Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 2, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESULTS REGARDING THE EFFECT OF CROP ROTATION AND FERTILIZATION ON THE YIELD AND QUALITIES AT WHEAT AND MAIZE IN SOUTH OF ROMANIA

Elena PARTAL[1], Mirela PARASCHIVU[2]

[1]National Agricultural Research and Development Institute Fundulea, 1 Nicolae Titulescu Street, 915200, Fundulea, Calarasi, Romania
[2]University of Craiova, Faculty of Agronomy, 19 Libertăţii Street, Craiova, Romania

Corresponding author email: ela_partal@yahoo.com

Abstract

In conditions of the modernization of agriculture, knowledge and management of the factors that can influence the production and quality are required. An important role belongs to the environmental factors and agrotechnical measures, which together with the genetic characteristics of the varieties or hybrids contribute to the variation of production and quality. The researches were performed during the 2015-2018, in the experimental field of NARDI Fundulea and aimed to study the influence of agrotechnical practices on the yields and quality of wheat and maize. The paper presents the results obtained in long term experiences with fertilizers and rotations, under non-irrigation condition. Yields and the quality is directly influenced by the fertilizers quantity and crop rotation. The results show that 4-year rotations and fertilization contribute with 20-50% to the increase of production and protein content increases with the nitrogen rate applied and less with phosphorus rate, but together (NP) have a significant effect for both wheat and maize. This percentage varied between 9.0-15.5% for wheat and 5.5-9.5% for maize depending on crop year.

Key words: *crop rotation, fertilization, yields and qualities, maize, wheat.*

INTRODUCTION

Crop rotation and fertilization represent basic technological links of modern agriculture, contributing to the increase of the productive potential of plants and implicitly of the soil.
Wheat and maize are among the most important agricultural crops and are the basis for food worldwide (Tack et al., 2015), and production and quality are closely related to the area of culture, plant genetics and technology (Sin, 2007).
Fertilizers, of any type, are applied to maintain the nutritional status of field plants in different crop systems (Kayan et al., 2018). The use of fertilizers is positivewhen we know the degree of soil supply with nutrients and the requirements of the crop plant (Pedersen et al., 2010; Ştefănescu et al., 1997).
Small doses of fertilizers are limiting factors of production, and high doses increase production costs and can cause harm by contaminating the environment with nutrient losses (Theago et al., 2014; Arenhardt et al., 2015, Ladha et al., 2016).
Research shows that crop rotation ensures the harmonization of factors that contribute to the growth and development of crop plants (Picu, 1984; Petcu et al., 2003, Bonciu, 2018).
The quality and level of production are the result of the interaction between the stability of the soil nutrition regime, the technological measures applied and the variation of the environmental factors (Bonciu et al., 2018; Mihăilă et al., 1996; Frye and Thomas, 1991).
The genetic background of the varieties or hybrids contributes to the modification of the quality and production parameters (Stefanescu & Tianu, 2001; Bonciu, 2019).

MATERIALS AND METHODS

Researches regarding the influence of crop rotation and fertilization on the production and its quality at wheat and maize crops was carried out on cambicchernozem from Fundulea, to the non-irrigated, in a stationary experience established in 1967.
The experimental variants studied are: monoculture of wheat and maize, 2-years

rotation (wheat - maize), 3-years rotation (wheat - maize - peas) and the 4-years rotation (wheat - maize - sunflower - peas).

In these rotations, the following fertilization system was applied: unfertilized (N0P0); fertilized with phosphorus at a dose of 75 kg P_2O_5/ha (N0P75), fertilized with nitrogen and phosphorus at a dose of 90 N kg/ha (N90P0), fertilized with nitrogen and phosphorus at a dose of 90 N kg/ha + 75 kg P_2O_5/ha (N90P75) and fertilizers with manure (autumn administration) at a dose of 20 t/ha.

