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RESEARCHES ON BEHAVIOR OF TWO MAIZE HYBRIDS GROWN IN CONVENTIONAL SYSTEM IN CLIMATE CONDITIONS OF THE ROMANIAN PLAIN

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Abstract

Maize, one of the most popular cereal, originates from the Central America and is very versatile, being used in various fields. It is used in food, as feed and in industry. The purpose of the paper regards the choice of hybrids which is one of the most important factors influencing the productivity and quality of the maize. The area where the crop is located influences the choice of the most suitable hybrid, as it must be selected according to the average temperature during the growing period and the type of soil. In this study, the experiments were carried out in the climate and soil conditions of Moara Domneasca Research Station. To find the right hybrid, several hybrids were selected to grow and later to compare their harvest and choose the optimal variant. To obtain the highest production of maize, the chosen hybrid should be also as resistant as possible to extreme weather conditions, such as periods of drought grown in the Romanian Plain, on a specific soil and fertilized with different doses of chemical fertilizers. The economic efficiency of the applied fertilization system was also analyzed. As a conclusion, the two hybrids tested reacted positively to chemical fertilization. The SC4140 hybrid behaved better in the non-fertilized version, achieving higher yields than the P9903 hybrid.

Key words**:** *fertilization doses, maize hybrid, production performance, economic efficiency*

INTRODUCTION

In Romania, maize occupies the largest grown area due to its high productivity and high yields per unit area [28]. The area grown with maize varies between 2.5-3.1 million ha depending on the level of precipitation in the cold season or as a result of the compromise of the autumn crops during the winter [29]. Maize is one of the most versatile crop plants, an enormous diversity of hybrids provides the basis for growing maize in different locations and conditions around the world [4, 27]. The yield components and the grain yield are influenced by several factors, either they are environment or technological.

The consumption of nutrients differs depending on the destination of the crop and silage or grain corn. Chemical fertilization is an agrotechnical measure essential in cropping systems and it guarantees yield boosts [10, 15, 25]. Basic nutrients N and P react very different at maize crop, depending on soil type and climate conditions Nitrogen is the element which determines the biggest increase in maize yield [11, 25]. The yields

for wheat and corn crops increased along with the increase in the rotation duration and in the dose of nitrogen fertilization; the increase was statistically relevant [8, 19, 26]. As a result, the association of rotation with fertilization leads to an increase in organic biomass, with amplified action of the factors in maize [14].

As a very important biological factor in the increase of production, the quality of the seeds from the agricultural point of view is given by their genetic and somatic value [16].

Maize (*Zea mays* L.) is a crop with a high production capacity, which is determined by the yield components participating to the yield formation [1, 18].

The yielding capacity is given for each maize hybrid by its genetics, but it is also influenced by the growth conditions, respectively by the environmental factors, mainly soil and climatic conditions, as well as by the crop technology used by the maize grower [5]. Yield potential can be diminished as a consequence of insufficient water supply to meet crop water demand [17]. But severe drought stress is affecting in a very significant way the yielding capacity of the maize plants, even leading in extreme conditions to the loss of the yielding capacity [8, 9]. Drought is the main yield constraint especially in South Romania, the most important Romanian growing area for maize [20]. Rainfed crop management systems need to be optimized to provide more resilient options in order to cope with the decrease in mean precipitation and more frequent extreme drought periods [13]. Therefore, it is of great importance for farmers but also for scientists to better understand the maize plant responses to drought under different technological conditions [2]. Farmers growing maize must consider crop technology as a tool for a maximum use of resources and for diminishing the effects of limitative environmental factors [16]. Preceding crop is among the important crop technology measures with a significant influence upon the yield and its components [14].

The exclusive use of chemical fertilizers does not reduce the importance of manure [7]. The largest gains at harvest are obtained from the combined action of chemical fertilizers with manure [12, 26].

In the last 30 years, the area cultivated with grain maize has increased by 8.58%, from 2,466,735 ha (26.23% of the total agricultural area) in 1990 to 2,678,504 ha (30.65% of the country's agricultural sector), in 2019. In three decades, the area reserved for growing has never fallen below 2 million hectares [6].

