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THE GENETIC POTENTIAL FOR THE GRAIN YIELD OF SOME MAIZE HYBRIDS, STUDIED IN DIFFERENT CONDITIONS OF ENVIRONMENT, IN ROMANIA

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ABSTRACT

The breeding activity for obtaining maize hybrids having high genetic potential for the grain yield, also good stability, in different environment conditions is of a great importance for the management of this crop. The potential for the yield brings the highest contribution to the crop efficiency. To increase the grain yield it is necessary to have a good developing of the plants in different conditions of growing.

We studied 24 maize hybrids, in two years (2018 and 2019) in six locations situated in different areas of Romania: Cogealac (south Romania); Mircea Vodă (south-eastern Romania); Portăreşti (south-western Romania); Şimleu Silvaniei (western Romania); Negreşti (eastern Romania) and Dej (north-western Romania). The hybrids were cultivated in three randomized replications.

Comparing the two years, 2018 and 2019, regarding the air temperatures and the amount of rainfall, in maize vegetation period, year 2018 was dryer comparing with 2019 year.

Results showed that the grain yield was different by location, by year, also by hybrid. In three locations (Dej, Mircea Vodă and Portăreşti) the hybrids released good grain yield, in both years. The lowest grain yield was obtained in both years in two locations (Cogealac and Şimleu Silvaniei). The grain yield was lower in 2018 year, in all locations, excepting Cogealac, comparing with 2019 year. The vegetation period was high influenced by location. TGW and hectolitre mass were different, specially, by location and by hybrid.

Keywords: maize, hybrids, genetic potential, environment, grain yield.

INTRODUCTION

Cereals are the major source of dietary protein for humans (Shewry, 2007) and maize represents 35% of total global cereal production (FAOSTAT, 2014).

Maize originated in southern Mexico (Matsuoka et al., 2002) and then spread across the Americas and subsequently to Europe, Africa and Asia.

In the mid-20th century in farmers activity increased the use of agrochemicals, chemical fertilizers and improved maize hybrids. Seed companies took the lead in commodity seed research and production.

Soon after, with increased market demand and rapid development and adoption of agricultural technology worldwide, grain production has specialized and intensified.

Environmental and economic costs for seed availability and provisioning are fundamental. Developing hybrids and producing seeds as important first step in grain production requires different investments and processes according to the required selection methods (Petcu et al., 2018) and breeding strategies (Le Buanec, 2008; Dalle Mulle and Ruppanner, 2010).

Modern national economies heavily depend on the utilization of renewable and nonrenewable natural resources as well as on related ecosystem services provided for free from the environment (Gurian-Sherman, 2009; Grassini et al., 2013).

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Since maize is among the most important crop worldwide, it can be considered a reference crop for the benefits of different management patterns characterized by different degrees of intensification.

Romania plays an important role in the international maize market, being in full ascendency in terms of production and export (Popescu et al., 2018).

So, the breeding activity for obtaining maize hybrids having high genetic potential for the grain yield, also very good stability, in different environmental conditions is of a great importance for the management of this crop. To increase the grain yield it is necessary to have a good developing of the plants in different conditions of growing, good tolerance to biotic and abiotic stress, adaptability to the cultivation technology (Cristea et al., 2004; Horhocea et al., 2020).

Very important are the local biotic factors, which can produce high seed yield losses (Bărbulescu, 2000; Cristea et al., 2015; Dudoiu et al., 2016).

An important objective in maize breeding is the fast water loss from the grains, this being influenced by climatic conditions but also is a genetic characteristics (Baute et al., 2002; Lackey, 2008; Iordan et al., 2016).

This paper is going to present the behavior of some maize commercial hybrids, regarding the genetic potential for the grain yield in different conditions of environment, also under stress caused by some biotic factors.

MATERIAL AND METHODS

A set of 24 maize hybrids were studied during two years (2018 and 2019) in six locations, situated in different areas of Romania: Cogealac (south Romania), Mircea Vodă (south-eastern Romania), Portăreşti (south-western Romania), Negreşti (eastern Romania), Şimleu Silvaniei (western Romania) and Dej (north-western Romania).