In the experience, all the technological links were respected, the quality determinations were made with the INFRATEC 1225 Grain Analyzer, and the data obtained were processed and statistically interpreted according to the method of analysis of the variance.

The climatic elements have registered important variations during the experimentation period.

Climatic aspects

Research has shown that production potential and quality are also influenced by the degree of favorable weather conditions (temperature evolution, precipitation quantity and distribution). The analysis of the climatic elements (Figure 1) allows appraisals regarding the climatic conditions, with direct implications on the evolution of the crops in correlation with the agrotechnical links applied.

For the study period (2015-2018), the analysis of the recorded rainfall shows their variability, compared to the multiannual average. Precipitation deficits were recorded mainly in the summer/autumn period, influencing the evolution of the crops or in the winter period, with a negative effect on the restoration of the soil water supply.

The 2017 was a humid year, and 2018 a dry year. From a thermal point of view, temperatures were registered with 1.0°C higher than the multiannual average. The variation of temperatures is different from one year to another so that, in 2018, the high temperatures during the summer period associated with the precipitation deficit led to a significant decrease of the harvests.

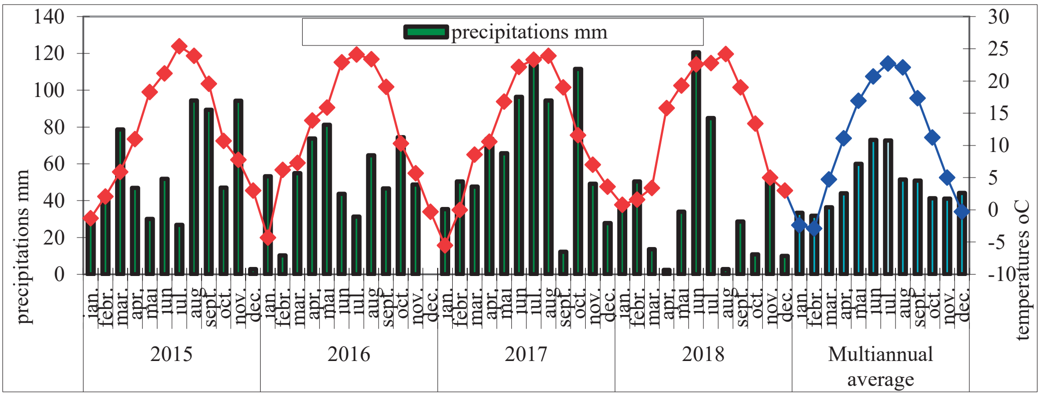

Figure 1. The evolution of the rainfalls and air temperatures, in the agricultural years 1999-2009, at Fundulea

RESULTS AND DISCUSSIONS

The wheat and maize productions obtaining in the period 2015-2018 demonstrate, for both crops, the role of rotation and fertilization with chemical and organic fertilizers, in conjunction with the variation of the climatic conditions of the crop year.

Considering that all the other technological links have been optimally respected and applied, the plants showed their genetic potential at maximum values, as much as they allowed the environmental conditions.

The experimental results obtained in the wheat crop (Figure 2) indicate a significant differentiation of the production, depending on the duration of the rotation and its succession. Thus, in 2018 the lowest level of wheat production is recorded, both within the existing rotations and in the case of monoculture, as a result of adverse climatic conditions. In 2016 and 2017, considered climatically normal, the highest yields are obtained, especially in the 3 and 4 year rotations, where the presence of a leguminous in the rotation is evident through statistically assured production increases.