Instead, in 10 years (1992, 1992, 1995, 1996, 1997, 1998, 1999, 2000, 2003, 2004), the area was greater than 3 million hectares, the absolute record being recorded in 1992, when there were cultivated 3.3 million ha with grain corn [24, 21]. The area cultivated with corn has kept a relatively constant level approx. 2,500-2,600 thousand ha with a small decrease in 2010, when the surface reached only 2,098 thousand ha [25, 26]. The maintenance of the areas grown with maize can be explained by the market demand for this crop, by the high productions obtained with this cereal, especially in favorable conditions of precipitation or irrigation, and by its quality as a good precursor to the other crops [13, 23].

Figure 1 shows visible increase both of the area and the production of maize in Romania in the period 2007-2020. This was due to the improvement of the technical endowment, the subsidies granted by the state, the high demand, the continuously increasing price.

The largest grown area was in 2012 (2,730.2 thousand ha) with an average production of 2,180 kg/ha and a total production of 5,953.4 thousand tons.

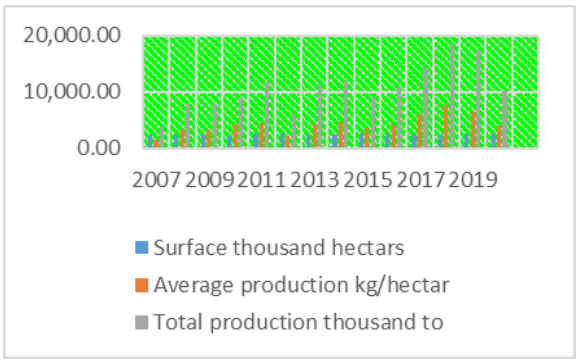

Fig. 1. Evolution of maize surfaces and productions in Romania in the period 2007-2020.
Source: NIS [22].

The highest total production was recorded in 2018, namely 18,353 thousand tons [3, 21]. Compared to the area grown in 2020, of 2,537 thousand ha, in 2021, the areas grown with maize in Romania increased to 2,493 thousand ha [21].

Recorded productions also increased, 2021 being a very good year for agriculture. The increases varied from 10,097 thousand tons in 2020 to 14,445 thousand tons in 2021.

In this context, the purpose of the paper is to test two maize hybrids SC4140 and P9903 for their production capacity under the soil and climate conditions and four levels of fertilization at the S.D.C.D.A. Moara Domnească Didactic Station of Agriculture Research and Development, situated in the South Romanian Plain.

MATERIALS AND METHODS

The research was carried out in the experimental field of S.D.C.D.A. Moara Domnească Didactic Station of Agriculture Research and Development on a preluvosol type soil, with a loamy-clay texture, a medium humus content in A (2.77-2.16%).

From the analytical data of the representative profiles of this soil unit, the following physico-chemical characteristics result: the texture is loamy-clay throughout the profile, with a variation of the clay fraction between 39.20% in A and 39.84% in Bt, which means a weak textural differentiation, Idr (textural differentiation index), having values up to 1.2; the main hydrophysical indices have medium to high values (CH Around 9% in A and up to almost 10% in B; CO over 13% in A and over 14% in B; CC 26-25% in A and 24-21% in B; humus content is medium in A (2.77-2.16%) and remains relatively high in A/B (around 1.2%); the sum of exchangeable bases has high values, generally over 21 me/100 g of soil, on the entire profile; the exchangeable hydrogen has low and very low values (2-5 me); the degree of saturation in bases usually have high values (79-89%); the reaction is weakly acid-neutral (in A, pH=6.2-6.6 and in B, pH=6.0-6.5); nitrogen indices are medium in A (above 2) and low in B (below 2), which shows a medium and weak nitrogen supply, respectively; at a depth of 20 cm from the surface (the active start of roots), the soil is moderately supplied in mobile phosphorus (17 ppm PAL) and well supplied in mobile potassium (184 ppm K_{AL}) [12].