Cogealac, placed at north-eastern side of Constanţa district is characterized by chemozem soils, well supplied with potassium and mid supplied with nitrogen and phosphorus. Mircea Vodă is situated in central western side of Brăila district, with chemozem soils, mid supplied with phosphorus and nitrogen.

Portăreşti is situated in south side of Dolj district with sandy haplic chemozem soils mid supplied with nitrogen and phosphorus. Şimleu Silvaniei is situated in north-eastern Crişana region, in Sălaj district. The soils are clay type, well supplied with potassium, mid supplied with phosphorus and less supplied with nitrogen. Negreşti is situated in central Moldavia, in Vaslui district, being characterized by cambic chemozem soil, well supplied with potassium and mid supplied with phosphorus and nitrogen. Dej is situated in Cluj district with black hydromorphic soils, limestone, mid supplied with phosphorus and less supplied with nitrogen.

The hybrids are belonging to the following FAO groups: 15 hybrids are mid early (300-400 FAO groups) and 9 hybrids are mid late (450-500 FAO groups). All of them are commercial hybrids, created by different seed companies, including NARDI Fundulea and Turda Research and Development Station.

The hybrids were cultivated in three randomized replications. Each plot had 4 rows with total area of 26.8 square meters. The plants density was 70,000 plants/hectare.

The soil and climatic conditions were very different from one location to the other one, also from year to year.

There have been studied some important characteristics, like thousand grain weight and hectoliter mass. Also it was noted, for each hybrid, the vegetation period from emergence to maturity.

For appreciation of resistance to the disease produced by pathogen *Fusarium* spp. it was used the resistant class, depending by the attack degree, established through notes.

RESULTS AND DISCUSSION

Comparing the two years, 2018 and 2019, regarding the air temperature, during maize vegetation period (Table 1) in all locations the highest values were registered in 2018 year. In germination-emergence time, the highest air temperatures were at Şimleu Silvaniei and Negreşti, in both years, the lowest being at Portăreşti. In flowering-maturity

period, in both years, the highest air temperatures were registered at Negreşti, Portăreşti, Cogealac and Mircea Vodă, the lowest being at Şimleu Silvaniei and Dej.

Table 1. The air temperature in two years and six locations

Location / Month	Portăreşti		Negreşti		Şimleu Silvaniei		Cogealac		Mircea Vodă		Dej	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
January	-1.8	-2.1	-1.7	2.2	6.4	0.5	2.7	1.9	4.6	-1.4	-0.2	-2.5
February	3.9	2.2	-3.0	2.8	8.0	6.5	2.6	4	5.2	2.9	-0.4	1.0
March	6.4	8.2	3.0	10	15.5	11.8	4.6	8.7	6.7	8.3	2.9	5.7
April	8.3	9.5	15.4	14.7	16.5	16.8	12.2	10.5	10.2	10.9	14.3	11.6
May	17.4	15.23	18.4	17	20.3	15.5	18.7	16.6	15.9	17.7	17.9	14.5
June	22.8	21.83	21.8	22	20.9	19.1	22.7	24.3	24.2	23.8	19.5	21.5
July	23.9	22.83	21.3	28	23.1	21.4	24.0	23.9	26.2	23	19.5	20.0
August	24.6	24.16	29.7	29.8	24.2	23.2	25.0	24.4	27.1	23.8	21.9	20.7

Regarding the rainfall (Table 2), in period of germination-emergence stage, in 2018, the highest amount of rainfall was in Şimleu Silvaniei and Dej locations. In period of flowering-maturity, it was registered the highest amount of rainfall in Portăreşti, Dej, Cogealac, Negreşti and Şimleu Silvaniei. In the other two locations it was a small amount of rainfall in this period.

