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BIODIVERSITY AND ADAPTABILITY OF SOME AGRICULTURAL PLANTS USED AS TECHNOLOGICAL ELEMENTS IN THE PRACTICE OF THE DRY-FARMING WORK SYSTEM IN SOUTHEAST AREA OF ROMANIA

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Abstract

Global warming has become a problem in many areas. The orientation of farmers towards an agriculture adapted to drought conditions, which uses dry-farming systems, allows the responsible and sustainable management of agricultural lands, without fragmenting habitats and contributing to the extinction of some species of flora and fauna. The survival of some species with a role in biodiversity for agricultural crops, the adaptability of some of them in dry areas and the improvement to create different hybrids with resistance to increasingly aggressive environmental factors, is due to this type of agriculture and to the new directions in specialized research. The study was conducted as an open-field experience, in the southeastern part of Romania, at the Agricultural Research and Development Station, Braila. The research started with the agricultural year 2019 but its climatic conditions were registered as excessive, which is why the capitalization of the results was made only for the agricultural year 2020-2021. Of the 7 cultivated plant species that do not normally fit into the crop plan in the study area, only three species (flax, sorghum, mustard) coped with climate stress and could be analyzed qualitatively and quantitatively.

Key words: *biodiversity, adaptability, dry-farming, climate stress, alternative species.*

INTRODUCTION

Classical agriculture has produced over time, through the application of cultivation schemes and intensive work, the degradation of the soil and the environment (Derpsch, 2001). Heavy machinery, inadequate soils (overmuch humidity) and over-exploitation of agricultural land, caused the erosion of the soil surface layer generating its loss of fertility, compaction, destruction of porosity (Lipiec et al., 2005) and reduction of degrading organisms that by their nature produce organic matter (Somasundaram et al., 2020) in the soil, necessary for plant nutrition. Agriculture, the main and secondary products of field crops, biodiversity and pedo-climatic conditions form an indispensable mutual link for humans and animals. For this reason, the main concern is to protect nature by all possible means, using environmentally friendly technological sequences. Protecting and restoring ecosystems has a positive impact on the environment, agricultural production and farmers' profits. These are the reasons why the dry-farming system, together with conservative agriculture, is gaining momentum in plant cultivation. Through minimally invasive tillage and the "recycling" of plant debris remaining after crop harvesting (Kassam et al., 2018), the quality of the soil (De Almeida et al., 2018) and the environment (Palm et al., 2014) improves over the years, resulting in higher yields (Dumanski et al., 2006) and reduced negative impact.

The crop of *Cannabis sativa* L. can be used in food industry (seeds), building materials (woody part of the stem) industry, textiles and pharmaceuticals industries. Due to its morphological characteristics, this plant has no natural parasites, suppresses weed growth (which is why it´s unnecessary to apply herbicides), creating a favourable microclimate for pollinating insects at the inflorescences level and attracting them by the odours emitted (Sorrentino, 2021) therefore favouring the distribution of pollen to the neighbouring flora. Hemp is a large plant that consumes CO_2, releasing less gas into the atmosphere, which is why it grows rapidly and develops a biomass three times higher than flax plants. To obtain an amount of 8-12 t/ha hemp biomass, it consumes 10-15 t CO_2 (Sorrentino, 2021). It has also been shown to produce more biomass when fertilized with urea, as it is eliminated more slowly than ammonium nitrate fertilizers, which are harmful to the environment due to the nitrogen oxide which has stronger greenhouse effect than carbon dioxide.

The crops of *Linum usitatissimum* L. and *Ricinus communis* L. are especially used in the production of edible oil. Castor is a plant that can withstand strong radiation, drought and heat conditions very well (Diaz-Lopez et al., 2020). *Sinapis alba* L. is a quality plant for animal feed but can also be used as a biofuel, with zero CO_2 emissions (Mikic et al., 2009). *Sorghum bicolor* M. is suitable for those cultivation areas with rainfall deficit. It is 95% cultivated for animal feed and only 5% for the production of ethanol, a less polluting oil substitute, which results from the fermentation of starch (Zhan et al., 2003). *Sorghum sudanense* L. is considered a weed in agricultural crops but cultivated as such, it is used in animal feed and bioenergy production due to its qualities, especially the large amount of biomass (Venuto & Kindiger, 2008), being also a plant that withstands the stress caused by environmental factors. *Panicum milliaceum* L. is also grown for animal feed. Corn, sunflower and mustard crops are grown in areas characterized by drought conditions but also in areas with normal conditions in terms of temperature and humidity.