Sowing was carried out between 15-18thApril 2022 and harvesting was carried out between 20-25thAugust 2022. For 2021, sowing was carried out between 5thApril and harvesting on 30thAugust. The preceding crop for the maize plots was soybean, a legume that fixes nitrogen in the soil, giving the corn an important and natural "supplement" for fertilization [14].

In autumn, the surface was scarified, in October and then, in November, the land was discussed in two passes. In spring, before sowing, a work was carried out with the combine.

Sowing was carried out on 15thApril and together with the sowing work, DAP 18:46:0 was also applied. From sowing to harvesting, the only work was weeding. The herbicide Adengo was applied before emergence (dose of 0.4 l/ha) and then, in the 8-10 leaf phase on 12thMay, Laudis was administered (dose of 2.2 l/ha). The total amount of precipitation was 288 liters per square meter, the rains being accumulated between February and August 2022.

The harvest took place on 25thAugust. Density at sowing: 66,000 grains/ha. The culture did not benefit from irrigation. The experiment was bifactorial based on the method of blocks with subdivided plots, with three repetitions, where factor A - the hybrid with two grades a1 SC4140 and a2 P9903, and factor B - doses of mineral fertilizers with the following grades: b1-N_0P_0 ; b2-$N_{50}P_{50}$; b3-$N_{100}P_{50}$; b4-$N_{150}P_{100}$.

RESULTS AND DISCUSSIONS

Effect of chemical fertilization on the production obtained in maize growing is shown in Table 1.

According to the data presented in Table 1, productions increased as the dose of fertilizers

increased, from 3,590 kg/ha to 6,940 kg/ha (average productions of the 2 years).

Table 1. Productions made on grown surfaces with hybrid SC4140

Fertilization Variant	Production kg/ha 2021	Production kg/ha 2022	Average production kg/ha	Production increase compared to control kg/ha	Production increase between variants Kg/ha
N_0P_0	3,250	3,930	3,590	Mt	Mt
$N_{50}P_{50}$	4,270	4,380	4,310	720	720
$N_{100}P_{50}$	5,580	5,900	5,740	2,150	1,430
$N_{150}P_{100}$	6,900	6,980	6,940	3,350	1,200

Source: own processing.

Production gains have increased significantly compared to the non-fertilized version, reaching values of over 3,000 kg/ha. The increase in production between the version fertilized with 50 kg a.s. and the one fertilized with 100 kg. to. N has grown significantly 1,430 kg. Fertilization with another 50 kg a.s. N. It did not determine increases of less than 1,200 kg, which means that the increase in doses does not imply an increase in gains.

Table 2. Productions obtained from the cultivated surfaces with P9903 hybrid in 2022 versus 2021

Fertilization Variant	Production kg/ha 2021	Production kg/ha 2022	Average Production kg/ha	Production increase compared to Control Kg/ha	Production increase between variants Kg/ha
N_0P_0	2,950	3,200	3,075	Control	Control
$N_{50}P_{50}$	3,300	3,550	3,425	350	350
$N_{100}P_{50}$	5,500	5,300	5,400	2,325	1,975
$N_{150}P_{100}$	6,850	6,700	6,775	3,700	1,375

Source: Own processing.

Table 2 shows the productions achieved on the areas grown with the P9903 hybrid.
It has positively reacted to the doses of fertilizers administered, reaching increases of 3,700 kg in the version fertilized with 150 kg N/ha a.s. Both the productions and the increases obtained were very significant.
The yield increase between the variants increased very significantly in the variant fertilized with 100 kg a.s.N, 1,975 kg/ha.
The version fertilized with 150 kg N a.s. recorded substantial but smaller increases compared to previous versions.
To analyze the influence of fertilizer doses on plant development, biometric measurements were performed.
The results presented in Table 3 were obtained by calculating the average of the measurements performed on a number of 10 plants from each experimental variant.

Table 3. Biometrical measurements

Variant	Height of plant m	No of leaves/ plant	Height of cob insertion/ fr. no.
N_0P_0	1.77	11	0.64 cm/5
$N_{50}P_{50}$	1.81	11	0.61 cm/6
$N_{100}P_{50}$	1.89	11	0.62 cm/5
$N_{150}P_{100}$	1.78	11	0.63 cm/5

Source: own processing.