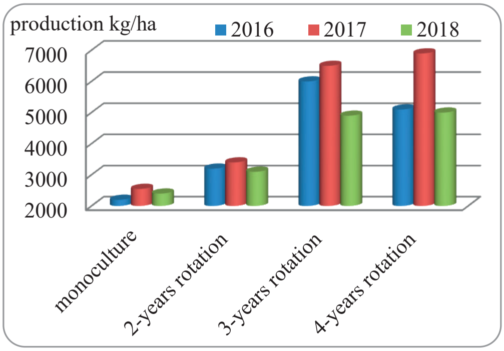

Figure 2. The influence of rotation on wheat yield, on constant nitrogen fertilization at Fundulea, 2015-2018

In maize cultivation (Figure 3), the production differences increased with the reduction of its weight in rotation, this exploiting more effectively the positive effect of placement after wheat and of the presence of leguminous plants in the rotation of 3 and 4 years.
The experimental data show the results of the placement of wheat after peas, within the 3-year rotation, where very significant production increases were obtained, 1.3 t/ha, compared to monoculture (Table 1).

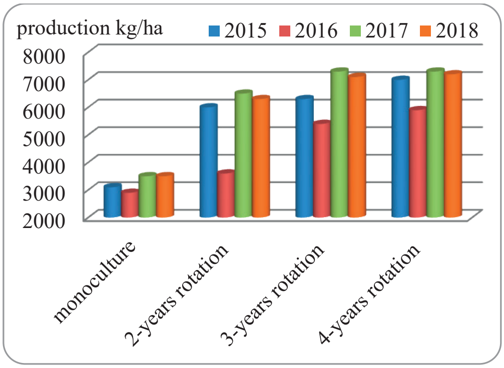

Figure 3. The influence of rotation on maize yield on constant nitrogen fertilization at Fundulea, 2015-2018

In the case of the application of chemical fertilizers, at a dose of 90 kg N/ha + 75 kg P_2O_5/ha, substantial increases of the production increase, between 1.0 and 2.7 t/ha, were obtained, regardless of the rotation used.
The application of manure in doses of 20 t/ha has led to production increases in all rotations, from 0.8 to 2.3 t/ha to wheat, compared to monoculture. Thus, with the monoculture control variant, in the 2-year rotation there was a production increase of 0.8 t/ha and in the 4-year version a production increase of 2.0 t/ha. These production enhancements are important and similar to those from the application of chemical fertilizers with N90P75.

Tabel 1. The effect of rotation and fertilization on wheat yield at Fundulea, 2016-2018

Rotations	N0P0		N90P0		N0P75		N90P75		Manure 20 t/ha	
	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±
Monoculture	2.2	0	3.1	0	2.3	0	2.9	0	2.8	0
2-years rotation	2.4	+0.2	3.6	+0.5	2.6	+0.3	3.9	+1.0	3.,6	+0.8
3-years rotation	3.5	+1.3 ***	3.9	+0.8 ***	3.8	+1.5 ***	5.6	+2.7 ***	5.1	+2.3 ***
4-years rotation	2.9	+0.7 ***	4.0	+0.9 ***	3.2	0.9 ***	5.0	+2.1 ***	4.8	+2.0 ***
LSD 5%	0.3		0.5		0.7		0.9		0.9	

The wheat cultivated in the monoculture to which fertilizers were applied achieved an increase between 0.1 and 0.6 t/ha, compared to the unfertilized variant, but does not represent a good technological variant, due to the production ceiling.
The increase of wheat production, as an average during the agricultural years 2016-2018 (with values between 0.9-2.7 t/ha) showed that crop rotation represents a real technological link, especially the rotation in which leguminous plants are introduced. Their lack of rotation leads to the decrease of the production increase and the conditioning of other technological elements, such as additional fertilization.
In general, the relatively small yields of wheat can be explained by the negative influence of the lower water supply of the soil in the unfavorable years and the high number of weeds in the case of monoculture and 2-year rotation.

For the maize culture, the results obtained during the rotations showed very significant harvest increases, ranging from 0.6 to 1.8 t/ha in rotations of two, three and four years, compared to monoculture (Table 2).

Following fertilization with 90 kg N + 75 kg P2O5/ha the production increase ranged from 1.0 to 2.2 t/ha.

The application of manure in doses of 20 t/ha has led to production increases in all rotations, from 1.2 to 2.1 t/ha to maize, compared with monoculture.

