were demonstrated in the second year of study - 67.3%, related to the first one - 34.2%. The translocated phosphorus was in range from 8.8 to 19.0 kg P_2O_5.ha^{-1}, respectively for 2013 and 2014. The highest efficiency of translocation-61.9% was reported in the first year of study. As a result of spike halving, it was established a loss of phosphorus after anthesis, therefore values of reutilization and efficiency of translocation were not reported.

Table 5. Dry mass accumulation after anthesis, dry mass translocation and contribution of pre-anthesis assimilates to the grain of barley

Parameters	2013 Barley	2013 Barley with reduced spike	2014 Barley	2014 Barley with reduced spike
Net dry mass after anthesis, $kg.ha^{-1}$	3120**	2201	3130	1070
Dry mass translocation, $kg.ha^{-1}$	1382**	1150	2260	1910
Dry mass translocation efficiency,%	27.0	22.5	5.9	23.6
CAVG, %	30.7	34.3		

Table 6. Phosphorus accumulation after anthesis, phosphorus translocation and contribution of pre-anthesis assimilates to the grain of barley

Parameters	2013 Barley	2013 Barley with reduced spike	2014 Barley	2014 Barley with reduced spike
Phosphorus after anthesis, kg $P_2O_5.ha^{-1}$	10.7	-7.1	13.7	-4.2
Phosphorus translocation, kg $P_2O_5.ha^{-1}$	19.0	-	8.8	-
Phosphorus translocation efficiency,%	61.9	-	43.0	-
CPG, %	64.4	-	39.0	-

CONCLUSIONS

Dry mass of vegetative plant parts in anthesis was higher, than dry mass of the growing spikes. The share of growing spike of biomass was 31.0% for the first year of study and 31.9% - for the second. After anthesis barley continues to accumulate dry biomass. The participation of pre-anthesis stem reserves in grain slightly amended due to the change of the acceptor. Sink reduction strongly reduced grain yield and harvest index and weakly affect the straw. The efficiency of reutilization of dry mass is higher in the first year of study. It was established a gain of phosphorus after anthesis and more significant values were demonstrated in the second year of study - 67.3%. The translocated phosphorus was in range from 8.8 to 19.0 kg $P_2O_5.ha^{-1}$, respectively for 2013 and 2014. The highest efficiency of translocation - 61.9% was reported in the first year of study. As a result of spike halving, it was established a loss of phosphorus after anthesis. The grain yields from plants with reduced spikes are lower-with 25.6% for 2013 and 41.0% for 2014.

REFERENCES

Abeledo L.G., Calderini D.F., Slafer G.A., 2008. Nitrogen economy in old and odern malting barleys. Field Crops Research. Volume (106): 171-178.

Arduini I., Masoni A., Ercoli L., Mariotti M., 2006. Grain yield, and dry matter and nitrogen accumulation and remobilization in durum wheat as affected by variety and seeding rate. European Journal of Agronomy, Volume (25): 309-318.

Blum A., Sinmena B., Golan G., Mayer J., 1988. The grain quality of landraces of wheat as compared with modern cultivars. Journal Plant Breed, Volume (97): 226-233.

Borras L., Slafer G.A., Otegui M.E., 2004. Seed dry weight response to source–sink manipulations in wheat, maize and soybean: a quantitative reappraisal. Field Crop Research, Volume (86): 131-146.

Cartelle J., Pedro A., Savin R., Slafer G.A., 2006. Grain weight responses to postanthesis spikelet-trimming in an old and modern wheat under Mediterranean conditions. European Journal of Agronomy, Volume (25): 365-371.

Cox M.C., Qualset C.O., Rains D.W., 1985a. Genetic variation for nitrogen assimilation and translocation in wheat. I. Dry matter and nitrogen accumulation. Crop Science, Volume (25): 430-435.

Cox M.C., Qualset C.O., Rains D.W., 1985b. Genetic variation for nitrogen assimilation and translocation in wheat. II. Nitrogen assimilation in relation to grain yield and protein. Crop Science, Volume (25): 435-440.

Cox M.C., Qualset C.O., Rains D.W., 1986. Genetic variation for nitrogen assimilation and translocation in wheat. III. Nitrogen translocation in relation to grain yield and protein. Crop Science, Volume (26): 737-740.

Dordas C., 2009. Dry matter, nitrogen and phosphorus accumulation, partitioning and remobilization as affected by N and P fertilization and source–sink relations. European Journal of Agronomy, Volume (30): 129-139.

Ercolia L., Lullib L., Mariottib M., Masoni A., Iduna Arduinio I., 2008. Post-anthesis dry matter and nitrogen dynamics in durum wheat as affected by nitrogen supply and soil water availability. European Journal of Agronomy, Volume (28): Issue (2): 138-147.

Jenner C.F., Ugalde T.D., Aspinall D., 1991. The physiology of starch and protein deposition in the endosperm of wheat. Australian Journal of Plant Physiology, Volume (18): 211-226.

Miralles D., Slafer G.A., 2007. Sink limitations to yield in wheat: how could it be reduced?. Journal of Agricultural Science, Volume (145): 139-149.

Mohammadi R., Amri A., 2008. Comparison of parametric and non-parametric methods for selecting stable and adapted durum wheat genotypes in variable environments. Euphytica, Volume (159): 419-432.

Papakosta D.K., Gagianas A.A., 1991. Nitrogen and dry matter accumulation, remobilization, and losses for Mediterranean wheat during grain filling. Agronomy Journal, Volume (83): 864-870.

Przulj N., Momcilovic V., 2001a. Genetic variation for dry matter and nitrogen accumulation and translocation in two-rowed spring barley. I. Dry matter translocation. European Journal of Agronomy, Volume (15): 241-254.

Przulj N., Momcilovic V., 2001b. Genetic variation for dry matter and nitrogen accumulation and translocation in two-rowed spring barley. II. Nitrogen translocation. European Journal of Agronomy, Volume (15): 255-256.

Rharrabtia Y.D., Villegasb C., Royob V., Martos-Núñeza et al., 2003. Durum wheat quality in Mediterranean environments: II. Influence of climatic variables and relationships between quality parameters. Field Crops Research, Volume (80): Issue 2: (20): 133-140.

Slafer G.A., Savin R., 1994. Sink–source relationships and grain mass at different positions within the spike in wheat. Field Crops Research, Volume (37): 39-49.

Wardlaw I.F., 1990. The control of carbon partitioning in plants. New Phytology. Volume (116): 341-381.

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Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

KARYOTYPE CHARACTERIZATION OF ALFALFA (*Medicago sativa* L.) COLLECTED FROM LAKE REGIONS OF TURKEY

Sebahattin ALBAYRAK[1], Mevlüt TÜRK[2], Cafer Sırrı SEVİMAY[3], Eissa ANAKHATOON[3]

[1]Vocational High School of Bafra, Ondokuz Mayıs University, Samsun, Turkey
[2]Department of Field Crops, Faculty of Agriculture, Süleyman Demirel University, Isparta, Turkey
[3]Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Turkey

Corresponding author email: sebahattinalbayrak@omu.edu.tr

Abstract

Alfalfa (Medicago sativa L.) is the one of the important and economic forage legume crops in the world and Turkey. Alfalfa has 60 species which 30 annual and perennial species were distributed in different regions of Turkey. Cytogenetical research on alfalfa lagged far behind other crops mainly because alfalfa chromosomes are very small, the chromosomes are morphologically very similar, cultivated alfalfa has relatively high number of chromosomes and alfalfa is an autotetraploid. The Yeşilova-3 alfalfa population was collected from Lake Regions of Turkey as clone. Root tips meristems obtained from plants of similar age that originated by vegetative reproduction from a single parent from plants grown under greenhouse conditions, were pretreated with saturated solution of ά-bromonaphthalene and 0.002 M 8-Hydroxiquinolin before staining with aceto-iron-hematoxylin. The measured chromosomal parameters were; Short arm, Long arm, Total length of chromosomes, Arm Ratio and chromosome type. Within the chromotosome complement, seven pairs of chromosomes were metacentric (chromosomes II, III, V and VI) and three numbers were submetacentric (chromosome I, IV and VIII). Karyotype analysis showed that Yeşilova accession was tetraploid (2n=4x= 32). The short arm, long arm and total length of chromosomes were ranged from 0.82-1.22, 1.17-1.80 and 2.21-2.85 micrometer, respectively.

Key words*: alfalfa, cytogenetic, chromosome, heteromorphic, karyotype.*

INTRODUCTION

Medicago sativa L. is one of the most important forage crops in the world. Cytogenetical research on alfalfa lagged far behind other crops mainly because: alfalfa chromosomes are very small, the chromosomes are morphologically very similar, cultivated alfalfa has relatively high number of chromosomes (2n=32), and alfalfa is an autotetraploid (Bauchan et al., 1997). Although there are several cytogenetical reports in *Medicago* species/cultivars from different regions of the world (Mariani et al., 1996; Stanton et al., 1994; Masoud et al., 1991; McCoy et al., 1991; McCoy, 1982), there are only few karyotypic reports from Turkey. The aim of the present study is to determine the chromosome morphologies of alfalfa.

MATERIALS AND METHODS

Alfalfa (*Medicago sativa* L.) (Yeşilova-3 genotypes, collected from Isparta, Turkey as clonally) root tips meristems obtained from plants of similar age that originated by vegetative reproduction from a single parent from plants grown under greenhouse conditions, were pretreated with saturated solution of ά-bromonaphthalene and 0.002 M 8-Hydroxiquinolin before staining with aceto-iron-hematoxylin (Agayew et al., 2010). The measured chromosomal parameters were; Short arm, Long arm, Total length of chromosomes and Arm Ratio.

RESULTS AND DISCUSSIONS

Collected from Yeşilova-3 region of Turkey alfalfa (*Medicago sativa* L.) genotype had 2n=4x=32 chromosome (Figure 3). The smallest chromosome was 2.21±0.08 μm and The longest chromosome was 2.85±0.12 μm and had four satellite (Figure 1 and 2). Chromosome 1 and 8 were submetasentric and the others metasentric. Mean chrosome length was 2.56±0.04 μm (Table 1).

Chromosome I had 2.85±0.11 µm length and 1.71±0.06 µm arm ratio. Chromosome 1 was submetasentric. Chromosome II had 2.71±0.10 µm length and 1.23±0.04 arm tation. It was metasentric. Chromosome III had 2.60±0.11 µm length and 1.27±0.06 arm ration. It was metasentric.

Chromosome IV had 2.52±0.07 µm length and 1.62±0.05 arm ration. It was metasentric or submetasentric. Chromosome V had 2.41±0.06 µm length and 1.23 ± 0.07 arm ration. It was metasentric. Chromosome IV had 2.32±0.07 µm length and 1.21±0.05 arm ration. It was metasentric. Chromosome IIV had 2.21±0.08 µm length and 1.13±0.03 arm ration. It was metasentric. Chromosome IIIV had 2.85±0.12 µm length and 1.66±0.06 arm ration. It was submetasentric. Our results confirm the findings of Bauchan and Campbell (1994) and Bauchan and Hossain (2001).

Table 1. The chromosomes of the Yeşilova-3 genotype of alfalfa

Chromosome	**Total (L+S) µm**	**Long arm(L) µm**	**Short arm (S) µm**	**Sat**	**Arm ratio (AR=L/S)**	**Type**
I	2.85±0.11	1.80±0.08	1.05±0.03	-	1.71±0.06	sm
II	2.71±0.10	1.49±0.06	1.22±0.05	-	1.23±0.04	m
III	2.60±0.11	1.45±0.08	1.15±0.04	-	1.27±0.06	m
IV	2.52±0.07	1.56±0.05	0.97±0.03	-	1.62±0.05	sm
V	2.41±0.06	1.31±0.02	1.10±0.05	-	1.23±0.07	m
VI	2.32±0.07	1.26±0.04	1.06±0.04	-	1.21±0.05	m
VII	2.21±0.08	1.17±0.05	1.04±0.04	-	1.13±0.03	m
VIII	2.85±0.12	1.34±0.05	0.82±0.05	-	1.66±0.06	sm
Mean	2.56±0.04	1.42±0.03	1.05±0.02	0.82	1.38±0.03	

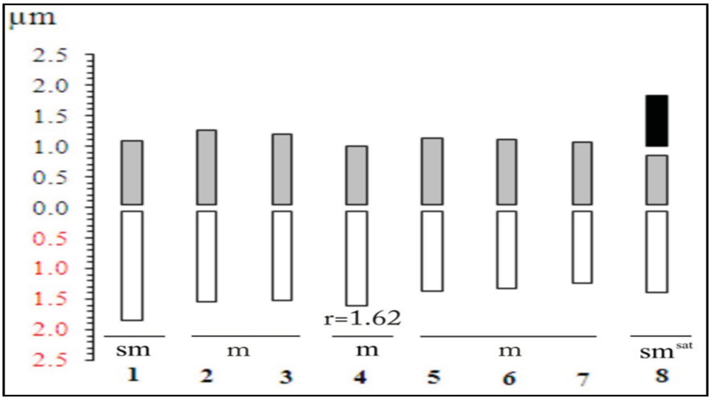


Figure 1. Haploid idiogram of alfalfa (2n=4x=32), m: Metasentric, sm: Submetasentric

CONCLUSIONS

Within the chromotosome complement, seven pairs of chromosomes were metacentric (chromosomes II, III, V and VI) and three number were submetacentric (chromosome I, IV and VIII). Karyotype analysis showed that Yeşilova accession was tetraploid (2n=4x= 32). The short arm, long arm and total length of chromosomes were ranged from 0.82-1.22, 1.17-1.80 and 2.21-2.85 micrometer, respectively.

ACKNOWLEDGEMENTS

This research work was Supported by TUBİTAK (The scientific and technological research council of Turkey). (Project number: 110 O 257).

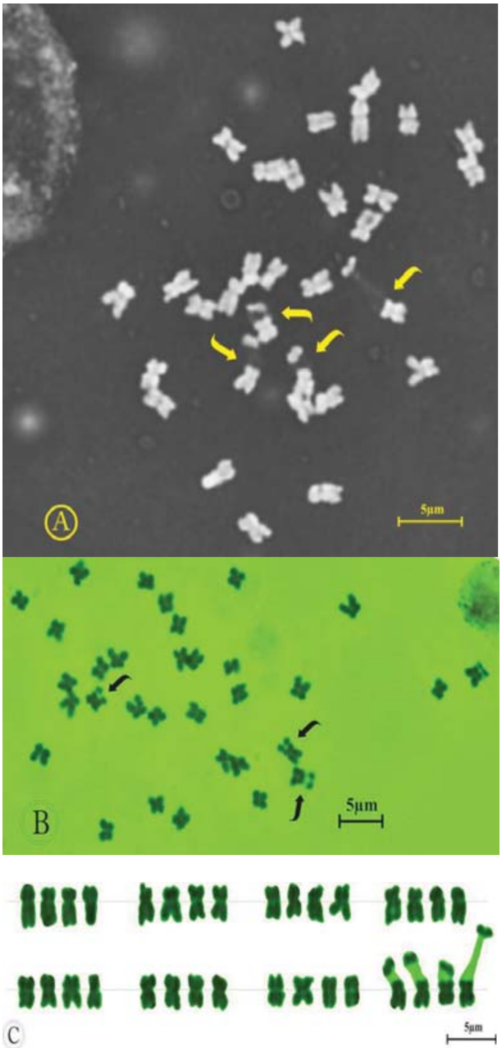


Figure 2. A, B: View of the alfalfa chromosome at mitotic metaphase, C: Caryogramme, Four satellite chromosomes were showed by arrow at all metaphase

REFERENCES

Agayev Y.M., Zarifi E., Fernandez J.A. 2010. A study of karyotypes in the *Crocus sativus* L. aggregate and origin of saffron. III International Symposium on Saffron: Forthcoming Challenges in Cultivation, Research and Economics. Acta Horticulturae 850, ISHS 2010, p. 47-54.

Bauchan G.R., Hossain M.A., 2001. A computerized image analysis system to characterize small plant chromosomes. Microscopy Analysis 48: 9-11.

Bauchan G., Hossain M., 1997. Identification of Alfalfa chromosomes using Geimsa banding and image analysis techniques. In: Proceedings of the XVIII International Rangeland Congress, Canada, p. 61-62.

Bauchan G.R., Campbell T.A., 1994. Use of an image analysis system to karyotype diploid alfalfa (*Medicago sativa* L.). Journal of Heredity 85:18-22.

McCoy T.J., 1982. The inheritance of 2n pollen formation in diploid *Medicago sativa.* Can. J. Genet. Cytol., 24: 315-323.

McCoy T.J., Bingham E.T., 1991. Alfalfa Cytogenetics. p. 399-418, In: Gupta, P. K. and Tsuchiya, T. (Eds.), Chromosome Engineering in Plants. Elsevier Pub.,Amsterdam and New York.

Mariani A., Pupilli F., Calderini O., 1996. Cytological and molecular analysis of annual species of the genus. Medicago. Can. J. Bot., 74: 299-307.

Masoud S.A., Gill B.S., Johnson L.B., 1991. C-banding and alfalfa chromosomes: Standard karyotype and analysis of a somaclonal variant. J. Hered., 82: 335.

Stanton M., Stewart McD., Percival A.E., Wendel J.F., 1994. Morphological diversity and relationship in the A-genome cottons, *Gossypium arboreum* and *G.herbaceum.* Crop Sci., 34: 519-27.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

SOME CHARACTERISTICS OF ALFALFA (*Medicago sativa* L.) POPULATIONS IN LAKE REGIONS OF TURKEY

Sebahattin ALBAYRAK[1], Mevlüt TÜRK[2], Cafer Sırrı SEVİMAY[3]

[1]Vocational High School of Bafra, Ondokuz Mayıs University, Samsun, Turkey
[2]Department of Field Crops, Faculty of Agriculture, Süleyman Demirel University, Isparta, Turkey
[3]Department of Field Crops, Faculty of Agriculture, Ankara University, Ankara, Turkey

Corresponding author email: sebahattinalbayrak@omu.edu.tr

Abstract

Clones were collected from 22 counties and 60 different points at Isparta, Burdur, Afyonkarahisar and Konya provinces. Alfalfa genotypes were characterized using phonologic and morphologic features. Collected clones were reproduced in greenhouse in 2011 and at the same year 2400 alfalfa plants were sown in the field, 80x80 cm row spacing and each population contained 40 plants. For all populations, characterizations were based on 10 different observations. Eğirdir-2, Yalvaç-3, Bolvadin-1, Senirkent-2, Yeşilova-3, Beyşehir-2, Çay-1, Sultandağı-2, Şarkikaraağaç-3 and Yenişarbademli-1 populations were selected for using synthetic variety breeding method. Selected genotypes had high covering area of plant at spring, summer, autumn and winter, high natural plant height, large crown diameter, high bud number at crown, high depth crown, high cut area of plant and dry matter yield of first cut features.

Key words: *alfalfa, Medicago sativa L., collecting materials, characterization, forage yield and qualities.*

INTRODUCTION

Alfalfa (*Medicago sativa* L.) is one of the most important forage legumes. It is adaptable to a wide range of environments and provides a high forage yield of good quality (El-Din and Assaeed, 1995; Berg et al., 2007; Grewal, 2010; Moreira and Fagaria, 2010). Increasing variability of selection material could be achieved by introducing distinct alfalfa varieties (Monirifar, 2011). Selection of promising genotypes in a breeding program is based on various criteria, most importantly final crop yield and its quality. Relationships between yield and yield contributing traits also play an important role (Diz et al., 1994; Guler et al., 2001; Rabiei et al., 2004). Selection may also be based on other plant and/or crop features, such as, early maturity (Ahmad et al., 1991), industrial crop yield (e.g. oil yield, Baye and Becker, 2005), crop resistance (e.g. Bridge, 2000; Singh et al., 2004) and yield quality features (e.g. Gravois, 1998). The aim of the study, some plantal features were observed of alfalfa.

MATERIALS AND METHODS

Alfalfa (*Medicago sativa* L) clones were collected from 22 counties and 60 different points at Isparta, Burdur, Afyonkarahisar and Konya provinces. Alfalfa genotypes were characterized using phonologic, morphologic, yield and quality features.

Alfalfa clones was started to collect at the 12 May 2011. For this purpose, it was accepted that each 5-15 km distance at the each district as one station. Each station was evaluated as 1 population so, 60 alfalfa populations was composed. Coordinate and altitude was recorded by GPS at the areas where alfalfa plants (Table 1).

Hundreds of alfalfa plants be founded together when went to the one station. First seen alfalfa plant direct not taken. Environment was carefully observed. Selected alfalfa plants had wide and great foliar, much branching, erect growth, habit with good height, high density of lateral roots at crown. All alfalfa populations was removed by roots (2-3 number/station) and put in pots of 25x30 cm in diameter and depth and was brought greenhouse in the Süleyman Demirel University. After alfalfa branches which had 4-5 cm were waited in the 500 ppm indol butyric acid at the 10 sec time, alfalfa clones were planted in to the 1:1 ratio peat and pearlite mixture in the greenhouse. Alfalfa clones were reached root length about 20-25 days. After they were waited for a time out of greenhouse, total 2400 clones were planted field at 100 x100 row spacing and intrarow at the 28 september 2011.

In the alfalfa clones, observations and measurements were made at plants in 2012 and 2013 years. Data were evaluated using "National plant Germplasm System" of the plant expression of USDA (Anonymous, 2013) and Prosperi et al. (2006).

In present research, covering area of plant at spring, summer, autumn and winter, plant height, crown diameter, bud number at crown, depth crown, cut area dry matter yield of first cut features were observed.

RESULTS AND DISCUSSIONS

Averaged over two years (2012 and 2013) 10 observations of 60 collected alfalfa populations were analyzed and the Duncan results were given in Table 1. For the mean of two years, the highest cover area in spring was determined at Beyşehir1 and Beyşehir2 populations. Beyşehir2 populations had the highest, cover area in summer, autumn and winter.

The highest plant height were measured from Yalvaç3 (80 cm) and Ş.Karaağça3 (77 cm) populations. Stem crown diameter varied form 2-4.5 points at alfalfa populations.

The greatest bus number in stem crown was determined in Sultandağı2 (44.5 number/plant) population. The depth of stem crown varied from 3 to 5 at all alfalfa populations. The highest harvest area of plant eas determined at Beyşehir2 population. Beyşehir-2 population had the highest dry matter yield of first cut (68.57 g/plant).

CONCLUSIONS

End of the research, Eğirdir-2, Yalvaç-3, Bolvadin-1, Senirkent-2, Yeşilova-3, Beyşehir-2, Çay-1, Sultandağı-2, Şarkikaraağaç-3 and *Yenişarbademli*-1 populations were selected for using synthetic variety breeding method. Selected genotypes had high covering area of plant at spring, summer, autumn and winter, high natural plant height, large crown diameter, high bud number at crown, high depth crown, high cut area of plant and dry matter yield of first cut features.

ACKNOWLEDGEMENTS

This research work was Supported by TUBİTAK (The scientific and technological research council of Turkey) (Project number: 110 O 257).

REFERENCES

Ahmad Q., Rana M.A., Siddiqi S.U.H., 1991. Sunflower seed yield as influenced by some agronomic and seed characters. Euphytica 56: 137-142.

Berg W.K., Cunningham S.M., Brouder S.M., Joern B.C., Johnson K.D., Santini J.B., Volenec J.J., 2007. The long-term impact of phosphorus and potassium fertilization on alfalfa yield and yield components. Crop Sci. 47: 2198-2209.

Baye T., Becker H.C., 2005. Genetic variability and interrelationship of traits in the industrial oil crop Vernonia galamensis. Euphytica 142:119-129.

Bridge J., 2000. Nematodes of bananas and plantains in Africa:research trends and management strategies relating to the small-scale farmer. Acta Horticulturae 540:391-408.

Diz D.A., Wofford D.S., Schank S.C., 1994. Correlation and path-coefficient analyses of seed-yield components in pearl millet × elephant grass hybrids. Theoretical and Applied Genetics 89:112-115.

El-Din S.S.T., Assaeed A.M., 1995. Effect of phosphorus fertilizer and irrigation frequency on yield and protein content of alfalfa. J. King Saud. Univ. Agric. Sci., 7:49-60.

Grewal H.S., 2010. Fertiliser management for higher productivity of established lucerne pasture. NZ J. Agric. Res., 53:303-314.

Gravois K.A., 1998. Optimizing selection for rough rice yield, head rice, and total milled rice. Euphytica 101: 151-156.

Guler M., Adak M.S., Ulukan H., 2001. Determining relationships among yield and some yield components using path coefficient analysis in chickpea (*Cicer arietinum* L.). European Journal of Agronomy 14: 161-166.

Monifirar H., 2011. Path Analysis of Yield and Quality Traits in Alfalfa. Not. Bot. Horti Agrobo., 39(2):190-195

Moreira A., Fagaria N.K., 2010. Liming influence on soil chemical properties nutritional status and yield of alfalfa grown in acid soil. Rev Bras Ciência (RBCS). 34: 1231-1239.

Rabiei B., Valizadeh M., Gharayazie B., Moghaddam M., 2004. Evaluation of selection indices for improving rice grain shape. Field Crops Research 89: 359-367.

Singh B.U., Padmaja P.G., Seetharama N., 2004. Stability of biochemical constituents and their relationships with resistance to shoot fly, Atherigona soccata (Rondani) in seedling sorghum. Euphytica 136: 279-289.

Table 1. The mean of some observations from alfalfa populations

No	Populations	1	2	3	4	5	6	7	8	9	10
1	Yeşiova1	3	4.5	5.5	4.5	47	3	34	4.5	11.53	52.07
2	Yeşiova2	5.5	5	5	3	45.5	2.5	19.5	4	10.09	23.53
3	Yeşiova3	7.5	5.5	6	4.5	72.5	4	38	5	14.02	52.59
4	Karamanlı1	7.5	4.5	2.5	2.5	42.5	4	24	5	13.46	21.60
5	Karamanlı2	7.5	4	2	2	37	4	34	5	13.11	22.82
6	Karamanlı3	7	4	2.5	3	61	4.5	34	3.5	16.1	25.94
7	Tefenni1	7	3.5	2.5	2.5	27	4.5	26	5	16.63	22.69
8	Tefenni2	2	2.5	2.5	2.	23.5	3.5	26.5	5	13.06	19.71
9	Tefenni3	5.5	3.5	2	2.5	51	3.5	25.5	5	13.21	20.48
10	Ağlasun1	5	4	2.5	2	49.5	4.5	30.5	4	16.09	20.30
11	Ağlasun2	1.5	4.5	3.5	3	69	2	39	5	14.85	47.41
12	Ağlasun3	7.5	6.5	4.5	3.5	34	4.5	37.5	5	12.68	25.28
13	Bucak1	2.5	2.5	2.5	2.5	43.5	2.5	19.5	5	10.38	24.80
14	Bucak2	8	6.5	4.5	3.5	57	4.5	40.5	5	17.93	49.64
15	Bucak3	6	4.5	3.5	2.5	45.5	3.5	24.5	4.5	10.90	27.14
16	Eğirdir1	8.5	4	2.5	2.5	53.5	4	33	3	16.08	22.66
17	Eğirdir2	9	6	4.5	4	74	4	39.5	5	15.66	55.32
18	Eğirdir3	8	5.5	4.5	3.5	74.5	4.5	35.5	5	16.79	32.32
19	G.dost1	7	4.5	3.5	2	68	4.5	32.5	4.5	16.89	36.43
20	G.dost2	7.5	5	3.5	3	46	4.5	34.5	5	16.29	20.55
21	G.dost3	7.5	5.5	2.5	3.5	50	4.5	40	4	16.00	21.59
22	Ş.Karaağaç1	7	5.5	5	3.5	47.5	4.5	27.5	5	13.57	36.87
23	Ş.Karaağaç2	7.5	5.5	3.5	3.5	56.5	3.5	37	5	15.68	48.39
24	Ş.Karaağaç3	8.5	6.5	5	4.5	77	3	40.5	5	17.36	55.89
25	Hüyük1	4.5	3.5	2.5	2.5	37	2.5	19.5	2.5	10.08	20.80
26	Hüyük2	3.5	4	2.5	2.5	55.5	2.5	22.5	2.5	10.53	22.66
27	Yalvaç1	6	5	3	2.5	47.5	3.5	25.5	5	14.28	24.91
28	Yalvaç2	8	5.5	4.5	2.5	62	3.5	31.5	5	12.29	36.85
29	Yalvaç3	9	6	4.5	3.5	80	4	40	5	14.70	63.59
30	Akşehir1	2.5	4	4	3.5	36	2	18.5	4.5	7.54	30.52
31	Akşehir2	5.5	4	2	2	58.5	2	35	4.5	8.42	26.96
32	Akşehir3	4.5	4.5	3.5	3	46	2	40	5	13.89	52.68
33	Keçiborlu1	6.5	4.5	2.5	3	59.5	4.5	39	4	16.30	23.91
34	Keçiborlu2	3	4	4.5	2.5	62	4.5	27.5	4.5	13.06	24.71
35	Keçiborlu3	6.5	4	5	4.5	66	2	32.5	4.5	15.15	41.43
36	Uluborlu1	6	6	4.5	4.5	36.5	2.5	37	4.5	15.33	40
37	Uluborlu2	7	7	4.5	5	49.5	2.5	40	5	16.50	46.23
38	Senirkent1	2.5	2.5	2.5	2.5	24	2.5	21.5	4	7.09	22.41
39	Senirkent2	8	6.5	5.5	4.5	73	3.5	38.5	5	11.9	54.02
40	Sandıklı1	2	2.5	5	3.5	47.5	2	25	4	13.88	48.39
41	Sandıklı2	2	2.5	2.5	2.5	26	2	26.5	5	8.19	20.43
42	Sandıklı3	4.5	4.5	3.5	2.5	59	2	35.5	5	12.83	43.55
43	Dinar1	7	4.5	3.5	3.5	62.5	4.5	18	3	13.68	22.39
44	Dinar2	7	4.5	4.5	3	69.5	4.5	34	4.5	13.91	42.05
45	Dinar3	3	2.5	2	2.5	29.5	4	23	3.5	12.92	22.48
46	Şuhut1	7.5	5	4	3.5	73.5	4	28	4	12.17	26.59
47	Şuhut2	6.5	4.5	3	2.5	55.5	4	23.5	4.5	15.20	23.85
48	Şuhut3	7	4.5	4.5	2.5	66	4	22.5	4	14.31	30.27
49	Çay1	7.5	6	4.5	4	76	3.5	38	5	12.67	64.03
50	Çay2	8	7	4.5	3.5	74	4.5	37.5	5	15.45	46.75
51	Çay3	8.5	6.5	3	4.5	64.5	5	32.5	4.5	16.82	36.18
52	Sultandağı1	7.5	6.5	5.5	4.5	65.5	3.5	42	4.5	10.35	49.89
53	Sultandağı2	8.5	7.5	5.5	4.5	74	4	44.5	5	13.73	62.68
54	Bolvadin1	8.5	6	4.5	4.5	74	3.5	36.5	4	12.70	64.66
55	Bolvadin2	6.5	6.5	4.5	4.5	49	2.5	32	5	9.165	33.80
56	Bolvadin3	8.5	7.5	5	4.5	70	4.5	39	5	16.32	51.48
57	Yenişar1	8	6.5	5	4.5	72	3	40.5	5	13.99	59.39
58	Yenişar2	6.5	5.5	5	4.5	50.5	3.5	38.5	5	14.25	53.82
59	Beyşehir1	9	7.5	4.5	4.5	69.5	4	40	5	15.82	52.5
60	Beyşehir2	9	8	6	5	72.5	4.5	44	5	17.54	68.57
LSD		0.81	0.90	0.87	0.86	6.47	0.96	3.95	0.65	1.70	5.27

1. cover area in spring, 2. cover area in summer, 3. cover area in autumn, 4. cover area in winter, 5. plant height, 6. : stem crown diameter, 7. bud number in stem crown, 8. depth of stem crown, 9. harvest area of plant, 10. dry matter yield of first cut

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESEARCH REGARDING THE DEVELOPMENT OF FROST, COLD-AND HEAT-NATURAL PHENOMENA WITHIN THE AGRICULTURAL REGION "SOUTH AND SOUTH-EASTERN MUNTENIA"

Alexandru-Marian CHIPER

The Institute for World Economy of the Romanian Academy, 13, 13 Septembrie Avenue, zip code 050711, Bucharest, Romania

Corresponding author email: alexchiper@yahoo.de

Abstract

Under the circumstances of continuous change of the environment conditions by increasing global warming, decreasing rainfall and soil erosion and also under the circumstances of continuous change of the social conditions by increasing population and implicitly by increasing food and drinkable and industrial water requirements, the agriculture and the connected industry must adapt themselves to this, by using competitive techniques and technologies for being able to offer the elementary products which are necessary for ensuring economical and social development.
The factors which mean a major risk and negative effects for agricultural production on regional or national areas are pedological drought, flooding, heat, freeze and frost which appear within long periods of time.
Within this research I have analyzed the climatic temperature parameters measured within the period from 1961 till 2012 on meteorological stations which are representative for the agricultural territory of South and South-Eastern Muntenia. The data have been analyzed both from the point of view of the intensity of such natural phenomena ($\Sigma T_{max} \geq 32°C$/heat units, $\Sigma T_{min} \leq -15°C$/frost units, $\Sigma T_{med} \leq 0°C$/cold units) and from the point of view of the duration of their appearance (the number of days with heat and the number of days with frost).
The agricultural regions in the South of the country (which in our case means South and South-Eastern Muntenia) are agricultural territories which are vulnerable when faced with heat and frost natural phenomena and within the period of time from 1961 until 2012 there have been registered here in this regions intensity values of heat and frost natural phenomena which belong to the highest values that have been noticed in whole Romanian agricultural teritory. This means that by using the obtained information (which shows the average values of these indicators for the years contained within the period of time 1981-2012) the farmers (both the farmers who are specialized on genetic amelioration of plant species and the farmers who are specialized on mass production) may produce hybrids which are economically competitive and adapted to climacteric circumstances and stress factors (heat and frost) which are representative for South and South-Eastern Muntenia.

Key words: *agriculture, risk factors, temperature, heat, frost.*

INTRODUCTION

Climate phenomena may be considered to be *risk factors* as they significantly diminish yield whenever they occur as severe manifestations at the wrong time, but mostly during critical crop development times (Sandu et al., 2010).
Major risk factors and adverse effects on regional or national agricultural production include pedological drought, flooding, intense heat, freezing and frost for extended periods (National Meteorological Administration [ANM], 2008).
The area selected for this study is one of the most important agricultural regions in Romania, with the highest yield potential despite its exposure to drought, intense heat, and frost and freezing phenomena (Dincă et al., 2012).
The winter phenomenon seen as a risk factor for the growth of autumn tree and evergreen crops is frost. Frost may adversely affect the growth of plants through both its occurrence and the intensity of the phenomenon or in relation to other climate parameters such as the absence of rain and snow protective layer, the presence of ice coating, high air humidity, strong winds, etc. (Berbecel et al., 1970).
Agriculturally and meteorologically, cold weather phenomena placing crops at risk are portrayed by abstract notions such as *winter rudeness* and *freezing intensity*.
Thermal strain indicators that adversely affect agricultural crops during the cold season are

therefore *“the cold”* and *“the frost”*. They generally have an obvious spatial spreading and the degree of winter rudeness varies from one area to another according to the amount of cold and/or frost units.

Temperature/heat requirements of plants differ by species (thermophilic or mesophilic plants, etcetera) and by phenological phase (*sprouting, germination, emergence, foliation*, etcetera). Certain *thermal thresholds* (temperature ranges) specific to every genetic type of plant must be attained in order to get through each phenological phase (Chițu et al., 2013). Insufficient heat triggers delays in phenological phases or their extension (e.g. uneven emergence) and badly affects crops (Podani et al., 1998).

On the other side, excess of heat is also bad for crops and plants altogether as it inhibits metabolic processes at tissue level through excessive sweating and dehydration and through accelerated evaporation of soil water and the occurrence of pedological drought (Stoica et al., 2012). Under the circumstances, the lack of substitution irrigations during drought is directly responsible for the expansion of pedological drought, desertification and soil degradation phenomena (IPCC, 2014, et al., 2010).

MATERIALS AND METHODS

Thermal risk phenomena for crops in South and South-Eastern Muntenia agricultural areas have been weighted based on daily temperatures measured between 1961 and 2013 at 7 weather bases belonging to the National Meteorology Agency (ANM) network, namely in Alexandria, Buzau, Calarasi, Fudulea, Giurgiu, Grivita and Turnu Magurele.

These data have been used to identify the number of days with minimum temperatures and negative average rates during the cold season (wind and frost intensity) and the number of days with maximum temperatures during the warm season (intense heat rate).

Measured values have been classified by decade (1961-1970, 1971-1980, 1981-1990, 1991-2000, 2001-2010, 2003-2102) and by 30-year intervals (1961-1990, 1971-2000, 1981-2010 and 1983-2013).

Resulting data have been interpreted by agricultural year within the 1962-2013 period and studied as follows in South and South-Eastern Muntenia:

- The amount of average air temperature rates below 0°C, ($\Sigma T_{med} \leq 0°C$, cold units) during cold season months (November-February), namely the overall quantity of "cold" accruing between the 1st of November and the 31st of March,
- The number of frost days ($T_{min} \leq -15°C$), namely the intensity of “frost” phenomenon ($\Sigma T_{min} \leq -15°C$ frost units), which phenomenon is specific to winter months (1st of December – 28th of February),
- The number of intense heat days ($T_{max} \geq 32°C$), namely the strength of the intense heat phenomenon ($\Sigma T_{max} \geq 32°C$, intense heat units) specific to the period ranging between 1st of June and 31st of August.

Depending on the target indicator, *cold units* ($\Sigma T_{med} \leq 0°C$ – November-March) or *frost units* ($\Sigma T_{min} \leq -15°C$ – December - January) during winter, the degree of rudeness or type of winter is expressed as follows (Table 1).

The study of *air temperature conditions* between November and March helps:

- Depict winters in agricultural and meteorological terms (*degree of rudeness, duration and intensity of frost)*;
- Hibernation and twinning conditions for autumn grains, the condition of tree and evergreen cultures in various cropping areas (Sandu et al., 2010).

The ‘intense heat’ units account for the difference between the highest daily air temperature and the 32°C critical threshold as aggregate values during both summer (June - August) and on a monthly basis, especially during those months when the strength and the duration of intense heat phenomenon records the highest occurrence values (Table 2).

heat units) and length (number of intense heat days).

The ‘intense heat’ event stands for a quantization of the *thermal strain* during the critical period of crops (June-August, respectively the flowering – formation and filling of grains / seeds in cereals and weeds), in terms of both strength ($\Sigma T_{max} \geq 32°C$/intense).

Table 1. Winter rudeness

Cold intensity (freeze) $\Sigma T_{med} \leq 0°C$ (November-March);		Frost intensity $\Sigma T_{min} \leq -15°C$ (December-February)	
up to 300°C cold units	mild winter low intensity	up to 10°C frost units	mild winter low intensity
250-300°C cold units	normal winter moderate intensity	11-30°C frost units	normal winter moderate intensity
301-400°C cold units	cold winter high intensity	31-50°C frost units	cold winter high intensity
401- 600°C cold units	very cold winter very high (severe) intensity	over to 50°C frost units	very cold and excessively cold winter extremely high intensity
over to 600°C cold units	excessively cold winter unbearable intensity		

Table 2. Heat phenomenon

Heat intensity $\Sigma T_{max} \geq 32°C$ (June-August)	
Up to 10°C heat units	lack of the heat
11-50°C heat units	low intensity
51-70°C heat units	high intensity
71-150°C heat units	very high intensity
≥150°C heat units	extremely high intensity

RESULTS AND DISCUSSIONS

As for the pedoclimate, cropping lands in south and south-eastern Muntenia are standard plain (*Romanian Plain*) and alluvial plain (*Danube Meadow*) areas.

1. Frost ($\Sigma T_{min} \leq -15°C$)

Indicators on the number of frost days and the intensity of the frost phenomenon ($\Sigma T_{min} \leq -15°C$) have been studied for the cold season, namely the period ranging from December to January of agricultural years. The data on the multiannual average number per annum of frost days and frost units and their total number per decade is exemplifying.

It has been therefore acknowledged that the overall number per decade of frost days between 1961 and 2012 took a slightly downward path with a more obvious decrease in values during decade 1971-1980.

The most intensive frost was felt during decade 1961-1970, especially at Fundulea during the winter of 1984-1985 when not less than 21 days of minimum air temperature below -15˚C was recorded for a total of 114 frost units.

Decade 1991-2000 is characterized by the lowest frost intensity, more specifically at weather bases in Calarasi and Buzau where 1 day of less than -15 degree was recorded in average, the decennial intensity of the frost phenomenon ranging somewhere around 2 frost units.

The multiyear analysis with the results entered in Figures 1 and 2 below confirmed a downward trend of both frost day umber and frost intensity, with the last 30 years (1981-2010) being the period during which the frost phenomenon significantly decreased in intensity with values ranging from 4 to 6 annual frost units.

As for weather bases involved in the study, both frost day number and intensity during the extended period (1961-2012) appear to be at their highest at Fundulea, Alexandria and Turnu Magurele and at their lowest at Buzau, Calarasi and Grivita.

A slight decrease in the decennial evolution of the number of frost days (Figure 3) appears to be a trend in Muntenia.

Such increases turned out to be significant due to the development of this phenomenon mostly in February up to the average rate 4.5 frost days/year and 12.5 frost units/year respectively.

If we stick to the 1971-2012 period only, we notice a slight increase of the frost phenomenon and this makes the decade 1961-1970 an unusual one due to the intensity of the phenomenon in January with values far too high and out of the ordinary for the second half of the century (Figure 4).