From Table 3, it appears that the variant in which the plants recorded the greatest increase in height was the one fertilized with the N150P100 formula. It can be concluded that high doses of nitrogen cause obvious vegetative growth. The number of leaves per plant was on average 11, the insertion height of the cob being between 0.61-0.64 cm.

The economic efficiency of the grow system analyzed

The technological measures applied were also analyzed from the point of view of economic

efficiency The financial result was influenced by the price of cereals on the market.

Table 4. Sale price of cereals

	Sale price (lei/kg)			
	2019	**2020**	**2021**	**2022**
Maize	0.62 ↑	0.76 ↑	1.0 ↑	1.5 ↑

Source: www.agrointeligenta.ro [2].

The sale price of maize has had an upward trend in recent years as shown in Table 4. This was influenced by the small productions achieved especially in 2020, an extremely difficult agricultural year due to the drought, but also in 2022, when the same climatic conditions led to a low harvest. As a result, increased demand and reduced supply led to higher prices.

Table 5. Costs made with fertilizers - lei

Variant	Costs of fertilizers lei/ha		
	2021	2022	Average
N_0P_0	-	-	-
$N_{50}P_{50}$	820	1,020	920
$N_{100}P_{50}$	1,380	1,548	1,464
$N_{150}P_{100}$	1,940	2,276	2,108

Source: Research Station data.

From the data presented in Table 5, it appears that the total expenses per ha were 1,320 lei in 2021 and 1,500 lei/ha in 2022. Maize is a crop that requires weeding and therefore higher expenditure on pesticides.

The price of DAP in 2021 was 4.2 lei/kg and 5.0 lei/kg in 2022. The price of ammonium nitrate was 5.2 lei/kg in 2022 and 4.0 lei/kg in 2021. To ensure the doses established for each variant, the following amounts were calculated and administered:

Variants:

-N_0P_0 - not fertilized

-$N_{50}P_{50}$- DAP 18:46:0- 100 kg pc/ha+ ammonium nitrate 100 kg pc/ha (33%N)

-$N_{100}P_{50}$- DAP 18:46:0- 100 kg pc/ha+ Ammonium nitrate 240 kg pc/ha (33%N)

-$N_{150}P_{100}$- DAP 18:46:0- 200 kg pc/ha+ Ammonium nitrate 330 kg pc/ha(33%N).

The values of costs with these doses of fertilizers are shown in Table 5.

Among the direct expenses, administered fertilizers had the largest share, the increase in doses also causing their increase.

The price of fertilizers also influenced the level of expenses incurred by farmers for the establishment and maintenance of crops (Table 6).

From Table 6, it appears that the expenses incurred per hectare were influenced by the amount of fertilizers administered. Thus, for the non-fertilized version, the expenses were 1,410 lei/ha, reaching 3,518 lei/ha for the one fertilized with 150 kg N a.s. The quantity and price of fertilizers drove these increases. The income obtained were influenced by the productions achieved but also by the price of the cereals at the time of utilization. Incomes per hectare were lower in 2021 because the selling price was only 1 leu/kg.

In the following year, the price increased to 1.5 lei/kg, thus increasing the income per ha. The lowest income was recorded in the non-fertilized version, an average of 4,573 lei/ha, the highest was obtained in the version where doses of N s.a. were administered. of 150 kg/ha, 8,685 lei/kg (Table 6).

Analyzing the table, we notice that the good price in 2022, 1.5 lei/kg and the higher productions but also the precipitation that fell at the critical moment for the plant influenced the financial result.

Thus, the profit increased from 4,395 lei/ha in the non-fertilized version to 6,694 lei/ha in the version fertilized with the maximum dose.

In 2021, although the productions were close, the sales price influenced the financial result, which was much lower.

We performed the economic efficiency calculation using the average production values for the two years and an average selling price of 1.3 lei/kg.

The data presented in Table 7 show that the productions increased proportionally with the increase in the doses of administered fertilizers, the yield increase also increased from 720 kg/ha to the variant in which it was fertilized with the dose of 50 kg N s.a. to 3,350 kg/ha in the fertilized version with a dose of 150 kg N a.s /ha.