The maize culture made more efficient use of the manure administered, being noticed the rotations of 3-4 years, where the productions exceeded 6.0 t/ha.

Tabel 2. The effect of rotation and fertilization on maize yield at Fundulea, 2015-2018

Rotations	N0P0		N90P0		N0P75		N90P75		Manure 20 t/ha	
	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±	t/ha	Dif. ±
Monoculture	2.6	0	3.0	0	2.8	0	4.6	0	4.2	0
2-years rotation	3.2	+0.6	4.5	+1.5	3.2	+0.4	5.6	+1.0	5.4	+1.2
3-years rotation	3.9	+1.3 ***	5.0	+2.0 ***	4.0	+1.2 ***	6.3	+1.7 ***	6.0	+1.8 ***
4-years rotation	4.4	+1.8 ***	5.1	+2.1 ***	4.6	+1.8 ***	6.8	+2.2 ***	6.3	+2.1 ***
LSD 5%	0.6		0.8		1.0		1.2		1.3	

The protein content of wheat grains registered the highest values in 2018, and they were obtained on agrofonds N90P0 and N90P75, from 3-year rotations (by 12.4% and 13.0%, respectively) and 4-years (by 12.0% and respectively 12.4%).

Among the existing functions in the Windows program - linear, logarithmic, polynomial, power and exponential - the polynomial function has the highest regression coefficient for the connection between agrotechnical measures (rotation/fertilization) and protein content in wheat (Figure 4).

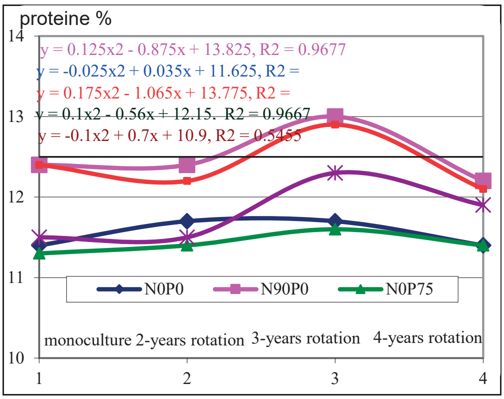

Figure 4. Correlation between agronomic measures and wheat protein content

The increase of the number of years in rotation and the application of nitrogen and phosphorus fertilizers, in economically efficient doses (respectively N90P0 or N90P75), ensure the correlations as being very positive, with regression coefficients between 0.54 and 0.96.

The practice of monoculture, associated with the lack of chemical or organic fertilizers, has resulted in a reduced amount of protein, and the regression coefficient is 0.53.

The percentage of protein in maize is directly correlated with the dose of nitrogen administered (Figure 5).

Thus, applying the dose of fertilizer with N90P0 or associated with phosphorus N90P75 led to increases of 2.0-2.6% compared to the unfertilized variant.

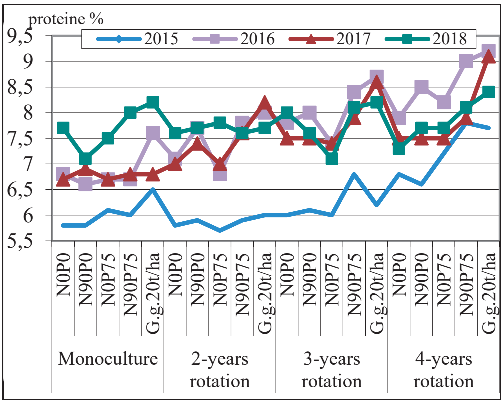

Figure 5. Influence of rotation and fertilization on maize protein content

Application of manure (20 t/ha) resulted in protein values greater than or equal to N90P75,