2. Cold (Freeze)

As for the total decennial number of freezing days, a general downward trend was noticed with 1037 freezing days between 1961 and 1970 down to 880 days during 2001-2010. The average annual number of cold units goes to about 188 cold units, which is 19 units less than the average number for the period 1961-2103 (207 cold units).

As we may see in Figure 5, cold phenomenon intensity follows a downward path and the number of cold days lowers.

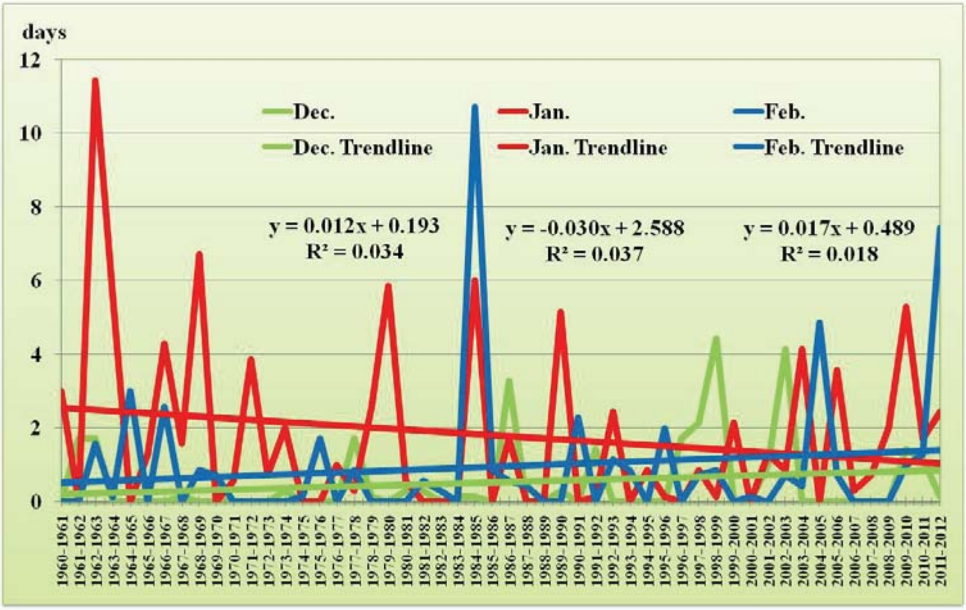


Figure 1. The annual evolution of the no. of days with frost temperature ($T_{min} \leq -15^{o}C$), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

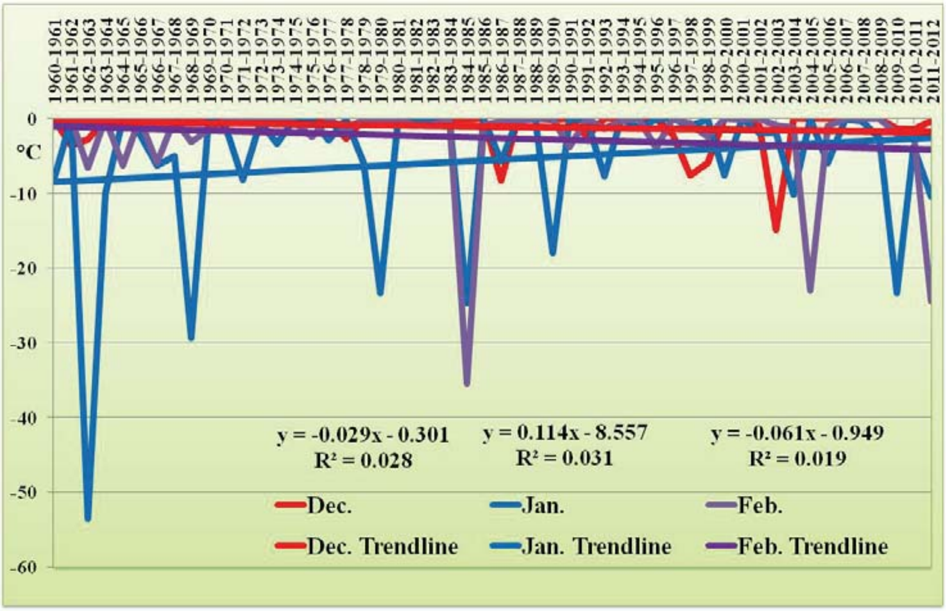


Figure 2. The annual evolution of the frost phenomenon ($\Sigma T_{min} \leq -15°C$) , in winter, between 1961 and 2012, in South and South-Eastern Muntenia

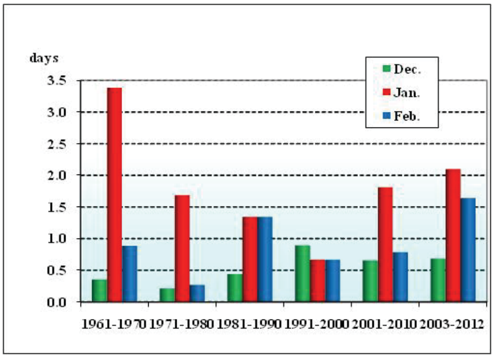


Figure 3. The decade evolution of the no. of days with frost temperature (T_{min}≤-15°C), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

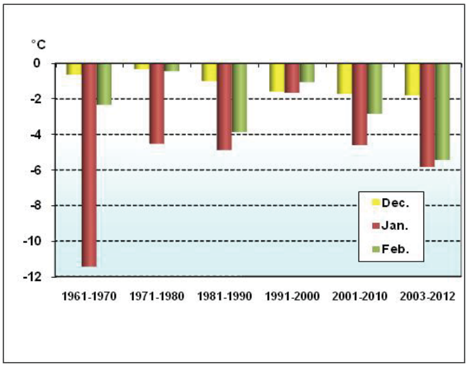


Figure 4. The decade evolution of the frost phenomenon (ΣT_{min}≤-15°C), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

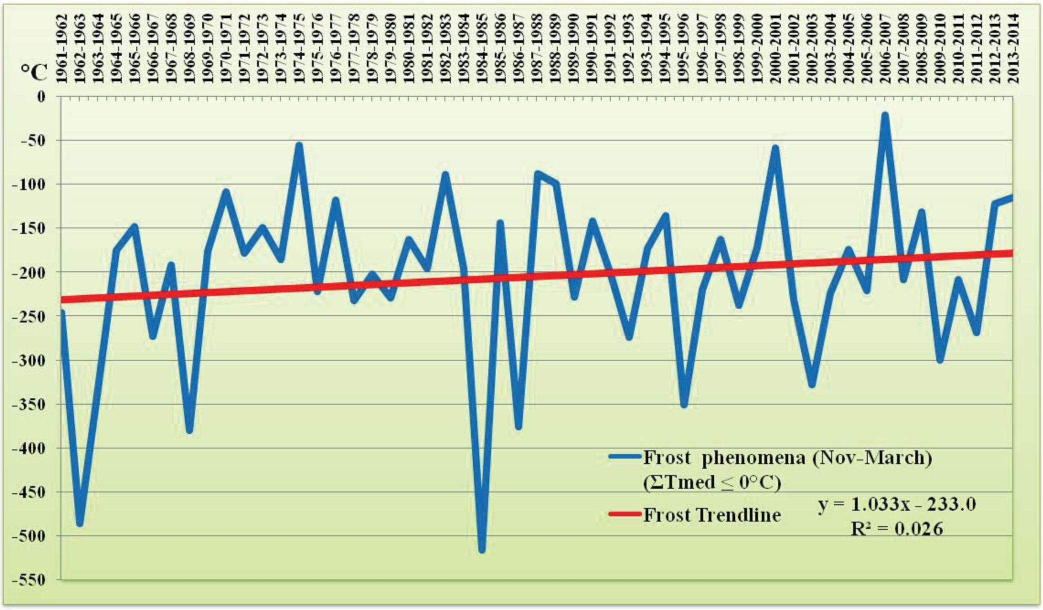


Figure 5. The annual evolution of freeze phenomenon (ΣT_{med} ≤0°C) in winter, between 1961 and 2012, in South and South-Eastern Muntenia

As for the evolution of this phenomenon every ten years (Figure 6), it followed a sinusoid curve during 1961-2012 and started with an abrupt decrease from 1961-1970 with 252 cold units down to decade 1971-1980 with 174 cold units. Later on, the freezing phenomenon recorded higher values and exceeded the threshold of 200 cold units (1981-1990), but went down subsequently to 188 cold units (1983-2012).

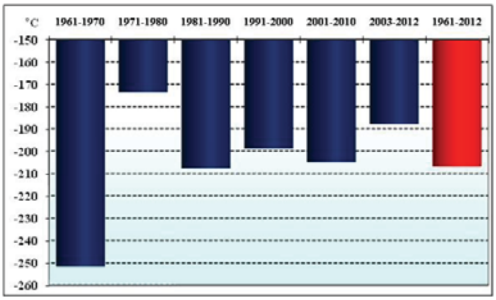


Figure. 6. The decade evolution of annual freeze phenomenon (ΣT_{med} ≤0°C), in winter, between 1961 and 2012, in South and South-Eastern Muntenia

As for the geographical spreading, the lowest number of freeze days was recorded at Calarasi and Giurgiu in southern Muntenia while the highest number Fundulea and Grivita in south-eastern Muntenia.

3. Intense Heat

Alarmingly, the number of intense heat days, namely days with the highest temperature beyond 32°C (Figure 7) doubled within the past 50 years in Muntenia. Such considerable increase of the number of intense heat days was especially acknowledged during the latest decade and mostly in July and August.

As for the evolution in *intense heat strength* ($\Sigma T_{max} \geq 32°C$), it went upwards consistently and fast during the past 30 years with twice the values in July and August and very high values in 2000 (162.4 intense heat units), 2007 (173.5 intense heat units) and 2012 (103.8 intense heat units).

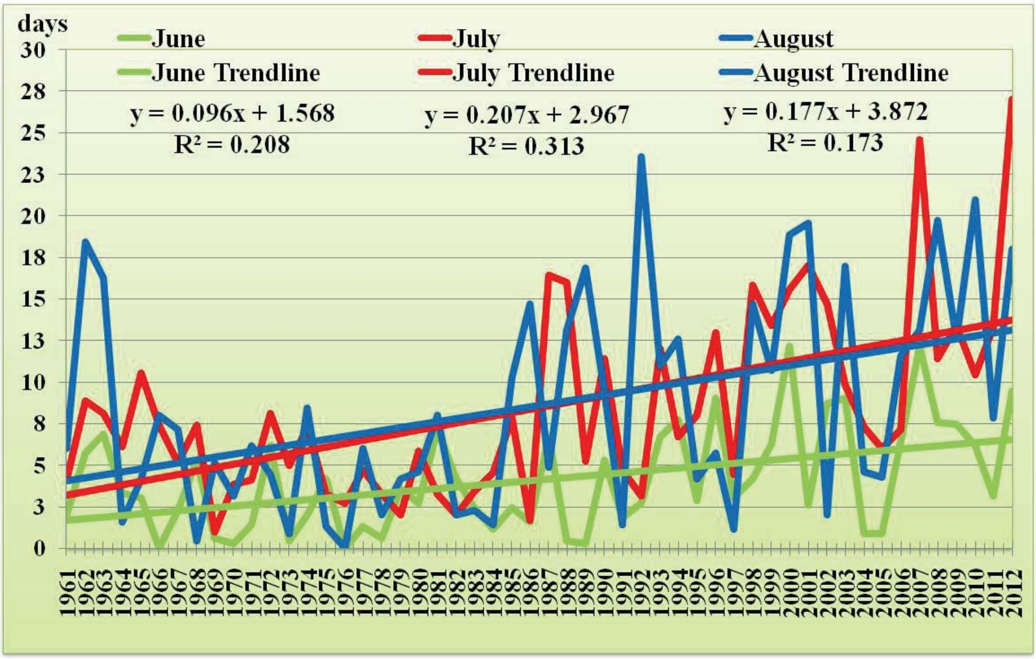


Figure 7. The annual evolution of the no. of days with intense heat ($T_{max} \geq 32^oC$) in summer, between 1961 and 2012, in South and South-Eastern Muntenia

In July 2007, one of the most dry years in Muntenia during the past 30 years, an aggregate value of (109°C intense heat units) was recorded which is over 5.5 higher than the average rate in the month of July within the last half-century (Figure 8).

Figures 9 and 10 indicate the decennial evolution of intense heat days and intense heat strength.

The decennial trend is a progressive one at all 7 weather bases studied in terms of both number of intense heat days and intense heat strength, as this phenomenon increased by 520% in strength over the past forty years.

The multiyear development of the annual average number of intense heat days and intense heat units highlights successive increases from one decade to another, with the highest values recorded during 1981-2010 in Giurgiu (32 intense heat units) and Turnu Magurele (31 intense heat units).

The highest values of intense heat strength were measured in 2007 at Giurgiu - namely 223^{o}C – for a number of 61 days, as well as in Turnu Magurele - 215^{o}C – for 58 days. On the other side, the highest annual average rates of intense heath strength between 1961 and 2010 were measured at Turnu Magurele (55^{o}C) and Giurgiu (56^{o}C) weather bases, and the lowest at Buzau (26.3^{o}C) and Grivita (32.3^{o}C) weather bases.

I also noticed that the strength of intense heat is never constant or directly proportional to the number of intense heat days. In some instances, the two indicators evolved separately as we may see from the geographical evolution of values measured at Alexandria - Calarasi and Giurgiu - Turnu Magurele weather bases.

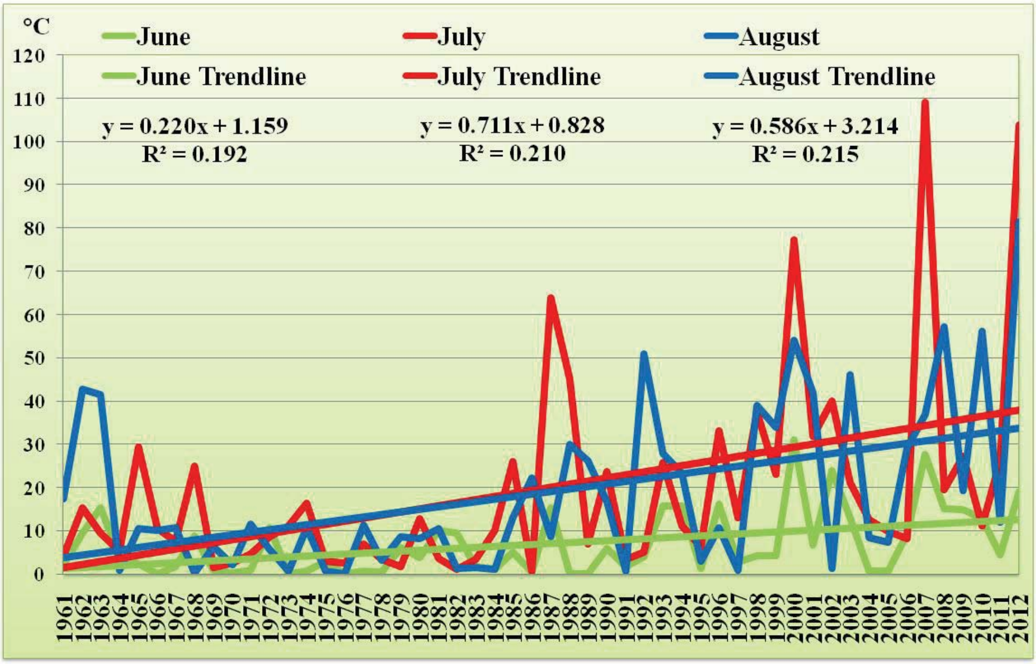


Figure 8. The annual evolution of the intense heat phenomenon ($\Sigma T_{max} \geq 32°C$), summer, between 1961 and 2012, in South and South-Eastern Muntenia

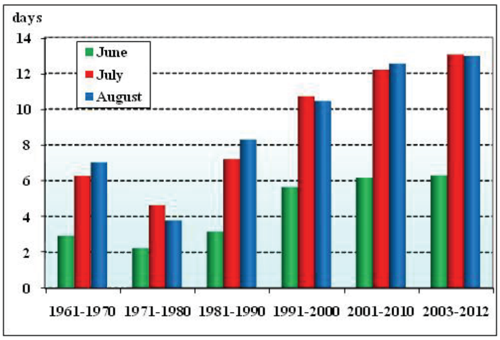


Figure 9. The decade evolution of the days with heat ($T_{max} \geq 32°C$) between 1961 and 2012, in South and South-Eastern Muntenia

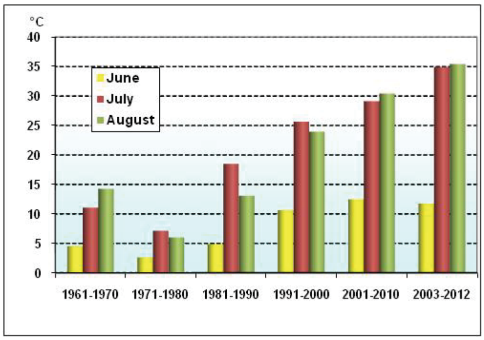


Figure 10. The decade evolution of the heat intensity ($\Sigma T_{max} \geq 32°C$) between 1961 and 2012, in South and South-Eastern Muntenia

4. Strain Indicator Zoning.

The mapping of cold and frost indicators as multiyear average rate across the agricultural Muntenia shows that the areas which are most at risk for frost lie at the heart, to the north and to the south-western part of the region where $\Sigma T_{med} \leq 0°C$ demonstrates values ranging from 200 to 300 "cold" units and $\Sigma T_{min} < -15°C$ between 11 and 30 "frost" units. They are classified as normal and moderate in intensity winter areas (Figures 11 and 12).

The north-western and eastern part of Muntenia is dominated by warmer winter climate with cold indicators between 100 and 200 "cold" units and frost indicators below 10 frost units and winters of lesser intensity.
In hilly fruit-farming areas to the north, namely at Candesti Piedmont, the climate is characterized by colder and ruder winters with cold indicators among 300 and 400 cold units and frost indicators ranging from 30 to 50 frost units.

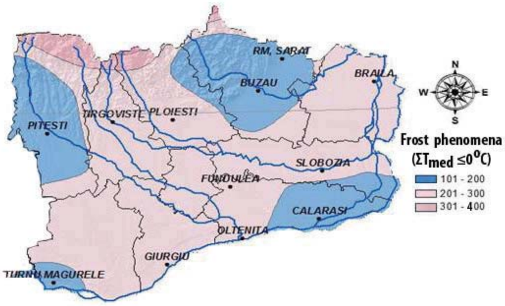


Figure 11. Muntenia cold phenomenon map (freeze)

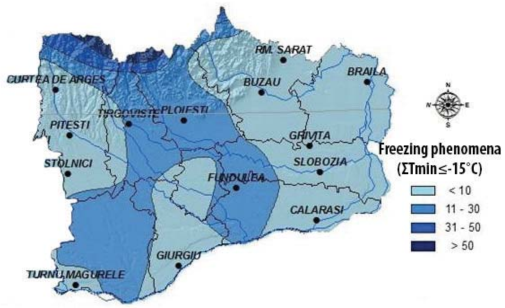


Figure 12. Muntenia frost phenomenon map

In order to assess the agricultural and weather conditions during periods with high water demand of crops (June-August), data on the intense heat strength in Muntenia have been processes. In summer (June to August), the most exposed to intense heat (T_{max}≥32°C) are areas lying south of the country (Figure 13). This way, the intense heat study expressed as quantity of intense heat units (∑Tmax.≥32°C) showed that the value of „intense heat" units lowered between the 1st of June and the 31st of August / 1961-2012 (below 50 „intense heat" units) almost over the entire region. Higher intense heat strength (> 50 „intense heat" units) is still locally detected in southern Muntenia where the highest strength values have been recorded within the past 30 years (Giurgiu, Alexandria and Turnu Magurele).

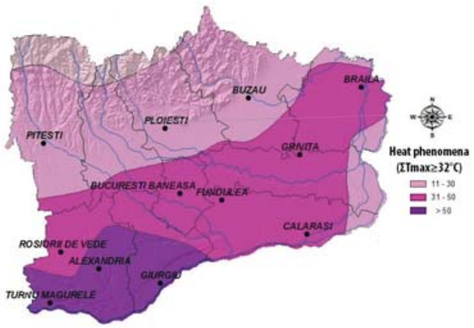


Figure 13. Muntenia heat phenomenon map

CONCLUSIONS

Farming areas in southern Romania, namely to the south and south-east of Muntenia Region, are farming lands vulnerable to intense heat and frost where intense heat strength levels recorded during 1961-2012 were found to be the highest nationwide.
Given the known phenomenon of lower agricultural production figures due to thermal and water strain levels, we may presume that the impact of these factors on agricultural production seems to be proportionate to their intensity (2007 was among agricultural years with the lowest returns for businesses active in the plant-growing industry).
Based on the data acquired, namely the multiyear average values of these indicators between 1981 and 2000, farmers specialized in both plant species genetic improvement and mass production may establish economically-competitive hybrids adapted to weather conditions and strain factors (intense heat and frost) specific to southern and south-eastern Muntenia.
Just as a recommendation, we believe complex pedological and climate forecast studies are further required in order to identify the impact of climate changes, namely the effect of intense heat on soil quality in Muntenia, as well as to map areas exposed to climate risks in the region for regular and alternative cropping and fruit growing.
We also think fit to harmonize crop irrigation and fertilization schemes with variations

produced by climate changes in the area and forecasts relying on environmental background history.

Furthermore, there is a need to develop and start growing competitive drought-hardy hybrids adapted to dryness and with a shorter yet accelerated vegetation period during periods with the best soil water reserve.

ACKNOWLEDGEMENTS

This paper has been financially supported within the project entitled "Horizon 2020 - Doctoral and Postdoctoral Studies: Promoting the National Interest through Excellence, Competitiveness and Responsibility in the Field of Romanian Fundamental and Applied Scientific Research", contract number POSDRU/159/1.5/S/140106. This project is co - financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007 - 2013. Investing in people!

REFERENCES

National Meteorological Administration [ANM], 2008. Clima României. Editura Academiei Române.

Berbecel O., Stancu M., Ciovica N., Jianu V., Apetroaei St., Socor E., Rogodjan I., Eftimescu M., 1970. Agrometeorologie. Editura Ceres, Bucureşti.

Chițu E., Giosanu D., Mateescu E., 2013. Seasonal and annual extreme temperature variability and trends of the latest three decades in Romania. Advances in Environmental Sciences, 06/2013, Volume 5, Issue 2, p. 70-88.

Dincă V., Stoica G.M., Chiper A.M., Valsan G., Mandache V., Uberti M., Fierbinteanu A., 2012. Estimation of drought tolerance of local and Pioneer top comercial corn hybrids tested in different pedo-climatic areas from south of Romania. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development" Volume 12 – Issue 1/2012. Publishers: University of Agricultural Sciences and Veterinary Medicine Bucharest, Romania and INVEL-Multimedia SRL, p. 49-52.

IPPC, 2014, Climate Change. Available online at: http://www.ipcc.ch/report/ar5/syr/.

Podani M., Ispas St., Laurentiu D.L., 1998. Climatologie si Aagrometeorologie. Editura Domini.

Romanian Academy, The Geography Institute, 2005. Geografia României: Câmpia Romāna, Dunărea, Podişul Dobrogei, Litoralul Românesc al Mării Negre şi Platforma Continentală, Editura Academiei Române, Bucureşti.

Sandu I., Mateescu E., Vatamanu V.V., 2010. Schimbari Climatice in Romania si efectele asupra agriculturii. Edituta Sitech Craiova.

Smith P., Olesen J.E., 2010. Synergies between the mitigation of, and adaptation to, climate change in agriculture. The Journal of Agricultural Science. Volume 148. Issue 05, October 2010, p. 543-552. Cambridge University.

Stoica G.M., Jinga I., Dinca V., Chiper A.M., 2012. The research in what concern the behaviour of some sunflower hybrids cultivated in irrigation conditions in Dobrogea. Scientific Papers Series "Management, Economic Engineering in Agriculture and Rural Development" Volume 12 – Issue 2/2012. Publishers: University of Agricultural Sciences and Veterinary Medicine Bucharest, Romania & INVEL-Multimedia SRL, p. 173-178.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE VIOLA SPECIES COMMONLY GROWING IN AGROECOSYSTEMS IN CENTRAL ANATOLIA

Muhittin DİNÇ[1], Şinasi YILDIRIMLI[2]

[1]Necmettin Erbakan University, Ahmet Keleşoğlu Faculty of Education, Department of Biology, 42090 Meram, Konya, Turkey
[2]Hacettepe University, Faculty of Science, Department of Biology, 06532 Beytepe, Ankara, Turkey

Corresponding author email: muhdinc@yahoo.com

Abstract

In this study, Viola species commonly growing around the fields in Central Anatolia were determined. The field trips for the study cover the years 1997-2001. As consequence of the study, it was determined that three Viola species, Viola occulta Lehm., Viola kitaibeliana Schult. and Viola modesta Fenzl., commonly grow in Agroecosystems in Central Anatolia. The brief descriptions, distribution maps in Turkey and the natural photos of the species were presented.

***Key words**: agroecosystems, Viola species, Central Anatolia, Turkey.*

INTRODUCTION

The *Violaceae* is a medium-sized family of perennial or rarely annual herbs or shrubs, including the violets or pansies. The family is cosmopolitan, but more typical of the temperate regions and tends to be restricted to higher mountainous areas. There are nearly 900 species belonging to 22 genera in the family. The genus *Viola* L. is the largest genus of *Violaceae*, has about 600 species which are widely distributed in the Northern Hemisphere (Heywood 1993, Ballard et al. 1999).

The genus *Viola* is represented by 34 taxa included in 32 species in Turkey (Dinç 2012). These taxa grow different habitats at different altitudes range from sea level to 3000 m. The aim of this study is to determine the Viola species commonly growing in the agroecosystems in Central Anatolia.

MATERIALS AND METHODS

The field trips for the study were carried out the years 1997-2001. Viola samples were collected from cultivated lands along the study in Central Anatolia. The samples were dried according to the standard herbarium technics and identified according to the Flora of Turkey (Coode & Cullen 1965, Davis et al. 1988, Yıldırımlı 2000). The recorded species were photographed and the photos were presented. The distribution map of the recorded Viola species in Turkey also was arranged based on the data from this study and Turkish herbaria.

RESULTS AND DISCUSSIONS

The results of this study show that the three species *Viola occulta*, Viola modesta and *Viola kitaibeliana* commonly grow in the agroecosystems in Central Anatolia. The brief descriptions, distribution maps in Turkey and the natural photos of the species were presented below (Figures 1-4).

Viola occulta Lehm.

Annual herb. Stems erect, 2.5-25 cm. Leaves narrowly oblong-spathulate, remotely crenate-serrate, glabrous to sparsely hispid. Stipules deeply divided. Pedicels ebracteolate or with a minute bracteoles adpressed to the calyx. Sepals broadly lanceolate, 7-13 mm, as long as or longer than the corolla, their appendages completely exceeding the corolla spur. Corolla white to cream, 6-8 mm, sometimes the petals with bluish margins (Figure 1).

Flowering: March-April.

Fruiting: April-May.

Habitat: Cultivated lands, *Quercus*, *Juniperus* and *Pinus* forest at altitudes at altitudes 550-2200 m.

Viola modesta Fenzl
Annual herb. Stems erect, 2.5-13 cm. Leaves narrowly oblong-spathulate, remotely crenate-serrate, glabrous to hispid-scabrous. Stipules very small, entire or few-toothed. Pedicels ebracteolate or with a minute bracteoles adpressed to the calyx. Sepals broadly lanceolate, 4-12 mm, as long as or longer than the corolla, their appendages not exceeding the corolla spur. Corolla purple or yellow, exceeding the sepals, 7-15 mm (Figure 2).
Flowering: March-April.
Fruiting: April-May.
Habitat: Cultivated lands, stony places, rocky slopes, *Quercus*, *Juniperus*, *Abies* and *Pinus* forest at altitudes 100-1900 m.

Viola kitaibeliana Roem. & Schult.
Annual herb, stems 2.5-25 cm, the whole plant with a dense indumentum of short hispid-crisped hairs. Stem branched or unbranched at base, ascending or erect. Lowermost leaves orbicular, the rest oblong-spathulate, all crenately lobed. Stipules pinnatipartite, with an oblong-spathulate, crenately lobed, petiolate terminal segment, and smaller lateral segments. Peduncle bibracteolate just below the flowers. Sepals lanceolate, 4.5-9 mm. Corolla creamy-white to yellow, with a yellow centre, the lowermost petal 7-11 mm (Figure 3).
Flowering: March-April.
Fruiting: May-June.
Habitat: Cultivated lands, steppe, stony slopes, screes, macchie, banks, *Juniperus*, *Pinus* and *Quercus* forest at altitudes 0-1900 m.

CONCLUSIONS

This study show that the three *Viola* species *Viola occulta*, *Viola modesta* and *Viola kitaibeliana* commonly grow in the agroecosystems in Central Anatolia. However, the three species do not appear to damage the cultural plants because of their distribution at field margins.

ACKNOWLEDGEMENTS

This study is the part of the project "A revision of the genus *Viola* in inner Anatolia". The author thanks to Scientific Investigation Project to Coordinate of Selçuk University (Project No. 05401046) for financial support.

Figure 1. *Viola occulta* in the field margin in Central Anatolia

Figure 2. *Viola modesta* in the field margin in Central Anatolia

Figure 3. *Viola kitaibeliana* in the field margin in Central Anatolia

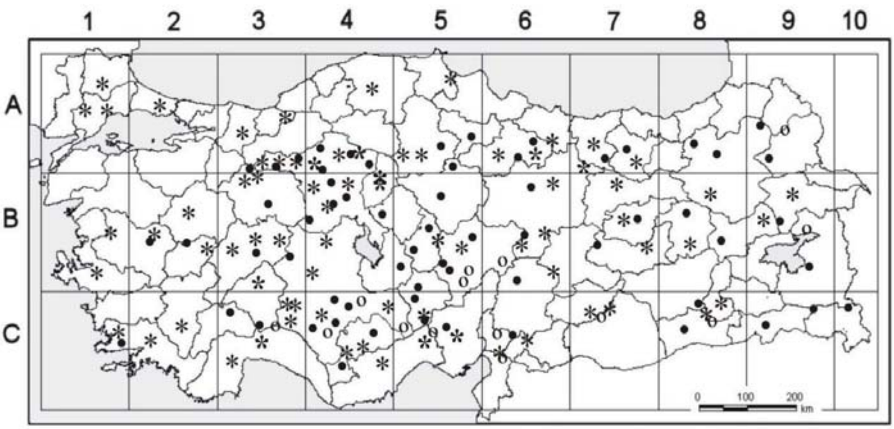


Figure 4. Distribution map of the *Viola* species commonly growing in agroecosystems in Central Anatolia. (•) *Viola occulta*, (○) *Viola modesta*, (*) *Viola kitaibeliana*.

REFERENCES

Ballard H.E., Sytsma K.J., Kowal R.R., 1999. Shrinking the violets: Phylogenetic relationships of infrageneric groups in Viola (Violaceae) based on Internal Transcribed Spacer DNA sequences. System. Bot. 23: 439-458.

Coode M.J.E., Cullen J., 1965. *Viola* L. in Davis PH (ed.), Flora of Turkey and the East Aegean Islands 1: 524-533. Edinburgh: Edinb.Univ. Press.

Davis P.H., Mill R.R., Tan K., 1988. Flora of Turkey and the East Aegean Islands. vol.10, Edinburgh: Edinb.Univ. Press.

Dinç M., 2012. Viola in Güner, A., Aslan, S., Ekim, T., Vural, M. & Babaç, M. T. (eds.) . Türkiye Bitkileri Listesi (Damarlı Bitkiler). Nezahat Gökyiğit Botanik Bahçesi ve Flora Araştırmaları Derneği Yayını. İstanbul.

Heywood V.H., 1993. Flowering Plants of the World. London: Univ. Press.

Yıldırımlı Ş., 2000. *Viola* L. in: A Güner, N Özhatay, T Ekim and KHC Başer (eds.), Flora of Turkey and the East Aegean Islands, 11: 43-44. Edinburgh: Edinburgh Univ. Press.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PARTICULARITIES OF AGRICULTURAL PRODUCTS CONSUMPTION IN ROMANIA

Alina DRAGOMIR

Institute of National Economy, 13 Calea 13 Septembrie Blvd, District 5, 050711, Romania

Corresponding author email: dag_alina@yahoo.com

Abstract

The paper aimed to present the particularities of agricultural products consumption in Romania. It is based on the statistical data provided by National Institute of Statistics, Ministry of Agriculture, Forests and Rural Development and Eurostat. The data have been processed into the following indicators: surfaces cultivated with cereals, production of agricultural products, consumptions and own consumption. Crop production is dominated by the production of cereal crops. During the last years, except year 2007 when production decreases, the crop production was stable. Consumption of fresh fruit varies by season. Own consumption of agricultural products registered considerable value in rural areas.

***Key words**: consumption, agricultural products, Romania.*

INTRODUCTION

Time produced changes in food products market, due to globalization and as a result of increased competition between active participants in the market.

In the current period, agricultural and food markets have become economic space in which producers and consumers, supposedly they are good knowledge of supply and demand are interested in obtaining the best price and the same time of the best and cheapest product (Zahiu, 1992).

If a consumer does not know how to distinguish between two foods, he chooses the more convenient alternative by price (Bonti-Ankomah and Yiridoe, 2006).

Practice has shown that the choice of food in the household is based on four requirements: quantity, quality, balance in choice and time for buying various products and food preparation (Manole et al., 2003).

MATERIALS AND METHODS

In order to characterize the particularities of agricultural products consumption in Romania was used statistical data provided by National Institute of Statistics, Ministry of Agriculture, Forests and Rural Development and Eurostat.

The data have been processed into the following indicators: surfaces cultivated with cereals, production of agricultural products, consumptions and own consumption.

RESULTS AND DISCUSSIONS

Areas planted grow from year to year; the largest areas are occupied by cereals and oleaginous plants (Figure 1).

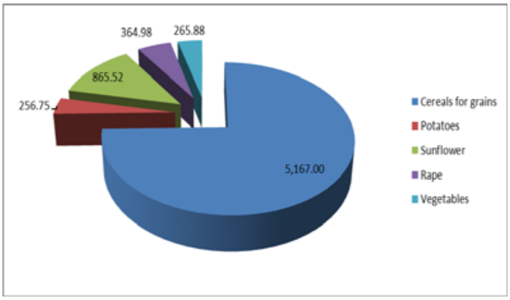


Figure 1. Average of cultivated areas, by main crops 2006-2011 (thou ha)

In year 2011, Romania produced 20823 thousand metric tons of cereals. Out of these, 7132 thousand metric tons representing wheat and 11718 thousand metric tons maize. Export represented 4830 thousand metric tons cereals. Imports of cereals in 2011 represented 10.6% of the total amount consumed nationwide. The largest amount of grain exported was

represented by wheat, followed by maize representing 22.7% respectively 20.2% of the amount produced. But, in terms of quantity exported, the amount of corn was 748 thousand metric tons higher than wheat quantity.
The largest quantity of cereals imported was the wheat, it represented 17% of total consumption.
It is known that the Romanians are great consumers of wheat and potatoes. Potatoes are the second most consumed food, the consumption is approximately 100 kg / year.
Regarding cereals, the biggest productions of the last 10 years have been recorded at maize and wheat, the maximum being registered in 2004, and minimum in 2007 (the driest year of this period) (Figure 2). Also, there was registered interest regarding production of durum wheat.

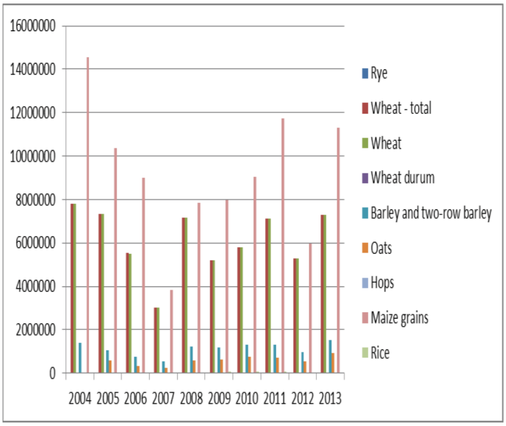


Figure 2. Evolution of cereals product between 2004-2013 (tons)

As shown in figure 3, the largest amount of vegetables is represented by the production of potatoes, followed by the white cabbage and tomatoes. In recent years there has been interest for the production of mushrooms.

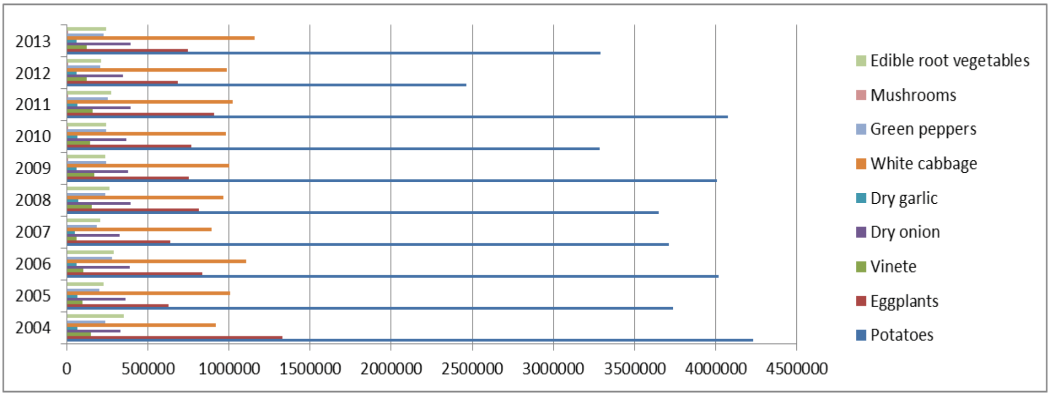


Figure 3. Evolution of vegetable production between 2004-2013 (tons)

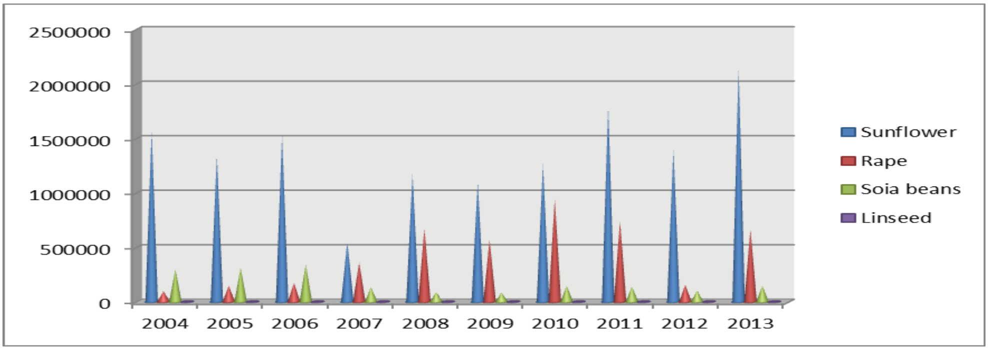


Figure 4. Evolution of oilseed crops production between 2004-2013 (tons)

The highest production of oilseed crops was registered at sunflower and rapeseed, these are the most cultivated oilseed crop; sunflower oil is the most used by Romanian consumers (Figure 4).
Fruit production in the period 2004-2010 has registered the highest quantities for apple and plum. From the total average production of 10 years, 43% were represented by the production of apples, 37.8% of plum production; they followed at a considerable distance from the production of cherries and cherry (5.6%). Starting with 2006, in the fruit production from Romania appear nectarines, highest production was registered in 2011.
Fruits from family gardens represented, in average, 4.8% in 2013.
The biggest production of fruit was registered in 2004 (Figure 5).

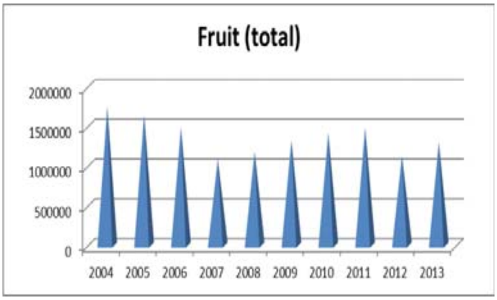


Figure 5. Evolution of fruits production between 2004-2013 (kg)

South Muntenia Region recorded 22.72% of fruit production in the period 2004-2013, followed by the North-West Region (17.64%) and the North East Region (15.58%).
In the period 2004-2009 there was an increase in meat consumption / capita, but in recent years the consumption registered a decrease (Figure 6).
In 2013, meat consumption is the lowest in the period under review, registering a decline of 11.59% compared to the average of 10 years.
Milk consumption has increased in the period 2004-2008, in 2009-2010 recorded a considerable decrease, but starting with year 2011 consumption become relatively stable (Figure 7).
Consumption of vegetables recorded fluctuations from year to year, which are correlated with the production of vegetables at national level, except in 2007, when although production decreased compared to 2005, consumption does not dropped significantly; in 2005 was recorded the lowest vegetable consumption (Figure 8).