MATERIALS AND METHODS

The agricultural crops studied in the Dry-Farming system are those of hemp (*Cannabis sativa* L.) - Succesiv variety, sorghum (*Sorghum bicolor* M.) - ES Alize hybrid, millet (*Panicum miliaceum* L.) - Marius variety, Sudan grass (*Sorghum sudanense* L.), castor (*Ricinus communis* L.) - Dragon variety, flax (*Linum usitatissimum* L.) - Lirina variety, mustard (*Sinapis alba* L.) - Alex variety, corn (*Zea mays* L.) - DKC 5141 hybrid and sunflower (*Helianthus annuus* L.) - Rustica hybrid, most of which are considered alternative crops for crop rotations in areas with prolonged drought.

The experience was placed within the S.C.D.A. Braila - plot 89 - Chiscani experimental field, during the agricultural years 2019 - 2021. The studies were carried out on the growth, development and production of some plants rarely found in the crop plans of agricultural farms in eastern Romania and on commonly used plants in zonal crops, grown on field processed using minimal work systems.

Straw crops (*Triticum aestivum* L., *Hordeum vulgare* L., *Secale cereale* L., *Triticale* M.), *Zea mays* L., *Helianthus annuus* L., *Sorghum bicolor* M. and *Panicum miliaceum* L. were sown in areas of 100 m^2 (30 m^2/plot - repetition), where five types of works of dry-farming system were applied (plowing, paraplowing, scarification, heavy-disk, no-tillage). In comparison, crops of flax, hemp, mustard, Sudanese grass and castor, together with maize, sunflower and sorghum, were sown on areas of 30 m^2 (10 m^2/plot - repetition), on a land cultivated by classic plowing system. Observations and measurements were made on the biometrics of the plants, on the quantity and quality of the seeds obtained, depending on the soil works and the phytotechnical characteristics of the plants, according to the specialized literature.

RESULTS AND DISCUSSIONS

The agricultural year 2019 - 2020 was one of heat and drought. The average annual temperature of 13.3ºC exceeded the multiannual temperature of 10.9ºC, by 2.3ºC. Precipitation was 221 mm lower the multiannual average of 442 mm (Table 1). This was reflected in the crops of straw, hemp, Sudanese grass and castor, which produced insignificant yields.

The agricultural year 2020-2021 was also hot but it accumulated precipitation about 40% above the multiannual average of 442 mm

(Table 2). Compared to the previous year, the deviation of the average annual temperature (12.4ºC), compared to the multiannual one (10.9ºC), was 1.5ºC. The accumulated annual rainfall was 618 mm, with a deviation of +176 mm from the annual multimedia (442 mm).

Table 1. The thermal and pluviometric regime of the agricultural year 2019-2020, at S.C.D.A. Braila

Climate conditions 2019 - 2020						
Month	**Average air temperatures (˚C)**	**Multiannual monthly average**	**Deviation from multiannual T (˚C)**	**Precipitations (mm)**	**Multiannual monthly average**	**Deviation from the multiannual precipitation average (mm)**
IX	18,5	11,5	7,0	1	32	-31,0
X	13,2	5,6	7,6	23,9	30	-6,1
XI	10,2	0,6	9,6	8,7	33	-24,3
XII	3,9	-2,1	6,0	14,3	36	-21,7
I	0,9	-0,2	1,1	4	28	-24,0
II	4,6	4,7	-0,1	28	27	1,0
III	8,7	11,2	-2,5	2,6	26	-23,4
IV	11,9	16,7	-4,8	4,6	35	-30,4
V	16,4	20,9	-4,5	45,8	48	-2,2
VI	22,0	22,9	-0,9	30,1	62	-31,9
VII	24,4	22,1	2,3	54,8	46	8,8
VIII	24,6	17,3	7,3	3,1	39	-35,9
Average	**13,3**	**10,9**	**2,3**	**221**	**442**	**-221**

Table 2. The thermal and pluviometric regime of the agricultural year 2020-2021, at S.C.D.A. Braila

Climate conditions 2020 - 2021						
Month	**Average air temperatures (˚C)**	**Multiannual monthly average**	**Deviation from multiannual T (˚C)**	**Precipitations (mm)**	**Multiannual monthly average**	**Deviation from the multiannual precipitation average (mm)**
IX	20,3	11,5	8,8	39,5	32	9,5
X	15,1	5,6	9,5	26,5	30	-6,5
XI	5,7	0,6	5,1	24,5	33	-11,5
XII	4,7	-2,1	6,8	67,7	36	39,7
I	2,2	-0,2	2,4	41,2	28	14,2
II	2,4	4,7	-2,3	7,4	27	-18,6
III	4,7	11,2	-6,5	31,4	26	-3,6
IV	9,4	16,7	-7,3	53,3	35	5,3
V	16,7	20,9	-4,2	75,8	48	13,8
VI	20,2	22,9	-2,7	173,8	62	127,8
VII	23,9	22,1	2,7	40,4	46	1,4
VIII	23,4	17,3	6,1	36,7	39	4,7
Average	**12,4**	**10,9**	**1,5**	**618**	**442**	**176**

The height of *Zea mays* L. plants was between the range of 150-300 cm in all types of soil works (Table 3). The crop sown on the plot prepared by heavy-disk work, had the smallest average size, while on the plot prepared using the scarifier, it had the largest average size. These differences show that the root system of *Zea mays* L. plants prefers loose soils both at the surface where germination takes place and at greater depths.