regardless of rotation.The protein content of the grains registered the highest values in the rotation of 3 and 4 years, compared to monoculture, as a result of a better recovery of nitrogen from fertilizers and by the presence of a leguminous plant in the rotation.
The protein content in 2018 varied slightly, with values between 7.0-8.5%, regardless of rotation or agrofond. The highest values were obtained by applying manure (8.5%).
The percentage of protein in the grain is higher in the less rainy years, with full influence of the hybrid and fertilization. In 2015, the lowest values of the protein were registered (5.6-7.7%).
The influence of the technological links on the fat content is more pronounced in the dry or normal climatic years.
The highest values of fat content (4.1-4.5%) were obtained in 2017, and the lowest (3.4-4.1%) in 2016.
The application of the 3 and 4 years rotation, associated with the fertilization of N90P75 or manure (20 t/ha) registered high increases compared to monoculture and unfertilized (Figure 6).

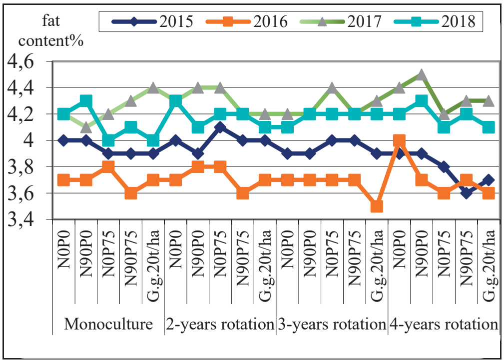

Figure 6. Influence of rotation and fertilization on maize fat content

The lowest values of the starch content were recorded in 2015, considered dry, below the value of 60.0% of the grain content (Figure 7).
The agricultural year 2018 achieved the highest starch contents, between 73-75%, especially when applying fertilizers with N90P75 or manure 20 t/ha.
These high values of starch content confer the qualitative traits necessary for corn to be used as a raw material in the starch industry.

The high fat content of the maize seeds makes from this plant a very good source of oil.

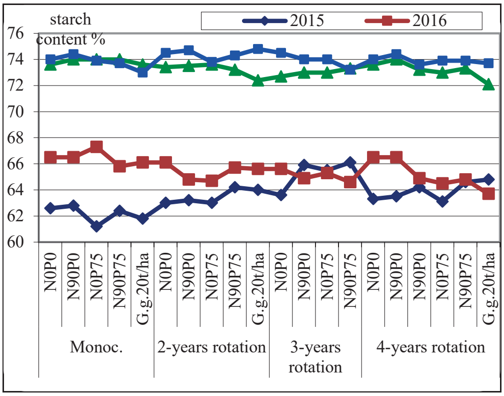

Figure 7. Influence of rotation and fertilization on maize starch content

CONCLUSIONS

Production and quality recorded variations from year to year, both for wheat and maize, depending on crop rotation and fertilization, as well as climatic conditions.
The rotations of 3 and 4 years increased the harvest, both in wheat and maize, compared to the monoculture and the simple rotation wheat / maize that did not have efficiency even under optimum conditions of fertilization.
In the 3-year rotation, wheat production is higher than that of the 4-year variant, due to the beneficial effect of the location of wheat after peas, this influence being enhanced by the unfertilized.
The placement of maize in multi-crop rotations, associated with the application of chemical fertilizers or manure, favors the production of over 6.0 t/ha.
The cultivation of wheat after maize (two-year rotation) and the application of fertilizers bring in yield increases of 0.8 t/ha and after sunflower (4-year rotation), of 2.0 t/ha.
The protein content of wheat groups the variants as follows: very good quality (protein > 13%), good (12-13%) and satisfactory (8-12%).
Thus, the application of fertilization with N90P0, N90P75 or manure (20 t/ha) and rotations of 3 or 4 years, resulted in an increase of the protein content at values of 12-14%,

compared with the unfertilized control and monoculture.

At the maize, the rotation of 3 or 4 years and the application of N90P0 or N90P75 fertilizers resulted in satisfactory values, on average over the whole period, of 5.5-9.5% in protein, 3.9-4.5% in fat and 60.0-75.0% in starch.