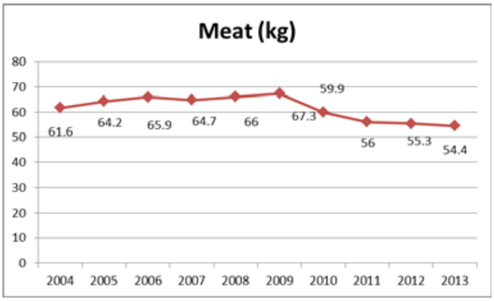


Figure 6. Evolution of average annual consumption for meat/capita in 2004-2013 (kg)

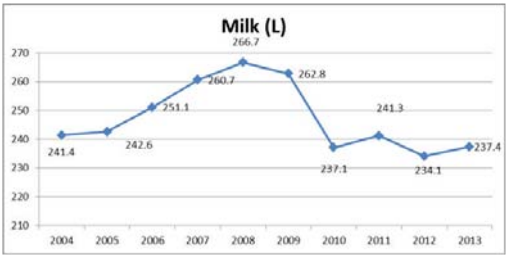


Figure 7. Evolution of average annual consumption for milk/capita in 2004-2013 (L)

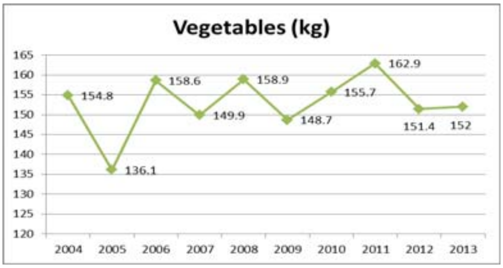


Figure 8. Evolution of average annual consumption for vegetables/capita in 2004-2013 (kg)

Potato consumption has increased in the analysed period, except years 2007 and 2010, when average of consumption was 101.4 kg / capita (Figure 9).
The consumption of cereal products decreased in the period 2004-2013, except for years 2011 and 2013 (figure 10). It is noted that, although in 2007 cereal production is greatly reduced compared to 2006 and 2008, the consumption of grain products remains relatively stable.

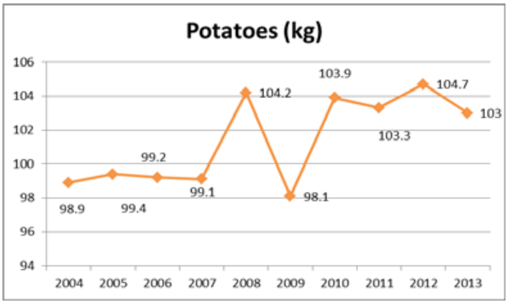


Figura 9. Evolution of average annual consumption for potatoes/capita in 2004-2013 (kg)

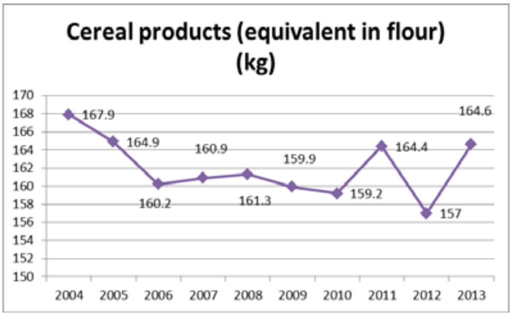


Figure 10. Evolution of average annual consumption for cereal products/capita in 2004-2013 (kg)

Quantity of consumed fruit is relatively stable, average of 10 years was 73 kg fruit / capita, the lowest amount being registered in the period 2007-2010, the average of its four years being 68 kg (Figure 10).

Sugar consumption declined in recent years, compared to an average of 25 kg for those ten years, the last four years was registered declines of 1-4 kg (Figure 11).

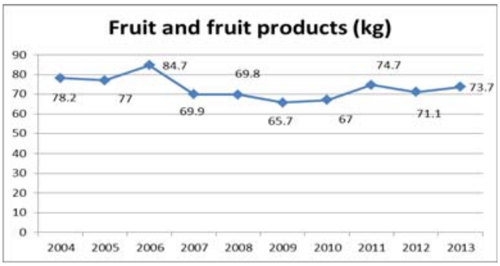


Figure 11. Evolution of average annual consumption for fruit and fruit products/capita in 2004-2013 (kg)

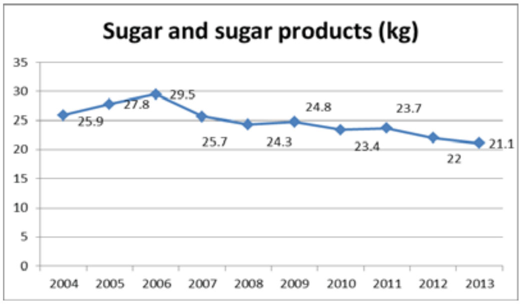


Figure 12. Evolution of average annual consumption for sugar and sugar products/capita in 2004-2013 (kg)

CONCLUSIONS

Consumer behaviour reflects the lifestyle, aspirations and its possibilities.

Cultivated areas increased, generally the grain and oilseed crops areas.

Meat consumption and sugar products are declining, but fruit consumption is relatively constant.

Potatoes and cereal products are consumed in the largest quantity, especially in rural areas, reflecting a food habit not very healthy.

ACKNOWLEDGEMENTS

This paper has been financially supported within the project entitled "Horizon 2020 - Doctoral and Postdoctoral Studies: Promoting the National Interest through Excellence, Competitiveness and Responsibility in the Field of Romanian Fundamental and Applied Economic Research", contract number POSDRU/159/1.5/S/140106. This project is co-financed by European Social Fund through Sectoral Operational Programme for Human Resources Development 2007-2013. Investing in people!"

REFERENCES

Bonti-Ankomah S., Yiridoe E.K., 2006 Organic and Conventional Food: A Literature Review of the Economics of Consumer Perceptions and Preferences. Final Report.

Manole V. et al., 2003. Agromarketing, Ediția a II-a Editura ASE, Bucureşti.

Zahiu L., 1992. Agricultura mondială şi mecanismele pieței, Editura Arta grafică, Bucureşti.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

AN INVESTIGATION INTO VINTAGE AND CLASSICAL TRACTOR COLLECTIONS, IN THE UNITED KINGDOM, AS A LONG TERM INVESTMENT OR HOBBY

Mark FRANCE[1], Lancelot BUTTERS[2]

[1]Myerscough College, Bilsborrow, Preston PR3 0RY, United Kingdom
[2]University of Central Lancashire, Preston, Lancashire, PR1 2HE, United Kingdom

Corresponding author email: mfrance@myerscough.ac.uk

Abstract

This paper critically examines agricultural tractor collection values as a financial investment for the future, or hobby for the present, it includes the make and model of tractor giving the best return on investment. Processed data proves a collection of vintage and classic tractors is a viable investment strategy, with rates of return reaching 7% and above. This demonstrates that a classic tractor investment has higher rates of return than other methods; including savings accounts, and is potentially less risky than stocks or shares. Tractors are at their lowest value when they are around 20 years old, the best age to invest; as they age further their value begins to appreciate, original and rare examples demanding higher values as these are seen to be more collectable. The majority of collectors have an industry related background, and do not collect these tractors solely for investment purposes; in fact most are collected as a hobby; contrary to the prediction at the start of this investigation. This research found for 30% of collectors it is just a hobby, whereas 20% collected as an investment and 50% combined both hobby and investment; however, collecting is not always merely a hobby; it can develop into an addiction, where the collector no longer just wants to collect tractors but has an uncontrollable need to collect them, completely changing the purpose of the collection from being an investment to being a psychological need. Additionally, it has been demonstrated that a number of those who collect classical and vintage tractors, as an investment, become too attached to their collections to sell them, meaning the collections can be passed down through families.

Key words: *collection, investment, tractor, hobby, classical, vintage.*

PROJECT AIMS

1. Critically analyse research to identify the investment advantages available and compare these to alternative investment methods in relation to rates of return and risk.
2. Compile a chart showing the prices from the date of purchase as new to their current prices which will show rates of depreciation and point of lowest value.
3. Discover the current and future trends to ascertain the best time for purchase and for selling as an investment.
4. Identify who is collecting and for what reasons, for a hobby or as an investment, or both.
5. Identify who is investing in vintage and classic tractors and why they have chosen this over alternative investments available.

INTRODUCTION

On a regular basis the media publishes articles covering the value of classical cars and the price they demand at auction; rarely does the press mention the developments of classical tractor collections, over the past twenty five years or so there has been huge growth in companies manufacturing reproduction components for tractors seventy years old and even older. A number of specialist magazines cater for the enthusiast (Classic Tractor, Tractor and Machinery, to name but a few). With this in mind the value of the classic tractor market has been investigated.

A considerable number of private classic tractor collections are in existence within the UK, the vast majority are not made public; by researching this facet of the sector, the value of collections can be calculated, interviewing a selection of collectors determined the objectives of the owners of these collections or what drives them to create such collections.

Collectable items have the potential to appreciate in value over time as they become rare and desirable, this can include such things as; art, wine and guitars. Collecting for an investment does require large capital inputs, thus making it not really profitable over the short term and meaning collectors need to be holding for the long term (Satchell, 2009). Most collections have been built up over many years and often comprise of one specific manufacturer or one specific model range within a manufacturer's portfolio. Research has endeavoured to determine the reasoning behind the choice of model and manufacturer and how this reflects on the value of current collections.

Further research investigates the comparison of capital return on a classic tractor collection compared with other forms of investment.

Six popular tractors were selected and were divided into two groups of three, from a similar period and similar in size and cost; thus making them competitors on the market. The first three similar tractors were from the early 1960s, around 45 horsepower and cost in the region of £660 at the time of purchase.

The latter three tractors were from the same manufacturers in the late 1970's after the introduction of new legislation in 1976 which required noise levels in tractor cabs to be below 90db. This led to the development of the Quiet Cab ("Q" Cab) (Ware, 2009). These three tractors are fitted with the "Q" Cab and are approximately 70 horsepower. At this time due to inflation these tractors cost approximately £6400-00.

Table 1. the breakdown of each tractor for its cost, power and production years (Williams A (1964); Fellows T (1977); TractorData (2013)

Manufacturer	Model	Production	Hp	Cost
David Brown	880 Implematic	1961-65	42.5	£670
Massey Ferguson	35X	1962-64	44.5	£652
Fordson	Super Dexta	1962-64	44.5	£666
David Brown	1212	1971-76	72	£6572
Massey Ferguson	575	1977-83	66	£6286
Ford	6600	1975-81	78	£6552

This study is expected to show that vintage and classic tractors are an alternative investment which can compete with more traditional investment methods. Due to this, it could be seen that most collectors are collecting tractors primarily as an investment. It is also expected to show that the older generation are selling their collections to supplement a pension

MATERIALS AND METHODS

The research project critically compared the original cost of each tractor with its market value over a period of circa 50 years, plotting depreciation in the early years and appreciation in the later years; using this data the future values could then be calculated. Inflation during the years between original purchase and current period was factored into the calculation. For an investment to be viable it must match or be greater than the rate of inflation to ensure a return on the investment long term (Aby and Vaughn, 1979).

Daryl Roxburgh states that for collectable items to provide a greater return they must be highly liquid, to allow for ease of sale, also rarity and homogeneity are essential to produce premium returns. Collecting as an investment can also have many joys for the collector, such as searching for missing items, showing their collection, visiting exhibitions and auctions (Satchell, 2009).

The collecting of tractors as an investment is similarly compatible to that of cars and other collectable items (Russell, 2008).

Due to the many risks involved in all these alternative investments many investors will compile an 'investment portfolio'. Coates (1978) defines a portfolio as a combination or collection of securities or other investments. By diversifying the money across several different investments, an investor can considerably lower the risk they expose themselves to without reducing the amount of money they may make. This diversification is not a new concept, remember the old saying:

"Don't put all your eggs in one basket"

By using numerous investments the gains will usually more than offset the losses, whereas when there is only one investment, the investor is often faced with either feast or famine (Coates, 1978).

This is sometimes overlooked because of the time and effort needed to develop expertise in several investment areas, thus leading to many investors concentrating in one particular type of investment (Coates, 1978).

Firstly a financial study investigated tractor price trends plotting the expected depreciation and identifying the point at which tractors start to appreciate in value. Gathering this information from agricultural and tractor magazines using the classified advertisements and auction reports as the data source, published from the 1960's.

The six identified test tractors were used to provide accurate data on the depreciation and appreciation of vintage and classic tractors. The tractors were studied in terms of price from new to the current date to plotting a depreciation chart for each tractor.

This report also investigated both the investment opportunities available through vintage and classic tractors and the mentality behind who is collecting what and the reasons behind their choice this involved two separate areas of research which both provided individual results. These were analysed together to produce an overall conclusion.

To provide accurate results the tractors were broken down into six categories relating to their condition, similar to that of the Tractor and Machinery's Price Guide divided into six levels of condition:

1. Spares or Repairs
2. Ex-Farm (requires full overhaul)
3. Original Condition
4. Working Order (may have some faults; mechanical or cosmetic)
5. Good Working Condition
6. Excellent Condition (new or recently fully restored)

Two main sources for tractor prices were used; copies of Farmer's Weekly magazine covering the period between 1960 and 2002 and Classic Tractor magazine from 2002 until 2011. These magazines were chosen for their distribution coverage and known to provide unbiased data also the local library had a complete set of the magazines, for the period of research, archived and available for research.

'Farmers Weekly' covered the period from 1960 through to 2002 where 'Classic Tractor' took over until the present date.

Secondly research focused on collectors and collections; carried out through interviews with collectors and visits to collections.

Using a short questionnaire to provide a structure to the interviews enabled all data required to be obtained including who is collecting and why.

The use of open ended questions encouraged the collector to talk about their collection freely and provided other information of use during this investigation, such as rarity in their collection and the history of some of their tractors.

RESULTS AND DISCUSSIONS

The results from the tractor prices compiled were identified and input into tables; using his information scatter graphs were produced. From this a trend line can be applied, this will replicate a depreciation / appreciation curve.

To provide accurate results, the prices used were from the condition grades 5 and 6, although where advertisement numbers are scarce, condition 4 were used.

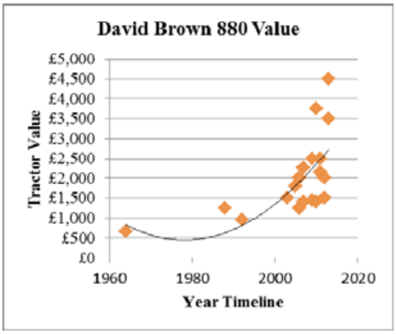


Figure 1. Value curve for David Brown 885

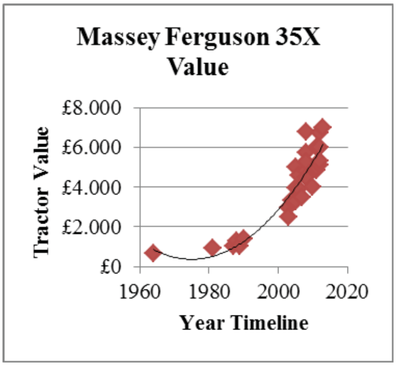


Figure 2. Value curve for Massey Ferguson 35X

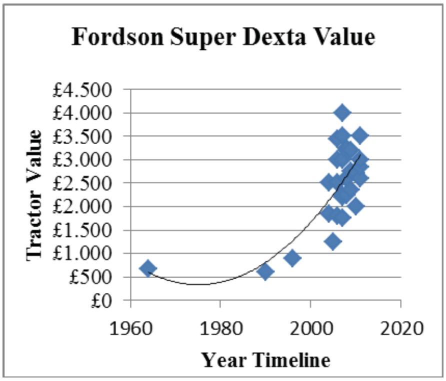


Figure 3. Value curve for Fordson Super Dexta

The three scatter graphs all follow a similar shape demonstrating an appreciating curve. However the graphs for the Massey Ferguson 35X and Fordson Super Dexta have a steeper gradient showing a better rate of appreciation compared with the David Brown 880. There is a lack of accuracy in the graphs between 1960 and 2000 due to a limited number of results from this time.

However the graphs do show depreciation during this period due to the trend line curve, although this is minimal. The expected cause of this would be the acceleration of inflation during this period, this would explain why the value of the tractors hardly reduced, as the inflation equated to money being worth less. Between 1964 and 1975 inflation had reached over 100% Associated Newspapers Ltd (2013). This means even if the tractor cost the same as its price at new, after the 11 years, its price would technically be equivalent to half that of its original price due to inflation, thus showing depreciation of fifty percent.

The increase in results on the graphs from the new millennium, make the trend curve more accurate, giving a more reliable representation of appreciation.

The three scatter graphs show the late 1970's tractors. They all follow a similar, reasonably symmetrical shape although on different gradients, with the Ford 6600 having a shallow gradient and the David Brown1212 having a steep gradient. This symmetry is due to the tractors current value being similar to that of their original price when new, without taking inflation into account.

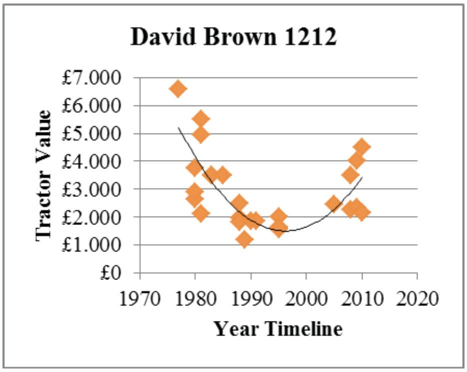


Figure 4. Value curve for David Brown 1212

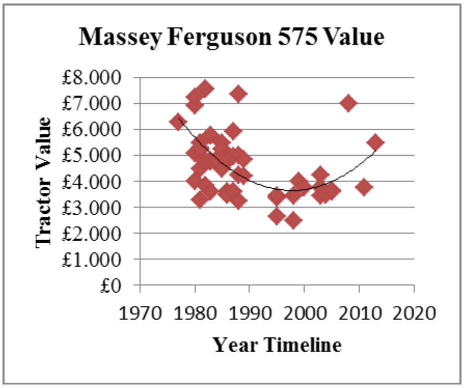


Figure 5. Value curve for Massey Ferguson 575

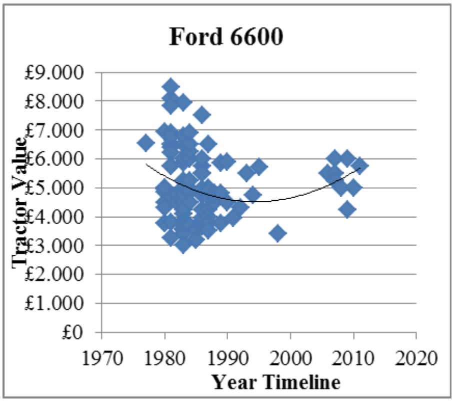


Figure 6. Value curve for Ford 6610

All three graphs show depreciation in the value of the tractors, with their lowest points all being during the 1990's when the tractors are approximately twenty years of age, however the Ford 6600 has the smallest depreciation out of the three tractors, having a drop of only £1500 on the trend curve, whereas the David

Brown 1212 graph demonstrates quite a significant depreciation in the tractor's value, with a drop of around £4000 on the trend curve. The Ford 6600 graph is also the most symmetrical, and its current value is most similar to its original price at new, whereas the David Brown 1212 and the Massey Ferguson 575 both have a current value which is less than their original price, although these both have a greater rate of appreciation than the Ford 6600, with the David Brown 1212 having the steepest appreciation.

Together the six scatter graphs show that the tractors featured are at their lowest values when they are approximately 20 years old, potentially this trend could be transferred onto newer tractors, which may also be at their lowest values when they reach 20 years old, which may possibly be followed by appreciation.

The scatter graphs for the older three tractors demonstrate a better rate of appreciation compared to the newer three, however since the appreciation of all these tractors seem to follow a polynomial growth trend, the appreciation may well begin to increase in rate for the newer three from now on since the appreciation for the older three started to increase more steeply from about 20 years after their minimum value, when they were about 40 years old. The newer three are now about 40 years old, their rate of appreciation may potentially begin to increase more rapidly. This could show that they are currently at an ideal time to be invested in, since they are already showing to be increasing in value yet are currently still affordable as their prices haven't "rocketed" yet.

Using the trend lines from the scatter graphs, and assuming that the market remains stable, it is possible to calculate the rate of return for each of these tractors by taking the values on the trend line for 2000 and 2010 and using the future value concept formula:

Sn = S0(1+r)n

Clayton G & Spivey C (1978)

Where

Sn is the value in 2010,

S0 is the value in 2000,

n = 10, the number of years,

r = the rate of return.

R, the percentage rate of return, can be worked out by rearranging the above formula to give:

r = [(Sn/S0)0.1-1]

R = r x 100

The results of these calculations are shown in the table below:

Table 2. Expected tractor value

Tractor	Value in 2000	Value in 2010	R (percentage rate of return)
Massey Ferguson 35X	£2,800	£5,300	6.59%
Fordson Super Dexta	£1,700	£2,900	5.49%
David Brown 880	£1,350	£2,350	5.70%
Massey Ferguson 575	£3,700	£4,600	2.20%
David Brown 1212	£1,600	£3,400	7.83%
Ford 6600	£4,600	£5,600	1.99%

These examples show that the Massey Ferguson 35X will give a much better return than the Ford 6600 if these rates of return stay constant over the next ten years, since the Massey Ferguson 35X's rate of return is currently so much higher. However, as explained previously, the rate of return for the Ford 6600 could increase up to a similar level as the other older tractors over the next 20 years; this may also be the case for the Massey Ferguson 575. The David Brown 1212 is already at a higher rate though, and is offering the best rate of return out of all six tractors studied.

Further to the results from the tractors, results from the interviews have revealed that when people collect tractors, they tend to have large collections, with over half of the collectors interviewed having more than 50 in their collections, as shown in the pie chart. Also, it can be seen that the majority of collectors do not collect them purely as an investment; they collect tractors as a hobby, showing that collectors often have an emotional connection to their tractors.

Further to the results from the tractors, the results from the interviews have revealed that when people collect tractors, they tend to have large collections, with over half of the collectors interviewed having more than 50 in their collections, as shown in Graph.7. Also, it can be seen from Graph 8, the majority of collectors do not collect them purely as an investment, but they collect tractors as a hobby, showing that collectors often have an emotional connection to their tractors.

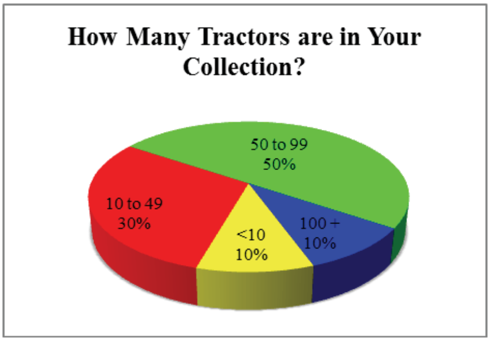


Figure 7. Size of tractor collections

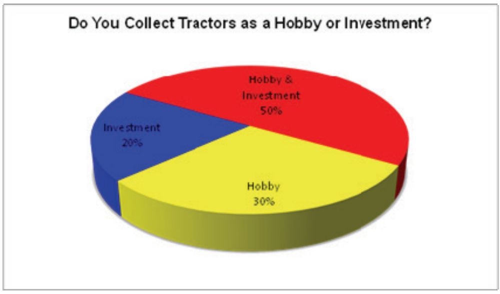


Figure 8. Breakdown of tractor collections

All of the collectors interviewed were found to have had a link to agriculture during their childhood which could be the cause for them choosing to collect tractors over other objects, possibly due to the psychological reasons for collecting as discussed previously (Muensterberger, 1994).

It has also been interpreted that the collectors seem to acquire tractors that they are more familiar with, and have been brought up to use, for example, one collector mainly collects 500 series Massey Fergusons since he was brought up with this particular model and learned to drive in a Massey Ferguson 550.

As shown on Graph 9, the majority of collectors restore the tractors themselves, this is related to the collectors level of expertise, how much it may cost to restore the tractors and also that tractor collecting is mostly done as a hobby, as well as an investment. For collectors, restoring the tractors themselves is all part of the fun, giving the collector enjoyment and a sense of satisfaction and achievement Satchell (2009).

Figure 9. Tractor restoration

CONCLUSIONS

To conclude on the research and investigation which set out to identify if vintage and classic tractor collecting is an investment or hobby, it has been shown that collecting vintage and classic tractors is a viable method of investment, with rates of returns of up to and above 7%. This demonstrates that investing in classic tractors has higher rates of returns than several other investment methods, such as using savings accounts, and is potentially less risky than other investment methods, such as stocks or shares. It has been shown that tractors are at their lowest prices when they are around 20 years old, hence showing that the best age to invest in one is when they are just over 20 years old when it can be seen that their value has begun appreciating, knowing this information is a great advantage when investing in them. It has also been shown that original and rare examples are demanding higher values as these are seen as more collectable and a better investment.

However, it has also been shown that the majority of vintage and classic tractor collectors have an industry related background, and do not collect these tractors solely for investment purposes, in fact most of them collect them as a hobby, contrary to what was predicted at the start of this investigation. This research has also discovered that collecting is not always merely a hobby, but can develop into an addiction, where the collector no longer just wants to collect tractors but has an uncontrollable need to collect them, completely changing the purpose of the collection from being an investment to being a psychological need.

Additionally, it has been demonstrated that even those that do collect the tractors originally as an investment do not actually experience the return for themselves. This is because they end up too attached to their collections and are unable to sell them, meaning the collections get passed down through their family generations.

REFERENCES

Satchell S., 2009. Collectible Investments, for the High Net Worth Investor. Elsevier Inc, USA.

Aby C., Vaughn D., 1979. Investment Classics. Goodyear Publishing, USA.

Coates R., 1978. Investment Strategy. McGraw-Hill Inc, USA.

Muensterberger W., 1994. Collecting: An Unruly Passion, Psychological Perspectives. Princeton University Press, USA.

Clayton G., Spivey C., 1978. The Time Value of Money. W. B. Saunders Company, Canada.

Russell J., 2008. Antique Tractors: A real investment vehicle. Accessed Via: http://www.npr.org/templates/story/story.php?storyId=95016730.

Associated Newspapers Ltd (2013) Inflation Calculator. Accessed Via: http://www.thisismoney.co.uk/money/bills/article-1633409/Historic-inflation-calculator-value-money-changed-1900.html on 14/03/2013.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

FLORA ASPECTS IN THE SLĂNICUL DE BUZĂU WATERSHED

Mihaela Ioana GEORGESCU, Marian MUŞAT, Alexandra Teodora RADU, Elena SĂVULESCU, Elisabeta DOBRESCU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: mihaelaigeorgescu@yahoo.com

Abstract

In two valleys of the Slănicul de Buzău watershed were conducted a series of observations on evolution of floristic composition of two meadows under the influence of changes registered in recent years in the rainfall regime and the land uses. The decrease of the anthropogenic intervention, recorded in the last fifteen years, led to changes in floristic composition of meadows and has permitted the installation of two new species, considered rare in the subcarpathian watershed of Slănicul de Buzău: Gentiana cruciata and Echium maculatum.

***Key words**: Aldeni, floristic composition, Gentiana cruciata, Echium maculatum.*

INTRODUCTION

The wathershed Slănicul de Buzău is a relief unit of the Curvature Subcarpathian. The area, with a continental climate, is regarded as one of the most affected by climate change, by increasing the frequency of extreme weather events such as rainfall torrents that causes violent and rapid high floods (Costache and Fontanine, 2013).

The fragile balance of the lands is affected by gully erosion and landslides that lead to loss of soil, exceeding 30-45 tonnes / ha / year (Ştirbu et al., 2010; Mircea and Petrescu, 2011).

Vegetation, represented by secondary meadow, formed as a result of deforestation of deciduous forests, and lands with diverse uses (arable crops, grasslands, vineyards and orchards), plays an important role in diminishing of surfaces affected by runoff and gully erosion (Costache and Fontanine, 2013; Mircea and Petrescu, 2011). Changes, in recent years, on climate regime and land use are detected in vegetation also.

There are few works about flora and vegetation of this area and they are owed, mainly, to V. Ciocârlan (1968, 1969 a, b) and to the authors who have studied the erosion processes in the region (Muș at, 2006).

Two valleys, part of Slănicul de Buzău wathershed, and their vegetation were included in our study in order to emphasise any alteration as a result of enviromental changes (rainfall, land uses) and to highlight the importance of these sites in biodiversity preservation.

MATERIALS AND METHODS

Our field studies were located on the right side of the Slănicul de Buzău river, in two valleys – Tătarului and Valea cu Drum, near Aldeni (Buzău county).

In this area, rainfall ranges between 500-600mm/year, distributed unequal over the year - the highest quantity is recorded during the months of April to June. In 2014, the average amount of rainfall was 781.95 l/m, the maximum recorded in April was 135.3 l/m (Table 1, Figure 1).

On the left side of the Tătarului valley with south exposition, the secondary meadow is edified by *Chrysopogon gryllus* while, on the right side of Valea cu Drum valley, with north exposition, the secondary meadows are edified by *Botriochloa intermedium* in the lower and middle part of the slope and, respectively, by *Festuca valesiaca* and *Stipa capillata* in the upper part of slope.

Itinerant method was used to mapping the vegetation. In July, observation territory was crossed in order to note all the plant species encountered. Plant species identification was made with field guides Ciocârlan, 2009 and

Sârbu et al. 2013. The plant lists were supplemented with personal data of the authors from previous autumnal assessments (Georgescu, Muşat – personal data).

Twenty-seven species and four families amongst those encountered in Valea cu Drum aren't in Tătarului valley meadows, while seventeen species and three families are characteristic to Tătarului valley.

Table 1. Climatic data - Aldeni, 2014

	The months of the year												Total and average
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Air temperature – monthly average	-2.7	-0.3	6.9	**9.0**	**14.0**	**17.4**	**20.3**	**19.7**	**14.8**	8.0	2.6	0.2	**9.16**
Soil temperature – monthly average	0.64	0.17	4.2	**7.2**	**11.0**	**14.9**	**17.6**	**18.3**	**14.1**	8.8	4.4	0.12	**8.45**
Rainfall – monthly average (l/mp)	55.6	3.55	26.3	**135.3**	**105.7**	**109.1**	**68.6**	**59.3**	**14.5**	54.4	62.2	87.4	**781.95**

Note: The average rainfall in the winter months (December, January, Febr.) are from melting snow fallen

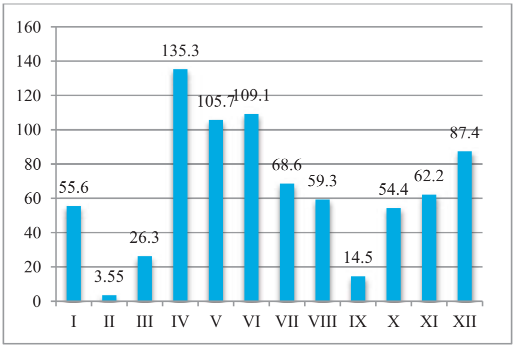


Figure 1. Monthly average rainfall recorded in Control Stationary of the Soil Erosion - Aldeni (Buzau county), 2014

RESULTS AND DISCUSSIONS

Floristic composition analysis

In total, in the two meadows, were recorded eighty-seven plant species. The sixty-seven plant species from Valea cu Drum valley are distributed in twenty-one plant family (Table 2, Figure 2). The Valea Tătarului meadows include sixty plant species, distributed in twenty families (Table 2, Figure 3).

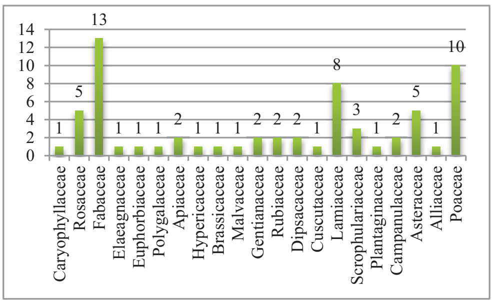


Figure 2. The plant families in Valea cu Drum

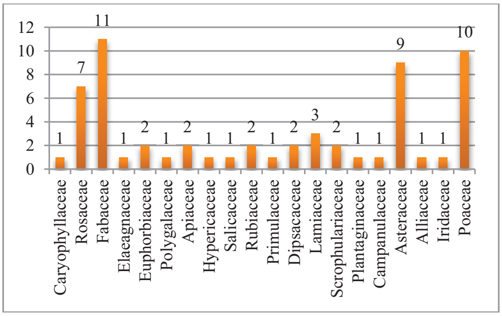


Figure 3. The plant families in Tătarului valley

Two species from Valea cu Drum are for the first time recorded in this area situated in the south of Slănicul de Buzău watershed.

Gentiana cruciata L. (Figure 4) – There are no records for this species in Buzău county in some important works about Romanian flora (Ţopa, 1961; Oprea, 2005). In 1968, Ciocârlan has noted the presence of this species in the north part of the Slănicul de Buzău watershed. The species is considerated rare in the area. We have identified the plant in a micro-depressions in the middle of the slope.

Figure 4. *Gentiana cruciata* L.

Echium maculatum L. (sin. *E. rubrum* Jacq.) (Figure 5) – About this species Flora RPR volume VI indicates that is common in all country regions in meadows , orchard etc. But in his Phd thesis Ciocârlan, 1968, noted that the species is rare and is found only in the northern part of Slănicul de Buzău watershed, also. We identified it in the upper part of Valea cu Drum valley.

Figure 5. *Echim maculatum* L.

Bioform analysis

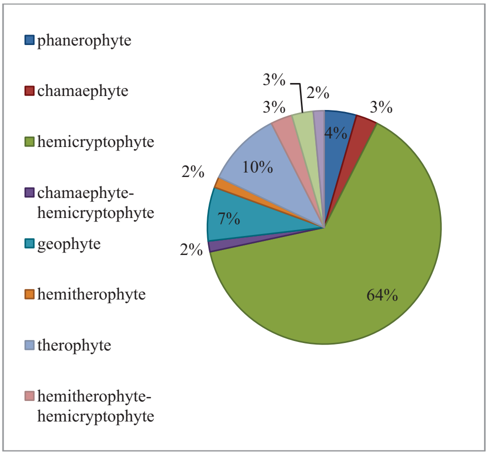


Figure 6. The bioform spectrum in Valea cu Drum

Out of the 67 plant species recorded in Valea cu Drum, thirteen are annual or annual hibernating and three are woody species; the majority of plant species are perennials: forty-three are hemicryptophytes, three are chamaephytes, and five are geophytes (Table 2). The total number of perennial species recorded in Tătarului valley is forty-two of wich thirty-five are hemicryptophyte, three are chamaephyte and four are geophyte. Annual species are represented by thirteen species, in the same number like in Valea cu Drum valley. Also, here there are five woody species (Table 2).

Analysing the bioforms spectrum, we can conclude that the vegetal associations from both meadows are stable. The high percentage of the hemicryptophyte species (64 % in Valea cu Drum and 58% in Tătarului Valley) and the low percentage in the case of therophyte species (only 10% in both associations) indicate a reduced pressure of antropic factor (Figures 6 and 7).

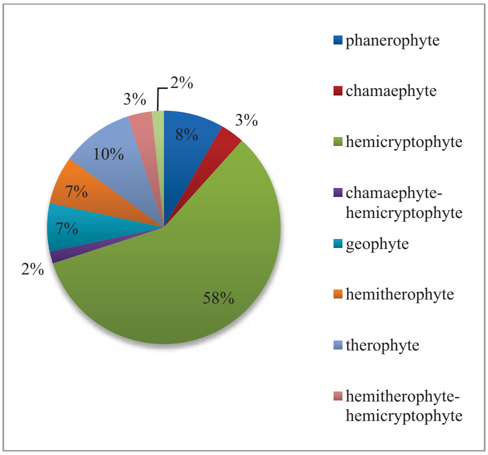


Figure 7. The bioform spectrum in Tătarului valley

Geoelement analisys

Elements of eurasin origin are the most reprezentative among species in terms of geoelements (45% in Valea cu Drum and 44% in Tătarului Valley) (Figures 8 and 9). This is conform geoelements spectrum in our country. Particulary, for the south part of Slănicul de Buzău watershed are species originate from Continental, Pontic, Ponto-Mediterranean, Ponto-Balkanic or Submeriterranean regions emphasizing the silvo-steppic character of meadows encountered in the two valleys (Table 2). Ciocârlan, 1968, shows that the great number of thermophilic elements met in the curvature Subcarpathian region date from the warm postglacial era, representing glacial refugia.

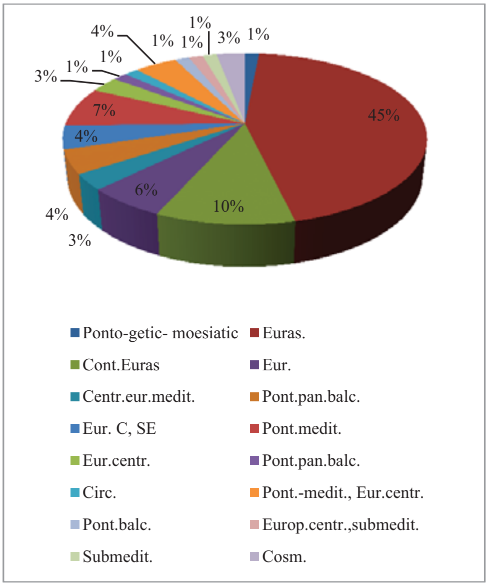


Figure 8. The geoelement spectrum in Valea cu Drum

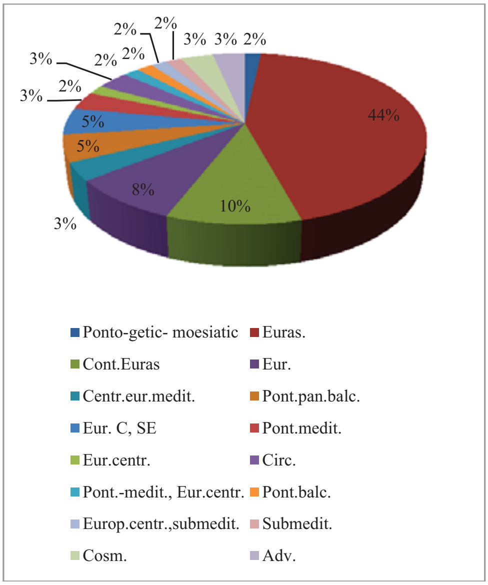


Figure 9. The geoelement spectrum in Tătarului valley

<u>The requirements for soil moisture analysis</u>

In the Valea cu Drum valley the spectrum of requirements for soil moisture is predominated moist soils (23 - mesoxerophytic). Other species are those adapted to dried soil (6 species, xero-xeromesophilic), moderately moist soil (5 species, mesophilic) and those indifferent to the soil moisture (5 species, eurihydric).

The spectrum of requirements for soil moisture in Tătarului valley is made of twenty-two species xeomesophilic, twenty-two mesoxerophilic, four xerophilic, two mesohygrophilic, two hygrophilic and five species indifferent.

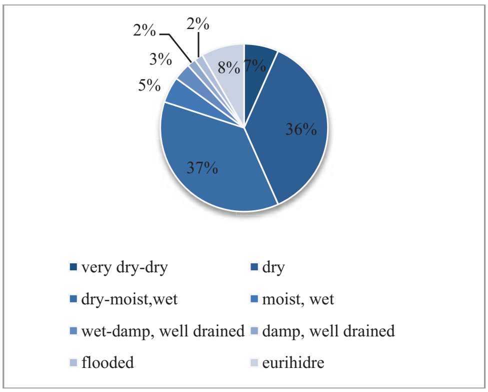


Figure 10. The soil moisture requirements spectrum in Valea cu Drum

The analysis of the species requirements for soil moisture confirms characteristic of the vegetal associations formed on the slopes of the two valleys, those of silvo-steppe meadows - the greatest part of plants species have low requirements for water factors (Figure 10,11).

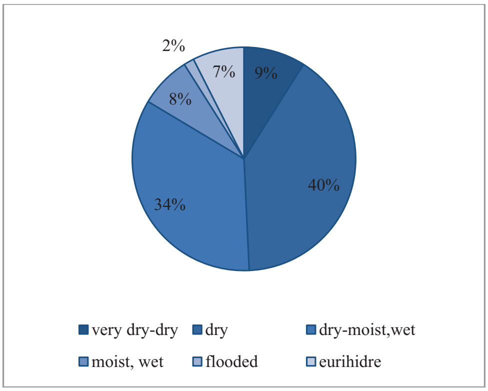


Figure 11. The soil moisture requirements spectrum in Tătarului valley

CONCLUSIONS

The two valleys - Tătarului and Valea cu Drum, are covered with plant associations of silvo-steppe meadows composed by many species of continental, pontic or sub mediterranean origin.

The decrease of the anthropogenic intervention, recorded in the last fifteen years, led to changes in floristic composition of meadows and has permitted the installation of new species, considered rare in the subcarpathian watershed of Slănicul de Buzău.

Although these types of meadow are considered of low conservative value (Doniță, 2005), they have an important role in maintaining the biodiversity by their richness in species, and can provide, also, important information about vegetation evolution.