The plants of *Helianthus annuus* L. have exceeded the upper limit of the size specified in the literature, on those plots prepared with the plow, the paraplow and the scarifier, which indicates that the worked soil at greater depths than 25 cm, allows the deep penetration of the root system, thus accessing the depleted water sources in the surface layer of the soil (Table 3). On the plot prepared with the heavy-disc and on the no tillage plot, sunflower presented average heights between 130 and 175 cm, reacting well to them as well. *Sorghum bicolor* M. on the other hand, did not reach the minimum plant height, described in the literature (Table 3).

The insertion height of the *Zea mays* L. cobs did not fall within the range according to the literature, but this depends on the characteristic of the hybrid, environmental factors and other parameters (Table 4). It should be noted, however, that the insertion heights were different depending on the soil work. On the scarified plot, due to the hight, the insertion point of the cob was also higher. Although in the paraplowed plot the plants were taller than those on the heavy-disk plot, the insertion point of the cob was lower. Compared to the plowing work, the insertion point of the cob was also lower although the plants had similar heights.

The calatidium of *Helianthus annuus* L. plants was larger in diameter than of the plants grown on scarified and heavy-disk prepared soils. These observations show that sunflower grows best on loose soils at greater depths (Table 4).

Table 3. Biometric measures of crops, depending on soil tillage and literature

Crop	Average height (cm)					Phytotechnical features in the literature
	Plow	Paraplow	Scarification	Heavy Disc	No Tillage	
Zea mays L.	212,17	212,00	228,67	190,33	208,67	150 - 300
Helianthus annuus L.	190,67	198,00	182,67	168,00	165,33	130 - 175
Sorghum bicolor M.	120,00	116,67	116,33	97,67	120,33	150 - 300

Table 4. Biometric measures of propagating organs, depending on soil tillage and literature

Indicator	Plow	Paraplow	Scarification	Heavy Disc	No Tillage	Phytotechnical features in the literature
Insert height of the *Zea mays* L. cob (cm)	77,09	55,00	84,50	63,33	70,00	100 - 130
Diameter of *Helianthus annuus* L. calatidium (cm)	19,33	18,67	23,00	22,33	19,33	10 - 40

Cannabis sativa L. showed a much smaller size than the lower limit of the range in the literature (Table 5). This may be due to pedo-climatic factors and applied technology sequences. *Sorghum sudanense* L. and *Ricinus communis* L. have developed much higher sizes than those described in the literature, so that the soil prepared by the classical-plow system, together with the pedo-climatic conditions specific to the study area, are favorable for these crops, stimulating the intense growth of biomass. The *Sinapis alba* L. crop behaved the same way, with an average plant hight above the maximum limit of the specific range, proving that it can be suitable for cultivation in the study area.

Table 5. Biometric measurements of poorly cultivated agricultural plants in the eastern part of Romania

Crop	Plant height (cm) / repetitions			Average height (cm)	Phytotechnical features in the literature
Cannabis sativa L.	128	123	164	138,33	180 - 320
Sorghum sudanense L.	285	300	310	298,33	150 - 200
Ricinus communis L.	230	215	245	230,00	100 - 150
Linum usitatissimum L.	55	60	53	56,00	55 - 75
Sinapis alba L.	112	93	117	107,33	60 - 100

In favourable conditions of plant growth and development, *Linum usitatissimum* L. plants can produce a yield between 1000 and 1100 kg/ha. As can be seen in Table 6, the average production exceeded by 46.5 kg/ha the upper limit described in the literature, confirming the adaptability of the crop to the conditions of the eastern part of Romania. However, the quality of the seeds was not optimal, the TGW being slightly below the limit of 7-8.5 and the specific weight with 9.7 kg/hl below the lower limit of 75 kg/hl.

The average crop yield of *Sinapis alba* L. was 767 kg/ha (Table 7). In optimal cultivation conditions, *Sinapis alba* L. can produce yields between 1000 - 1500 kg/ha. The quality indices were also below the optimal limits of 6.3 g in terms of TGW and 68 kg/hl regarding the specific weight.