REFERENCES

Arenhardt, E.G., Silva, J.A.G., Gewehr, E., Oliveira, A.C., Binelo, M.O., Valdiero, A.C., Gzergorczick, M.E., Lima, A.R.C. (2015). The nitrogen supply in wheat cultivation dependent on weather conditions and succession system in southern Brazil. *African Journal of Agricultural Research, 10*, 4322–4330.

Bonciu, E. (2018). Evaluation of cytotoxicity of the herbicide Galigan 240 EC to plants. *Scientific Papers. Series A. Agronomy, LXI*(1), 175–178.

Bonciu, E. (2019). Some observations on the genotoxicity of the yellow food dye in Allium cepa meristematic cells. *Banat's Journal of Biotechnology, 10*(20), 46–50.

Bonciu, E., Roșculete, E., Olaru, A.L., Roșculete, C.A. (2018). Evaluation of the mitodepressive effect, chromosomal aberrations and nuclear abnormalities induced by urea fertilization in the meristematic tissues of *Allium cepa* L. *Caryologia, 71*(4), 350–356.

Frye, W.W., Thomas, W.G. (1991). Management of long-term field experiment. *Agronomy Journal, 83*. 1.

Kayan, N., Kutlu, İ., Ayter, N.G. (2018). The influence of different tillage, crop rotations and nitrogen levels on plant height, biological and grain yield in wheat. *AgroLife Scientific Journal, 7*(1), 82–91.

Ladha, J.K, Tirol-Padre, A., Reddy, C.K., Cassman, K.G., Verma, S., Powlson, D.S., van Kessel, C., de B. Richter, D., Chakraborty, D., Pathak, H. (2016). Global nitrogen budgets in cereals: A 50-year assessment for maize, rice, and wheat production systems. *Nature Scientific Reports, 6*, 19355.

Mihăilă, V., Burlacu, Gh., Hera, C. (1996). Rezultate obţinute în experienţe de lungă durată cu îngrăşăminte pe cernoziomul cambic de la Fundulea. *An. ICCPT Fundulea, LXIII*, 91–104.

Pedersen A., Zhang K., Thorup-Kristensen K., Jensen L.S. (2010). Modelling diverse root density dynamics and deep nitrogen uptake - A simple approach. *Planta and Soil, 326*(1-2), 493–510

Petcu, Gh., Sin, Gh., Ioniţă, S. (2003). Evoluţia producţiilor de grâu şi porumb în experienţe de lungă durată sub influenţa rotaţiei şi a fertilizării. *An. I.C.D.A., LXX*, 181–190.

Picu, I. (1984). Eficienţa unor metode culturale de maximizare a producţiei la cereal şi plante tehnice. *Probleme de agrofitotehnie teoretică şi aplicată, VI*(4), 331–349.

Sin, Gh. (2007). Cercetări agrotehnice la culturile de câmp. *An. I.N.C.D.A. Fundulea, vol. LXXV*. Vol. Jubiliar.

Stefănescu, M., Tianu, M., (2001). Influenţa fertilizării asupra unor indici calitativi ai recoltei de grâu. *Analele I.C.C.P.T., LXVIII*, 177–188.

Ştefănescu, M., Mihailă, V., Nagy, C. (1997). Fertilizarea minerală la grâu şi porumb în experienţele de lungă durată. *An. ICCPT Fundulea, LXIV*, 129–139.

Tack, J., Barkley, A., Nalley, L.L. (2015). Effect of warming temperatures on US wheat yields. *Proceedings of the National Academy of Science of the U.S.A., 112*, 6931–6936.

Theago, E.Q., Buzetti, S., Teixeira Filho, M.C.M., Andreotti, M., Megda, M.M., Benett, C.G.S. (2014). Doses, sources and time of nitrogen application on irrigated wheat under no-tillage. *Revista Brasileira de Ciência do Solo, 38*, 1826–1835.