Table 6. Economic analysis of grow with SC4140 - hybrid (lei/ha)

Variant	Production kg/ha		Income /ha lei/ha			Costs /ha lei/ha			Profit lei/ha	
	2021	2022	2021	2022	Media	2021	2022	Media	2021	2022
N_0P_0	3,250	3,930	3,250	5,895	4,573	1,320	1,500	1,410	1,930	4,395
$N_{50}P_{50}$	4,270	4,350	4,270	6,575	5,422.5	2,140	2,520	2,330	2,130	4,055
$N_{100}P_{50}$	5,580	5,900	5,580	8,850	7,215	2,700	3,048	2,874	2,880	5,802
$N_{150}P_{100}$	6,900	6,980	6,900	10,470	8,685	3,260	3,776	3,518	3,640	6,694

Source: Own processing based on the data from the Research Station.

Table 7. Economic efficiency of crop culture SC4140 hybrid

Variant	Prod kg/ha	Prod. increase Kg/ha	Fertilizer costs lei	Profit for production increase lei/ha
N_0P_0	3,590	Control	Control	Control
$N_{50}P_{50}$	4,310	720	920	936
$N_{100}P_{50}$	5,740	2,150	1,464	2,795
$N_{150}P_{100}$	6,940	3,350	2,108	4,355

Source: Own processing based on the data from the Research Station.

Fertilizer costs increased as applied rates increased. The profit recorded on the increase in production increased proportionally with the increase in the doses of fertilizers used as a result of the increase in production, from 936 lei/ha to 4,355 lei/ha. As a result, the administration of increased doses of fertilizers causes significant increases in production, the expense of these high doses being economically justified. Above these doses, the plants no longer registered significant increases in production, which no longer economically justifies spending on higher doses of administered fertilizers.

The incomes obtained were influenced by the productions achieved but also by the price of the cereals at the time of utilization. Revenues per hectare were lower in 2021 because the selling price was only 1 leu/kg. In the following year, the price increased to 1.5 lei/kg, thus increasing the income per ha. The lowest income was recorded for the non-fertilized version, an average of 3,875 lei/ha, the highest, for the version with doses of N s.a.of 150 kg/ha, 8,450 lei/kg (Table 8).

Table 8. Financial results for P9903 hybrid

Variant	Production kg/ha		Income lei/ha		Costs lei/ha		Profit lei/ha	
	2021	2022	2021	2022	2021	2022	2021	2022
N_0P_0	2,950	3,200	2,950	4,800	1,760	1,940	1,190	2,860
$N_{50}P_{50}$	3,300	3,550	3,300	5,325	2,580	2,960	720	2,365
$N_{100}P_{50}$	5,500	5,300	5,500	7,950	3,140	3,488	2,360	4,462
$N_{150}P_{100}$	6,850	6,700	6,850	10,050	3,700	4,216	3,150	5,834

Source: Own processing based on the data from the Research Station.

The profit made per hectare was influenced by the yields obtained, by the price of cereals on the market at the time of harvesting, but also by the expenses for the establishment of the crop.

The non-fertilized or low-dose fertilized variants did not achieve high yields, as a result, incomes were lower in 2021 but higher in 2022 favored by the increased price of grain on the market.

The profit increased for the variants fertilized with higher doses of fertilizers as a result of the increase in the harvest, higher prices in 2022 and the increases in production recorded (Table 9).

The production increases significantly as the dose of fertilizers administered increases, reaching from 3,075 kg/ha in the unfertilized version to 6,775 kg/ha in the version fertilized with 150 kg N a.s.

The increase in harvest was 3,700 kg/ha, the profit achieved was also high, 4,810 lei/ha.

Table 9. Economic efficiency of P9903 crop system

Variant	Prod. kg/ha media	Prod. increase Kg/ha	Costs with fertilizers Lei	Profit for production increase lei/ha
N_0P_0	3,075	-	-	-
$N_{50}P_{50}$	3,425	350	920	455
$N_{100}P_{50}$	5,400	2,325	1,464	3,022
$N_{150}P_{100}$	6,775	3,700	2,108	4,810

Source: Own processing based on the data from the Research Station.