Table 2. The plant species from Valea cu Drum and Tătarului valleys

Species/ Family Bioforms;Geoelements;soil moisture index	Valea cu Drum	Tătarului valley
1. *Dianthus membranaceus* Borbás *Caryophyllaceae* H;Pont.-getic-moes;3	✓	✓
2. *Agrimonia eupatoria* L. *Rosaceae* H;Euras;4	✓	✓
3. *Crataegus monogyna* Jacq. Ph;Euras.;4	-	✓
4. *Filipendula vulgaris* Moench *Rosaceae* H;Euras.;4	-	✓
5. *Fragaria viridis* Duchesne *Rosaceae* H;Euras.;3	✓	✓
6. *Potentilla recta* L. *Rosaceae* H;Cont.euras.;3	✓	✓
7. *Prunus spinosa* L. *Rosaceae* Ph;Eur.;x	-	✓
8. *Rosa canina* L. *Rosaceae* Ph;Eur.;4	✓	✓
9. *Sanguisorba minor* L. *Rosaceae* H;Euras.;3	✓	-
10. *Astragalus onobrychis* L. *Fabaceae* H;Cont.euras;3	-	✓
11. *Coronilla varia* L. *Fabaceae* H;Centr.eur.-medit.;4	✓	✓
12. *Cytisus austiacus* L. *Fabaceae* Ph;Pont.-pan.-balc.;3	✓	-
13. *Dorycnium pentaphyllum* Scop. *Fabaceae* Ch;Eur.centr. ş i SE;4	✓	✓
14. *Lathyrus tuberosus* L. *Fabaceae* H;Euras.;4	✓	-
15. *Lotus corniculatus* L. *Fabaceae* H;Euras. ;4	✓	✓
16. *Medicago falcata* L. *Fabaceae* H;Euras. ;3	✓	✓
17. *Medicago lupulina* L. *Fabaceae* T-H;Euras. ;4	✓	✓
18. *Melilotus officinalis* (L.) Pall. *Fabaceae* Ht;Euras. ;3	✓	✓
19. *Ononis spinosa* L. *Fabaceae* Ch-H;Eur. ;x	✓	✓
20. *Onobrychis viciifolia* Scop. *Fabaceae* H;Euras.;3	✓	✓
21. *Trifolium arvense* L. *Fabaceae* T;Euras. ;3	✓	✓
22. *Trifolium pannonicum* Jacq. *Fabaceae* H;Pont.-medit. ;4	✓	-
23. *Trifolium pratense* L. *Fabaceae* H;Euras.;x	✓	✓
24. *Hippophäe rhamnoides* L. *Elaeagnaceae* Ph;Euras. ;4	✓	✓
25. *Euphorbia cyparissias* L. *Euphorbiaceae* H;Euras.;3	✓	✓
26. *Euphorbia glareosa* Pall. ex M.Bieb. *Euphorbiaceae* H;Est, centr.-est eur. ;2	✓	✓
27. *Linum flavum* L. *Linaceae* H;Pont.-pan.-balc. ;4	✓	-
28. *Polygala major* Jacq. *Euphorbiaceae* H;Pont. - medit;3	✓	✓
29. *Bupleurum rotundifolium* L. *Apiaceae* T;Euras.;3	✓	-
30. *Daucus carota* L. *Apiaceae* Ht;Euras.;4	-	✓
31. *Eryngium campestre* L. *Apiaceae* H;Pont.-medit. ;3	✓	-
32. *Ferulago campestris* (Besser) Grecescu *Apiaceae* H;Pont.-medit.;3	-	✓
33. *Hypericum perforatum* L. *Hypericaceae* H;Euras. ;4	✓	✓
34. *Erysimum repandum* L. *Brassicaceae* T;Euras. Cont. ;4	✓	-
35. *Salix alba* L. *Salicaceae* Ph;Euras.;7	-	✓
36. *Lavatera thuringiaca* L. *Malvaceae* H;Euras. Cont. ;5	✓	-
37. *Centaurium erythraea* Rafn *Gentianaceae* T-Ht;Eur.centr. ;5	✓	-
38. *Gentiana cruciata* L. *Gentianaceae* H;Euras. ;3	✓	-
39. *Asperula cynanchica* L. *Rubiaceae* H;Centr.eur.-medit.; ;3	✓	✓
40. *Galium verum* L. *Rubiaceae* H;Euras. ;4	✓	✓
41. *Primula veris* L. *Primulaceae* H;Euras.;4	-	✓
42. *Knautia arvensis* (L.) Coult. *Dipsacaceae* H;Eur. ;4	✓	✓
43. *Scabiosa ochroleuca* L. *Dipsacaceae* Ht-H;Euras.cont; 3	✓	✓

44. *Cuscuta epithymum* L. ssp. *trifolii* (Bab.)Berther *Cuscutaceae* T;Euras.; x	✓	-
45. *Echium maculatum* L. *Boraginaceae* T-Ht;Pont.-pan.; 3	✓	-
46. *Clinopodium vulgare* L. *Lamiaceae* H;Circ.;4	✓	✓
47. *Salvia nemorosa* L. *Lamiaceae* H;Pont.-medit.-centr.eur. ;4	✓	✓
48. *Nepeta cataria* L. *Lamiaceae* H;Euras. ;4	✓	-
49. *Nepeta nuda* L. *Lamiaceae* H;Euras.cont.;3	✓	-
50. *Origanum vulgare* L. *Lamiaceae* H;Euras. ;3	✓	-
51. *Phlomis herba-venti* L. ssp. *pungens* (Willd.) Maire ex DeFillips *Lamiaceae* H;Pont.-medit. ;3	✓	-
52. *Stachys recta* L. *Lamiaceae* H;Pont.-medit.- centr.eur. ;3	✓	-
53. *Teucrium chamaedris* L. *Lamiaceae* Ch;Eur.centr. ;2	✓	✓
54. *Melampyrum arvense* L. *Scrophulariaceae* T;Eur.;3	✓	✓
55. *Rhinanthus rumelicus* Velen. *Scrophulariaceae* T;Pont.-pan.-balc. ;5	✓	✓
56. *Veronica austriaca* L. ssp.*austriaca* Maly *Scrophulariaceae* H;Pont.-medit.- centr.eur. ;2	✓	-
57. *Plantago lanceolata* L. *Plantaginaceae* H;Euras.;x	✓	✓
58. *Campanula glomerata* L. *Campanulaceae* H;Euras.;4	✓	-
59. *Campanula persicifolia* *Campanulaceae* H;Euras.;4	✓	-
60. *Campanula sibirica* L. *Campanulaceae* Ht;Cont.-euas.;x	-	✓
61. *Achillea millefolium* L. *Asteraceae* H;Euras.;4	✓	-
62. *Carlina vulgaris* L. *Asteraceae* Ht;Euras.;4	-	✓
63. *Centaurea orientalis* L. *Asteraceae* H;Pont.-balc.;3	✓	✓
64. *Centaurea stoebe* L. ssp. *australis* (A.Kern.) Greuter *Asteraceae* Ht-H;Eur.centr.,SE;2	✓	✓
65. *Cichorium inthybus* L. *Asteraceae* H;Euras.;4	-	✓
66. *Erigeron annuus* (L.) Desf. *Asteraceae* T;Adv. (Am. de N);6	-	✓
67. *Erigeron canadensis* L. *Asteraceae* T;Adv. (Am. de N);3	-	✓
68. *Leucanthemum vulgare* (Vaill.) Lam. *Asteraceae* H;Euras.;4	✓	-
69. *Pilosella officinarum* Vaill. *Asteraceae* H;Euras.;4	-	✓
70. *Senecio jacobea* L. *Asteraceae* H;Euras.;4	✓	-
71. *Senecio vulgaris* L *Asteraceae* T;Euras.;4	-	✓
72. *Taraxacum serotinum* (Waldst.et Kit.) Fisch. *Asteraceae* H;Pont.-pan.-balc.;3	-	✓
73. *Xeranthemum annuum* L. *Asteraceae* T;Pont.-medit.;2	✓	-
74. *Allium rotundum* L. *Alliaceae* G;Centr.eur.-submedit.;3	✓	✓
75. *Iris pumila* L. *Iridaceae* G;Pont.-pan.-balc.;3	-	✓
76. *Agrostis stolonifera* L. *Poaceae* H;Circ.;6	-	✓
77. *Bromus inermis* Leyss. *Poaceae* H;Cont.euras;4	-	✓
78. *Botriochloa ischaemum* (L.) Keng *Poaceae* H;Euras. (submedit.);3	✓	✓
79. *Calamagrostis epigejos* (L.) Roth *Poaceae* G;Euras.;x	✓	-
80. *Chrysopogon gryllus* (L.) Trin. *Poaceae* G;Submedit.;3	✓	✓
81. *Elymus hispidus* (Opiz) Melderis *Poaceae* G;Cont. euras;3	✓	-
82. *Dactylis glomerata* L. *Poaceae* H;Euras.;4	✓	✓
83. *Festuca valesiaca* Schleich. ex Gaudin *Poaceae* H;Cont. euras.;3	✓	✓
84. *Phleum pratense* L. *Poaceae* H;Euras.;5	✓	✓
85. *Phragmites australis* (Cav.)Trin.ex Steud *Poaceae* G;Cosm.;10	✓	✓
86. *Poa pratensis* L. *Poaceae* H;Cosm.;5	✓	✓
87. *Stipa capillata* L. *Poaceae* H;Euras.;2	✓	✓

REFERENCES

Ciocârlan V., 1968. Flora şi vegetaţia bazinului subcarpatic al Slănicului de Buzău. Universitatea Bucureşti, Teză de doctorat, Bucureşti.

Ciocârlan V., 1969. Asociaţii vegetale noi din bazinul subcarpatic al Slănicului de Buzău. Lucr. Şt. Seria A - Agronomie, Bucureşti, vol 12: 367-372.

Ciocârlan V., 1969. Asociații vegetale noi din bazinul subcarpatic al Slănicului de Buzău (II). Şt. şi Cerc. Biol. Seria Botanică T.21, nr. 6: 419-427.

Ciocârlan V., 2009. Flora ilustrată a României: Pteridophyta et Spermatophyta. Ed. Ceres, Bucureşti.

Costache R., Fontanine Iulia, 2013. Land use changes in subcarpathian area between Buzău and Slănic rivers, during 1990-2006 and their consequences on surface runoff. Riscuri şi catastrofe, nr. XII, vol. 13/2: 171-182, Cluj.

Doniță N., Popescu A., Paucă-Comănescu Mihaela, Mihăilescu Simona, Biriş I.A., 2005. Habitatele din România. Editura Tehnică Silvică, Bucureşti.

Guşuleac M., 1960. Familia *Boraginaceae*. Flora RPR, vol. VII. Ed. Acad. RPR, Bucureşti.

Mircea S., Petrescu N., 2011. Indicators for gully erosion assesment on agricultural torrential watershed. Annals Food Science and techonology, vol. 12/1: 92-96 Târgovişte.

Muşat M., 2006. Studiul solurilor afectate de eroziune din zona colinară a bazinului hidrografic Slănic - Buzău în vederea stabilirii măsurilor de ameliorare şi stăvilire a procesului de eroziune. USAMVB, Teză de doctorat, Bucureşti.

Oprea A., 2005. Lista critică a plantelor vasculare. Editura Universității „A.I.Cuza”, Iaşi.

Sârbu I., Ştefan N., Oprea A., 2013. Plante vasculare din România: determinator ilustrat de teren. Ed. Victor B Victor, Bucureşti.

Ştirbu Clara Claudia, Ştefania Iordache, Cezarina Necula, Alexandra Teodora Radu, 2010. The influence of land management on soil erosion from Buzău hillcock area. Proceedings of the 3rd International Conference on Environmental and Geological Science and Engineering, Constanța, p. 32-35.

Țopa E., 1961. Familia Gentianaceae. Flora RPR, vol. VIII,. Ed. Acad. RPR, Bucureşti.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

FURROW OPENER WITH CONSTRAINED SEED FLOW

Cristian IACOMI, Octavian POPESCU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: cristian.iacomi@yahoo.co.uk

Abstract

A seeder should place seed in an environment for reliable germination. The main objective of sowing is to put seeds at a desired depth and spacing within the row. Uniform seed distribution within soil result in better germination and emergence and increase yield by minimizing competition between plants for available light, water, and nutrients. A number of factors affect seed distribution in soil. Seed metering system, seed delivery tube, furrow opener design, physical attributes of seed and soil conditions all play a part in determining seed distribution. The demand for uniform distribution into the soil of grain seeds and especially small grain seeds has increased during the last decade. Improvements had been made on new metering devices, furrow openers and grain flow. The present research was focused on improving seed distribution into the soil, regarding the furrow opener design and grain flow. Research was carried out in the Department of Mechanisation of the Faculty of Agriculture of the University of Agronomic Sciences and Veterinary Medicine of Bucharest and used a three row simulator of a conventional grain drill.

Key words: *conventional drills, furrow opener, seed distribution, uniformity.*

INTRODUCTION

What can you do with an old fashion gravity seed drill to give it extra performance and make it a good machine. The answer is to find out what can be done to improve some of its parameters. Uniform soil seed distribution was and is a major target with all major manufacturers of conventional grain drills in the world. Usually, the research was focused more on development of furrow openers and less on grain flow. The present research was focusing both on the flow of small grains (winter wheat) from the metering devices to the furrow opener and to study the changes of laying seeds into the soil. For this a simulator based on a conventional gravity drill was manufactured using parts and recicled parts of an old one. This simulator was tested and changes were made mainly in the flow of seeds within the furrow opener. Further researches are carrying on to cover the flow from the metering devices to the furrow opener and the results will be presented in future papers.

MATERIALS AND METHODS

The simulator (Figure 1) was manufactured more than 90% of recycled components and coppied entirely a real drill, except the fact that the seed bulk was designed to supply seeds for three rows instead of 29 or more rows. To simulate the passing over the field a fabric belt soaked in oil was used so the seeds were easily sticked.

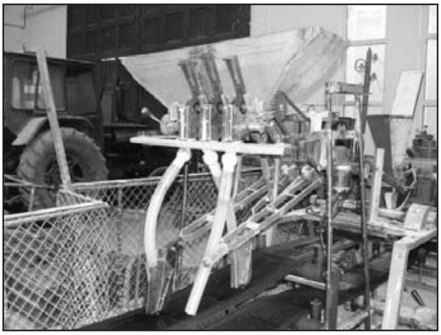


Figure 1. The conventional three row drill simulator

This belt was powered by an AC electric motor and covered two speeds (low speed and high speed). To simulate different seed rates, the metering device was powered by a 12 V DC electric motor and through the help of various ratios obtained by a chain drive transmission it could be covered up to 6 different rates (Figure 2).
After each test the sticked seeds were pictured and the quality of seed distribution on the belt was measured and also the number of seeds per

meter. For each test there were used just two furrow openers, one classic opener and the second one modified according to the protocols (Figure 3).

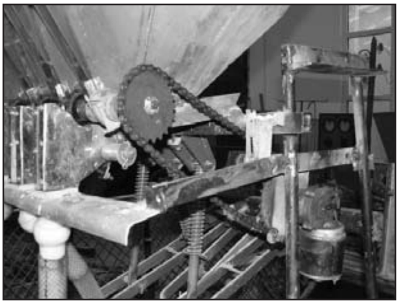


Figure 2. The chain drive transmission

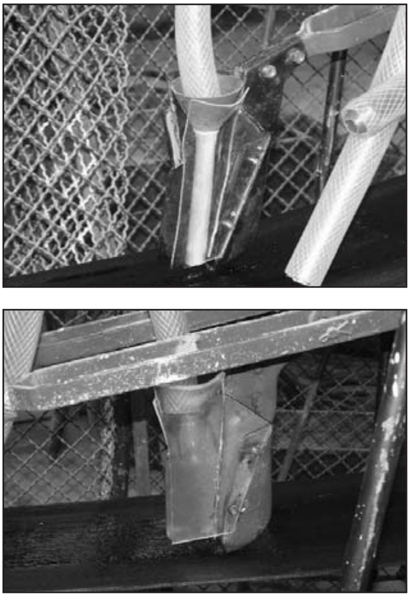


Figure 3. A modified and a classic opener

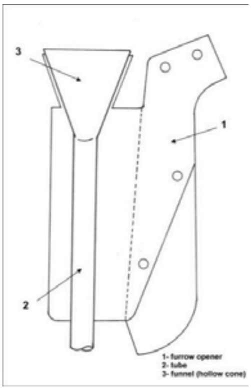


Figure 4. The vertical tubular device in the furrow opener

In this research the modified opener used an original design of a cone and tube device fixed in a classic opener wings, to narrow the channel of seeds but to properly keep the flow of seeds. The entire research used three different shapes of the tube, one vertical, one curved and the third of a narrow ***S*** shape (Figures 4, 5 and 6).

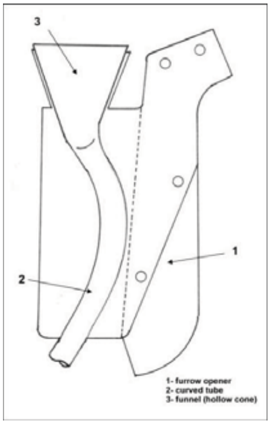


Figure 5. The curved tubular device in the furrow opener

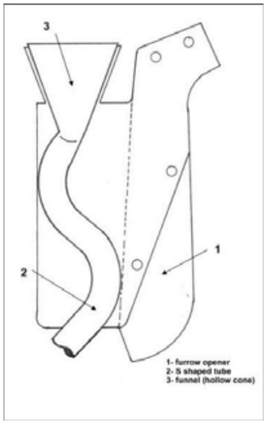


Figure 6. The ***S*** shaped tubular device in the furrow opener

RESULTS AND DISCUSSIONS

After each test the sticked seeds were measured as they were spread over the belt (quality factor) and as number of seeds per meter (quantity factor).
For each trial a number of five tests were done. Tests using vertical and curved devices showed none or minor improvement in longitudinal seed distribution.

But the great results were obtained using the ***S*** shaped device.The tests results for winter wheat seeds using the ***S*** shaped device are shown briefly in table 1.

As shown in figure 7 and figure 8 the tests shown an improvement in longitudinal seed distribution using this modified opener.

All tests with this type of device showed that modified opener was keeping seeds together and the gaps which appeared using the classical openers had a trend to dissapear, performing an improved longitudinal distribution of seeds.

Table 1. Longitudinal seed distribution specs

Trials	Band speed	Seed metering ratio	No. of seeds/ meter (classic/ modified opener)	Quality factor (longitudinal distribution)	
				classic opener	modified opener
V1_1	Low	30/22	120/116	G	I
V1_2	High	30/22	95/89	G	I
V2_1	High	30/16	108/112	G	I
V2_2	Low	30/16	123/131	G	I
V3_1	Low	30/10	142/158	G	I
V3_2	High	30/10	134/126	G	I
V4_1	High	30/9	141/150	G	I
V4_2	Low	30/9	165/156	G	I

G- grouped seeds; I- improved longitudinal distribution

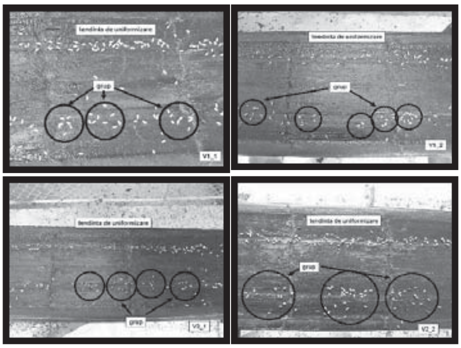


Figure 7. Improvements in longitudinal seed distribution (trials V1_1, V1_2, V2_1, V2_2)

For each trial a number of five tests were done. As shown in figure 4 and figure 5 the tests shown an improvement in longitudinal seed distribution using various modified openers.

All tests showed that modified openers were keeping the seeds together and te gaps which appeared using the classical openers have had a trend to dissapear, performing an improved distribution of the seeds.

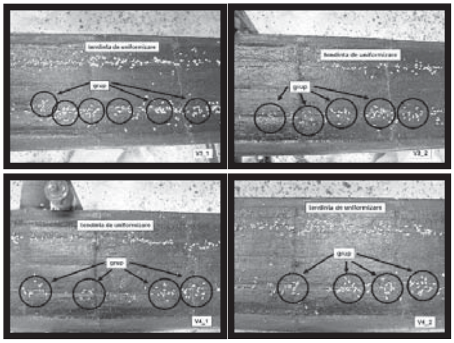


Figure 8. Improvements in longitudinal seed distribution (trials V3_1, V3_2, V4_1, V4_2)

CONCLUSIONS

1. Lab tests shown that it was possible to get a better longitudinal seed distribution into the soil for conventional grain drills, using modified openers.
2. No impediments and obstructions were observed in the flow of seeds from the mettering device to the furrow opener.
3. The seed rates in various tests were kept within resonable limits without any exceptions.
4. Further tests will be done using different devices adapted for classical openers to show the influence of the shape of the narrowed channel on the longitudinal seed distribution.

REFERENCES

Iacomi C., 2005. Mecanizarea agriculturii. Ed. Cartea Universitară. Bucureşti.

Kepner R., Bainer R., Barger E., 1978. Principles of Farm Machinery, ASAE Book.

Lerat P., 1999. Les machines agricoles. Ed.TEC&DOC. Paris.

Popescu S., Şandru A. ş.a., 1983. Exploatarea utilajelor agricole, EDP. Bucureşti.

Scripnic V., Babiciu P., 1979. Maşini agricole. Ed.CERES. Bucureşti.

Srivastava A., Goering C., Rohrbach R., 1993. Engineering Principles of Agricultural Machines. ASAE Book.

Şandru A. şi colab., 1971. Exploatarea agregatelor agricole. Ed. CERES, Bucureşti.

Toma D., Sin Gh., 1987. Calitatea lucrărilor agricole executate mecanizat. Ed.CERES. Bucureşti.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

DROUGHT IN ROMANIA. EFFECTS AND ADAPTIVE STRATEGIES

Lucian Horia IORDAN

National Agriculture Research and Development Institute Fundulea, Călăraşi County,
Nicolae Titulescu Street, nr. 1, Romania

Corresponding author email: iordanhoria@gmail.com

Abstract

Climate change is manifested by increased average temperature and reduced precipitation amounts, that determined in recent decades, a growth in drought affected surfaces in our country and worldwide with repercussions on economically, socially and environmentally development. This creates one of the largest challenges facing humanity due to its disastrous effects: increasing air and water temperature, increased risk of floods, drought, drinking water depletion, increased risk of fires that reduce vegetable and animal natural resources and leads to degradation of ecosystems.

***Key words**: Climate change, temperature, precipitation, drought, effects, adaptive strategies.*

INTRODUCTION

Global climate change generates some of the greatest challenges facing humanity at present, due to the disastrous effects induced by increased air and oceans temperature, increased risk of floods, droughts, water shortages, increased risk of fire that reduce vegetal and animal resources, changes in ecosystems and natural resource degradation, increased risk of illness. In Europe, climate change affects all regions of the continent, and the effects of these changes are increasingly visible in our country, where in recent years there have been disastrous events of great magnitude, such as heat and drought, rainfall and catastrophic floods, extreme weather phenomena (tornado type), alteration of traditional seasons. All these disasters have made a strong impression on the socio-economic life of our country registering many casualties and considerable property damage among the population, and at community level, in terms of economic units and social infrastructure.

Climate warming is a phenomenon widely accepted by the international scientific community, as already pointed out by analyzing observational data over long periods of time.

Addressing the effects of climate change is a priority in the strategic development of the EU member countries and beyond.

MATERIALS AND METHODS

Modelling climate and projected changes in climate is a resource-intensive research activity, usually involving supercomputers and a multidisciplinary approach. These disciplines range from socio-economics (scenarios), to computing, physics, chemistry (climate models) and Earth and life sciences (impact models), as well as statistics and probability (analysis). To set up and run a climate "experiment", using a computer model to simulate 100 years of climate evolution on a global scale, can take weeks or months. Analysis of the results takes even longer.

THE WCRP CMIP3 MULTIMODEL DATASET

A New Era in Climate Change Research

The history of climate change modeling was first characterized in the 1980s by a number of distinct groups developing, running, and analyzing model output from their own models with little opportunity for anyone outside of those groups to have access to the model data.

The down-scaled climate model information will help to contribute to the proper depiction of meteorological forcing mechanisms responsible for extreme precipitation events. Understanding these contributing variables to extreme precipitation events and how they might change under future climate conditions is important to assessing the potential risks of more frequent or more intense storms. Furthermore, identification of regions with increasing/decreasing potential for extreme rainfall events could serve as an important decision-making consideration for future planning.

In response to a proposed activity of the World Climate Research Programme's (WCRP's) Working Group on Coupled Modelling (WGCM), PCMDI (Program for Climate Model Diagnosis and Intercomparison) volunteered to collect model output contributed by leading modeling centers around the world.

Climate model output from simulations of the past, present and future climate was collected by PCMDI mostly during the years 2005 and 2006, and this archived data constitutes phase 3 of the Coupled Model Intercomparison Project (CMIP3). In part, the WGCM organized this activity to enable those outside the major modeling centers to perform research of relevance to climate scientists preparing the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). The IPCC was established by the World Meteorological Organization and the United Nations Environmental Program to assess scientific information on climate change.

RESULTS AND DISCUSSIONS

Drought definition

In 1977 Passioura said about drought tolerance that: „is like an unknown factor that keeps increasing the more you look at it". Drought can be defined as an extreme condition, characterized in that a region suffers from lack of water, accompanied by heat.

Drought can be classified as:

Meteorological drought - occurs over a longer period of time and is manifested by complete or partial lack of rainfall.

Agricultural drought - existence of a sufficient amount of water needed for agriculture (derived from rainfall or groundwater).

Hydro-geological drought - substantial decrease in the level of water (groundwater reservoir), the rivers and backwaters.

As *forms* of drought we distinguish: soil and atmospheric drought.

Soil drought occurs frequently at the beginning and during the summer, as a consequence of insufficient rainfall.

Atmospheric drought (lack of water in the atmosphere (10-20%).

How does drought occurs

The cause: deficiency precipitation, soil degradation, increasing ocean water temperature, increasing the concentration of carbon dioxide in the atmosphere. In recent years there is more and more talking about global warming, ozone decrease, greenhouse effect, catastrophic drought and its effects on nature and human life. Climate changes caused by humans are becoming increasingly apparent, and researchers agree that the main cause of this phenomenon is the burning of fossil fuels. The specialists point out that droughts and phenomena generated by it are caused by changes in the general circulation of the atmosphere, by the greenhouse effect and also by manifestation of some anthropogenic causes, due to wasteful use of resources, deforestation and changes in landscape with negative effects on the water balance.

Climate changes are presently a great concern worldwide. According to the 4th Report of IPCC, climate scenarios made with different global climate models, predicted an increase in global average temperature by the end of XXI century (2090-2099), compared to the period 1980-1990, between 1.8ºC and 4.0°C, depending on the scenario considered for greenhouse gases emissions. At the same time major changes of rainfall regime are expected, as well as an increased frequency of extreme weather events.

These patterns of climate change conclude the following effects:

- temperature across Europe increased by nearly one degree Celsius, more than the overall rate of warming (0.74°C);
- currently, the concentration of greenhouse gases in the atmosphere exceeds the values recorded in the last 650,000 years and projections indicate an unprecedented increase;
- by 2100, global temperature will be higher with 6.3°C, and ocean levels will rise with approximately 58 cm;
- the frequency, occurrence and intensity of

extreme weather events (storms, tornadoes, hurricanes) has been increased;

- regional patterns of climate and rainfall (heat waves, droughts, floods) have changed, and trends indicate a gradual increase in the coming years;
- decreased thickness of Arctic glaciers and the area occupied by them (by 40% over the last 30 years), possibly their complete disappearance until 2100;
- development of mutations in biosystems: Early flowering plant species, species extinction of amphibians etc.

Ecoclimatic change impact in ROMANIA

Romania has already suffered important climate modifications in the last years.

The complexity of the climate system, the different nature of the components that compose it (atmosphere, ocean, cryosphere, biosphere, lithosphere) and the interactions between them, require the use of highly complex numerical models, which are based on systems of equations associated with the laws of physics. Influence of anthropogenic factor introduces uncertainty over the evolution of greenhouse gas emissions in the future.

Romanian researchers' studies have helped refine the region projection methodologies in order to predict global warming. Statistical modeling methods were used and applied to global climate model results (Figures 1, 2, and 3) and conducting numerical experiments with regional climate models and analyze their results together with observed data in order to highlight the mechanisms by which local factors modulate climate changes (Figure 4).

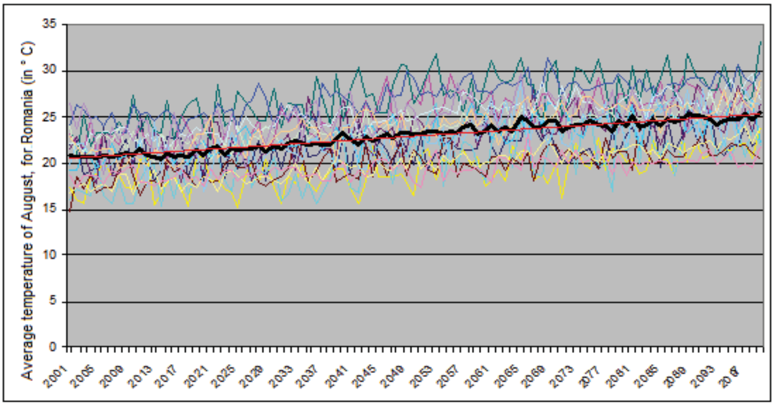


Figure 1. Progress regarding the average temperature of August, for Romania (in °C) for 16 climate models and ensemble average (black); tendency for multimodel average (red line). A1B scenario is used and it shows the averages of 17 climate models extracted from the CMIP3 database

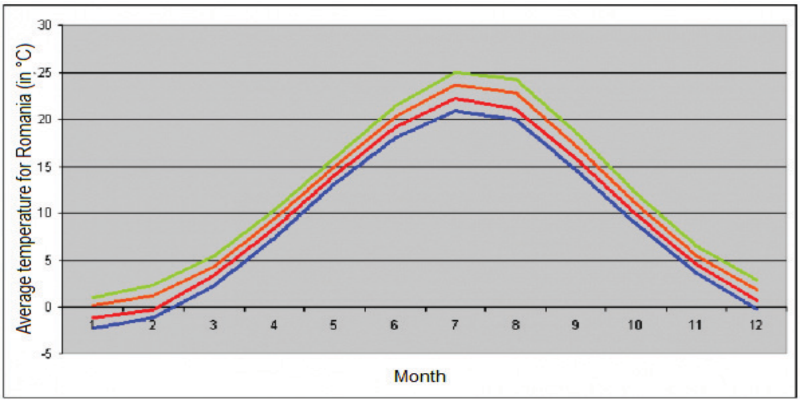


Figure 2. Seasonal cycle of temperature for the corresponding intervals between 1961 and 1990 (blue), 2001-2030 (red), 2031-2060 (orange) and 2061-2090 (green) average temperature for Romania (in °C). A1B scenario is used. The averages of 17 climate models were used and extracted from the CMIP3 database

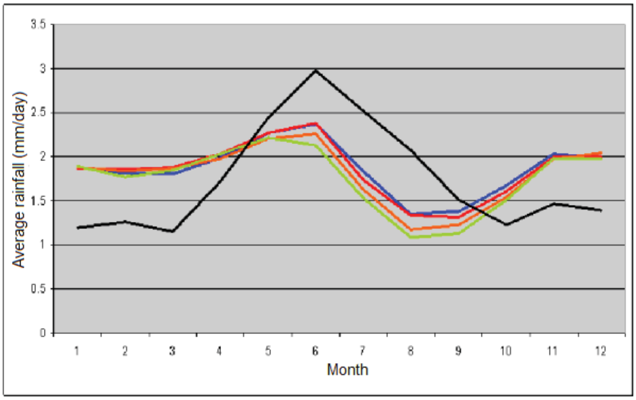


Figure 3. The seasonal cycle of rainfall for appropriate intervals 1961-1990 (blue), 2001-2030 (red), 2031-2060 (orange) and 2061-2090 (green) if the monthly average is analyzed for Romania (daily rate rainfall (in mm). A1B scenario is used. With black to represent the seasonal cycle of daily precipitation rate for Romania, calculated from the data of observation at meteorological stations. The averages of 17 climate models were used and extracted from the CMIP3 database

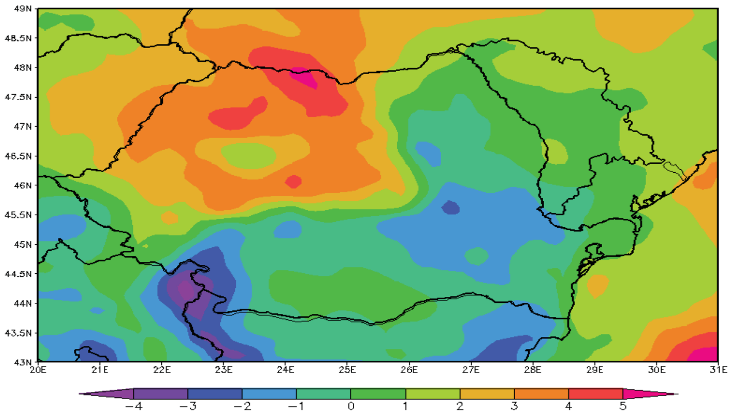


Figure 4. Change in annual rainfall amount estimated for 2001 to 2030 (in%) (reference period - 1961-1990) according to the A1B scenario. The results of a series of 11 experiments were used as stated by the regional climate models from FP6 ENSEMBLE project

Based on the research conducted by the National Agency of Meteorology, the future changes in regime of climate in Romania will fit into the global context, with specificity for the geographic region where our country is located. A warming similar to that projected for Europe, between 0.5°C and 1.5°C for the period 2020-2029 and between 2.0°C and 5.0°C for 2090-2099 is expected (Busuioc et al., 2010). In terms of rainfall, for the period 2090-2099, over 90% of forecast models, predicted drought during the summer in Romania, especially in the south and southeast, with negative deviations of more than 20% as compared with 1980-1990 (Christensen et al., 2007; Sandu et al., 2010).

Climate models simulate global climate system evolution under increased atmospheric concentration of greenhouse gases, based on the laws of physics using numerical methods. Climate scenarios are based on projections of rising global emissions of greenhouse gases and aerosols are subject to social and economic factors (population growth, economic development, technological change anticipated). A1B emissions scenario (IPCC, 2007) assumes a moderate increase in the concentration of greenhouse gases for the XXI century.

Romania will be basically divided into two distinct areas - northern half will be affected more by rainfall and low temperatures, while the south will get high temperatures that will cause desertification in some areas.

Biodiversity, agriculture, water resources, forestry, infrastructure, energy, tourism and public health are just a few of the areas that will be heavily affected by these ecoclimatic changes.

Below we can see climatic weather scenarios for Romania. In the figure 5, the average of a set of numerical experiments was used with nine regional models, under A1B scenario (European FP6 ENSEMBLE project). In the figure 6 the average of a set of numerical experiments was used with nine regional models, under A1B scenario (European FP6 ENSEMBLE project).

EXTREME EVENTS AND WEATHER RELATED NATURAL DISASTERS following these climatic changes.

Drought and desertification affect sustainable development through interrelations with social problems and enhances them:

- heavy rains / floods, landslides, hail, lightning, ice, avalanches, storms, blizzards, droughts, heat waves, cold waves;
- reduction in water reserves, potential for food production and thus food security for the population;
- poverty, the most serious dysfunction in areas affected by these phenomena;
- deterioration of human health due to inadequate food consumption, generating anemia, malnutrition and malnutrition.

STRATEGIES FOR MITIGATION AND ADAPTATION TO CLIMATE CHANGE

Strategies that can be implemented to adapt to climate change are:

- developing integrated programs to reduce spoilage and anthropogenic influence on watershed geomorphology, preserving the natural flow and preserving biodiversity, conservation and restoration of natural areas in the sectors identified with risk floods;
- measures to increase the capacity of multiannual regularization of water flow;
- encouraging investment in hydrographic infrastructure; providing support to increase water use efficiency in agriculture and technological measures to adapt crops to become more resistant to drought and low amounts of water;
- promote land use management;
- promoting integrated information system for climate change adaptation;
- support measures in order to extend natural forest barriers (including forest plantations);

promotion of environmental friendly technologies in forestry activities.

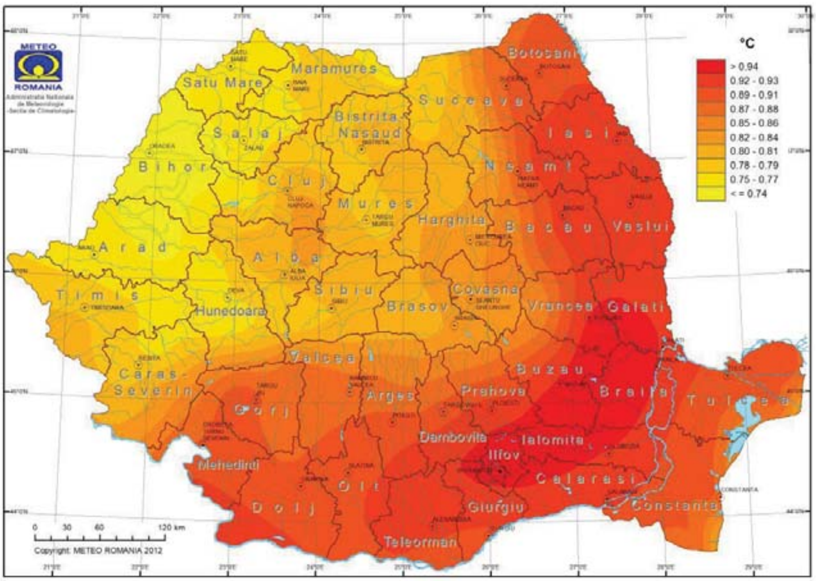


Figure 5. Average annual temperature increase (° C) between 2001-2030, compared to the reference period 1961-1990 (European FP6 ENSEMBLE project)

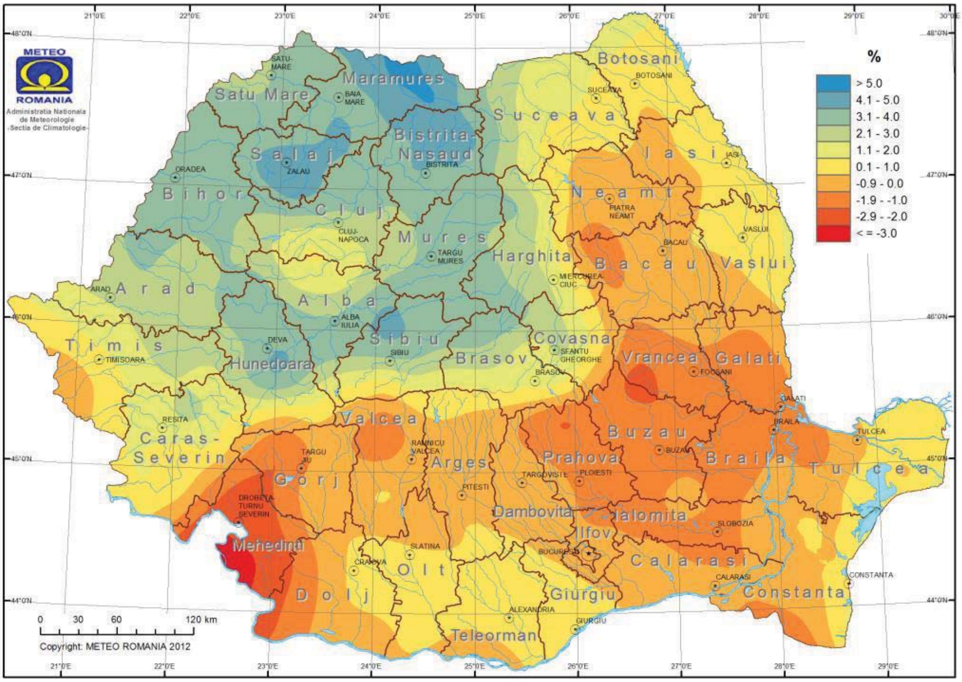


Figure 6. The difference in annual average precipitation amount (%) between the period 2001-2030 and standard climatological normal (for precipitation) (1961-1990) (European FP6 ENSEMBLE project)

CONCLUSIONS

Climate change affects the entire planet, with repercussions on the entire population, economically, socially and environmentally aspect. They provide one of the greatest challenges facing humanity at present, due to the disastrous effects induced by the increase of air and oceans temperature, increased risk of floods, droughts, diminishing drinking water supplies, increased risk of fire and reduction of plant and animal natural resources, changes and degradation of ecosystems and natural resource degradation, increased risk of ill health.

The effects of these changes are increasingly visible in our country. The Romanian climate has suffered and will suffer more radical changes that will impact many human settlements defining characteristics.

REFERENCES

Baciu M., Busuioc A., Breza T., 2004. Spatial and temporal variability of meteorological phenomena frequency in the cold season. Romanian Journal of Meteorology, vol.6, nr 1-2, 27-39.

Busuioc et al., 2010. Variabilitatea şi schimbarea climei în România. Ed. Pro Universitaria, ISBN 978-973-129-549-7, Bucuresti, p. 1-226.

Boroneant C., 2002. Anthropogenic Climate Influences. In "Natural Resource System Challenge II: Climate Change, Human Systems and Policy" (Ed. A. Yotova) - Encyclopedia of Life Support Systems, EOLSS Publishers Co., Oxford, UK, http://www.eolss.net/B.aspx

Brierley C.M., Thorpe A.J., Collins M., 2009a. An example of the dependence of the transient climate response on the temperature of the modelled climatestate. AtmosphericScience Letters 10, 23–28.

Collins M., Brierley C.M., Mac Vean M., Booth B.B.B., Harris G.R., 2007. The sensitivity of the rate of transient climate change to ocean physics perturbations. Journal of Climate 20, 2315–2320.

Christensen J.H., Hewitson B., Busuioc A., Chen A., Gao X., Held I., Jones R., Kolli R.K., Kwon W.T., Laprise R., Magana Rueda V., Lmearns C., Menendez G., Raisanen J., Rinke A., Sarr A., Whetton P., 2007. Regional Climate Projection. In: Climate Change 2007: The Physical Sciernce Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernamental Panel on Climate Change, edited by S. Solomon et al., chap. 11, Cambridge Univ. Press, New york, p. 847-940.