Straw grain production was on average 2800 kg/ha in the agricultural years 2019 - 2021 (Figure 1), being affected by the excessive drought of 2019-2020, when they recorded productions with 1586.4-2284.2 kg/ha lower than those obtained in the agricultural year 2020-2021 (Figure 2). *Zea mays* L., *Helianthus annuus* L. and *Sorghum bicolor* M. have been shown to be particularly resistant to the lack of rainfall due to their morphological characteristics, in particular of the pivoting root system, which allowed them to access soil water at greater depths.

Table 6. Flaxseed crop yields and quality indices in the agricultural year 2020-2021

Flaxseed (*Linum usitatissimum* L.)					
Repetition	Yield (kg/10 m.p.)	Production (kg/ha)	U %	MH (kg/hl)	MMB (g)
1	0.92	936.18	7.4	62.8	6.86
2	1.16	1179.12	7.5	64.9	7
3	1.3	1324.29	7.3	65.2	6.94
Average	1.13	1146.53	7.40	64.30	6.93

Table 7. Mustard crop yields and quality indices, in the agricultural year 2020-2021

Mustard (*Sinapis alba* L.)					
Repetition	Yield (kg/10 m.p.)	Production (kg/ha)	U%	MH (kg/hl)	MMB (g)
1	0.78	769.71	10.2	61.8	5.72
2	0.64	635.08	9.7	65.8	6.33
3	0.9	897.03	9.3	65.6	5.48
Average	0.77	767.27	9.73	64.40	5.84

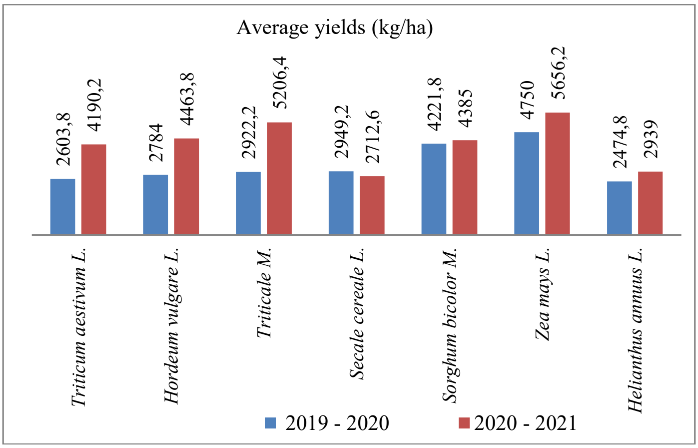

Figure 1. Average yields of crops, in the agricultural years 2019-2021

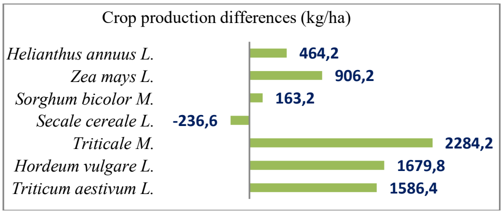

Figure 2. The differences in crop production, between the agricultural years 2020-2021 and 2019-2020

CONCLUSIONS

The drought of the agricultural year 2019-2020 had a negative impact on most crops, especially on straw crops that produced insignificant yields. The adaptability of the less common crop plants to the agricultural cultivation schemes of the Eastern area of Romania, regarding the yield, was achieved by *Linum usitatissimum* L. and *Sinapis alba* L. crops, in the agricultural year 2020-2021. *Sorghum bicolor* M has produced almost equal yields in both years, which proves that it is a crop plant resistant to climate change. *Sorghum sudanense* L., *Ricinus communis* L. and *Sinapis alba* L. responded positively in terms of biomass development to the amounts of rainfall accumulated in the second year of the study. *Helianthus annuus* L. has developed well in the deep loosened soil, on plots where plowing, scarifying and paraplow works were applied. *Zea mays* L. plants had a lower insertion height of the cob compared to the interval described in the literature, but this may be due to several factors related to both the genetic characteristics of the hybrid and pedoclimatic factors. In both years, both *Zea mays* L. and *Helianthus annuus* L. crops recorded stable yields despite the variability of climatic factors.

In terms of seed quality, *Linum usitatissimum* L. and *Sinapis alba* L. did not show significant differences compared to the specific optimum values. The insertion of *Cannabis sativa* L., *Sorghum sudanense* L., *Ricinus communis* L., *Linum usitatissimum* L. and *Sinapis alba* L. in the agricultural crop plan may be a beneficial alternative to soil, biodiversity of agricultural species and agricultural land use, where ordinary crops are no longer suitable in the new climatic context. The system of dry-farming works is not suitable for all agricultural crops, which is why it is important to continue the study, in order to alternate at certain periods of time, the minimum system of soil works with the classic one, especially for crop plants which have a penetrating and pivoting root system. At the same time, observations must be made over several years to cover a wide range of climatic conditions.

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