In conclusion, as the data in Table 9 shows, the expenses with fertilizers were lower than the profit achieved, which means that from an economic point of view the additional expenses with the administered doses are justified.

CONCLUSIONS

The application of mineral fertilizers determines higher yields and significant increases in production. The unbalanced application of chemical fertilizers can produce imbalances in the plant and the crop increases recorded are increasingly lower as the amount administered increases beyond the useful limit for the plants, which causes higher expenses that are not found in the increases achieved.

Another goal of this analysis was to follow the reaction of hybrids to fertilization and choose for the future the one that brought us the best results without generating large expenses.

The two hybrids tested reacted positively to chemical fertilization, the gains obtained being significant and close for both hybrids.

The SC4140 hybrid behaved better in the non-fertilized version, achieving higher yields than the P9903 hybrid.

The costs of the additional amounts of fertilizers administered were approx.500 lei for each option, expenses that were economically justified by the increases obtained and the revenues recorded. The incomes achieved were about 3,000 lei/ha for the unfertilized version of both hybrids and more than 10,000 lei/ha for the versions fertilized with 150 kg N s.a./ha.

Expenses were about the same for the two hybrids, slightly higher for P9903, the difference being driven by the higher price of seed material. Profit influenced by slightly lower seed costs was higher in hybrid SC4140.

Both hybrids can be grown with good results, taking into account the climatic conditions of the year, the type of soil and the price of the genetic material. In the climatic conditions of the years 2021 and 2022, doses of up to 150 kg N/ha s.a. they generated crops that justified the costs of fertilization. The application of higher doses did not lead to significant increases in production to justify the additional expense.

REFERENCES

[1]Agapie, A.L., Sala, F., 2022, The variation of protein content in maize grains in relation to the fertilization level, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4), 31-37.

[2]Agrointeligenta.ro, Bursa cerealelor, Astazi oretul porumbului l[-a depasit pe cel al graului, https://www.agrointeligenta.ro/ https://agrointel.ro/249477/bursa-cerealelor-astazi-pretul-porumbului-l-a-depasit-pe-cel-al-graului/, Accessed on Feb. 1, 2023.

[3]Bâtcă, A., 2011, How Romanian agriculture performed from 2010, Ceres Publishing House, Bucharest, p. 14.

[4]Băşa, A. Gh., Ion, V., Dumbravă, M., Temocico, G., Epure, L.I., Ştefan, D., 2016, Grain Yield and Yield Components at Maize under Different Preceding Crops and Nitrogen Fertilization Conditions, Agriculture and Agricultural Science Procedia, Vol.10, 104-111, https://doi.org/10.1016/j.aaspro.2016.09.025, https://www.sciencedirect.com/science/article/pii/S2210784316302182, Accessed on Sept. 10, 2023.

[5]Bărbos, A., Moldovan, Gr., Micu, O., 2016, The influence of genotype, treatment and storage period on ageing process of hybrid corn seeds. Agriculture Science and Practice Journal, 70-75, Academicpres, Cluj-Napoca.

[6]Berca, M., 2019, Modern transformation of agriculture, Ceres Publishing House, Bucharest, p. 321.

[7]Berca, M., Buzatu, C.S., 2011, Maize answer modelling at nutrition with nitrogen and phosphorous within the Romanian space, Scientific Papers Series Agronomy, University of Agricultural Sciences and Veterinary Medicine of Iasi, Vol. 54 (1), 102-105.