Passioura J.B., Angus J.F., 2010. Improving Productivity of Crops in Water-Limited Environments. Advances

in Agron., Vol. 106, Burlington: Acad. Press, p. 37-75.
Mariana S., Dumitru C., Cristina H., 2010. Impactul schimbărilor ecoclimatice recente asupra calității vieții. Calitatea vieții, XXI, nr. 3-4, 231-237.
Müller W.A., Roeckner E., 2008. ENSO teleconnections in projections of future climate in ECHAM5/MPI-OM. Climate Dynamics 31, 533-549.
Rimbu N., Boroneant C., Buta C., Dima M., 2002. Decadal variability of the Danube river streamflow in the lower basin and its relation with the North Atlantic Oscillation. International Journal of Climatology, 22, 1169-1179.
Sillmann J., Roeckner E., 2008. Indices for extreme events in projections of anthropogenic climate change. Climatic Change 86, 83-104.
Stainforth D.A., Aina T., Christensen C., Collins M., Faull N., Frame D.J., Kettleborough J.A., Knight S., Martin A., Murphy J.M., Piani C., Sexton D., Smith L.A., Spicer R.A., Thorpe A.J., Allen M.R., 2005. Uncertainty in predictions of the climate response to rising levels of greenhouse gases. Nature 433, 403-406.
Van der Linden P., Mitchell J.F.B. (eds.). 2009. ENSEMBLES: Climate Change and its Impacts: Summary of research and results from the ENSEMBLES project. Met Office Hadley Centre, FitzRoy Road, Exeter EX1 3PB, UK, p. 1-160.
***, Administrația Națională de Meteorologie, Guvernul României, Ministerul Mediului, Apelor şi Pădurilor - (http://www.meteoromania.ro/anm/?page_id=1211).
***, Intergovernmental Panel of Climate Change (IPCC 2007), Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri R.K., Reisinger A.]. IPCC, Geneva, Switzerland, p. 1-73.
***, Ministerul Mediului şi Pădurilor, 2012. Strategia Națională a României privind Schimbările Climatice 2013 - 2020, p. 3-70.
***, Ministerul Mediului-strategia națională pentru dezvoltare durabilă, 2008. Dezvoltarea durabilă la nivel mondial, »Strategia Națională pentru Dezvoltare Durabilă a României Orizonturi 2013–2020–2030 »Național Sustainable Development Strategy România 2013–2020–2030 *(http://www.mmediu.ro/beta/domenii/dezvoltare-durabila/strategia-nationala-a-romaniei-2013-2020-203/)*
***, Ministerul Mediului şi Schimbarilor Climatice, Elaborator: dr. ing. Cornel F. G., 2013. Raport de mediu: Strategia Natională şi Planul Național de Actiune pentru Gestionarea Siturilor Contaminate din România, p. 3-59.
***, Ministerul Mediului şi Pădurilor Agenția Națională pentru Protecția Mediului, 2012. Raport național privind starea mediului pentru anul 2011, 193-216.
***, Program for Climate Model Diagnosis and Intercomparison, About the WCRP CMIP3 Multi-Model Dataset Archive
(http://www-pcmdi.llnl.gov/ipcc/about_ipcc.php)

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ARIEŞ RIVER VALLEY AS MIGRATION CORRIDOR FOR ALIEN PLANT SPECIES AND CONTAMINATION SOURCE FOR THE SURROUNDING GRASSLANDS AND AGRICULTURAL FIELDS

Marilena ONETE[1], Roxana ION[1], Larisa FLORESCU[1], Minodora MANU[1], Florian Paul BODESCU[2], Aurora NEAGOE[2]

[1]Institute of Biology Bucharest of the Romanian Academy,
Spl. Independenței 296, Sector 6, 060031, Bucharest, Romania
[2] CESEC, Bucharest University, Spl. Independenței 91-95, Sector 5, Bucharest, Romania

Corresponding author email: marilena.onete@gmail.com

Abstract

In the Transylvanian region, the Arieş Valley stretches along the course of the Arieş River, ending as tributary of Mureş River. As well as these areas of great biodiversity value, the Arieş Valley (drainage area of 2,540 km^2) also crosses the region where local people set their villages and towns and use the surrounding areas as grasslands for grazing, mowing and fields for agriculture. The grassland types are present in patches, those used for hay production are scattered among agricultural fields and human settlements.
Evidence from statistical analysis of the vegetation cover of a riparian area of Arieş River Valley indicates that in the inventorying plots with low species diversity, there is a dominance of one or two species with individuals unequally distributed within and between plots. The layer 1-5 m is dominated by alien invasive species: *Fallopia japonica, Helianthus tuberosus, Impatiens glanduligera,* the studied area of Arieş River Valley becoming a source for these alien species to invade the surrounding grasslands and agricultural fields. Especially *Fallopia japonica* individuals form compact patches invading the pastures and agricultural fields and the local farmers cannot use the land any more for fulfilling their own needs. The invasive species replace the native species from the grasslands and make the agricultural field inappropriate for crops cultivation. The river acts as a migration corridor for the alien species helping them to spread by seeds or fragments and invade new places, especially during spring and/or autumn floods, and a contamination source for the surrounding grasslands and agricultural fields.

Key words: *alien, Arieş, corridor, migration, plants*.

INTRODUCTION

Rivers of the world connect large areas and diverse landscapes. River valleys are mostly regarded as ecological corridors related with the conservation biology and nature conservation (Gallé et al., 1995; Dombrowski et al., 2002). The riparian zones are the most important structural and functional elements connecting aquatic and terrestrial areas (Malm Renöfält, 2004; Rodriguez-Iturbe at al., 2009). Riparian zones, comprising ecosystems situated along the different type of water bodies, are the subject of alien/non-native/exotic plants invasion, playing an important role as a corridor especially at the regional scale in their spread and establishment in the native plant communities (Souza et al., 2011). The riparian zones also behave as filters for nutrients, critical areas for biogeochemical processes, providers for resources and shade, stabilization of stream banks, etc. (Rodriguez-Iturbe et al, 2009). These corridors are hydrological connected, this connection being both the cause of the high species diversity and serve as dispersal vector for alien species invasion (Miyawaki and Washitani, 2004; Malm Renöfält et al., 2005 Kalusová et al., 2014)
Studies developed on rivers of the world (inland waterways) as corridors for invasion enable predictions about: increase in the rate of colonization, increase in the diversity of donor area and the origin of alien species, diversification of the vector of spread, increase of speed of colonization, strong shift of the taxonomic structures of the communities, dramatic reduction (occasionally local extirpation) of native species, invasive exotic species becoming a vector of spread for highly pathogenic parasites and diseases (Parker et al., 1999; Sher and Hyatt, 1999; Slynko et al., 2002; Karatayev et al., 2008; Rood and

Kalischuk, 2008; Hejda et al., 2009; Panov et al, 2009, Resasco et al., 2014).

The migration of a species consists in any change in its spatial distribution or any change in distribution of successfully established mature plants along its life cycle and generations (Sauer, 1988; Turnbull et al., 2007; Gardner and Engelhardt, 2008). The species occurring naturally in an area dispersing independent of human intervention are defined as native (indigenous) species. The species not occurring naturally in an area (it has not long history) and its dispersal depends on direct or indirect human intervention are defined as alien/non-native/non-indigenous/exotic. The alien are defined as naturalized species when, following introduction, the species established self-sustaining populations in the wild and have a long history together with native species in the resident communities. The native and alien plant species become invasive when ones established in natural or semi-natural habitats they change and threaten native biological diversity and ecological processes and cause economic losses (Panov et al., 2009; Sîrbu and Oprea, 2011; SRBMP, 2013).

The main factors determining the spread of the alien species are: disturbance regime gradient, physic, chemical and geo-morphological attributes, influences of humans and climatic (Planty-Tabacchi et al., 2001; Ervin et al., 2006; Montserrat et al., 2007; Früh et al., 2012; Moles et al., 2012).

Disturbance and propagule pressure are regarded as individual factors that strongly influence invasion process (Kinlan and Gaines, 2003; Britton-Simmons and Abbot, 2008; Früh et al., 2012).

The alien species are widely investigated in respect for species diversity, temporal trends, geographical patterns and ideas have been identified for future research (MacIsaac et al., 2001; Heger and Trepl, 2003; Lambdon et al., 2008; Moles et al., 2003; Török et al., 2003; Pienimäki and Leppäkoski, 2004; McGeoch et al., 2006; Zaiko et al., 2011).

The invasion of alien plant species is regarded as one of the biggest threat of the Romanian biodiversity (Anastasiu and Negrean, 2005). The alien invasive and potentially invasive plant species from the Romanian territory have been identified and the impact on natural and semi natural habitats were assessed for prevention and control measures (Anastasiu and Negrean, 2005, 2006, 2008, 2009; Dihoru, 2004; Sîrbu and Oprea, 2010) and preliminary studies were developed on wetlands (Anastasiu et al., 2008). A very comprehensive work regarding the adventive plant species from Romanian Flora was published by Sîrbu and Oprea (2011).

The richness and diversity of vegetation on Arieş catchment area was studied over decades but the studies were focused mainly on calcareous sites, gorges, and other interesting sites from the floristic point of view and recently on grasslands between Lupşa and Turda (Pál, 2010).

Are lacking studies focused on slopes, banks and floodplain of Arieş River Valley.

MATERIALS AND METHODS

In the Transylvanian region, the Arieş River Valley stretches from west to east the Gilău-Muntele Mare Massif in the left and Metaliferi Mountains in the right, ending as tributary of Mureş River. The present hydrogeomorphology is due to the human activity along the centuries, intensified in the last decades resulting in major changes of the natural relief. The numerous human settlements and ore mining activities modified the natural environment provoking intensified erosion and pollution processes, forming quarries, dumps tailing ponds and artificial terraces (Pál, 2010).

As well as these areas of great biodiversity value, the Arieş Valley (drainage area of 2,540 km^2) also crosses the region where local people set their villages and towns and use the surrounding areas as grasslands for grazing, mowing and fields for agriculture. Friedel and Linard (2008) stipulate that in the Arieş River basin the lad use categories comprise: pasture, 19.9%; range (grasses), 15.8%; and agricultural (generic and row crops), 13.8%. The areas at the confluence with Seşii Valley (belonging to the middle sector of Arieş River Valley) had been chosen because the water rich in pollutants from Seşii rivulet flows into Arieş River and percolate in the surrounding areas being a major disturbing driver in the area (Figure 1).

The maximum altitude is 478 m a.s.l. and the minimum altitude is 464 m a.s.l. due to the irregularities of the studied area. Scattered among higher areas are low areas where the water is retained for longer time during year, following the flooding, forming small wetlands with hygrophilous vegetation.

In 2014 we recorded the species composition and percentage cover of the vegetation in 91 plots, each of 2 m^2 (Figure 1). The plots were set in the riparian area to cover 92,500 m^2 representing the total coverage of the riparian vegetation. The plots were numbered starting with those in the vicinity of water course, beginning from the new formed area due to the river meander, going on rows, alternatively, till the riparian area ended in private grasslands and agricultural fields.

In every plot we recorded the vascular plant species according with the natural height layers: 0-1 m (herbaceous and new offsprings of tall herbaceous, shrubs and trees), 1-5 m (tall herbaceous, shrubs and offsprings of taller shrubs and trees), 5-15 m (tall shrubs and small trees and offsprings of tall trees) and 15-30 m (tall trees). Species identification and synonymy, their natural spread and ecological characterization were accomplished according with Ciocârlan (2009) and Sârbu et al. (2013).

From the total number of 150 vascular plant species recorded, in the present paper we highlight only alien species.

For the statistical analysis we used XLSTAT 2014.2.06 and it comprise Multidimensional Scaling (MDS) for 0-1 m height layer level and Bray-Curtis similarity (single linkage) for 1-5 m height layer level.

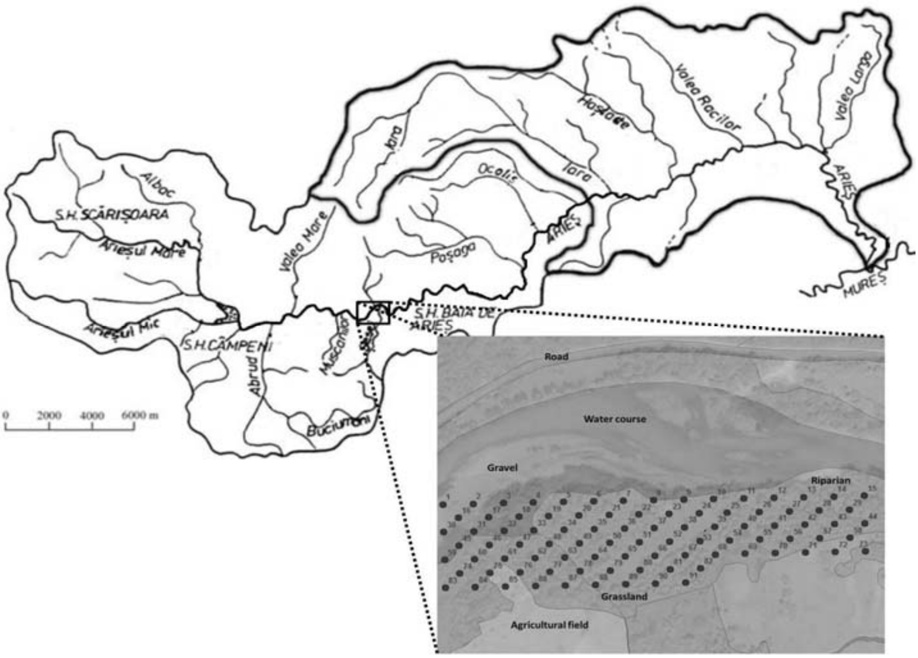


Figure 1. Arieş River basin – hydrometric network map (modified after Socorovchi et al., 2002). Studied area and the location of sampling plots on Arieş Valley at the confluence with Seşii Valley

RESULTS AND DISCUSSIONS

The grassland and agricultural fields are present on Arieş River Valley in small patches, those used for hay production are scattered among agricultural fields and human settlements. In the area where the sampling plots were settled, the grassland and agricultural fields are small private areas, in the mosaic of riparian areas along Arieş River.

The percentages of the species presented below are bases on the presence-absence of the species in the total number of investigated plots. In the layer 0-1 m height we registered: 3.34% *Erigeron annuus* (L.) Pers. (*Stenactis annua* (L.) Less.), 0.89% *Fallopia japonica*

(Houtt.) Ronse Decr. (*Polygonum cuspidatum* Siebold et. Zucc.; *Reynoutria japonica* Houtt.), 0.44% *Galinsoga parviflora* Cav*,* 1.45% *Lysimachia nummularia* L., 0.78% *Oenothera biennis* L., 1.11% *Oxalis fontana* Bunge (*O. stricta* auct. non L.; *O. europaea* Jord.), 0.56% *Robinia pseudoacacia* L.

The Multidimensional Scaling (MDS) for 0-1 m height layer level shows the structural similarity among the plots. The isolated plots are those situated in the patches formed by agricultural fields, grasslands and newly formed areas of the river meander (Figure 2).

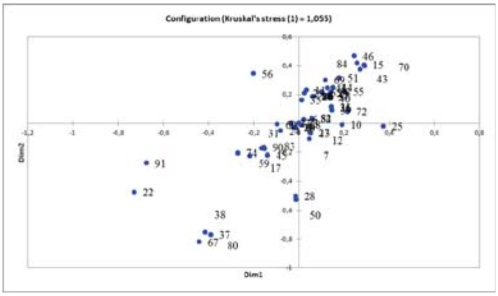


Figure 2. The Multidimensional Scaling (MDS) of the sampling plots based on the percentage coverage of the recorded plans species for 0-1 m height layer

The highest species diversity is in the grasslands and agricultural fields, these areas comprising also the offspring of both invasive rhizomatous herbaceous perennial knotweed species (*F. Japonica*) and tree *R. pseudoacacia*. The species diversity is low in the layer 1-5 m height, this being dominated by alien herbaceous adult species: the annual *Impatiens glanduligera* (3.83%), perennial *Fallopia japonica* (49.53%) and, *Helianthus tuberosus* (4.50%), and saplings of tree *Robinia pseudoacacia* (1.69%). The total coverage of this layer consists from the coverage of shrubs, saplings of trees, tall perennial herbaceous and annuals as it is shown in Bray-Curtis similarity Bray-Curtis (single linkage) (Figure 3).

The dominance of 1-5 m height layer (Figure 4) is due to tall herbaceous native perennial *Dryopteris filix-mas* (L.) Schott in the most plots growing together with *Fallopia japonica* displaying the same coverage in the investigated plots.

Robinia pseudoacacia is present in 17.65% of the plots in the layer 5-15 m height together with native shrubs and trees, and in the layer 15-30 m height, the species is present in 14.37% of the plots together with other tall trees characteristic for riparian Arieş River Valley.

The spatial distribution analysis of the species in the plots (Figure 4) highlighted that the most representative layer is 1-5 m height comprising all the alien species recorded in the area. The species density (above ground biomass) in most of the plots allows only a few native shrubs (Figure 3) and trees to survive, the only survivors being old trees established before the mass development of the alien species.

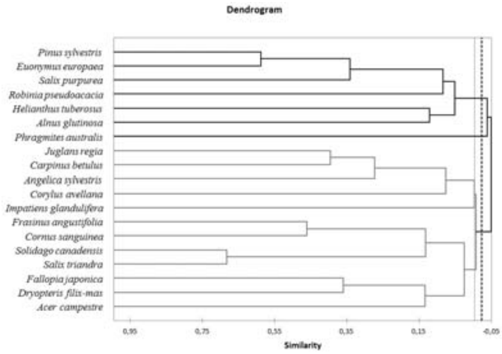


Figure 3. Similarity among the species coverage based on the percentage coverage of recorded vegetation of 1-5 m height layer

Apart of heavy metal pollution, another impact on old trees is their cutting by humans for fire or other purposes.

The clearing of the riparian forests creates gaps suitable for alien species allowing them to invade the riparian territory and surrounding areas.

All the herbaceous perennial species inventoried in the riparian area of Arieş River Valley are clonal plants, the predominant vegetative reproduction make them more resistant to the disturbance occurring in the riparian area, including water and soil pollution. The ramets can escape the intense polluted patches and find the more suitable patches in the nearby areas (Kershaw, 1980). Alien invasive species are able to change ecosystem function and soil properties, they have a highly significant negative impact for denitrifiers abundance, modify the potential microbial activity ecosystems (Dassonvile et al., 2011).

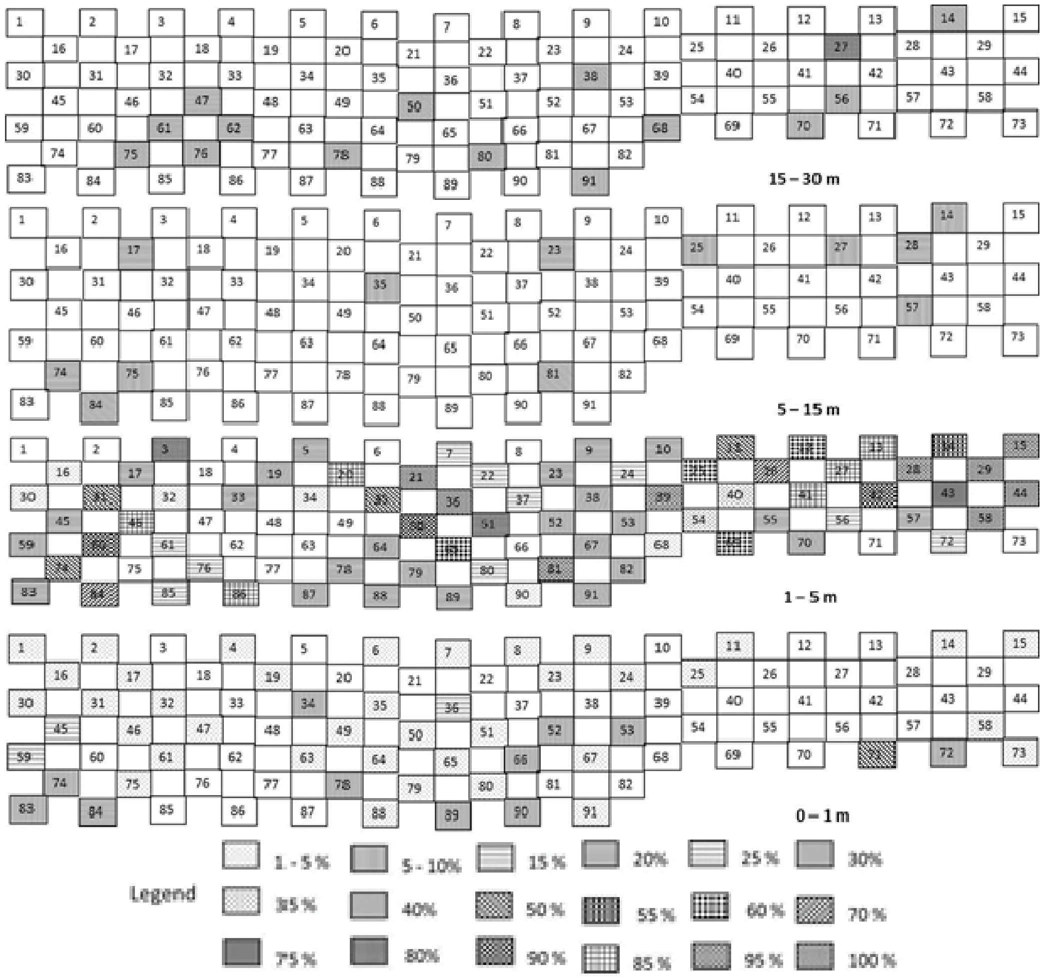


Figure 4. The spatial distribution analysis of the alien species in the inventorying plots

Cushman and Gaffney (2010) stipulate that the exotic clonal plants cause significant community-level effect because they are superior competitors in the riparian areas. Propagating predominantly clonally, they exhibit rapid growth dominating the vegetation of riparian corridor, compete more efficiently for resources and moisture, are more anchored in the soil escaping during intense flood velocity. The knotweed occurs particularly along the stream and riparian corridors (Claeson et al., 2014) *Fallopia* has a wide ecological niche that enables it to establish in different ecosystems (Dassonvile et al., 2011). Because the species display a rhizomatous growth, spread clonally, it may form monocultures very quickly reducing local species diversity, thus suggesting that clonal growth trait is possible to increase the impact and/or invasiveness of introduced species (Bailey et al., 2009; Aguilera et al., 2010). Their biological and ecological traits (tall stature, high biomass, high growth rate and fecundity, efficient dispersal) make them more successful as invasive species (Čuda et al., 2014).

The high species density and low diversity in the layer 1-5 m height with the dominance of alien species make the area a reservoir (recipient habitats) with propagules, a source for nearby areas invasion especially during river flooding. The farmers owning the agricultural lands and grasslands in the studied area were complaining about the more and more areas occupied with alien species over the years especially after flooding. Especially *F. japonica* forms monotype stands in grasslands and potato fields.

We argue that the riparian studied area situated in the vicinity of water flow behave as a reservoir for the propagules (seeds, plant fragments) brought here by water and sediment from upstream during flood. Once the alien plant species establish and develop in the riparian area, via wind, water, animals or other dispersal mechanism specific to every species (anemochory, zoochory, hydrochory, etc.) they spread in the agricultural fields and grasslands. Following establishment and development also in these areas, they might disperse from there laterally in other areas and/or back in the riparian area and also downstream invading more areas. Zedler and Kercher (2004) stipulate that the agricultural fields and urbanized catchments fed the wetlands through surface water thus making them more prone to invasive species development. Kowarik (2003) specified that invasion is the result of interplay of anthropogenic and biological mechanisms.

The invasion success is regulated by: biotic factors at local scale (neighbourhood and community) where the environmental conditions are more homogenous and biotic interactions can influence invasion and abiotic extrinsic factors (i.e. propagules pressure and disturbance) at a larger scale where the environmental conditions are more heterogeneous (Souza et al., 2011).

CONCLUSIONS

The offspring of alien plant species recorded in agricultural lands and grassland on a sector of Arieş River Valley and compact stands of adult clonal individuals of alien species shows that the riparian area behave like a reservoir for alien species invading the agricultural land and grasslands nearby the Arieş River. Especially *F. japonica* individuals form compact patches invading the pastures and agricultural fields and the local farmers cannot use the land any more for their own needs. Due to their dispersal mechanisms and intensified factors helpinh the dispersal, the area of Arieş River Valley is a source (recipient) for these alien species to invade the surrounding grasslands and agricultural fields and the areas downstream, behaving also as corridor for alien invasive species, from local to regional scale. The connections among the areas, especially the hydrologic one, make them more prone to alien species invasion. Also, the disturbance in the area is major due to pollution, direct human intervention (tree cutting, trash brought by the river during floods, etc.) increase its suitability for alien species development.

Arieş River acts as a migration corridor for the alien species helping them to spread by seeds or fragments and invade new places, especially during spring and/or autumn floods.

ACKNOWLEDGMENTS

Data obtained in the framework of Contract 98/2014 project code PN-II-PT-PCCA-2013-4-2171 financed by UEFISCDI and the project RO1567-IBB01/2015 financed by Romanian Academy.

REFERENCES

Aguilera A.G., Alpert P., Dukes J.S., Harrington R., 2010. Impact of the invasive plant *Fallopia japonica* (Houtt.) on plant communities and ecosystem processes. Biological Invasions, 12: 1243-1252.

Anastasiu P., Negrean G., 2005. Alien plants in Romania (I). Analele ştiinţifice ale Universităţii "Al. I. Cuza" Iaşi, Biologie vegetală, LI (II): 87-96.

Anastasiu P., Negrean G., 2006. Alien vascular plants in Dobrogea (Romania) and their impact on different types of habitats, plant, fungal and habitat diversity investigation and conservation. Proceedings of IV BBC – Sofia, 590-596.

Anastasiu P., Negrean G., 2008. New alien plants to Romania. Analele Univ. din Craiova. Seria Agricultură, Montanologie, Cadastru. 38/B: 1-10.

Anastasiu P., Negrean G., 2009. Neophytes in Romania. In: Rácosy L., Momeu L. (Eds.), Neobiota din România, Presa Universitară Clujeană, 66-97.

Anastasiu P., Negrean G., Başnou C., Sîrbu C., Oprea A., 2008. A preliminary study on the neophytes of wetlands in Romania. Biological invasions–from ecology to conservation. Neobiota, 7: 180-190.

Bailey J.P., Bímová K., MandáK B., 2009. Asexual spread versus sexual reproduction and evolution in Japanese knotweed s.l. sets the stage for the 'Battle of the Clones'. Biological Invasions, 11: 1189-1203.

Britton-Simmon K.H., Abbot K.C., 2008. Short- and long-term effects of disturbance and propagule pressure on a biological invasion. Journal of Ecology, 96: 68-77.

Ciocârlan V., 2009. The illustrated flora of Romania, Pteridophyta et Spermatophyta. Editura Ceres, 1141 p.

Claeson S.M., LeRoy C.J., Barry J.R., Kuehn K.A., 2014. Impact of invasive riparian knotweed on litter decomposition, aquatic fungi, and macroinvertebrates, Biological Invasions, 16: 1531-1544.

Cushman J.H, Gaffney K.A., 2010. Community-level consequence of invasion: impacts of exotic clonal plants on riparian vegetation. Biological Invasions, 12: 2765-2776.

Čuda J., Skálová H., Janovský Z., Pyšek P., 2014. Habitat requirements, short-term population dynamics and coexistence of native and invasive Impatiens species: a field study. Biological Invasion, 16: 177-190.

Dassonvile N., Gillaumaud N., Piola F., Meerts P., Poly F., 2011. Niche construction by invasive Asian knotweed (species complex *Fallopia*): impact on activity, abundance and community structure of denitrifiers and nitrifiers. Biological Invasions, 13: 1115-1133.

Dihoru G., 2004. Invasive plants in Romanian's flora. Analele Universitatii din Craiova, IX (XLV): 73-82.

Dombrowski A., Głowacki Z., Kovalchuk I., Nikiforov M., Michalczyk Z., Szwajgier W., Wojciechowski K.H., 2002. Bug River Valley as the ecological corridor. State-threats-protection. IUCN Office for Central Europe (Foundation IUCN Poland), 145 p.

Ervin G., Smothers M., Holly C., Anderson C., Linville J., 2006. Relative importance of wetland type versus anthropogenic activities in determining site invisibility. Biological Invasion, 8: 1425-1432.

Friedel M.J., Linard J.I., 2008. Initial Sediment Transport Model of the Mining Affected Aries River Basin, Romania. Open-File Report 2008-1171, 23 p.

Früh D., Stoll S., Haase P., 2012. Physicochemical and morphological degradation of stream and river habitats increases invasion risk. Biological Invasions, 14: 2243-2253.

Gallé L., Margóczi K., Kovács É., Györffy Gy., Körmöczi L. and Németh L., 1995. River valleys: Are they ecological corridors? Tiscia, 29: 53-58.

Gardner R.H., Engerlardt K.A.M., 2008. Spatial processes that maintain biodiversity in plant communities. Perspective in Plant Ecology, Evolution and Systematics, 9: 211-228.

Heger T., Trepl L., 2003. Predicting biological invasion. Biological Invasions, 5: 313-321.

Hejda M., Pyšek P., Jarošik V., 2009. Impact of invasive plants on the species richness, diversity and composition of invaded communities. Journal of Ecology, 97: 393-403.

Kalusová V., Milan Chytrý M., Robert K., Peet R.K., Thomas R., Wentworth T.R., 2014. Alien species pool influences the level of habitat invasion in intercontinental exchange of alien plants. Global Ecology and Biogeography, DOI: 10.1111/geb.12209, 1-10.

Karatayev A., Mastitsky S.E., Burlakova L.E., Olenin S., 2008. Past, current, and future of the Central European corridor for aquatic invasion in Belarus. Biological Invasions, 10: 215-232.

Kershaw K.A., 1980. Quantitative and Dynamic plant ecology. Butler & Tanner Ltd., Great Britain, 308 p.

Kinlan B.P., Gaines S.D., 2003. Propagule dispersal in marine and terrestrial environments: a community perspective. Ecology, 84 (8): 2007-2020.

Kowarik I., 2003. Human agency in biological invasions: secondary releases foster naturalization and population expansion of alien plant species. Biological Invasions, 5: 293-312.

Lambdon P.W., Pyšek P., Basnou C., Hejda M., Arianoutsou M., Essl F., Jarošík V., Pergl J., Winter M., Anastasiu P., Andriopoulos P., Bazos I., Brundu G., Celesti-Grapow L., Chassot P., Vilà M., 2008. Alien flora of Europe: species diversity, temporal trends, geographical patterns and research needs. Preslia, 80: 101-149.

Lockwood J.L., Hoopes M.F., Marchetti M.P., 2007. Invasion Ecology, Blackwell Publishing, 304 p.

MacIsaac H.J., Grigorovich I.A., Ricciardi A., 2001. Reassessment of species invasion concepts: the Great Lake basin as model. Biological Invasions, 3: 405-416.

Malm Renöfält B., 2004. Vegetation patterns and processes in riparian landscapes. Doctoral dissertation, Solfjädern Offset AB, 31 p.

Malm Renöfält B., Roland Jansson R., Christer Nilsson C., 2005. Spatial patterns of plant invasiveness in a riparian corridor. Landscape Ecology, 20:165-176.

McGeoch M.A., Chown S.L., Kalwij J.M., 2006. A global indicator for biological invasion. Conservation Biology, 20(6): 1635-1646.

Miyawaki S., Washitani I., 2004. Invasive Alien Plant Species in Riparian Areas of Japan: The Contribution of Agricultural Weeds, Revegetation Species and Aquacultural Species. Global Environmental Research, 8(1): 89-101.

Moles A.T., Gruber M.A., Bonser S.P., 2008. A new framework for predicting invasive plant species. Journal of Ecology, 96: 13-17.

Moles A.T., Flores-Moreno H., Bonser S.P., Warton D.I., Helm A.,Warman L., Eldridge D.J., Jurado E., Hemmings F.A., Reich P.B., Cavender-Bares J., Eric W., Seabloom E.W., Mayfield M.M., Sheil D., Djietror J.C., Peri P.L., Enrico L., Cabido M.R., Setterfield S.A., Caroline E.R., Lehmann C.S.A., Thomson F.J., 2012. Invasions: the trail behind, the path ahead, and a test of a disturbing idea, Journal of Ecology, 100: 116-127.

Montserrat V., Joan P., Xavier F., 2007. Regional assessment of plant invasions across different habitat types. Journal of Vegetation Sceince, 18: 35-42.

Pál F.J., 2010. Grasslands of the Arieş Valley between Lupşa and Turda. Structure, Ecology, Sustainable Management. Presa Universitară Clujeană, 250 p.

Panov V.E., Alexandrov B., Arbačiauskas K., Binimelis R., Copp G.H., Grabowski M., Lucy F., Leuven R.S., Nehring S., Paunović M., Semenchenko V., O Son M., 2009. Assessing the Risks of Aquatic Species Invasions via European Inland Waterways: From Concepts to Environmental Indicators. Integrated Environmental Assessment and Management, 5 (1): 110-126.

Parker I.M., Simberloff D., Lonsdale W.M., Goodell K., Wonham M., Kareiva P.M., Williamson M.H., Von Holle B., Moyle P.B., Byers J.E., Goldwasser L., 1999. Impact: toward a framework for understanding the cological effects of invaders. Biological invasion, 1: 3-19.
Pienimäki M., Leppäkoski E., 2004. Invasion pressure on Finish Lake district: invasion corridors and barriers. Biological Invasion, 6: 331-346.
Planty-Tabacchi A.M., Tabacchi E., Salinas Bonillo M.J., 2001. Invasions of river corridors by exotic plant species: patterns and causes. In Brundu G., Brock J., Camarda I., Child L., Wade M. (Eds.), Plant invasions: species ecology and ecosystem management, 221-233.
Resasco J., Haddad N.M., Orrock J.L., Shoemaker D.W., Brudvig L.A., Damschen E.I., Tewksbury J.J., Levey D.J., 2014. Landscape corridors can increase invasion by an exotic species and reduce diversity of native species. Ecology, 95(8): 2033-2039.
Rodriguez-Iturbe I., Muneepeerakul R., Bertuzzo E., Levin S.A., Rinaldo A., 2009. River networks as ecological corridors: A complex systems perspective for integrating hydrologic, geomorphologic, and ecologic dynamics. Water Resources Research, 45, W01413, doi: 10.1029/2008WR007124.
Rood S.B., Kalischuk A.R., 2008. Weed Invasion in Alberta's River Valley Corridors. WLA, 16(4): 16-18.
Sauer J.D., 1988. Plant migration. The dynamics of Geographic Patterning in seed plant species. University of California Press, 282 p.
Sher A.A., Hyatt L.A., 1999. The disturbed resource-flux matrix: a new framewrok for patterns of plant invasion. Biological Invasions, 1: 107-114.
Sîrbu C., Oprea A., 2010. Contribution to the Knowledge of the Alien Flora of Romania: *Rudbeckia triloba* L. and *Senecio inaequidens* DC. Not. Bot. Hort. Agrobot. Cluj, 38 (1): 33-36.
Sîrbu C., Oprea A., 2011. Adventive plants in Romanian Flora. Editura Ion Ionescu de la Brad, Iaşi, 733 p.
Sîrbu I., Ştefan N., Oprea A., 2013. Vascular plants from Romania, Illustrated field identifier. Editura Victor B Victor, 1320 p.
Slinko Y.V., Korneva L.G., Rivier I.A., Papchenkov V.G., Scherbina G.H., Orlova M.I., Therriault T.W., 2002. The Caspia-Volga-Baltic Invasion corridor. In Leppäkoski et al. (Eds.), Invasive aquatic species of Europe, Kluwer Academic Publishers, Netherlands, 399-411.
Socorovschi V., Şerban Gh., Bătinaş R., 2002, Hydrological hazards in the lower basin of Arieş River. Revista Riscuri şi Catastrofe, 1: 143-148.
Souza L., Bunn W.A., Weltzin J.F., Sanders N.J., 2011. Similar biotic factors affect early establishment and abundance of an invasive plant species across spatial scale. Biological Invasions, 13: 255-267.
SRBMP, 2013. Background paper no. 7, Invasive alien species. http://www.savacommission.org
Török K., Botta-Dukát Z., Dancza I., Németh I., Mihály B., Magyar D., 2003. Invasion gateway and corridors in the Carpathian Basin: biological invasion in Hungary. Biological Invasion, 5: 349-356.
Turnbull L.A., Coomes D.A., Purves D.W., Rees M., 2007. How spatial structure alters population and community dynamics in a natural plant community. Journal of Ecology, 95: 78-89.
Ward J.V., 1998. Riverine landscapes: biodiversity patterns, disturbance regimes and aquatic conservation. Biological Conservation, 83: 269-278.
Zaiko A., Lehtiniemi M., Narščius A., Olenin S., 2011. Assessment of bioinvasion impacts on a regional scale: a comparative approach. Biological Invasions, 13: 1739-1765.
Zedler J.B., Kercher S., 2004. Causes and consequences of invasive plants in wetlands: opportunities, opportunists, and outcomes. Critical Review in Plant Sceinece, 23(5): 431-452.
*** Addinsoft XLSTAT - Pro 2014, http://www.xlstat.com/en/

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

ROMANIA'S AGRICULTURE FROM THE EU ACCESSION UP TO PRESENT - EVOLUTION AND STRUCTURE

Elisabeta ROŞU

Institute of Agrarian Economy of the Romanian Academy, Calea 13 Septembrie no.13, District 5, Bucharest, Romania

Corresponding author email: betty_rosu@yahoo.com

Abstract

From Romania's accession to the European Union up to present the agriculture's evolution and restructuring process was rather a slow one.
The phenomenon of structural coexistence of the two types of agricultural farms, with or without juridical personality was maintained in this whole period.
The agricultural farms' structure as regards the utilized agricultural area is one of contrasts, from some ars in the case of the subsistence households, to tens of thousands hectares in case of commercial farms. Thus, 97.8% of total of agricultural farms own 55.7% of the agricultural area, while, 2.2% of them own 44.3% of the country's agricultural area.

Key words: *agriculture, agricultural farms, structure.*

INTRODUCTION

The Romanian agriculture's state is determined by the Romanian agrarian structure and is the most important economic and social present issue.
The multifunctional role of agriculture is fully recognized, reason for which an overall knowledge of its structure and evolution has in view mainly the agricultural farm.
The evolution of the agricultural farm was and is strictly linked to the transformations in the Romanian society.

MATERIALS AND METHODS

The information analyzed was collected through the documentary study of the papers regarding the theme approached. The methodology comprised the statistical analysis of primary data using as a working instrument the program of quantitative analysis Excel. The statistical data which stood at basis of the analysis were at national level, covered the 2007-2013 period and came from the following sources: a) statistical data NSI: i) publications – Romania's Statistical Yearbook 2013; ii) statistical data/ information on line - www.tempo-online; b) statistical data /information on line from the MARD.

RESULTS AND DISCUSSIONS

Agriculture represents a sector of first importance due to the contribution which has in the national economy. Agriculture's contribution in the GDP is high, oscillating from a maximum of 6.6 % in year 2008, to a minimum of 4.9% in the year 2012, the average of EU-27 being of 1.7%.

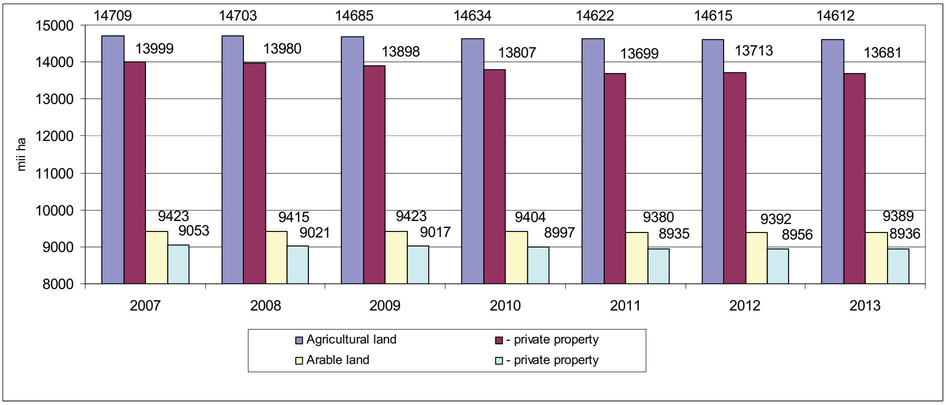
Table 1. Share of agriculture in the GDP

	2007	2008	2009	2010	2011	2012	2013
%	5.8	6.6	6.4	5.7	6.5	4.9	5.6

Source: www.madr.ro; Romania's Statistical Yearbook, 2013, tab.11.1; data for the year 2013: NSI - press communicate no.80 from April 2 e 2014 (provisory data)

The land fund

Agriculture represents an important factor of the natural environment having in view that the share of the agricultural land in the ensemble of the country's territory is of over 61%.
In the year 2007 Romania's agricultural area was of 14.7 mill. ha (95.2% private ownership), and the area of the arable land was of 9.4 mill. ha (95.7% private ownership). In the year 2013, Romania's agricultural area was of 14.6 mill. ha (93.8% private ownership), and the area of the arable land was of 9.4 mill. ha (94.7% private ownership) (Figure 1).



Source: www. INSE tempo online

Figure 1. The land fund situation, by the utilization way, on ownership forms

Table 2. The situation of the agricultural farms in the years 2007 and 2010

Indicative	MU	Total Agricultural farms		Of which: Agricultural farms with juridical personality		Of which: Agricultural farms without juridical personality	
		2007	2010	2007	2010	2007	2010
Total number of agricultural farms	thousand	3931	3859	17	31	3914	3828
Agricultural farms which utilized agricultural area	thousand	3851	3724	17	30	3834	3694
Utilized agricultural area	thousand ha	13753	13306	4787	5856	8966	7450
The agricultural utilized area averagely:							
- per an agricultural farm	ha	3.50	3.45	270.45	190.78	2.29	1.95
- per an agricultural farm which utilized the agricultural area	ha	3.57	3.57	275.37	193.74	2.34	2.02

Source: NSI, Romania's Statistical Yearbook, 2013, tab. 14.4

In the analyzed period the areas of agricultural land and arable land were not modified significantly, while their shares being in the private ownership decreased in year 2013 opposed to the year 2007. The transfer of the land areas to the forestry sector and that of constructions has constituted the main cause of the reduction of the agricultural area in the last years. The reduction of the land areas, by their including into the urban zone, represents a phenomenon met in the zones with higher productivity, while the change of the utilization category for the agricultural land into that of forestry appears, mainly, in the less favored zones.