https://www.uaiasi.ro/revagrois/PDF/2011/paper/2011-54(1)-23-en.pdf, 102-105, Accessed on Sept. 10, 2023.
[8]Blaise, L., 2012, Rotation of crops, M.A.S.E. Publishing, Bucharest, p. 57 and p.78.
[9]Bologa, G. C., 2014, Sustainable rural development in Romania, Pro Universitaria Publishing House, Bucharest, p. 38.
[10]Burcea, M., 2018, Anthropic impact studies on the agrochemical quality condition of the soil, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 18(1), 109-113.
[11]Burcea, M., Oltenacu, N., 2019, The bonitation method for assessing the fertility of the chernozem, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 19(3), 107-111.
[12]Ciontu, C., Săndoiu, D. I., Penescu, A., Gâdea, M, Schiopu, T., Obriscă, M., Dincă, L., 2012,The essential role of crop rotation and nitrogen fertilization in wheat and maize in the sustainable agriculture system of reddish preluvosoil, AgroLife Scientific Journal 1(1), 68-77,
https://agrolifejournal.usamv.ro/index.php/agrolife/article/view/10, Accessed on Sept. 10, 2023.
[13]Cociu, A., Cizmaș, G.D., 2015, Maize yield and its stability as affected by tillage and crop residue management in the eastern Romanian Danube Plain. Scientific Papers. Series "AgroLife Journal", Vol. 4(1), 46-51.
[14]David, Gh., Borcean A., 2011, Cereals and legumes for grains, Eurobit Publishing House, Timișoara, p. 13.
[15]Dobre, M., 2019, Agrotechnics, Universitaria, Publishing House, Bucharest, pp. 29-31.
[16]Dumbrava, M., Basa, A.G., Ion, V., Dobrin, I., 2015, Analysis of the yield components at maize under the specific conditions from South Romanian. Book of Proceedings, Sixth International Scientific Agricultural Symposium „Agrosym 2015“, pp. 291-295.
[17]Grassini, P., Yang, H., Cassman, K.G., 2009, Limits to Maize Productivity in Western Corn-Belt: A Simulation Analysis for Fully Irrigated and Rainfed Conditions. Agricultural and Forest Meteorology, 149, pp. 1254-1265.
[18]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. Agronomy, Vol. LVI, pp. 276-283.
[19]Ionescu, G., Staicu, I.R., 2008, Agrotechnics (Vol. I), Agro-Silvică Publishing Houser, Bucharest, p. 22.
[20]Mihai, M., 2019, Romania Encyclopedia, South-East development region, Bucharest, p. 48.
[21]Ministry of Agriculture and Rural Development, MARD, Statistics, https://www.madr.ro/, https://www.madr.ro/statistica.html, Accessed on Sept. 9, 2023.
[22]National Institute of Statistics, NIS, Vegetal production for the main crops in 2022, https://insse.ro/cms/, https://insse.ro/cms/sites/default/files/com_presa/com_pdf/prod_veg_r22.pdf, Accessed on Sept. 9, 2023.
[23]Oltenacu, C. V., Burcea, M., Oltenacu, N., Dima, F. M., 2022, The evolution of cultivated areas and the productions obtained at four agricultural crops cultivated in a conventional and ecological system in the period 2016-2020 in Călăraşi county. AgroLife Scientific Journal, 11(2).https://doi.org/10.17930/AGL2022216.
[24]Popescu, A., 2018, Maize and wheat - top agricultural products produced, exported and imported by Romania. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 18(3), 339-352.
https://managementjournal.usamv.ro/pdf/vol.18_3/volume_18_3_2018.pdf, Accessed on Sept. 10, 2023.
[25]Sala, F., Boldea, M., 2011, On the optimization of the doses of chemical fertilizers for crops. AIP Conference Proceedings, 1389, 1297.
[26]Săndoiu, D.I., Dumitrescu, N.C., Ștefanic, Gh., Obrișcă, M., Gheorghiță, N., Ciontu, C., Săndoiu, I.F., 2007, Influence of crops rotation and fertilization with nitrogen on autumn maize productions and grains and fertilization of brown-red soil. In vol. Improvement, preservation and use of damaged soils by anthropic interventions, Ion Ionescu de la Brad Publishing House, Iași, pp. 20-40.
[27]Shah, T.R., Prasad, K., Kumar, P., 2016, Maize - A potential source of human nutrition and health: A review. Cogent Food & Agriculture, 2(1), 1166995.
[28]Stancu, M. R., 2010, Romania's agriculture compared to EU exigencias, ASE Publishing House, Bucharest, p. 12.
[29]Toader, M., Roman G.M., 2008, General Agriculture, Part I – Universitaria Publishing House, Bucharest, pp. 62 -63.