Agricultural farms

According to the statistical data[1] in Romania it existed in the year 2010 a total number of agricultural farms of 3,859 thousand, with 1.8% less than in the year 2007 (3,931thousand).

The number of agricultural farms which utilized the agricultural area was with 3.3% smaller in the year 2010 (3,724 thousand) than in the year 2007 (3,851 thousand).

The utilized agricultural area diminished from 13753 thousand ha (2007), to 13306 thousand ha (2010), such that the average size of a farm decreased, from 3.50 ha/farm in the year 2007, to 3.45 ha/farm in the year 2010. With all this, the average size of an agricultural farm which utilized agricultural area was of 3.57 ha/farm, both in the year 2007 and in the year 2010 (Table 2).

Since the year 2007, from the accession of Romania to the EU, the phenomenon of structural duality of agricultural farm maintained itself, the structural modifications being rather small. Thus, in the analyzed period

[1] NSI, R*omania's Statistical Yearbook*, 2013

there were farms with juridical personality and without juridical personality.

In the year 2010 the total number of the agricultural farms without juridical personality was of 3828 thousand, with 2.2% less in the year 2007.

As regards the number of agricultural farms without juridical personality which utilized agricultural area, in 2010 there were 3,694 thousand farms, less with 3.6% than in the year 2007. The utilized agricultural area by them decreased from 8966 thousand ha (2007), to 7450 thousand ha (2010), such that the agricultural area per agricultural farm without agricultural personality decreased from 2.29 ha/farm (2007), to 1.95 ha/farm. The average size of an agricultural farm without juridical personality which utilized agricultural area decreased from 2.34 ha/farm (2007), to 2.02 ha/farm (2010).

Even though in the analyzed period, the total number of farms registered a decrease, the number of agricultural farms with juridical personality was that which registered a significant increase. In the analyzed period the agricultural farms with juridical personality represented an extremely low percentage in the total number of farms, but their evolution was a positive one, registering an increase of 1.7 times in the year 2010 opposed to the year 2007.

On the background of the increase in the number of agricultural farms with juridical personality and of the increase of the utilized agricultural areas by them (from 4787 thousand ha in year 2007, to 5858 thousand ha in year 2010), nevertheless, the average size of the agricultural farm with juridical personality diminished from 270.4 ha/farm (in year 2007) to 190.8 ha/farm (in year 2010). A decreasing trend was registered also in the case of the average size of the agricultural farms with juridical personality which utilized agricultural area, from 275.27 ha/farm (2007), to 193.74 ha/farm (2010).

In the year 2007, the farms without juridical personality were utilizing 65% of the agricultural area, and the farms with juridical personality were utilizing 35% of the agricultural area of Romania. In the year 2010 these shares suffered major changes, such that the farms without juridical personality were utilizing 56% of the agricultural area, and those with juridical personalities were utilizing 44% of the agricultural area of Romania.

The profile of the agricultural farms

The number of mixed agricultural farms, with utilized agricultural area and livestock numbers, registered a decrease, from 3254.2 thousand (2007), to 2702.4 thousand (2010).

In the analyzed period, the numbers of agricultural farms specialized only in crop production and only in animal production registered increases, from of 1.7 times, in both cases.

Table 3. Agricultural farms which utilized agricultural areas and/or owned livestock numbers

- thousand -

	2007	2010
Agricultural farms with utilized agricultural area and livestock numbers, of which:	3254.2	2702.4
- agricultural farms only with utilized agricultural area	597.5	1021.9
- agricultural farms only with livestock numbers	79.6	134.6

Source: NSI, Romania's Statistical Yearbook, 2013, tab.14.3

The way of lands' farming

In the year 2007, from the total of utilized agricultural area, the area under ownership represented 73.2%, that leased 17.0%, that concessioned 2.1%, that taken in shares 2.0%, the rest being famed under other forms.

Table 4. The way of farming the lands in the year 2010 opposed to the year 2007

- % -

	2007	2010
Ownership	73.2	60.0
Lease	17.0	27.0
Concession	2.1	3.0
In shares	2.0	2.1
Others	5.7	7.9

Source: The Presidential Commission for Public Policies for Agricultural Development, The National Rural Strategic Framework, 2013

In the year 2010 the share of areas under ownership decreased, while the shares of the other forms of farming the lands increased, the highest increasing trend being registered by the leased areas, from 17.0% (2007), to 27.0% (2010), which means that the leasing phenol-menon started to get amplitude.

Romania's agrarian structure

Romania's agrarian structure is made of four big categories of agricultural farms[2]:

- The family agricultural households with areas comprised between 0.1-1 ha, which because of the small agricultural areas and strongly fragmented are not eligible for the EU financing; their agricultural land is made mostly by gardens, pastures, natural hayfields and the soil is weakly productive;
- Subsistence and semi subsistence farms with agricultural areas comprised between 1-10 ha which are producing mainly for their self consumption needs;
- Commercial family farms with areas between 10-100 ha;
- The commercial companies with areas bigger than 100 ha, with agricultural areas made of arable land of the best quality, placed in most favourable zones (table 5).

The two types of farms, those with areas under 1 ha and those of subsistence and semi subsistence are the ones which give the image of the Romanian agriculture. These represented 97.4% of the total of the agricultural farms in 2007 and respectively 97.8% in 2010 and they were utilizing 55.7% of the agricultural area of the country both in and in 2010.

The family commercial farms, with agricultural areas between 10 and 100 ha represented 2.3% of total agricultural farms in 2007 and 1.8% in the year 2010 and utilized 10.1% of the agricultural area of the country. These types of farms are majoritary in the countries in the European Union, but in Romania they are more weakly represented from number point of view.

Table 5. Agricultural farms by size class and utilized agricultural area

	2007	2010	2007		2010	
	%	%	UAA (thousand ha)	%	UAA (thousand ha)	%
0.1-1 ha	43.8	54.2	5079	34.5	5059	34.6
1-10 ha	53.6	43.6	3114	21.2	3102	21.2
10-100 ha	2.3	1.8	1500	10.2	1485	10.1
Over 100 ha	0.3	0.4	5016	34.1	4988	34.1
Total	100	100	14709	100	14634	100

Source: own calculations on basis of data from the Statistical Yearbook 2012, NSI

The commercial companies with areas of over 100 ha represented 0.3% of the total of agricultural farms in 2007 and respectively 0.4% in the year 2010 and were utilizing 34.1% of the country's agricultural area. The commercial companies were owning the smallest share of the total number of the agricultural farms, but they owned one third of the country's agricultural area, area formed of arable land and situated in the most favourable zones.

The last two categories of agricultural farms represented 2.6% of the total number of agricultural farms in 2007 and respectively 2.2%, in 2010 they utilized 44.2% of the agricultural area of the country.

CONCLUSIONS

In the period 2007-2013 agriculture's contribution to the GDP maintained at a high level, much over the EU average.

The areas of agricultural land and arable land did not change significantly, but suffered changes the shares of them under private ownership, registering decreases in the year 2013 opposed to the year 2007. The leasing phenomenon was in a full evolution process because the share of areas under ownership decreased, but grew the share of the areas leased in.

The total number of agricultural farms decreased, it also diminished the utilized agricultural area, and the average size of a farm decreased from 3.50 ha/farm in the year 2007, to 3.45 ha/farm in the year 2010.

The number of agricultural farms without juridical personality decreased, it also decreased the utilized area by them, such that the average size of an agricultural farm without juridical personality which utilized agricultural area decreased from 2.34 ha/farm in 2007, to 2.02 ha/farm in year 2010.

In total of agricultural farms, those with juridical personality are holding a very small percentage, but their number increased by 1.7 times in the year 2010 opposed to year 2007. It also increased the utilized agricultural area by them, but the average size of an agricultural farm with juridical personality which utilized agricultural area decreased from 275.27 ha/farm in 2007, to 193.74 in the year 2010.

[2] Otiman, P.I., (2012), The present agrarian structure of Romania– a great (and unsolved), social and economic issue, of the country, in the Romanian Sociology Magazine, new series, year XXIII, no.5-6, p.339-360, Bucharest

These decrease of the average size shows the fact that the agricultural farms with juridical personality utilize only the areas of land with a high productivity.

In the year 2007, the farms without juridical personality were utilizing 65% of the agricultural area, and the farms with juridical personality were utilizing 35% of Romania's agricultural area. In the year 2010 these shares have suffered major changes, such that the farms without juridical personality were utilizing 56% of the agricultural area, and those with juridical personality were utilizing 44% of the agricultural area of Romania.

In the period 2007-2010, on the background of the decrease of the number of mixed farms, it grew the number of those specialized, only in the crop farming or only in livestock raise.

Predominant in the Romanian agriculture there were the farms with less than 1 ha agricultural land and the subsistence and semi subsistence farms, which represented over 97% of the total number of farms and which were utilizing almost 56% of the country's agricultural area. Even though these are not contributing to the development of a performant agriculture they have an important social role because they are ensuring the food security of the inhabitants in the rural environment.

The commercial agricultural farms, the family farms and the commercial companies were owning an extremely reduced percentage from the total number of farms, but they were utilizing over 44% of the country's agricultural area. The territorial amalgamation of these agricultural farms confers to them a competitive potential.

Such a distribution, accentuate bipolar, with most of the agricultural land divided, on one side, between farms, extremely modest as physical size, which are producing in majority for the own needs, and on the other side, of a relatively small number of agricultural commercial farms which are producing in industrial system and are adopting modern technologies are the main factor limiting the growth of competitiveness of the Romanian agriculture and which reveals the structural imbalance of it.

REFERENCES

Luca L., Cionga Cristina, Giurca Daniela, 2012. Consolidarea exploatațiilor agricole. Editura Economică, București.

Otiman P.I. (coord.), 2011. Alternativele economiei agrare rurale a României: dezvoltarea agriculturii sau Insecuritate alimentară şi deşertificare rurală severă". Ed. Academiei Române, Bucureşti.

Otiman P.I., 2012. Structura agrară actuală a României – o mare (şi nerezolvată) problemă socială şi economică a țării. In Revista Română de Sociologie, anul XXIII, nr. 5-6, Bucureşti.

Samochiş B., Glogovețan Oana, 2011. Polarizarea exploatațiilor agricole din România ținând seama de dimensiunile lor. Tribuna Economică, nr. 35.

Stanef R.M., 2010. Agricultura României în fața exigențelor Uniunii Europene. Ed. ASE, Bucureşti.

*** Guvernul României, Ministerul Agriculturii şi Dezvoltării Rurale, *Programul Național de Dezvoltare Rurală 2007-2013* – versiune consolidată decembrie 2012

*** Preşedenția României, Comisia Prezidențială pentru Politici Publice de Dezvoltare a Agriculturii în România şi Academia Română, Institutul de Economie Agrară, 2013, Cadrul Național Strategic pentru Dezvoltarea Durabilă a Sectorului Agroalimentar şi a Spațiului Rural în perioada 2014-2020-2030, Cadrul Național Strategic Rural, Editura Academiei Române, Bucureşti.

*** Institutul Național de Statistică, Anuarul Statistic al României, anii 2008 şi 2013.

*** www.insse.ro – baza de date statistice TEMPO-Online.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

CONTRIBUTION TO THE KNOWLEDGE OF MORPHO-ANATOMICAL CHARACTERISTICS IN SOME AUTOCHTHONOUS AQUATIC PLANTS

Emilia Brînduşa SĂNDULESCU, Mala-Maria STAVRESCU-BEDIVAN, Tudor ŞCHIOPU, Nicoleta OLTENACU

University of Agronomic Sciences and Veterinary Medicine of Bucharest, Faculty of Agriculture, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: emasand@yahoo.com

Abstract

In an aquatic environment, plants undergo some major adaptative changes that are reflected in their hydromorphic structure. Thus, the aquatic plants have modified appearance, organ's forms and functions.
This paper highlights the morpho-anatomy and adaptations of some plant species from the Romanian flora (Ceratophyllum submersum, Lemna trisulca, Ranunculus sceleratus and Salvinia natans), so that in future studies we might establish the links between the growth conditions and vegetative structures.

Key words: *aquatic plants, morpho-anatomic features, adaptative changes.*

INTRODUCTION

The water plants can be divided into several groups: submerged (oxygenators), deep-water plants, floating plants and marginals (Robinson, 2004). Aquatic plant species have different forms that are associated with different environmental conditions, since they are modified for living in excess of water. Thus, the morpho-anatomical characteristics of those plants are related to their habit, reflecting the plasticity of their organs (Scremin-Dias, 2009).
When correlate the internal structures of the plant with the aquatic environment, some adaptations are interesting to note: the type of root system, for holding the plant or to allow it to move; gaseous exchange system, to aid flotation of leaves and stems; formation of aerenchyma for carrying oxygen down to the root zone; waxines of leaves, in order to protect against transpiration and saturation (http://www.penritlake-e.schools.nsw.edu; http://ag.arizona.edu/azaqua/aquaplants/).
Ceratophyllum submersum L. (*Ceratophyllales*, *Ceratophyllaceae*) is a cosmopolitan aquatic plant that lives entirely submerged (Rutishauser, 1999). The leaves and stems are delicate, with a green or reddish coloration (Kasselmann, 2003).
Another vascular aquatic plant is *Lemna trisulca* L. (*Alismatales*, *Lemnoideae*), a small species with a rapid grow, which lives submerged except when flowering (Daubs, 1965; Kara & Kara, 2005). The ivy-leaved duckweed plants are connected by short stalks, so they form a dense mat across the water surface (Hiscock, 2003).
An annual herb often found on small water bodies, marshes and pastures is *Ranunculus sceleratus* L. (*Ranunculales*, *Ranunculaceae*) (Hrivnak & Csiky, 2009; Mei et al., 2012).
As regarding the free-floating fern *Salvinia natans* L. (All.) (*Pteridophyta*, *Salviniaceae*), this annual plant can grow in large populations at the surface of lakes, ditches or canals, being protected in the Danube Delta where occupies significant areas in the shallow waters (RIZA rapport, 2002.049; http://www.iucnredlist.org; Bercu, 2006).
Although all four of the above-mentioned plant species are native to Romanian vascular flora, data about their morpho-anatomical features and life adaptations are almost lacking in scientific literature, with few exceptions (Bercu, 2006). The hydrophytic features of those plants, highlighted by cross sections made through different part of their organs are in accordance to the aquatic habitat.

MATERIALS AND METHODS

We used vegetal material of the following species: soft hornwort (*Ceratophyllum submersum*), ivy-leaf duckweed (*Lemna trisulca*), celery-leaved butter cup (*Ranunculus sceleratus*) and floating fern (*Salvina natans*) (Figure 1). After being sampled from their natural habitat (Comana Natural Park, respectively Danube Delta, in the case of the last mentioned species), those aquatic plants were preserved in jars with 70% ethyl alcohol for further investigations.
Microscopic characterization of the morpho-anatomic structures was made by analysing several cross-sections through different levels of the studied plants, with the aid of a ML-4M IOR microscope (Andrei, 2003).

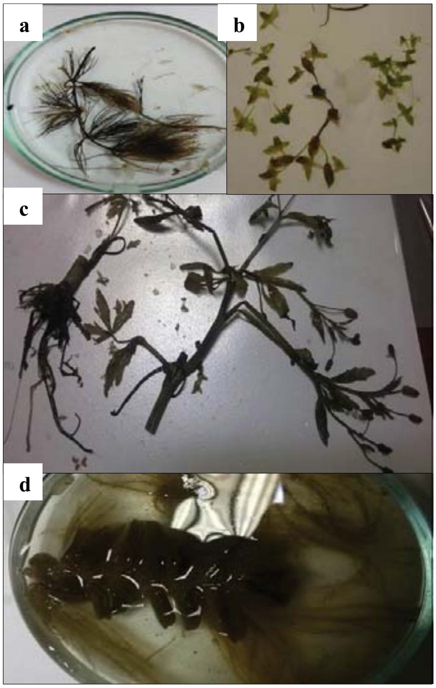


Figure 1. Alcohol-preserved plant species for morpho-anatomic study: a. *Ceratophyllum submersum*; b. *Lemna trisulca*; c. *Ranunculus sceleratus*; c. *Salvinia natans*

RESULTS AND DISCUSSIONS

Results regarding morpho-anatomical features of *Ceratophyllum submersum* (soft hornwort)

This submerged, free-floating perennial plant has a submersible branched stem that bears whorls of soft leaves, bifurcated 2-3 times in 4-8 filiform lacinia (Figure 1a).
The cylindrical stems are slender.
In cross section, the stem of soft hornwort presents epidermis, cortex and the central cylinder, while the pith is lacking (Figure 2).

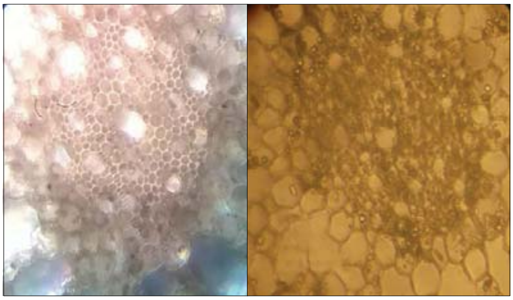


Figure 2. *Ceratophyllum submersum*: stem cross section

The unistratified epidermis is covered by a thin cuticle (Figure 3).

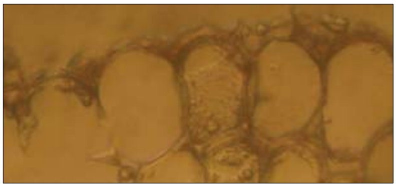


Figure 3. Soft hornwort: stem epidermis

The cortical parenchyma is well developed Aerenchyma surrounds the central cylinder, poorly developed. In the cells of aeriferi parenchyma, raphides are present – acicular crystals of calcium oxalate (Figure 4).

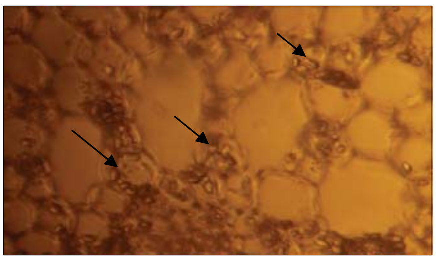


Figure 4. Raphides in aeriferi parenchyma of *C. submersum* stem (see arrows)

The cross section through the leaf shows a single-nerved structure, oval-shaped (Figure 5).

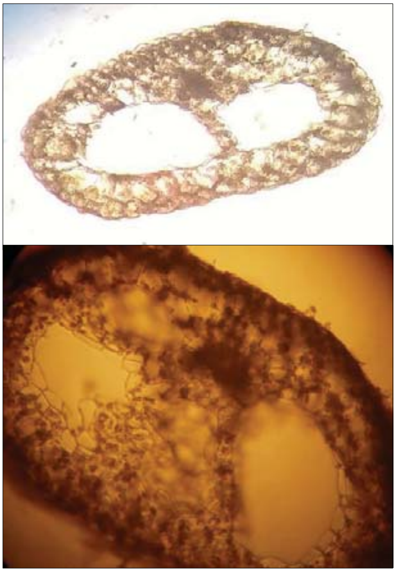


Figure 5. *Ceratophyllum submersum*: leaf cross section

The leaves of soft hornwort have a unistratified epidermis, covered by a developed cuticle. In the homogeneous mesophyll, the aeriferi parenchyma is well developed, consisting of many aeriferous canals by different sizes, around the conducting tissue (Figure 6).
The ribs are underdeveloped.

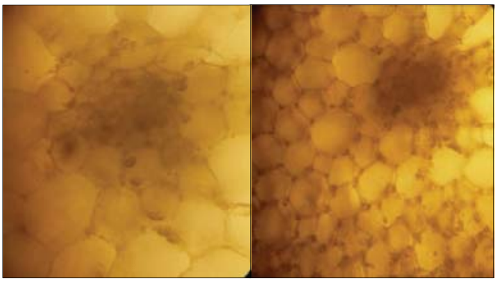


Figure 6. Aeriferi parenchyma of *C. submersum* leaf

Results regarding morpho-anatomical features of *Lemna trisulca* (ivy-leaf duckweed)
The cosmopolit duckweed presents floating oval fronds, with elongated stalks providing plant clustering (Figure 1b).
In cross section through stalk, numerous air spaces can be noticed (aerenchyma) (Figure 7).

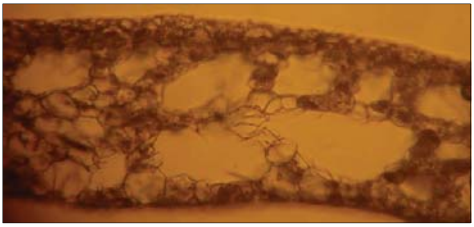


Figure 7. *Lemna trisulca*: stalk cross section

The filiform root of this aquatic plant presents a root cap (Figure 8). Central position of the conducting tissue helps to increase the tensile strength of the organs.

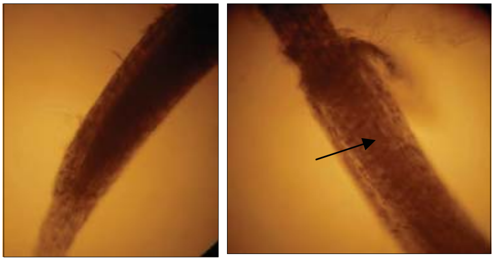


Figure 8. Root of *Lemna trisulca* (arrow indicates the root cap)

Results regarding morpho-anatomical features of *Ranunculus sceleratus* (celery-leaved buttercup)
The fibrous root of buttercup has a very well developed aerenchyma, with big aeriferous canals, arranged in one or two rows (Figure 9).
The central cylinder possesess four wooden fascicles and four liberian fascicles.
The endodermis has Caspary thickening.

Figure 9. *Ranunculus sceleratus*: root cross section with aerenchyma

The epidermis of the stem is unistratified (Figure 10). The cortical parenchyma contains larger air spaces arranged towards the outside and smaller air spaces arranged towards the central cylinder.

Figure 10. *Ranunculus sceleratus*: stem cross section

The stele is represented by numerous liberian and wood fascicles, bounded by well developed sclerenchyma (Figure 11).

Figure 11. Central cylinder of *Ranunculus sceleratus*

The leaves has unistratified epidermis with stomata (Figure 12).

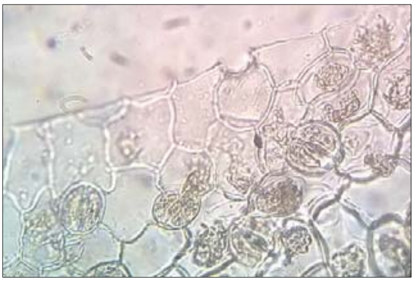


Figure 12. *Ranunculus sceleratus*: leaf stomata

The mesophyll is differentiated in palisadic tissue (Figure 13) formed by one-row cells and lacunar tissue.
The ribs are underdeveloped (Figure 14).

Figure 13. *Ranunculus sceleratus*: palisadic tissue

Figure 14. *Ranunculus sceleratus*: leaf cross section

Results regarding morpho-anatomical features of *Salvinia natans* (floating fern)
The oval-elliptical petiolate leaves are arranged opposite at each node of the short stem (Figure 15).
The petiole has epidermis, cortex and stele (Figure 15). Epidermis contains one single row of cells with thin cellular walls, being covered by a soft cuticle and elongated, sharp tectorial sharp hairs (trichomes).

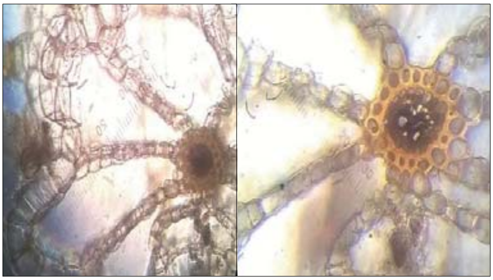


Figure 15. *Salvinia natans*: cross section of the petiole

The cortex is well developed, represented by aerenchyma with 8-9 air chambers disposed around the stele. The air chambers are separated by a row of cells, forming so-called trabecullae. The endodermis has large thick-walled cells.
The stele has a single xylem-phloem conducting fascicle, underdeveloped, situated

in the centre of the section, with one-layered pericycle (Figure 16). Thus, like any fern, the floating fern is characterised by a hadrocentric stele (xylem lying in the centre and liberian vessels facing the pericycle).

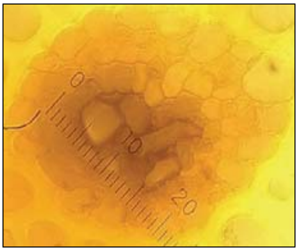


Figure 16. *Salvinia natans*: hadrocentric stele

In cross section, the submerged leaves of the floating fern have unistratified epidermis (Figure 17), with many trichomes, formed by elongated cells, very similar to those disposed on the petiole (Figure 18).

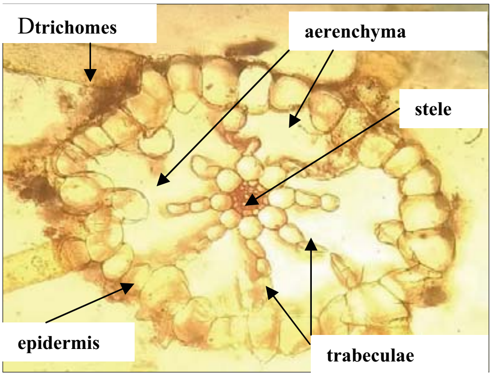


Figure 17. *Salvinia natans*: cross section of the submerged leaf

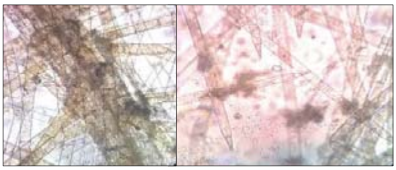


Figure 18. *Salvinia natans*: epidermal sharp hairs of the submerged leaves

According to some authors (Bercu, 2006), the third submerged leaf of the floating fern serves as a root. Actually, the modified leaves of *S. natans* are root-like structures and do not represent a real root; we have not identified any absorbent root hairs or secondary roots.

The cortex is composed of well developed aerenchyma, with eight air chambers separated by trabeculae.

The stele (Figure 19), centrally disposed, is surrounded by eight parenchyma cells. The conspicuous pericycle contains cells by different sizes. The conducting vessels are represented by central xylem and peripheral phloem.

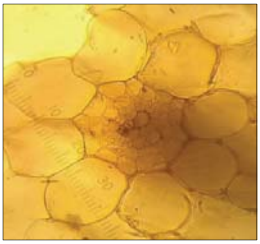


Figure 19. *Salvinia natans*: cross section of the leaf, showing the stele

The floating leaf has unistratified upper epidermis bearing groups of papillae and covered by a thin cuticle (Figure 20).

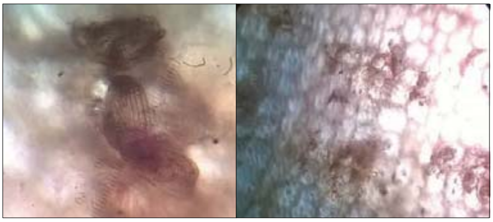


Figure 20. *Salvinia natans*: groups of papillae in the floating leaf

The cells of lower epidermis have corrugated cell walls and many-celled hairs (trichomes) with elongated cells, last of their cell being very sharp (Figures 21-22).

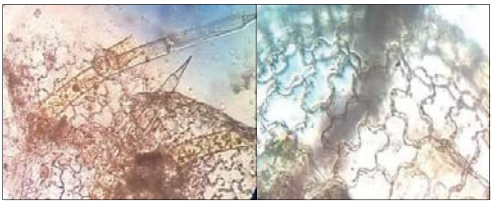


Figure 21. *Salvinia natans*: lower epidermis of the floating leaves showing the trichomes

The mesophyll presents intracellular large, hexagonal spaces, delimited by one row of cells (Figures 23). The conducted vessels are reduced, being surrounded by 11 cells of the mesophyll (Figure 24).

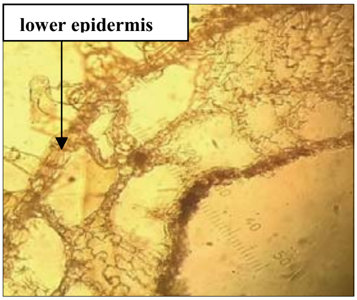


Figure 22. *Salvinia natans*: cross section of the floating leaf

Figure 23. *Salvinia natans*: intracellular spaces of the mesophyll

Figure 24. *Salvinia natans*: conducting vessels of the floating leaf

Cross sections made throughout all levels of the studied plants revealed some important adaptations for life in water. Thus, the submerged species like soft hornwort show a very thin cuticle, lack of roots and stomata, reduced xylem and large air-filled cavities. The numerous hairs of the floating fern leaf allow the plant to remain floating. On the other hand, marsh plants like celery-leaved buttercup have a tough xylem which enables resistance to winds and fluctuations in water levels.

CONCLUSIONS

As far as we know, the morpho-anatomical structures of *Ceratophyllum submersum*, *Lemna trisulca* and *Ranunculus sceleratus* were described for the first time in the Romanian scientific literature, highlighting the plant adaptation at aquatic environment.

In terms of *Salvinia natans*, we contributed to the knowledge of morpho-anatomical structure of this species, by analysing the cross sections of its leaves. The many-celled sharp hairs from the surface of the submerged leaves are very similar to those described in the petiole and lower epidermis of the floating leaves. No absorbent hairs or secondary roots were noticed; thus, the submerged leaves of the floating fern can not substitute a real root.

REFERENCES

Andrei M., 2003. Microtehnică botanică. Niculescu SRL, Publishing House, Bucharest.

Bercu R., 2006. Anatomical features of the vegetative organs of *Salvinia natans* (L.) All. (Salviniaceae). USAMVBT Symposium, 5th section Biology researchers with implications in agriculture: 321-324, http://agricultura.usab-tm.ro/.

Daubs E.H., 1965. A monograph of Lemnaceae. Urbana, Univerisity of Illinois Press. 34, 118 pp.

Hiscock P., 2003. Encyclopedia of Aquarium Plants. Interpret Publishing, Canada, 205 pp.

Hrivnak R., Csiky J., 2009. Aquatic and marsh plant communities of the Cerovávrchovina Mts. (Slovakia), the Karancs and Medves Regions (Hungary). Thaiszia - J. Bot., Košice, 19: 71-89.

Kara Y., Kara I., 2005. Removal of cadmium from water using duckweed (*Lemna trisulca* L.). International Journal of Agriculture & Biology, 7 (4): 660-662.

Kasselmann C., 2003. Aquarium Plants. Krieger Publishing Company. Malabar, Florida, 518 pp.

Mei H., Zuo S.,Ye L., Wang J., Ma S., 2012. Review of the application of the traditional Chinese medicinal herb, *Ranunculus sceleratus* Linn. Journal of Medicinal Plants Research Vol. 6(10): 1821-1826.

Robinson P., 2004. Rock and water plants. Practical gardening handbook. Anness Publishing, London, 132 pp.

Rutishauser R., 1999. Polymerous leaf whorls in vascular plants: developmental morphology and fuzziness of organ identities. Int. J. Plant Sci. 160 (6 Suppl.): S81–S103.

Scremin-Dias E., 2009. Tropical aquatic plants: morphoanatomical adaptations, pp. 84-132. In: K. Del-Claro & Rico-Gray (orgs.). Encyclopedia of Tropical Biology and Conservation Management. EOLSS (www.eolss.net). First edition. UNESCO/EOLSS, Paris. Vol I.

***http://www.penritlake-e.schools.nsw.edu

***http://ag.arizona.edu/azaqua/aquaplants/

***http://www.iucnredlist.org

***RIZA rapport, 2002.049. Vegetation of the Biosphere Reserve “Danube Delta” with Transboundary Vegetation Map.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EFFECTS OF COTTON PICKER AGES ON COTTON LOSSES AND QUALITY

Abdullah SESSİZ[1], Reşat ESGİCİ[2]

[1]Department of Agricultural Machinery, Faculty of Agriculture, University of Dicle, Diyarbakır, Turkey
[2] Bismil Vocational High School, University of Dicle, Diyarbakır, Turkey

Corresponding author email: assesiz@dicle.edu.tr

Abstract

In this study, the effects of the cotton picker model and drivers ability on cotton harvest losses and cotton quality were investigated. In experiments, five cotton pickers were used. Four cotton pickers have four rowed and one picker has six rowed with baler. John Deere cotton pickers were used in 2013 cotton harvest season. All of the experiments were conducted on BA119 cotton variety with and without defoliant treatment in Diyarbakır city.
Defoliant and boll opening chemicals (DROP Ultra + FINISH Pro) that were applied 15-25 days prior to harvest. In conclusion, no difference was found between in cotton lint quality by hand harvest and cotton pickers. On the other hand, cotton picker model and drivers ability were statistically differed on harvest losses. The highest harvest loss (60 kg da^{-1}) was found on 1998 model picker. The harvest losses were low than 25 kg da^{-1} on 2007 and the youngest model pickers. Fiber property measurements made by High Volume Instrument (HVI) systems. It is widely used to describe cotton quality in international commerce.

Key words*: cotton, harvest, cotton losses, lint quality.*

INTRODUCTION

Cotton is a major raw material for textile sector in Turkey and worldwide. Turkey is one of the important cotton producer countries. In Turkey, Cotton cultivation is mostly made especially in Southern east, Aegean and Çukurova regions. With the full implementation of the GAP gradually, Aegean and Çukurova region showed a decrease in cotton production areas, Southeastern Anatolia Region has also been an increase in the production area. This increase can also be provided based on the development of the cotton industry. Therefore, this has a strategic importance for the region. GAP covered in Diyarbakır, Şanlıurfa, Mardin and Batman as agricultural areas with more as well as the producers of the region opportunities for irrigation on the gap in the provinces of through boreholes have opened their own facilities, irrigated farmland has increased significantly. With water, a significant increase in the area of cotton production has occurred. This increase, today more than half of Turkey's cotton production is covered by the South Eastern Anatolia. In 2013, 2,250,000 tons cotton were cultivated in 450,890 ha area and 4,990 kg ha^{-1} fiber yield was estimated in Turkey. In GAP region 131,368 tons cotton cultivated in 278,950 ha area which is 58% of the total Turkish production (Tuik, 2014). Harvest in cotton production costs in the region, constitute the largest proportion of about 20-25% share. This value is very high. For many years, cotton production was made in the Aegean and Çukurova in Turkey and performed manually by the harvest workers. Significant reductions in the number of outgoing workers as cheap labor with the adoption of irrigated agriculture in the GAP region has occurred. Therefore, due to the reduction in workforce, cotton producing areas in the Aegean and Çukurova has reduced. Naturally fertile land with water having increased cotton production areas in the GAP region and provide labor for the cotton harvest has started to become an important issue. In particular, the inability to meet the demand for labor in response to increasing cotton production area, and for reasons such as difficulties in providing workers, although it increased harvesting costs, decreased the economic advantages of harvesting by hand. Demand for workers and increase the cost of harvesting, has pushed manufacturers to use the machine as required. Because of the increase in labor costs in the region and in Turkey, paved the way for the use of cotton harvesters. The machine used in the cotton harvest becomes widespread for these reasons. The continuing increase of the support grants to irrigation systems and machinery-equipment by the government, and the spread of drip irrigation in cotton cultivation, it is expected more years of cotton production in the region will be made and the number of cotton harvest machines will increase. The use of different brands of harvesters is increasing every year in Bismil and Çınar district of Diyarbakır city which has an intensive cotton production. Although the situations like this, operator skills, machine age, plant varieties, precipitation, machine settings, inappropriate harvesting time, the losses due to equipment such as improper machine operation parameters, machine harvest losses are more than hand harvest and decreased fiber quality is reported by the manufacturer. In these reasons, it was decided to carry out such a study to determine the source of the problem in the GAP region at the manufacturer conditions. The aim of the study was to determine the effect of the age of machine and skill of the operator by using cotton harvesters of different ages on harvest losses and cotton fiber quality.

MATERIALS AND METHODS

Harvest experiments were carried out in the fields belonging to different manufacturers that the BA 119 cotton varieties cultivated in Bismil district of Diyarbakir province in 2013. Four four-five rowed cotton harvesters and one six rowed cotton harvester which makes round balers in different ages were used in the study (Figure 1). Plant row spacing was 70 cm, therefore, all the machines in the JD 9970 series were used four rowed for a smooth operation. All experiments were carried out with BA119 cotton variety and the same brand cotton harvest machines (John Deere 9970 and 7760). The working speed of all machines was tried to be 2.5-2.7m s^{-1} during the trial. Ideally, cotton harvest should be completed within 30 days after a defoliant was applied. Many times this cannot be accomplished due to adverse weather conditions (Khalilian et al., 1999). In present study, the defoliant treatment was performed 16-25 days before harvest. Boll opener and defoliant treatment (DropUltra+Finish Pro) was done. Harvest experiments were done in defoliant applied field.

Figure 1. Views of the cotton harvester in experiment area

In addition, to determine the values of efficiency, three each 1kg sample was taken from the tank of the machine in each field. These samples were sent to Ak Çırçır factory laboratory in Bismil district to be taken for roller ginning without any pre-cleaning process.
After ginning, these samples were taken to Fiber Analysis Laboratory of Diyarbakır Commodity Exchange and some important technological features were determined by using HVI (High Volume-Precision Instrument) instrument (Öz and Evcim, 2002 a; Anonymous, 2005; Demirtaş and Doğan., 2006; Bakeret al,. 2010; Kılıçkan et al., 2011; Sessiz et al., 2011). Fiber quality class was determined according to standard test HVI. To determine the field seed cotton yield and

harvest losses, measurements were made on 14 m^2 of randomly selected in two rows of three different places (row spacing 70 cm) and 10 m in-row spacing before and after harvest.

RESULTS AND DISCUSSIONS

Before the tests, measurements about plant were done on randomly selected five different locations on the experimental field. The mean values of these measurements, the yield values and the results of HVI analyze of the variety were given in Table 1.

Table 1. The mean values of the measurements, the yield values and the results of HVI analyze

Features	Mean values	
Plant height, cm	85.40	
Boll number on the plant, number	16.40	
Row spacing, cm	70	
In-row spacing, cm	10	
Seed cotton yield (kg da^{-1})	444.50	
HVI analyze results (cotton quality index)	Machine harvest	Hand harvest
Mean ginning yield	43.00	42.73
Fiber length (mm)	28.40	28.20
Uniformity index (%)	84.60	83.80
Fiber strength (g tex^{-1})	32.40	31.10
Fiber fineness (micronaire)	4.25	4.00
Spinning ability of cottons	151.80	149.00
Elongation (%)	6.55	6.40
Trash content	195.60	142.00

There is no statistically difference between the ginning yield values of BA 119 variety from the fields. Thus only the mean value (43%) was given in the table. This value varieties of catalog value obtained (42-43%) were found to match. Also the mean quality values obtained from HVI test were given in Table 1.

As it can be seen in Table 1, fiber quality classification was made by HVI standards (Öz and Evcim, 2002; Anonymous, 2005;) and the longest fiber length (28.40 mm), the highest length uniformity (84.60%), the highest fiber durability (32.40 g tex^{-1}), the highest fiber thickness (4.25 mm) and the highest elasticity (6.55%) were obtained in machine harvest. Thus, it can be seen that machine harvest has no negative effect on technological properties of cotton. There was no statistical difference on the analyze results between machine harvest and hand harvest.

The mean seed cotton lint yield and mean yield loss values of the cotton picked up from the 14 m^2 area before and after harvest were given in Table 2. Stalk loss, or the amount of seed cotton that was not removed from the plant by picking. The highest yield loss (60.18 kg da^{-1}) with a percent of 12.3% was determined on 1998 model JD 9970 cotton harvest machine. The lowest yield loss was determined on 2007 model JD 9970 cotton harvest machine. As it can be seen in Table 2, harvest losses are not only related with the age of machine but also it is related with maintenance, capability of operator and field conditions.

Table 2.The mean seed cotton yield and mean yield loss values of the cotton

BA 119 Cotton variety	**Machine Model**				
Properties	1998	2007	2011	2012	2012
	JD 9970	JD 9970	JD 9970	JD 9970	JD7760 (Baled)
Time of defoliant and boll opener application, days prior to harvest	20	25	15	25	16
Harvest dates	22.10.2013	27.10.2013	24.10.2013	23.10.2013	25.10.2013
Cotton lint yield, kg da^{-1}	486.42	443.57	458.5	346.2	487.85
Mean loss, kg da^{-1}	60.18	25.71	38.51	25	33.14
Loss rate, %	12.3	5.8	8.4	7.22	6.79

CONCLUSIONS

It was determined that machine harvest has no negative impact according to hand harvest in ginning, fiber quality and the harvest losses; conversely has big advantages in working time and labor. Thus, it will be advantageous to generalize the machine harvest for producers and country economy. Total of 25% harvest losses of will be reduced.

REFERENCES

Anonymous, 2005. Guidelines for HVI Testing. http://www.ams.usda.gov/cotton/cnpubs.htm.

Baker K.D., Hughs E., Foulk J., 2010. Cotton qualıty as affected by changes in spindle speed. Applied Engineering in Agriculture .Vol. 26(3): 363-369 2010 American Society of Agricultural and Biological Engineers ISSN 0883-8542.

Demirtaş M., DoğanT., 2006. Traktöre monte edilebilir tip pamuk hasat makinasının bazı pamuk çeşitleri üzerindeki performansının belirlenerek ekonomik analizinin yapılması. Tarım Makinaları Bilimi Dergisi, 2(1); 49-56, İzmir.

Khalilian A., Sullivan M.J., Mueller J.D., 1999. Increasing picker efficiency by using a boll saver attachment. The Journal of Cotton Science, 3:122-125.

Kiliçkan A., Uçer N., Yalçin İ., Coşkun B., 2011. Determination of performance of cotton harvest machine at different cotton production techniques. 11th International Congress on Mechanization and Energy in Agriculture Congress, Proceedings, p. 152-156, İstanbul, Turkey.

Öz E., Evcim H.Ü., 2002. Makinalı hasadın pamuk lif teknolojik özellikleri üzerindeki etkilerinin belirlenmesi. Ege Üniv. Ziraat Fak. Derg., 2002, 39(2): 119-126.

Öz E., Tekin B., Evcim H.Ü., 2007. Kuyruk Mili Tahrikli, Traktöre Bindirilir İki Farklı Tip Pamuk Hasat Makinasının Nicesel ve Nitesel İş başarılarının Belirlenmesi. Tarım Makinaları Bilimi Dergisi, 3(4), S: 271-276, İzmir.

Sabir E.C., Güzel G., 2010. Türkiye'de ve dünyada pamuğun balyalama standardizasyonu: Genel Bakış Ve Son Durum. Ç.Ü. Müh. Mim. Dergisi, 25(1-2), Adana.

Sessiz A., Turgut M.M., Pekitkan F.G., 2009. Dicle vadisinde pamuk üretimi yapan işletmelerin mekanizasyon özelliklerinin belirlenmesi üzerine bir çalışma. Tarımsal Mekanizasyon 25 Ulusal Kongresi, S:65-69, 1-3 Ekim, İsparta.

Sessiz A., Esgici R., Eliçin A.K., Gürsoy S., 2012. Makinalı hasadın farklı pamuk çeşitlerinde pamuk lifinin teknolojik özelliklerine etkisi. 27. Ulusal Tarımsal Mekanizasyon Kongresi, S:154-159, Samsun

TUİK, 2014. Türkiye İstatistik Kurumu. www.tuik.gov.tr.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE ESTIMATION OF NITROGEN RATE (KG/HA) FOR WINTER WHEAT AND SUNFLOWER CROPS, IN AN AGRICULTURAL FARM LOCATED IN BOTOŞANI COUNTY

Gigel ŞTEFAN[1], Claudia ŞTEFAN[2], Georgeta BELENIUC[3]

[1]Westland Farm Management, 55 Floreasca Street, district 1, Bucharest, Romania
[2]Academy of Agricultural and Forestry Sciences, 61 Mărăşti Bvd., district 1, Bucharest, Romania
[3]Ovidius University Constanta, Faculty of Natural and Agricultural Sciences, 124 Mamaia Boulevard Constanta, Romania

Corresponding author email: gigi.stefan10@yahoo.com

Abstract

The aim of this paper is to present the estimation of nitrogen rate - N (kg/ha) for two agricultural crops – winter wheat and sunflower, as part of a rotation that includes soybean – winter wheat – sunflower, in a farm located in Botoşani county, on a phaeozem soil type, whose characteristics have previously determined. The estimation is based on the method introduced by Davidescu D., which establishes the fertilizers rates in accordance to agrochemical indicators, by calculation, taking into account the following indicators: the quantity of N extracted from soil in relation to the predicted yield - N_{ex} (kg); the soil total reserve in N - N_t (kg) and the coefficient of N using from fertilizers (%). By calculation, it was estimated that the N rate for winter wheat after soybean in rotation is 36 kg N/ha and the nitrogen rate for sunflower after wheat is 136.16 kg N/ha, for the considered region, its specific soil type and the predicted yield. The results in case of winter wheat indicated the influence of the leguminous crop in rotation, that provides a significant nitrogen intake in soil reserve. Thus, the residual nitrogen from previous crop (one of the components of soil nitrogen reserve) is 61.25 kg/ha at wheat after soybean, compared to only 19.16 kg/ha in case of sunflower after wheat.

***Key words**: nitrogen rate, soil nitrogen reserve, plant specific consumption, predicted yield, winter wheat, sunflower.*

INTRODUCTION

Regarded as the most important mineral element which highly influences the crop productivity, especially in the case of winter wheat, nitrogen can be absorbed both from the soil reserve, provided mainly from organic matter mineralization, from biological processes of nitrogen fixation, as well as from mineral fertilizers (Davidescu et al., 1987; Hera and Borlan, 1975; Lăcătuşu, 2006; Roman et al., 2011). However, the application of optimum rates in case of nitrogen, as well as for the other macronutrients like phosphorus and potassium, may represent a delicate issue, since there are many factors to be considered, such as: the level of the predicted yield and its specific consumption, the soil content in easily absorbed by plants nitrogen and its mobility in soil, remaining nitrogen from the previous crop, climate characteristics, etc. For Romania's conditions, the optimum level of nitrogen rate in case of winter wheat is between 50-160 kg/ha, according to Hera, cited by Bîlteanu, 1989, cited by Roman, 2011.

There are specific calculation methods for estimating the necessary nitrogen rate, taken into account the particularities of the different crops and other different indices such as drought indicator, root spreading coefficient etc. (Davidescu, 1999).

One method considers the following elements: plant specific consumption (kg N/t) - Cs, predicted yield (t/ha) - Rs, soil intake (kg/ha) - Ns, manure intake - Ng and a correction indicator depending on the previous crop – Npr, respectively: $D_N = Cs \times Rs \times Ns - Ng \pm Npr$ (Roman et al., 2011).

Another calculation method is based on the difference between the level of N extracted from soil by plants and the soil total reserve in nitrogen, all in relation to the coefficient of nitrogen using from fertilizers, according to formula: D_N (N rate) = $(N_{ex} - N_t)/C_u \times 100$ (kg/ha), where: N_{ex} represents the nitrogen extracted from soil, necessary for expected yield (kg); N_t is the total nitrogen reserve in soil (kg); C_u is the coefficient of nitrogen using from fertilizers (%) which, according to standards, has a value rated between 38-71% (Davidescu and Davidescu, 1999). This relation method has the particularity to consider, also, the residual nitrogen after harvesting and the nitrogen lost through the leaching process.

In this context, the present paper presents an estimation of the necessary of nitrogen rate by calculation method, based on soil agrochemical indicators, in order to establish the adequate level of fertilization for two crops - winter wheat and sunflower, on a phaeozem soil type, at an agricultural farm located in Mitoc - Botoşani county, Romania.

MATERIALS AND METHODS

In order to establish the nitrogen rate, it was considered the relation introduced by Davidescu and Davidescu (1999), previously mentioned. This method is based on estimation of soil nitrogen total reserve, which can be used by plants during their vegetation. The estimation was made in accordance to the soil characteristic features, previously determined for arable horizon (Am in this particular case, 0-30 cm), respectively: pH (H_2O) - 7.11; humus content (%) – 4.8; bulk density – 1.21 g/cm^3 (tefan et al., 2012). The total nitrogen reserve in soil is related to nitrogen provided by different sources, such as: the nitrogen provided by rainfalls (and atmospheric dust), the nitrogen provided by symbiotic and non-symbiotic bacteria, nitrogen provided by humus mineralization process, residual nitrogen provided by previous crop and also, the nitrogen provided by organic fertilizers. In estimation of the total nitrogen reserve in soil, it is also taken into account the nitrogen lost through leaching, according to the formula:

$N_t = (N_p + N_b + N_s + N_h + N_r + N_0) - N_l$, where: N_p – N provided by rainfalls; N_b – N provided by non-symbiotic bacteria activity; N_s – N provided by symbiotic bacteria activity; N_s refers to leguminous crops which, after harvesting, provide a significant amount of nitrogen in soil, as a result of symbiosis with nitrogen retainer bacteria; the specific amount of nitrogen retained in soil by the previous leguminous crop varies, mainly depending on the symbiotic bacteria activity, depending also by other factors, such as low or increased temperatures which can negatively influence the symbiotic process; Voss and Shrader, 1984; Schepers and Mosier, 1991; Bundy et al., 1993 cited by Matias and Larry, 1995 state that "soybean harvested for grain can supply an average of 45-67 kg N/ha to a following crop (1-1.5 kg/ha of N for 60 kg/ha of soybean harvested)"; other data state that, for soybean case and in favourable conditions, symbiosis determines the accumulation in soil of a nitrogen amount rated between 60-168 kg/ha (Muntean et al., 2001), while Davidescu (1999) estimated that soybean may fix in average up to 100-120 kg N/ha; also, according to additional data, the specific amount of N retained by soil as a supply for next crop is 20 kg N/to of principal product for soybean, 35 for beans, 25 kg for peas, 6 kg for alfalfa (kg N/to of principal product) (www.icpa.ro); N_h - N provided by humus mineralization process; N_r - residual N provided by previous crop; No – nitrogen provided by organic fertilizers; N_l – nitrogen lost through leaching (estimated between 2 – 15 kg/ha/yr). In calculation, there has also been considered the humus content in nitrogen (%), usually between 3.5-5%, at 4.84% (Borlan et al., 1994).

Regarding the specific consumption of the two crops – Csp (kg N/to), it has been considered that, the medium exports of nutrients (kg nutrients/t principal and secondary yield) is 26.5 in case of winter wheat (grains - straw is 1:1.3) and 36.5 in case of sunflower (seeds – strain is 1:3) (ICPA Bucharest, 2003).

The winter wheat variety considered is *Gasparom*, a biological creation of Suceava Agricultural Research and Development Station, certified in 1998, adapted at Moldova climate conditions; its productive potential can reach over 7 to/ha.

In case of sunflower, the variety considered is *Neoma*, a Syngenta medium early hybrid, with high yield potential and a good adaptability for the cultivated area.

RESULTS AND DISCUSSIONS

The nitrogen estimated rate for winter wheat

In case of winter wheat, there have been considered the following elements: the previous crop is soybean, with a specific consumption

(Csp) of 70 kg N/ha and an obtained yield of 2.5 to/ha.

The nitrogen provided by rainfalls is depending on the amount of annual precipitation and the rainfall content in nitrogen, respectively: $N_p = p \times Kp$, where p is precipitation (mm) and Kp is the coefficient of precipitation content in N and conversion in kg/ha N (usually between 0.02 – 0.03 – specific estimations state that, every 100 mm provide approximately 2 kg N/ha). For Botoşani County, the average annual rainfalls values are between 600 - 650mm/year. Considering Kp value of 0.025, the determined N_p level in this case is 14 kg/ha.

N_b value, reflecting the nitrogen provided by non-symbiotic bacteria, is calculating based on the relation between number of days with temperatures over 8°C and the daily accumulation of nitrogen: N_b (kg/ha/yr) = $Z \times K_b$, where Z-days; K_b-coefficient of daily accumulation of nitrogen (0.2-0.3 kg N/ha/year). For the researched area there are approximately 175 days with positive and over 8°C temperatures, resulting N_b value estimated at 35 kg/ha/yr.

N_s indicates the nitrogen resulted by symbiotic bacteria activity; estimating an average of 1 kg/ha N supply for 60 kg/ha soybean harvested, respectively 20 kg N/t principal product, it results that, in case of 2.5 kg/ha yield, the soybean N supply in soil is approximately 40 – 50 kg/ha, beneficial for winter wheat with soybean as previous crop.

N_h (kg/ha) reflecting the nitrogen provided by the process of humus mineralization, is based on relation: $N_h = (H \times Cm \times K_h) / 10$, where: H –the humus soil reserve (t/ha); Cm – humus content in nitrogen (%) and K_h – humus annual decomposition coefficient (0.012 for non-row crops and 0.018 in case of row crops). Since the soil humus content was previously determined at 4.8%, soil reserve in humus (to/ha) was estimated at 174.2 to/ha, with the following relation: % humus × bulk density (BD) × depth (m) × 100. As a result, the estimation of N_h is 1.01 kg/ha.

N_r (kg/ha) is calculated based on relation: N_r= previous crop yield (t/ha) × Csp × k_{rem}, where k_{rem} represents the coefficient of remanence (0.15 for non - leguminous crops and for 0.35 leguminous crops). For 2.5 to/ha average yield and taking into account the soybean specific consumption indicator, N_r is determined at 61.25 kg N/ha.

In case of No, this is equal to 0, since no organic fertilizers were applied.

N_l was estimated at 10 kg/ha/yr (limits between 2– 15).

Considering all the previously mentioned indicators, the determination of soil nitrogen reserve (N_t) on this specific soil is 141.26 kg.

N_{ex}, calculated as a produce between predicted yield and its specific consumption (Csp), is determined at N_{ex}=159 kg N/ha (the predicted yield is 6 to/ha for *Gaşparom* winter wheat variety and for the region specific conditions).

As a result of that, the nitrogen rate resulted by calculation is estimated at 75.6 kg/ha (table 1).

The nitrogen estimated rate for sunflower

In case of sunflower, the following elements have been considered: the previous crop is winter wheat, with a specific consumption (Csp) of 26.5 kg N/ha and a 6 to/ha as a predicted yield.

Also, the predicted yield in case of *Neoma* sunflower variety is 3.5 to/ha.

In estimation of the nitrogen rate, the determination indicates the following values:

N_{ex} related to sunflower predicted yield and specific consumption is 127.75 kg N/ha.

N_p and N_b values are similar to those corresponding to the winter wheat, respectively N_p is 45 kg/ha and N_b 35 kg/ha/yr.

N_s is considered 0, taking into account that, in rotation, sunflower comes after winter wheat as a previous crop, so there is not any nitrogen resulting from symbiosis.

N_h resulted by calculation is 1.51 kg N/ha (k_h is 0.018 for row crops).

N_r resulted by estimation is 19.16 kg N/ha (the specific consumption is 36.5 kg N/to and k_{rem} is 0.15). No is also 0, due to the fact that organic fertilizers are not considered for application. According to the mentioned considerations, the N rate resulted by calculation is estimated at 136.16 kg/ha (Table 1).

Table 1.The estimation of nitrogen rate (kg/ha) based on specific agrochemical indicators

Previous crop	Annual crop	Predicted yield (t/ha)	Specific consumption (Cs)	Soil indicators (0-30 cm)			N_t(kg)							N_{ex} (kg)	Cu (%)	D (kg/ha)
				pH (H_2O)	% Hum.	Rh (t/ha)	N_p (kg/ha)	N_b(kg/ha/yr)	N_s (kg/ha)	N_h (kg/ha)	N_r (kg/ha)	N_o (kg/ha)	N_l(kg/ha/y)			
soybean	Winter wheat	6	26.5	7.11	4.8	174.2	14	35	40	1.01	61.25	0	10	159	50	36
Winter wheat	Sun-flower	3.5	36.5	7.11	4.8	174.2	14	35	0	1.51	19.16	0	10	127.75	50	136.16

As it resulted by determination, the level of nitrogen rate estimated at 36 kg/ha in case of winter wheat, considerable low, is deeply influenced by the significant nitrogen intake of leguminous crop in rotation, which offers the possibility of reducing the quantity of applied nitrogen.

As it could be observed, the residual nitrogen level from previous crop (N_r) is 61.25 kg/ha at wheat after soybean, which is significant comparing to only 19.16 kg/ha, in case of sunflower after winter wheat in rotation. Such difference emphasizes the role of introducing leguminous crops in rotation.

CONCLUSIONS

The nitrogen values of 36 kg/ha for winter wheat, respectively of 136 kg/ha for sunflower present theoretically importance, as they should be considered as a guidance in application of nitrogen fertilizers, as part of the crop technology corresponding to considered area.

It is important to mention that, in the estimation of optimum nitrogen rates, a considerable importance resides in the climate characteristics for the reference year (which can enhance the nitrogen leaching).

If we refer to plant specific consumption (Cs), it is to specify that - as agricultural practice has showed – sometimes, for the same species, there may be registered differences regarding the value of this indicator, even if they are not evident enough to modify the value of N_{ex}.

Also, according to this relation it is to consider that, when manure is applied, the nitrogen rate should also be decreased, due to its contribution to soil intake in nitrogen.

Finally, the fertilization technology may also influence the level of the predicted yield, beside other factors.

REFERENCES

Borlan et al., 1994. Soil fertility and soils fertilization. Ceres Publishing House, Bucharest.

Davidescu D., Davidescu Velicica, 1987. Agrochemistry as a production support. Ceres Publishing House, Bucharest, p. 114-126.

Davidescu D., Davidescu Velicica, 1999. Agrochemical Compendium. Romanian Academy Publishing House, Bucharest, ISBN 973-27-0677-5, Chap. 7, 607-626.

Hera Cr., Borlan Z., 1975. Guide for structuring the fertilization plans. Ceres Publishing House, Bucharest.

Lăcătuşu R., 2006. Agrochemistry. Terra Nostra Publishing House, Iaşi.

Vanotti M.B., Bundy L., 1995. Soybean effects on soil nitrogen availability in crop rotation. Agronomy Journal, vol. 87, 676-680.

Muntean L.S. et al., 2001. Crop Science, "Ion Ionescu de la Brad" Publishing House, p. 256-267.

Roman Gh.V., 2011. Crop Science. Vol. I, Chap. 2. Universitara Publishing House, Bucharest, 112-113.

Ştefan Claudia, Ştefan G., 2012. An overview on the main properties of a gleyic phaeozem located in Mitoc, Botoşani county, Romania. Scientific Papers. Series A. Agronomy, Vol. LV, p. 117-122.

*** Good Agricultural Practice Code, 2003. Vol. I, ICPA Bucharest, Expert Publishing House, Bucharest ISBN 973-618-001-8, Chap. 11, 87-106; Annexes – Annex 1, 137.

*** www.icpa.ro/useful information/good agricultural practice code/fertilization plans.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

PLANT SPECIES FOR RENEWABLE ENERGY PRODUCTION IN THE REPUBLIC OF MOLDOVA

Victor ȚÎȚEI

Botanical Garden (Institute) of the Academy of Sciences of Moldova, Chişinău, 18 Padurii str., MD 2002 Republic Moldova

Corresponding author email: vtitei@mail.ru

Abstract

In the context of the current sharp rise in energy prices and climate changes, humankind faces two major problems: food provision and energy shortages. The Republic of Moldova possess few energy resources, so being forced to import near 95%, energy crops cultivation seems to offer an ideal solution to the problem of alternative energy sources.
The investigation of introduced tall perennial grasses for biofuel production is an important object in Botanical Garden (Institute) of ASM. Agro biological peculiarities introduced plant species provide perspectives for cultivation in the Republic of Moldova: Macleaya cordata, Sorghum almum, Sida hermaphrodita, Helianthus tuberosus, Miscanthus x giganteus, Symphyotrichum novi-belgii with 10-20 years longevity. Cultivation and harvesting of these species do not need sophisticated mechanisms and specific equipment as in forest exploitations, ensuring a high quantity of dry biomass: 11.0-27.2 t / year / ha with gross calorific value – 18.5 to 20.0 MJ / kg. Biomass potential of these species can be developed in three main directions for biofuel production briquettes or pellets, bio-ethanol, biogas being transformed into energy.

Key words: *agro biological peculiarities, energy characteristics of biomass, Macleaya cordata, Sorghum almum, Sida hermaphrodita, Helianthus tuberosus, Symphyotrichum novi-belgii.*

INTRODUCTION

In the context of the current sharp rise in energy prices and climate changes humankind faces two major problems: food provision and energy shortages. Energy is the dominant factor that determines the welfare of the country and people, influences the level of development of all spheres of activity in society. The sources of renewable energy acquire considerable interest, if accompanied by a more rational use of energy, to facilitate the transaction by a high use of fossil fuels to a sustainable use of renewable energy. There are many alternative energy sources such as wind, solar, geothermal and biomass that fulfill the criteria of sustainability and economic feasibility. The complex problems of the development of renewable energy have become a global political dimension. The European Commission approved the Energy Policy for Europe which envisages the following objectives for 2020: a 20% increase in energy efficiency, a 20% reduction in emissions of greenhouse gases, achieving a 20% share of renewable energy. For this reason it is estimated that as a consequence it will be biomass which will constitute the most important source of energy, particularly essential in comparison to conventional sources, since it is renewable. Plant species are efficient users of solar energy for converting CO_2 into biomass. Biomass currently accounts for 2/3 of renewable energy in Europe and bioenergy will play a key role in achieving the ambitious targets approved by the renewable energy directive. 20 % of the final energy consumption has to be provided using renewable sources by 2020. Pahkala et al. (2009) estimated that energy crop potential would be about 3 EJ by 2050 in EU-27.

The Republic of Moldova has few fossil energy resources, so being forced to import near 95%, depending entirely on the supplying countries. Therefore, the issue of renewable energy sources has been and remains actuality. Moldova has taken the first steps in this field in 2007 when it was approved the Renewable Energy Law, in 2013 – the Energy Strategy by 2030, implemented the project "Moldova: Energy and Biomass", financed by the European Union and UNDP Moldova. Solving the problem concerning the creation of secure alternative sources of energy requires, first of all, the production of volumes of renewable biomass at industrial scale, the processing of which allows obtaining the necessary quantity of fuel. The structure expected by 2020 of the total production and consumption of energy obtained from renewable sources based on biomass will constitute approximately 70.0%. The climatic conditions from the years 2011 - 2012, which had serious consequences on the development of agriculture, revealed that only on the basis of agricultural remains - straw, sunflower stalks and corn, the problem of biomass supply cannot be solved, which determined the orientation of the research and innovation policy towards identifying new plant species by analyzing their productivity, environmental impact, economic efficiency and ensuring that they didn't affect the food supply of the population. For biomass production on industrial scale, the most efficient crops that use to a great extent the photosynthetically active solar energy during the vegetation period, accumulate a considerable amount of dry matter and demand optimal expenses for establishment and low expenses for maintenance, harvesting and processing should be selected and implemented (Wróblewska et al., 2009; El Bassam, 2010; Kalensky et al., 2010; Rakhmetov, 2011). Over more than half a century, as a result of the introduction and acclimatization researches done in the Botanical Garden (Institute) of the ASM, collections and exhibitions of plants with multiple use, necessary for the development of the national economy, were founded. The investigation of local as well as introduced tall perennial species for biofuel production is an important object. Currently, about 100 species of plants from the Botanical Garden can be used to produce different types of biofuels.

The aim of the present study was to evaluate some agro biological peculiarities and energy characteristics of biomass of the species: *Macleaya cordata, Sorghum almum, Sida hermaphrodita, Helianthus tuberosus, Symphyotrichum novi-belgii.*

MATERIALS AND METHODS

The introduced plant species from the collections of the Botanical Garden (Institute) of the ASM were used as material for research: *Macleaya cordata* (Willd.) R. Br., *Sorghum almum* (Piper) Parodi, *Sida hermaphrodita* Rusby, *Helianthus tuberosus* L., *Miscanthus x giganteus*, *Symphyotrichum novi-belgii* (L.) G.L. Nesom. The experiments were performed on non-irrigated experimental land. The plant growth and development, their productivity were done according to methodical indications (Ivanov, 1985). The moisture content of biomass (chopped material) was determined by CEN/TS 15414 in an automatic hot air oven MEMMERT100-800. Content of ash was determined at 550°C in a muffle furnace HT40AL according to CEN/TS 15403. Automatic calorimeter LAGET MS-10A with accessories was used for the calorific value determination, according to CEN/TS 15400. The cylindrical containers were used for determination of bulk density, calculated by dividing the mass over the container volume. The briquetting was carried out by hydraulic piston briquetting press BrikStar model 50-12 (Briklis). The mean compressed (specific) density of the briquettes was determined immediately after removal from the mould as a ratio of measured mass over calculated volume.

The scientific researchers were performed during the 2010-2014 years.

RESULTS AND DISCUSSIONS

The introduced non-food herbaceous perennial plant species with intensive growth is Plume poppy, *Macleaya cordata* (Willd.) R. Br., family *Papaveraceae*, natives of eastern Asia (China, Japan). Is cultivated as a garden plant, the aerial parts have long been used as a medicine (Xinrong, 2003, Kosina et al. 2010). As a result of the study of the biological peculiarities in the first year of vegetation, we can mention that in April, from the rhizomes of the species *Macleaya cordata* at the soil surface appears the bud which develops erect, glaucous, basally lignified, yellow lactiferous stems; the leaves are light green to olive green, simple lobed, alternate arrangement; the flower is radially symmetrical, panicles of creamy white flowers. At the end of vegetation the plant height reaches 168 cm. The productivity of biomass constitutes 0.47-0.51 kg/m^2 dry matter.

In the second year and the following years of vegetation, in spring, when the air temperature exceeds 8°C, starts plant development from generative buds formed on the rhizomes, which go through all stages of ontogenetic development finishing with seed formation, the plant height reaches 318-343 cm (Figure1).

At the end of the period of vegetation and with the establishment of negative temperatures the stems are completely defoliated, the humidity of the stems – about 33-35%, in January - below 23%, and in early March 10-13%.

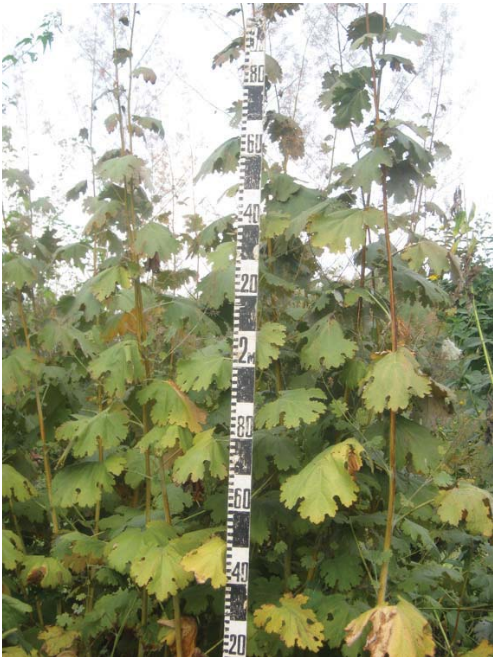


Figure 1. *Macleaya cordata*(Willd.) R. Br.

The productivity of the harvested biomass constitutes 16.7-20.1 kg/m^2 dry matter. The bulk density of the chopped stems is 146-185 kg/m^3. The gross calorific value absolutely dry mass reaches 19.12 MJ / kg. The density of the briquettes made from biomass is 860 kg/m^3. The ash content absolutely dry mass is 1.7%.

Taking into account the expansion of areas of soils with a high salt content and the frequency of droughts in our country, an introduced plant that can help solve the above mentioned problems is Columbus grass, *Sorghum almum* Parodi, family *Poaceae*, plant group C_4, native to South America (Argentina, Paraguay, Uruguay) is a robust, tussocky perennial with numerous tillers and thick short rhizomes which curve upwards to produce new shoots near the parental stool. Culms are solid and pithy, about 1 cm thick, sometimes reaching a height of 3-3.6 m. The leaves are 2.5-4.0 cm wide and waxy. The inflorescence is a large pyramidal panicle (25-33 cm) with secondary and tertiary branches, generally drooping as seed ripens. 2n = 40. It reproduces by seeds (Uteush, 1990; Heuzé et al., 2015).

We have established that seedlings of *Sorghum almum* appear on the soil surface after 5-7 days from sowing and growth and development are intensive in the first year, the plant goes through all phenological phases till full ripening of seeds, it develops a strong root system and its aerial part is a bush of 2-4 branches, about 2.0 m tall, it forms 8-12 leaves with a length of 82-124 cm and a width of 1.2-3.0 cm (Figure 2).

In the following years, the resumption of vegetation starts in April and a bush can develop up to 20 shoots which attain a height of 3.0 m and a diameter of 0.8-1.3 cm. Its seed productivity reaches 1.5-2.4 t/ha.

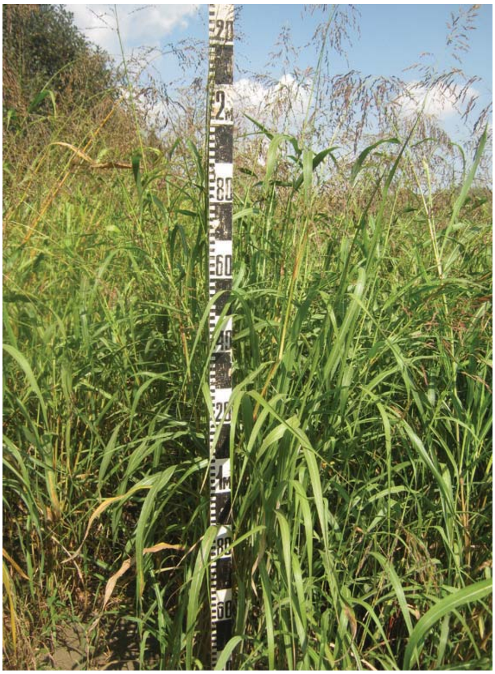


Figure 2. *Sorghum almum* Parodi

To produce solid biofuel, the *Sorghum almum* plants can be harvested in August-September by mowing and drying in swaths or by grinding in November-December when the temperatures are below 0ºC and when the humidity is reduced to 10%. The yield, depending on age and manner of exploitation of the plantation, is about 11-15 t/ha. The bulk density of the biomass is of 118-133 kg/m^3, the gross calorific value reaches 18.6 MJ/kg.

The density of the briquettes is 700 kg/ m^3. The ash content absolutely dry mass is 3.7%. Columbus grass has anti-erosion properties, it is pest and disease tolerant, highly resistant to drought, heat and salty soil and averagely resistant to frost.

Virginia mallow, *Sida hermaphrodita* Rusby, family *Malvaceae*, is a perennial herbaceous native to North America with tubular, erect stem, smooth surface coated with a waxy layer, solid, with high lodging resistance. It reproduces by seeds and vegetatively (cutting, root pieces). It is sown in late autumn or early spring with layered seeds at a depth of 2-3 cm with a norm of 2-3 kg/ha, the distance between rows – of 45 cm or 70 cm, with soil compaction before and after sowing.

Figure 3. *Sida hermaphrodita* Rusby*,* variety Energo

The vegetative propagation is done by planting cuttings in the middle of May (25-30 thousand/ha), in the first 45 days, the plants have a slow rate of growth and development of aerial parts, the stem formation begins, in the next period, the growth rate is accelerating and, in the middle of September, flower bud formation begins and shoots reach a height of 171 cm. When propagation by seed is used, seedlings grow slowly, forming a strong, erect, branched stem, which is up to 1.4 m tall and 1.7-2.1 cm thick at the base. Virginia mallow plants develop maple-like leaves; the leaf blade has double-serrated, light green edge. In the first year of vegetation, it develops a strong, pivoting, extended root system. Fresh mass productivity reaches 24-28 t/ha at the end of September.

In the next years, plant growth and development starts in spring, when temperatures are above 0ºC, the shoots appear in the middle of April, they are vigorous and numerous (8-17 shoots on a bush). Due to the pivoting and highly branched root system, which reaches to a depth of 2.5-3.0 m, Virginia mallow plants efficiently use soil moisture accumulated in autumn and winter, the shoots grow and branch intensely and at the end of growing season attain a height of 3-4 m and a diameter of 3-7 cm at the base. It blooms from the middle of July to August, and in some years – until the end of growing season, providing a late pollen collection for bees (that produce about 60 kg/ha of honey) and serves as a source of food for other pollinating insects. When the frosts begin, all the leaves fall from the stems and their dehydration increases so that the dry biomass can be harvested in December-January. It has been found that the bulk density of the collected material is 268 kg/m^3. The gross calorific value of the dry matter reaches 18.7 MJ/kg. The ash content is 1.5%.

The fresh aerial biomass is used as substrate for obtaining biogas - 395 m^3/t dry matters (Oleszek et al., 2013).

By individual selection of the introduced population, the local variety Energo of Virginia mallow (Figure 3) was created and registered in the Catalogue of plant varieties of the Republic of Moldova in 2014. The fresh mass productivity in the 3rd-4th years reaches 96-112 t/ha, the potential of obtaining biogas is 11-12 thousand m^3, equivalent to 5.0-5.5 thousand m^3 of natural gas, and the dry biomass productivity reaches 22 t/ha with an energy potential of 380 GJ/ha.

Jerusalem artichoke, *Helianthus tuberosus* L., family *Asteraceae*, plant group C_4 native to North America, it has a coefficient of utilization of photosynthetically active solar energy of over 3.5% exceeding 3 times the maize (Kays and Nottingham, 2008)

In the Botanical Garden (Institute) of the ASM, over the years, a collection of over 60 different taxa of Jerusalem artichoke with different growing season, plant habitus, shape and color of tubers was created, being selected promising forms to create new varieties.

Figure 4. *Helianthus tuberosus L.,* variety Solar

The variety Solar of Jerusalem artichoke (Figure 4) was created in the Botanical Garden (Institute) of the ASM by clonal selection from large populations and was mainly intended for animal feeding. It was registered in the Catalogue of plant varieties of the Republic of Moldova in 2014. It propagates vegetatively, is planted in April at a depth of 7-10 cm (1.5-2.3 t/ha tubers).

It was found that from the buds on the tubers, during 13-18 days after planting, 2-3 seedlings develop and appear on the soil surface. During the growing season they develop erect stems of green color with shades of anthocyanin, covered with a film of bluish-gray wax, 300-450 cm tall and with a diameter of 2-5 cm at the base, rough, porous, branched in upper part, with 50-70 leaves. The leaves are dark green, on the lower part of the stem they are opposite and on the upper part - alternate, petiolate, the leaf blades are ovate, medium sized with coarse toothed edge. Inflorescence is a solitary calathidium situated at the ends of branches, with a diameter of 4-6 cm at flowering. The root system develops rapidly and during the first month the fibrous roots can grow as long as 30 cm. On the underground part of the stem, at the end of May, stolons start forming, the stolons of the Solar variety are 10-23 cm long and by thickening of the terminal part thereof, during July, first tubers are formed, the period of tuber formation and growth lasts until the end of September. The tubers are placed in the hole in a scattered way. The medium-sized tubers weigh 43-65 grams, are oval-oblong, with a thin peel of cherry color with a strong anthocyanin intensity and white core (Teleuță and Țîței, 2013)

In several countries, the tubers of Jerusalem artichoke are used in food, pharmaceutical industry, as well as to obtain bioethanol, and the fresh aerial biomass is used to obtain biogas and liquid biofuels (Kays and Nottingham, 2008; El Bassam, 2010; Halford and Karp, 2011; Micu, 2011)

At the end of growing season and after frost, over 15-35 days, depending on weather conditions, *Helianthus tuberosus* stems are completely defoliated, they dehydrate faster than those of *Macleaya cordata*, the bulk density of the harvested biomass is 268-288 kg/m^3. The gross calorific value of the dry matter of *Helianthus tuberosus* reaches 18.5-18.7 MJ/kg. The ash content is 2.2 %. Specific density of the briquettes is 720-760 kg/m^3

In 2013, at the variety Solar, the yield of tubers reached 44.0 t/ha which allowed to obtain 3850 l/ha bioethanol and the yield of dry aerial biomass – 27.2 t/ha with an energy potential of 470 GJ/ha.

One of the most commonly used herbaceous energy crops is *Miscanthus x giganteus*, a sterile tetraploid hybrid, parental forms: *Miskanthus sinensis* Andersson and *Miscanthus sacchariflorus* (Maxim.) Franch., family *Poaceae*, plant group C_4, native to tropical and subtropical regions of Africa, Southeast Asia, is characterized by a rapid growth and development, is tolerant to soil and environmental conditions being widely used for fuel production in North and Central Europe since the 80s of the last century. It propagates vegetatively through rhizomes or plantlets obtained from tissue culture. *Miscanthus* rhizomes are planted at a depth of 8-10 cm in early spring when temperatures are above 8ºC. The plantlets of *Miscanthus* are planted during May-June with the equipment used for planting vegetables. Planting scheme: 1.0m x 0.7m or 1.0m x 1.0 m, about 10-14 thousand bushes per hectare (Lewandowski et al., 2000). In the first year of vegetation, in the conditions of the Republic of Moldova, *Miscanthus x giganteus* develop, in the underground part, the root system and new rhizomes, and the shoots can reach 1.2-1.8 m tall, with high leaf content. In the following year, vegetation starts in April and, from rhizomes, grow shoots which by the end of vegetation reach 3.0 m tall (Figure 5), the leaf content is below 20%, the root system reaches 2 m depth, the number of rhizomes increases considerably.

Figure 5. *Miscanthus giganteus*

The biomass yield from the plantation founded by rhizomes reaches 7-8 t/ha in the second year. In the following years, plant growth is more intensive, the number of shoots on a bush increases significantly influencing positively the crop. The dry biomass productivity of a 3-4 year old plantation reaches 14.2-16.3 t/ha and, in 2013, due to the high amount of rainfall – 20 t/ha. We can mention that when temperatures below 0ºC are established, dehydration and defoliation of shoots accelerate so that in December biomass harvesting can be started. Forage harvesters are used to harvest Miscanthus plants by chopping directly the stems or by mowing and baling them. The bulk density of the chopped biomass is of 138-153 kg/m^3. The gross calorific value of the dry matter reaches 18.7-20.0 MJ/kg. The ash content is 1.9-2.2%. Specific density of the briquettes is 760-800 kg/m^3.

Longleaf Aster, *Symphyotrichum novi-belgii* (L.) G.L.Nesom, family *Asteraceae,* is an ornamental perennial plant native to North America (Canada and the United States). It is a branching, multi-stemmed plant that grows up to 100–140 cm. It has narrow, green, oblong or lance-shaped leaves. It is a prolific bloomer. Large flower heads are arranged in showy panicles. The heads consist of a ring of 20 or more purple or pink or occasionally white ray florets that surround a central cluster of yellow disc florets. Flowers are frequented by monarchs and other butterflies, skippers and bees. Rhizomatous roots make it a good soil stabilizer. Propagate from seed, clump division and cuttings (Brouillet et al., 2006).

Figure 6. *Symphyotrichum novi-belgii*

We have found that *Symphyotrichum novi-belgii* plants are characterized by a fast growth of the aerial part and of the root system. So, in the 3rd-4th years of vegetation, 8-10 erect shoots up to 120-140 cm tall grow on a bush (Figure 6). Dehydration of shoots during 20-30 days after the beginning of frosts is very severe, reaching values of 85-90%. The aerial biomass productivity is of 11.7-12.5 t/ha, with a leaf content of 10-18%. After harvesting the plants using a forage harvester, the bulk density of biomass is of 248-256 kg/m^3. The biomass can be easily processed into briquettes. The specific density of the briquettes is 843-913 kg/m^3. The gross calorific value is 18.6-18.7 MJ/kg of dry matter. The ash content is 1.8-3.2%. *Symphyotrichum novi-belgii* can be used for the exploitation of eroded and polluted soils.

CONCLUSIONS

Agro biological peculiarities and energy characteristics of biomass provide perspectives for implementation in the Republic of Moldova the species: *Macleaya cordata*, *Sorghum almum*, *Sida hermaphrodita*, *Helianthus tuberosus*, *Miscanthus x giganteus* and *Symphyotrichum novi-belgi*i with 10-20 years longevity. Cultivation and harvesting of these species do not need sophisticated mechanisms and specific equipment as in forest exploitations, ensuring a high quantity of dry biomass: 11.0-27.2 t/year/ha, gross calorific value – 18.5 to 20.0 MJ/kg. Biomass potential of these species can be developed in three main directions for biofuel production briquettes or pellets, bio-ethanol, biogas being transformed into energy.

REFERENCES

Brouillet L., Semple J.C., Allen G.A., Chambers K.L., Sundberg S.D., 2006. *Symphyotrichum*. In: Flora of North America 20, Oxford University Press, New York & Oxford, p. 465

El Bassam N., 2010. Handbook of bioenergy crops : a complete reference to species, development and applications. Earthscan, London Washington. 544 p,

Halford N.G., Karp A., 2011. Energy Crops. Royal Society of Chemistry, London, p. 426.

Heuzé V., Tran G., Baumont R., 2015. *Columbus grass (Sorghum x almum)*. Feedipedia.org. A programme by INRA, CIRAD, AFZ and FAO. http://www.feedipedia.org/node/378 *Last updated on February 2, 2015, 9:43*

Ivanov A.I., 1985. The study collections of perennial forage plants (guidelines). Edit. Agropromizdat Leningrad, p. 48.

Kalensky S., Rakhmetov D., Kalensky V., Iunik A., E. Kachur E, Novitskaya N., 2010. The energy plant resources. Edit. Lithuanian Agricultural University Kaunas, 93 p.

Kays S.J., Nottingham S. F., 2008. Biology and chemistry of jerusalem artichoke: *Helianthus tuberosus* L. CRC Press INC, 2008, p. 478.

Kosina P., Gregorova J., Gruz J., Vacek J., Kolar M., Vogel M., et al. 2010. Phytochemical and antimicrobial characterization of Macleaya cordata herb. *Fitoterapia* 81, 1006-1012.

Lewandowski I., Clifton-Brown J.C., Scurlock J.M.O., Huisman W., 2000. *Miscanthus*: European experience with a novel energy crop. Biomass and Bioenergy, 19, p. 209-227.

Micu V., 2011. Surse regenerabile de bioenergie din agricultură: posibilități şi oportunități de producere si utilizare. Akademos. 2(21): 75-81.

Pahkala K., Hakala K., Kontturi M., Niemeläinen O., 2009. Peltobiomassat globaalina energianlähteenä. Field crops as global energy source. Maaja elintarviketalous, 137, p. 48.

Oleszek M., Matyka M., Lalak J., Tys J., Paprota E., 2013. Characterization of Sida hermaphrodita as a feedstock for anaerobic digestion process J. Food Agric. Environ., 11 (3,4):1839–1841.

Rachmetov J.B., 2011. Fundamental and applied aspects introduction of plants in Ukraine. Edit. Agrar Media Group, Kyiv, p. 398.

Teleuță A., Țîței V., 2013. Biological peculiarities and utilization possibilities of the cultivar “Solar” of *Helianthus tuberosus* L. Revista Botanica Vol. V, 2(7): 42-48.

Uteush Y.A., 1990. New promising forage crops. Edit. Naukovo dumka, Kyiv, p.192.

Wróblewska H., Komorowicz M., Pawłowski J., Cichy W., 2009. Chemical and energetical properties of selected lignocellulosic raw materials. Foliaforestalia polonica Series B, Issue 40, 67-78.

Xinrong Y., 2003. Encyclopedic Reference of Traditional Chinese Medicine. Springer, p. 436.

* Legea energiei regenerabile a Republicii Moldova nr.160-XVI din 12.07.2007. Monitorul Oficial nr.127-130/550 din 17.08.2007.

* Strategia energetică a Republicii Moldova pînă în anul 2030. HG nr. 102 din 05.02.2013 Monitorul Oficial Nr. 27-30 din 08.02.2013.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

THE CHANGE IN THE FORAGE QUALITY OF CRESTED WHEATGRASS (*Agropyron cristatum* L.) IN GRAZING AND NON-GRAZING ARTIFICIALLY ESTABLISHED PASTURES

Mevlüt TÜRK[1], Sebahattin ALBAYRAK[2], Yalçın BOZKURT[3]

[1]Süleyman Demirel University, Faculty of Agriculture, Department of Field Crops, Isparta, Turkey
[2]Ondokuzmayis University, Vocational School of Bafra, Samsun, Turkey
[3]Süleyman Demirel University, Faculty of Agriculture, Department of Animal Science, Isparta, Turkey

Corresponding author email: mevlutturk@sdu.edu.tr

Abstract

This research was conducted to determine the chemical composition of crested wheatgrass in artificial pasture from the years 2010 to 2012. The mixture of the pasture used were alfalfa (Medicago sativa L.) + sainfoin (Onobrychis sativa Lam.) + crested wheatgrass (Agropyron cristatum L.) + smooth bromegrass (Bromus inermis L.). Forage samples were collected from grazing and non-grazing areas once every 15 days during the grazing seasons. The crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, in vitro dry matter digestibility (IVDMD), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), ratios were determined on the crested wheatgrass forage samples. According to results, CP, IVDMD and K contents decreased throughout the grazing season, while ADF and NDF contents increased in grazing areas. In non-grazing areas, the CP content, IVDMD, Mg, P and K contents decreased throughout the grazing season, while ADF, NDF and Ca contents increased. The ADF, NDF, Ca contents of crested wheatgrass in non-grazed areas were higher than the grazed areas, while CP, IVDMD, P, Mg and K contents of grazed areas were higher than non-grazed areas. It can be concluded that the harvesting at the late stages caused a reduction in forage quality of crested wheatgrass in grazing and non-grazing areas.

***Key words**: Agropyron cristatum, artificial pasture, ADF, CP, forage quality.*

INTRODUCTION

A successful grazing management plan should consider seasonal quality of forage resources, adapt them to animal requirements and maximize animal production without adversely affecting longterm forage production. Van Poollen and Lacey (1979) reviewed specialized grazing systems on western ranges and concluded that they increased mean annual forage production by 13% compared to continuous or season-long grazing. Reducing stocking levels had an even greater effect. Additionally, Allison and Kothmann (1979) found that with lower stocking levels animals selected higher quality diets.

Crested wheatgrass has a growing season of April, May, and June. Forage is of high nutritive value early in the season but decreases rapidly in digestible protein and energy with increasing maturity. Young rapidly growing animals can efficiently utilize early season high quality forage and yearling steers can maintain daily gains above 0.8 kg through mid-June (Raleigh 1970). After this time, gains decrease with decreasing forage quality. Crested wheatgrass develops stiff unpalatable culms and a high stem to leaf ratio with increasing maturity. However, Hyder and Sneva (1963) have shown that adjusting stocking levels to achieve close grazing in late May, while plants are in the boot stage, will reduce formation of reproductive shoots and stimulate vegetative growth.

The relative performance of animals is generally associated with the forage quality. Higher nutritive quality of feeds are dependent on higher levels of cell-soluble, crude protein and mineral contents. These components of forage decline substantially with the advanced plant growth and reach the lowest level when plants become quality (Koc and Gokkus, 1994) as in all steppe vegetation. The changing trend of nutritive component of forage shows great differences among range types because the timing and length of growing season differ among them due to climate (Holechek et al., 2004). Most plants show a similarity in declining nutrient composition with advancing development towards maturation (Rebole et al., 2004).

Therefore, in this research it was aimed to determine chemical composition of the crested wheatgrass during the grazing season in artificial pastures established in the Mediterranean Region of Turkey.

MATERIALS AND METHODS

This research was conducted at Suleyman Demirel University Research Farm in Isparta Province (37°45′N, 30°33′E, elevation 1035 m) located in the Mediterranean region of Turkey on three consecutive years of 2010 and 2012. The total precipitation and average temperature data for the experimental area are given in Figures 1 and 2. The major soil characteristics of the research area were as follows: The soil texture was clay loam, the organic matter was 1.3% as determined using the Walkley–Black method, the lime was 7.1% as determined using a Scheibler calcimeter, the total salt was 0.29%, the exchangeable K was 122 mg kg^{-1} by 1 N NH_4OAc, the extractable P was 3.3 mg kg^{-1} by 0.4 N $NaHCO_3$ extraction, and the pH of a soil-saturated extract was 7.7. The soil type was calcareous fluvisol.

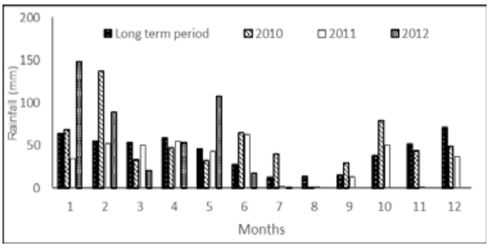


Figure 1. Rainfall values for individual experimental years and over the long term

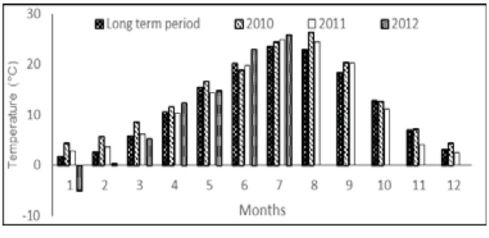


Figure 2. Temperature values for individual experimental years and over the long term

In March 2010, two artificial grazing lands, covering 1.5 ha pasture each land were established at university farm. Pasture was composed of alfalfa (*Medicago sativa* L., 15%) + sainfoin (*Onobrychis sativa* Lam., 15%) + crested wheatgrass (*Agropyron cristatum* L., 35%) + smooth bromegrass (*Bromus inermis* L., 35%). Cutting and maintenance applications were made in the first year. Pastures were harvested twice during the end of June and beginning of October in 2010. Animal grazing applications were performed in the second and the third year of the study since the first year covered only the establishment of the artificial pastures. The animals were turned out to pasture for grazing on the 1st of May and the grazing was terminated on the 1st of August each year. 10 Holstein male calves with an average 6 months old were included and allocated evenly to artificially established pasture in the experiment which lasted for 90 days in 2011 and 2012. The animals had a free access to the water during all experimental periods.

Four non-grazed areas within pasture were established in order to determine chemical composition changes of crested wheatgrass and fenced with wires by 4×3m size and grass samples were collected by using 0.5m^2 (0.5×1 m) quadrats fortnightly from May to August each year. The crude protein (CP), acid detergent fibre (ADF), neutral detergent fibre (NDF) contents, *in vitro* dry matter digestibility (IVDMD), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg), ratios were determined as well.

The collected samples after the harvest were weighed and dried at 70°C for 48 h. The dried samples were reassembled and ground to pass through a 1-mm screen. The crude protein (CP) content was calculated by multiplying the Kjeldahl nitrogen concentration by 6.25 (Kacar and Inal, 2008); K, Ca and Mg contents of samples was determined using an atomic spectrophotometer after digesting the samples with $HClO_4$:HNO_3 (1:4); P content was determined by vanadomolybdophosphoric yellow colour method (Kacar and Kovancı 1982). The acid detergent fiber (ADF) and neutral detergent fiber (NDF) concentrations were measured according to methods from Ankom Technology. Tilley and Terry's (1963) methods were used to determine *in vitro* dry matter digestibility (IVDMD) of samples.

The data were subjected the analysis of variance using GLM procedure (MINITAB 2010). The means were compared by pairwise comparison test by Duncan at the 5% level of significance

RESULTS AND DISCUSSIONS

The effects of the grazing and sampling times on all investigated traits were significant as shown in Table 1. The effects of the grazing and sampling times on CP contents were significant. The CP contents were decreased linearly throughout the grazing season in grazed and non-grazed areas (Figure 3). The highest CP contents were obtained from beginning of the grazing season while the lowest CP contents were determined at end of the grazing season (Figure 3). Maturity stage at harvest is the most important factor determining forage quality. Besides N, and hence protein, most minerals, decline with advancing plant development. Other reports also support that the CP contents decreases by advancing stage of maturity (Koc et al., 2000; Rebole et al., 2004), suggesting that animals should be supplemented with protein sources, especially towards the end of the grazing season. As a result of this process, forage quality lessens substantially towards the end of growing season. The CP ratios of the grazed areas were higher than that of non-grazed areas in the present study. This could be associated with the continued re-growth of the plants in grazed areas because young plant tissues are more nutritious than dead or mature plant (Lyons et al., 1996).

Table 1. Results of analysis of variance and mean squares of the traits determined

Sources of variations	df	CP	NDF	ADF	IVDMD	P	K	Ca	Mg
Block (year)	6	0.01 ns	1.13*	1.42**	0.77 ns	0.001 ns	0.003*	0.001 ns	0.001 ns
Year	1	69.21**	311.3**	572.2**	102.1**	0.002 ns	0.411**	0.614**	0.046*
Grazing (G)	1	3.61**	22.27**	2.95**	213.12**	0.009**	0.472**	0.171**	0.179**
Sampling Times (ST)	6	178.11**	1312.22**	781.33**	1341.1**	0.051**	1.891**	4.511**	0.136**
G x ST intr	6	0.39 ns	5.66 ns	2.41 ns	8.13 ns	0.002 *	0.018 *	0.007 *	0.011 *
G x Year	1	1.28 ns	12.77 ns	0.09 ns	1.41 ns	0.0001 ns	0.007 ns	0.023 ns	0.001 ns
ST x Year	6	0.44 ns	0.22 ns	0.22 ns	0.09 ns	0.0001 ns	0.001 ns	0.005 ns	0.0003 ns
G x ST x Year intr.	6	0.027 ns	0.45 ns	0.11 ns	0.04 ns	0.0001 ns	0.003 ns	0.001 ns	0.0001 ns
Error	78	0.02	0.67	0.32	0.71	0.0001	0.001	0.001	0.0002

df: degrees of freedom, ns: not significant, *P<0.05 and **P<0.01

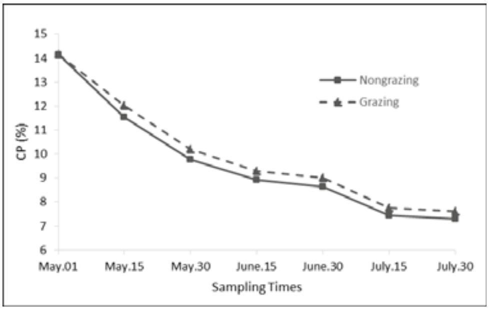


Figure 3. Seasonal variation of CP content of crested wheatgrass in artificial pastures

As shown in Table 1, ADF and NDF contents of crested wheatgrass were significantly affected by both grazing and sampling times. Acid detergent fiber and NDF contents were increased during the grazing season in grazed and non-grazed areas (Figures 4 and 5). This could be explained by the decrease in proportion of leaves and the increase of the stems proportion with advanced maturity. Because, ADF and NDF contents of stems are higher than the leaves. Similar results were reported by Karslı et al. (2003), Kaya et al. (2004), Erkovan et al. (2009), Turk et al. (2014), Albayrak et al. (2009). The trends in ADF and NDF contents with increasing maturity are normally the reverse of protein (Rebole et al., 2004). Young plant cells has the primary cell wall, but also the secondary cell wall occurs with maturing. This causes being the more fibrous of mature plants (Arzani et al., 2004).

ADF and NDF contents of non-grazed areas were higher than those of grazed areas in the present study. This could be explained by the continued re-growth of the plants in the grazed areas.

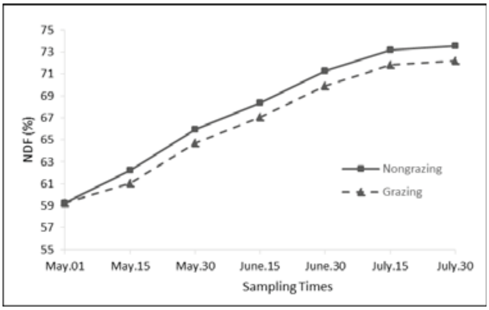


Figure 4. Seasonal variation of NDF content of crested wheatgrass in artificial pastures

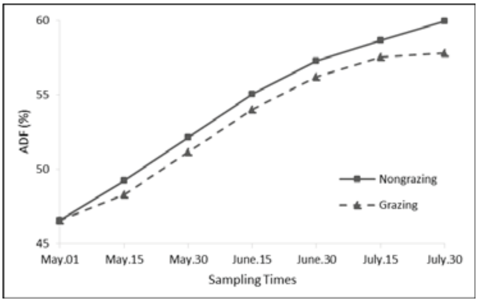


Figure 5. Seasonal variation of ADF content of crested wheatgrass in artificial pastures

The grazing and sampling times showed significant effects on IVDMD of crested wheatgrass (Table 1). The IVDMD was decreased throughout the grazing season in grazed and non-grazed areas (Figure 6). Similar results were reported by Hitz and Russell (1998), Karsli et al., (1999). The reason for this decrease in digestibility of plants is the increase in the lignin content (Jung and Vogel, 1992). The decrease in IVDMD resulted from the increase structural tissues in stems (Arzani et al., 2004). Pinkerton (1996) stated that there is a close relationship between digestibility and cell wall structure. Overall, IVDMD varies depending on crude cellulose levels in its structure. Digestibility of plenty of leafy green forage is very high, whereas the increase of the stems proportion with advanced maturity causes a decrease digestibility (Aksoy and Yilmaz, 2003).

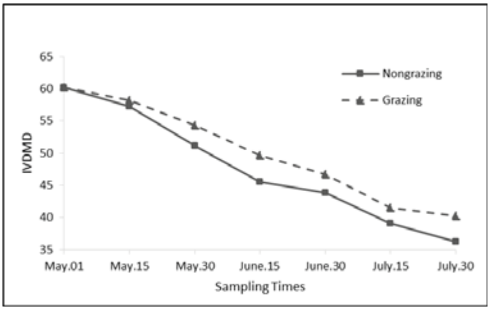


Figure 6. Seasonal variation of IVDMD of crested wheatgrass in artificial pastures.

Statistically significant interactions between grazing × sampling times were found for P, K, Ca and Mg ratios in crested wheatgrass (Table 1). These interactions indicated that harvesting stage affected P, K, Ca and Mg ratios differently according to the different grazing applications. The Mg and P contents of crested wheatgrass in non-grazing areas were decreased with advanced maturity, while those of grazing areas did not change statistically significant. The Ca content of crested wheatgrass in non-grazing areas was increased with advanced maturity, while that of grazing areas did not change statistically significant. The K content was decreased in grazing and non-grazing areas of artificial pasture during the grazing season. The changing trend of nutritive component of forage shows great differences among range types because the timing and length of growing season differ among them due to climate (Holechek et al., 2004). Most plants show a similarity in declining nutrient composition with advancing development towards maturation (Rama et al., 1973).

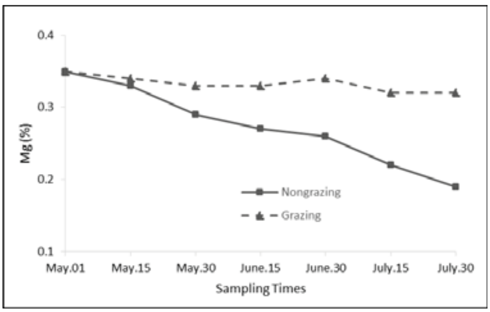


Figure 7. Seasonal variation of Mg content of crested wheatgrass in artificial pastures

Forage quality is determined by maturity stage at harvest as the most important factor. Because P, Ca, Mg and K contents of forage decreased with delayed cutting, forage quality declines with advancing maturity (Blaser et al., 1986; Tan and Serin, 1996; Turk et al., 2007). There is a rapid uptake of minerals during early growth and a gradual dilution as the plant matures (Lanyasunya et al., 2007).

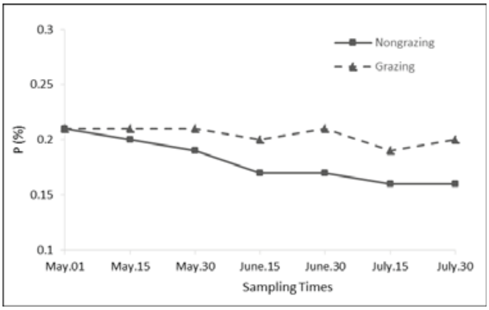


Figure 8. Seasonal variation of P content of crested wheatgrass in artificial pastures

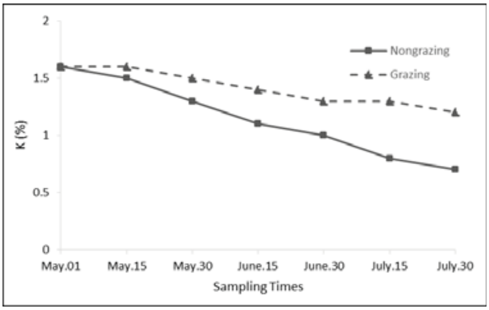


Figure 9. Seasonal variation of K content of crested wheatgrass in artificial pastures

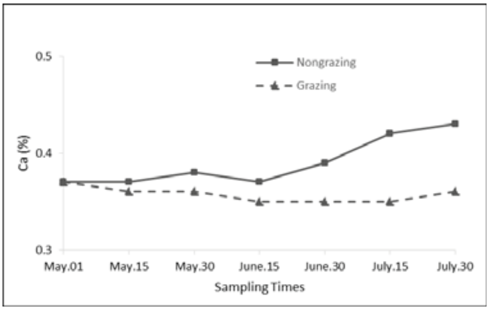


Figure 10. Seasonal variation of Ca content of crested wheatgrass in artificial pastures

The changes in element content with maturity are related to the increasing stem to leaf ratio. Leaves are richer in mineral nutrients than stems (Tan et al., 1997), and the proportion of leaves declines as plant growth advances because of senescence of the lower leaves or damage by diseases (Albrecht and Marvin, 1995). Changes in P content normally parallel those of protein in regard to seasonal changes. Phosphorus and Mg contents both decreased significantly with advancing season (Oelberg, 1956). In contrast, Ca content generally increases as the season advances (Savage and Heller, 1947). The increase with maturity was explained on the basis of the increased amount of cellular material which is composed principally of this element.

In the present study the Ca ratios of the non-grazed areas were higher than that of grazed areas The P, Mg and K ratios of the grazed areas were also higher than that of non-grazed areas. The American National Research Council (NRC 1996) recommends that forage crops should contain 3.1 g kg^{-1} Ca, 6.5 g kg^{-1} K concentration for beef cattle. Tajeda et al. (1985) reported that forage crops should contain at least 0.3% of Ca, 0.2% of Mg, 0.8% of K for ruminants. The chemical properties found in this research indicate that the nutritional quality values of artificial pastures were higher than all the recommended standard values for ruminants.

CONCLUSIONS

The results from the change in the forage quality of crested wheatgrass in grazing and non-grazing artificially established pastures in Mediterranean conditions of Turkey can be summarised as follows:

1. CP, IVDMD and K contents decreased throughout the grazing season, while ADF and NDF contents increased in grazing areas.
2. The CP content, IVDMD, Mg, P and K contents decreased throughout the grazing season, while ADF, NDF and Ca contents increased in non-grazing areas.
3. The ADF, NDF, Ca contents of crested wheatgrass in non-grazed areas were higher than the grazed areas.
4. The CP, IVDMD, P, Mg and K contents of grazed areas were higher than non-grazed areas.

5. It can be concluded that the harvesting at the late stages caused a reduction in forage quality of crested wheatgrass in grazing and non-grazing areas.

ACKNOWLEDGMENTS

This work was financially supported by TUBITAK (Turkish Scientific and Technological Research Council, project no. 109O162).

REFERENCES

Aksoy A., Yilmaz A., 2003. Metabolizable energy values and dry matter and organic matter digestibilities of some alfalfa varieties. Journal of Agricultural Sciences, 9 (4): 440-444.

Albrecht K.A., Marvin H.H., 1995. Hay and silage management. In: Barnes RF, Miller DA, Nelson CJ ed. Forages, vol. I: an introduction to grassland agriculture. Ames, Iowa, Iowa State University Press, p. 155-174.

Allison C.D., Kothmann M.M., 1979. Effect of level of stocking pressure on forage intake and diet quality of range cattle. Proc. West. Sec. Amer. Sot. Anim. Sci. 30: 174-178.

Arzani H., Zohdi M., Fish E., Zahedi Amiri G.H., Nikkhah A., Wester D., 2004. Phenological effects on forage quality of five grass species. J Range Manage 57: 624-629.

Blaser R.E., Hames R.C., Fontenot J.P., Bryant H.T., Polan C.E., Wolf D.D., McClaugherty F.S., Kline R.G., Moore J.S., 1986. Growth stages of plants forage quality and animal production. In: M. C. Holliman (Ed.) Forage-Animal Management Systems. P. 9. Virginia Agricultural Experiment Station Bulletin, p. 86-7.

Erkovan H.I., Gullap M.K., Dasci M., Koc A., 2009. Changes in leaf area index, forage quality and above-ground biomass in grazed and ungrazed rangelands of Eastern Anatolia Region. Journal of Agricultural Sciences,15 (3): 217-223.

Hitz A.C., Russell J.R., 1998. Potential of stockpiled perennial forages in winter grazing systems for pregnant beef cows. J Anim Sci 76: 404-415.

Holechek J.L., Preper R.D., Herbel C.H., 2004. Range Management Principles and Practices. Pearson Education, Inc., New Jersey, 607 p.

Hyder D.N., Forrest A., Sneva., 1963. Morphological and physiological factors affecting the grazing management of crested wheatgrass. Crop Sci. 3: 267-271.

Jung H.J.G., Vogel K.P., 1992. Lignification of switcgrass (*Panicum virgatum*) and big bluestem (*Andropogon gerardii*) plant parts during maturation and its effect on fibre degradability. J Sci Food Agric 59: 169-176.

Kacar B., Inal A., 2008. Bitki Analizleri. Nobel Akademik Yayıncılık, Ankara, 1-892.

Kacar B., Kovancı I., 1982. Evaluation of results and phosphorus analyses in plant, soil and fertilizer. Ankara University Agricultural Faculty Publications, 354 p.

Karsli M.A., Deniz S., Nursoy H., Denek N., Akdeniz H., 2003. The effects of maturity on range quality and animal performance. Turk J Vet Anim Sci 27: 117-124.

Kaya I., Oncuer A., Unal Y., Yıldız S., 2004. Nutritive value of pastures in Kars district. I. Botanical and nutrient composition at different stages of maturity. Turk J Vet Anim Sci 28: 275-280.

Koç A., Gökkus A., 1994. Güzelyurt Köyü (Erzurum) mera vejetasyonunun botanik kompozisyonu ve topragı kaplama alanı ile bırakılacak en uygun anız yüksekliginin belirlenmesi. Türk Tarım ve Ormancılık Derg., 18: 495-500.

Koc A., Gokkus A., Bakoğlu A., Ozaslan A., 2000. Palandoken Meralarının Farklı Kesimlerinden Alınan Ot örneklerinde Bazı Kimyasal özelliklerin Otlatma Mevsimindeki Değişimi, International Animal Nutrition Congress, Isparta, p. 471-478.

Lanyasunya T.P., Wang H.R., Kariuki S.T., Kuria D.M., Chek A.L., Mukisira E.A., 2007. Effect of maturity on the mineral content of hairy vetch (*Vicia villosa*). Tropical and Subtropical Agroecosystems 7: 53-58.

Lyons R.K., Machen R., Forbes T.D.A., 1996. Why range forage quality changes. Texas Agric. Extension Service. College Station. B-6036. 8p.

Minitab 2010. Minitab Reference Manual. Release 16 for Windows Minitab Inc.

NRC 1996. Nutrient requirements of domestic animals. Nutrient requirements of beef cattle. 6th revised ed. Washington, NAS-NRC.

Oelberg K., 1956. Factors affecting the nutritive value of range forage. Journal of Range Management 9: 220-225.

Pinkerton B., 1996. Forage Quality. Crop and Soil Environment Science Department, College of Agriculture, Forest, and Life Science, Clemson University, Clemson, South Carolina, 1-998.

Raleigh R.J., 1970. Symposium on pasture methods for maximum production in beef cattle: manipulation of both livestock and forage management to give optimum production. J. Anim. Sci. 30: 108-I 14.

Rama Rao M., Leniel H.H., Smith E.F.S., 1973. Seasonal changes in nutritive value of bluestem pastures. J Range Manage 26: 419-422.

Rebole A., Alzueta C., Ortiz L.T., Barro C., Rodriguez M.L., Caballero R., 2004. Yields and chemical composition of different parts of the common vetch at flowering and at two seed filling stages. Span J Agric Res 2(4): 550-557.

Savage D.A., Heller V.G., 1947. Nutritional qualities of range forage plants in relation to grazing with beef cattle on the Southern Plains Experimental Range. USDA Technical Bulletin 943.

Tajeda R., Mcdowell L.R., Martin F.G., Conrad J.H., 1985. Mineral element analyses of various tropical forages in Guatemala and their relationship to soil concentrations. Nutrition Reports International 32: 313-324.

Tan M., Bakoğlu A., Koç A., 1997. The changing of aboveground biomass and chemical composition of birdsfood trefoil (*Lotus corniculatus* L.) during growing period. II. Field Crops Congress in Turkey, Samsun, p. 693-695.

Tan M., Serin Y., 1996. The effects of mixture rates and cutting dates on the macro nutrient compositions in vetch + cereal mixtures. III . Grassland and Forage Congress in Turkey, Erzurum, p. 308–315.

Tilley J.M.A., Terry R.A., 1963. A two-stage technique for the in vitro digestion of forage crops. J Br Grassl Soc 18: 104-111.

Turk M., Albayrak S., Yüksel O., 2007. Effects of phosphorus fertilization and harvesting stages on forage yield and quality of narbon vetch. New Zeal J Agr Res 50: 457-462.

Turk M., Albayrak S., Bozkurt Y., 2014. Seasonal trends in chemical composition of different artificial pastures. Turkish Journal of Field Crops, 19(1): 53-58.

Van P., Walt H., John R.L., 1979. Herbage response to grazing systems and stocking intensities. J. Range Manage, 32: 250-253.

Scientific Papers. Series A. Agronomy, Vol. LVIII, 2015
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

FERTIGATION CONTROLLER WITH IoT GATEWAY FUNCTIONALITY

Constantin VASILESCU, Viorel POPESCU

Research and Development Department, Mibatron SRL, Bucharest, Romania

Corresponding author email: constantinvasilescu@rdslink.ro

Abstract

A command and control unit of an irrigation system, fertilization and plants treatment, very compact, which has the hardware and software resources to ensure the communication in a network of sensors and in the IoT cloud platform is presented. This fertigation controller – called here UCCSI is an element of IT infrastructure for precision farming, "visible" on the Internet, with the user interface in cloud. The use of this command and control unit leads to savings in materials and workmanship in a notable degree.

Key words*: fertigation controller, sensor network, IoT cloud platform, Ethernet controller.*

INTRODUCTION

In the internet world and ubiquitous computer, the control, monitoring, remote supervision became accessible both in terms of technology and price. The new technologies developed M2M and IoT have found their place rapidly in all activities, from industry and agriculture to transport and health.

In the context in which agriculture benefits from incorporation of technological advances primarily developed for other industries (Naiqian et al., 2012) was developed this command unit UCCSI, the central element of a system of irrigation, fertilization and plants protection - fertigation, for small and medium vegetable farms with a maximum area of 50,000 square meters. The command and control unit - UCCSI meets at the same time the requirements of the control and monitoring of a system for irrigation, fertilization and treatment and those imposed by the communication on the IoT cloud platform and a network of sensors in the 2.4GHz ISM band. UCCSI has a compact structure that includes specific process interfaces, a communication interface into wireless sensors network and an Ethernet interface. Thus UCCSI appears as fertigation controller with IoT gateway functionality.

Communication capacity on a IoT cloud platform allows the virtualization of user interface. This leads to simplification of UCCSI hardware structure embodied by the disappearance of display (or any other displaying device) and of keyboard. This leads to notable savings in materials and workmanship, given by the fact that the application requires a high degree of protection - IP65.

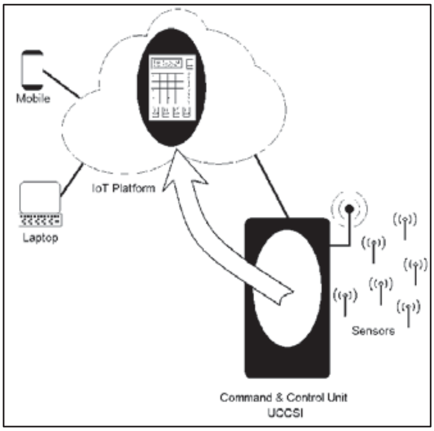


Figure 1. The User Interface of UCCSI is in cloud

The command and control unit for ferigation system - UCCSI has the hardware and software resources to assure:

a- the acquisition and processing of signals from sensors that control the operation of the irrigation system (pressure sensors, flow, level);

b- the acquisition and processing of signals from sensors measuring of soil parameters (humidity, temperature, pH, conductivity) and of environmental parameters (tem-

perature, relative humidity, light intensity, atmospheric pressure);
c- the connectivity in a wireless sensor network;
d- the implementation of algorithms irrigation, nutrient and pesticide management;
e- the command of execution elements of the system (solenoid valves, pumps, dispensers);
f- the communication on a IoT cloud platform;
g- the virtualization of user interface.

The functions from a. to f. are specific functions of a irrigation/fertigation/treatment plants controller while functions g. and h. are specific to a IoT gateway.

MATERIALS AND METHODS

The hardware structure of command and control unit for fertigation system - UCCSI is shown in figure 2.

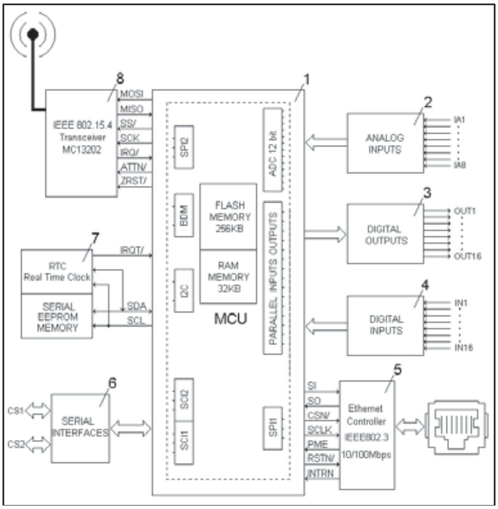


Figure 2. Block diagram of Command and Control Unit UCCSI

A. Processor block

Processor block 1 (Figure 2), consists of 32 bits microcontroller – MCU, with (Vasilescu et al., 2009) 256KB Flash memory read/program/erase over full operating voltage and temperature, 32KB static random access memory - SRAM, security circuitry to prevent unauthorized access to SRAM and flash contents, A/D converter with 12-bit successive approximations and asynchronous clock source for lower noise operation - 12-bit ADC, 2 full-duplex serial communications interfaces - SCI1, SCI2, 2 serial peripheral interfaces – SPI1, SPI2, inter-integrated circuit interface compatible with IIC bus standard - I2C, interface for debugging and programming on a single wire BDM and 69- input/output port line for general use.

B. Analog inputs block

The block of analog inputs 2 (Figure 2), receives signals from transducers and sensors connected by wires. The output of these transducers and sensors can be in unified or differential signal. This block has 8 analog inputs of which 6 entries for unified signal and 2 entries for differential signal. Unified signal inputs are provided with operational amplifiers with unitary gain and the differential signal inputs with operational amplifiers with digital programmable gain. The sensors with 4...20 mA output and the sensors with differential output are connected to terminal block of analog inputs.

C. Digital outputs block

The block of digital outputs, 3 (Figure 2) ensure the transmission of commands in process. This block consists of 16 digital outputs with Single Pole Double Throw (SPDT) relay, identical in terms of electrical schematics. To give full freedom to connect in the process is output from the terminal, for all 16 outputs, besides that switch contact COM and the normally closed contact (NC) and normally open contact (NO). Thus each digital outputs correspond three terminals marked NOi, COMi and NCi (i = 1 ... 16). The control circuits of motors and solenoid valves are connected to terminal block of digital outputs.

D. Digital inputs block

The block of digital inputs 4 (Figure 2), receives status signals of the process signals in frequency or pulse train. This block consists of 16 digital inputs, identical in terms of electrical schematics, isolated from the process by optocouplers. The level sensors of buffer tank, the clogging detectors for water filters and the rain sensor (wired RainSensor - Irritrol) are connected to terminal block of digital inputs.

E. Ethernet interface block

Ethernet interface block 5 (Figure 2), ensures the connection and communication in an Ethernet network. This block consists of a specialized controller (MCF51AC256

ColdFire® Integrated Microcontroller Reference Manual, 2011) with Auto MDIX feature and self- diagnosis communication cable, a serial EEPROM memory and an Ethernet connector with transformer and two LED indicators incurporated. The specialized controller communicates with the microcontroller MCU through full-duplex synchronous serial peripheral interface SPI1 and port lines: PME – power management event, RSTN/ - reset signal of controller specialized and INTRN - interrupt signal to host MCU.

F. Serial Comunication block

The block of serial communication interfaces 6 (Figure 2), consists of two serial channels, independent, identical in terms of electrical schematics, CS1 and CS2 using asynchronous serial ports SCI1, SCI2 and two lines port of MCU for switching between reception/ transmission. These two serial channels ensure direct connection of UCCSI to a computer, a programming console or modem.

G. RTC and serial EEPROM block

The block RTC and serial EEPROM 7 (Figure 2), consists of circuit RTC - Real Time Clock, with automatic backup supply using a non-rechargeable battery and 16KB serial EEPROM memory. Real time clock circuit and serial EEPROM memory communicate with the microcontroller MCU through semi-duplex synchronous serial interface I2C and the line port IRQT/- interrupt signal to host MCU.

H. IEEE® 802.15.4 standard communication block

The block IEEE® 802.15.4 standard communication interface, denoted by 8 in Figure 2, consists of a specialized controller (KSZ8851SNL/SNLI Single-port Ethernet Controller with SPI Interface, 2009) and a single mode adaptive antenna circuit. Specialized controller communicates with the microcontroller MCU through full-duplex synchronous serial peripheral interface SPI2 and port lines ATTN/ - command signal for specialized controller, ZRST/ - reset signal of specialized controller and IRQ/ - interrupt signal to host MCU. This block provides the necessary hardware resources to communication in a wireless sensor network in the 2.4GHz ISM band.

Beside the hardware the UCSSI unit is provided with a specific software.

The program written in non-volatile memory of the microcontroller controls, in real-time, the hardware resources of the command and control unit - UCCSI, ensures its functionality in the irrigation/fertilization/treat application and the communication in a wireless sensor network in the 2.4GHz ISM band and on a IoT cloud platform via the Ethernet interface. This software is developed around an In-House real-time operating system – RTOS, described in (MC13202 2.4 GHz Low Power Tranceiver for the IEEE®802.15.4 Standard Reference Manual, 2010).

The flowchart of the UCCCSI functionality is showed in Figure 3.

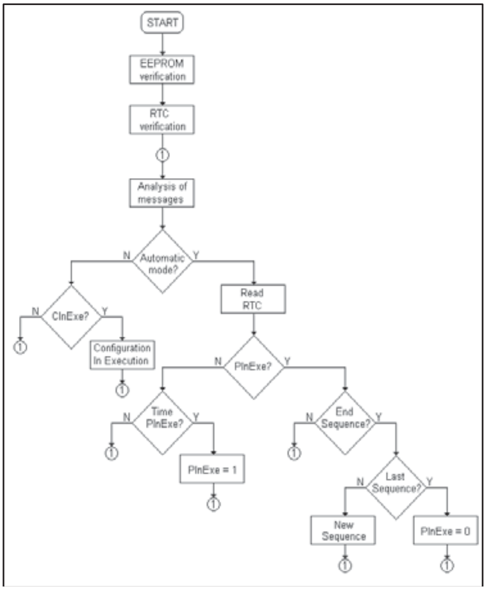


Figure 3. The flowchart of the UCCSI functionality

For irrigation, fertilization and plants treatment the farmer uses different recipes depending on the culture and values of certain parameters measured. These recipes are applied at some moment of time or a certain periodicity and are translated into a sequence of digital output configurations - sequences with a predetermined duration. Recipes and their moment of applications are configurable information stored in the EEPROM memory of the UCCSI.

The UCCSI controller has two working modes: **automatic** and **configuration**, respectively. Setting time recipes and timing of their application can be made only in the configuration mode - **Configuration In Execution** block Figure 3, through the Ethernet interface or one of the two serial communication channels CS1, CS2. Configuration of the command and control unit UCCSI is done from a computer or a programming console remotely connected via an IoT platform or by direct connection.

At power on, **START** in Figure 3, the controller are initialized hardware and software resources, then it is checked EEPROM memory - **EEPROM verification** block and function of the real time clock RTC - **RTC verification** block. EEPROM memory is checked to determine if are stored recipes and timing of their application.

Point **1** in Figure 3. marks the entrance to the main loop of application software. Within it are received and interpreted the messages received via Ethernet interface, the wireless sensor network and CS1 and CS2 serial channels - the block of **Analysis** of **messages**. Then, it executes, as appropriate, the configuration mode or automatic – the decisional block **Automatic mode** (Figure 3).

UCCSI it is found in configuration mode - the negative branch of the decisional block **Automatic mode**, when in EEPROM memory not are stored recipes, if the real time clock is not running or after receiving of a configuration message by communication (Ethernet interface and one serial communication channels CS1, CS2.). In configuration mode it check if received a configuration message – the decision block **CInEx**. If YES is running through the block **Configuration In Execution** then resumes the main loop - it returns in the point noted **1**. If it doesn't received a configuration message resumes the main loop.

In automatic mode it reads the real time clock - the **Read RTC** block and it checks if are running a recipe for irrigation, fertilization and treat plants - **PInExe** decisional block - **P**rogram **In Exe**cution. The negative branch compares the real time clock with the time when the recipe must be applied – the decisional block **Time PInExe**. In case coincide, the affirmative branch, is initiated the recipe - block **PInExe = 1**, and then, the main loop it resumes. The negative branch directly leads to the resumption of the main loop. The affirmative branch of decision block **PInExe**, in which the execution of recipes irrigation, fertilization and treat plants is underway, it checks if is the end of a sequence - the decisional block **End Sequence**. If **Y**es, it check whether is the last sequence – the decisional block **Last Sequence**. If is the last sequence, the affirmative branch, is marked the end of the recipe - **PInExe = 0**. If is not the last sequence it execute the following sequence – the block **New Sequence**.

After all these actions resumes the main loop - it returns in the point noted **1**.

CONCLUSIONS

The command and control unit UCCSI, providing hardware and software resources specific to the fertigation controller but also the necessary communication in a wireless sensor network and an IoT cloud Platforms, assure a new perspective to the control and monitoring of irrigation, fertilization and plants treatments. UCCSI is an element of IT infrastructure for precision farming, "visible" on the Internet, with the user interface in cloud.

The use of the ferigation controller UCCSI has to the following advantages:

- Increased reliability in terms of reduced consumption due to the compact structure and of the user interface's disappearance;
- Low effort and cost of installation and operation due to the use of wireless sensors;
- Easy access, minimal effort and cost effective control, monitoring and reconfiguration of application due to a connection via Ethernet Interface to an IoT cloud platform.

ACKNOWLEDGEMENTS

The research was done under the Project "*Interactive automated system to optimize inputs of water, nutrients and pesticides, in order to increase technical and economic competitiveness of small and medium sized vegetable farms - SIOPTEF*" (PN-II-PT-PCCA-2011-3, No.121/2012).

REFERENCES

Naiqian Zhang, Maohua Wang, Ning Wang, 2012. Precision agriculture a worldwide overview. Computers and Electronics in Agriculture 36, ELSEVIER, p.113-132

Vasilescu C., Dobrescu R., Popescu D., Nicolae M., 2009. Real Time Image and Data Acquisition, Processing and Communication Functions Implementation into a Mobile Sensor Node Configuration. Proceedings of the 10th WSEAS Internațional Conference on AUTOM ATION & INFORMATION, Praga, p. 396-401.

*** "MCF51AC256 ColdFire® Integrated Microcontro-ller Reference Manual", Freescale Semiconductor Inc., Rev. 6, September 2011.

*** "KSZ8851SNL/SNLI Single-port Ethernet Control-ler with SPI Interface", Micrel Inc., Rev.2.0, August 2009.

*** "MC13202 2.4 GHz Low Power Tranceiver for the IEEE®802.15.4 Standard Reference Manual", Freescale Semiconductor Inc., Rev. 1.3, May 2010.