In 2019 year, the rainfall amount, in period of germination-emergence was higher comparing with 2018 year, in all locations. In period of flowering-maturity, in Negreşti and Portăreşti it was the best situation regarding the rainfall amount, comparing with the other four locations.

Table 2. The rainfall in two years and six locations

Location / Month	Portăreşti		Negreşti		Şimleu Silvaniei		Cogealac		Mircea Vodă		Dej	
	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019	2018	2019
January	26	31	314.0	37	49.1	22.2	38.5	45	22.0	36	37.8	24.0
February	20	24	52.0	23.5	21.0	8.4	64.0	11	72.0	6	25.8	39.5
March	32	23	71.4	0	46.0	20.5	59.0	22	49.0	11	51.5	46.2
April	38	55	12.8	81.6	22.0	21.3	5.0	15	25.0	30	25.8	147.4
May	24	45	6.0	72	50.6	200.1	18.0	44	8.0	27	39.1	60.6
June	28	137	126.7	121	110.9	43.5	73.0	48	5.0	104	191.1	32.5
July	142	79	76.4	36	57.2	46.6	117.0	74	44.0	25	79.7	73.9
August	21	5	0	57	25.0	16	0	0	5.0	30	4.0	22.9

The grain yield was different by year and by location (Figures 1 and 2). In each location there have been some differences between hybrids. In three locations (Dej, Mircea Vodă and Portăreşti) the hybrids released the highest grain yield, in both years. The lowest grain yield was obtained in both years, in two locations (Cogealac and Şimleu Silvaniei). In 2018 year, the grain yield was lower than 2019 year, in all locations, excepting Cogealac.

The differences between hybrids, regarding the grain yield, in all locations and both years, were not so high. Only one hybrid (Turda 201) released the lowest grain yield, in both years and almost all locations. The highest grain yield, in both years and all locations was released by DKC 5830 hybrid, followed by P 0412 and P 9911.

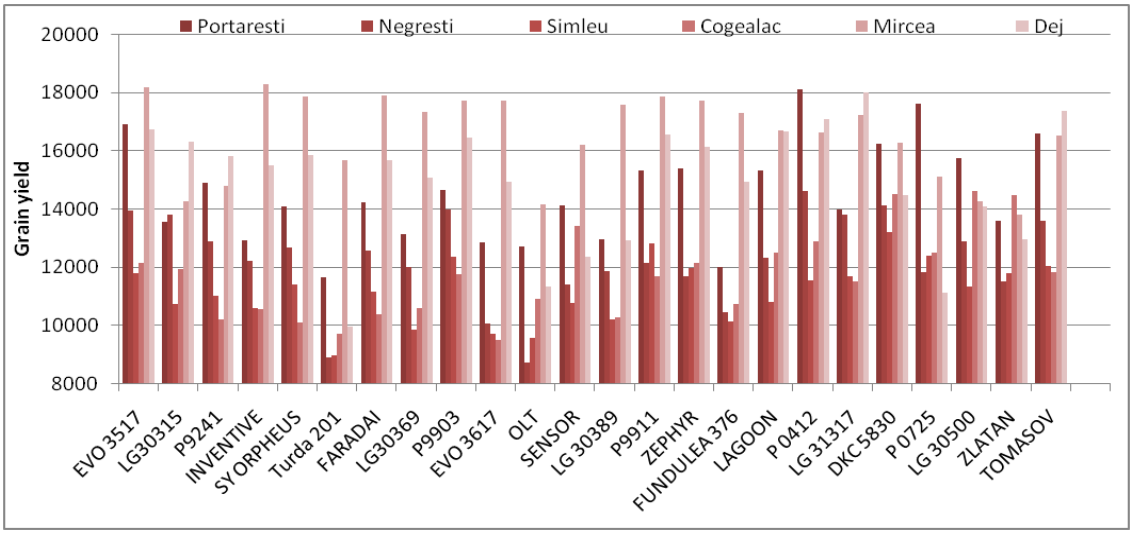

Figure 1. The grain yield for studied maize hybrids, in 2018 year

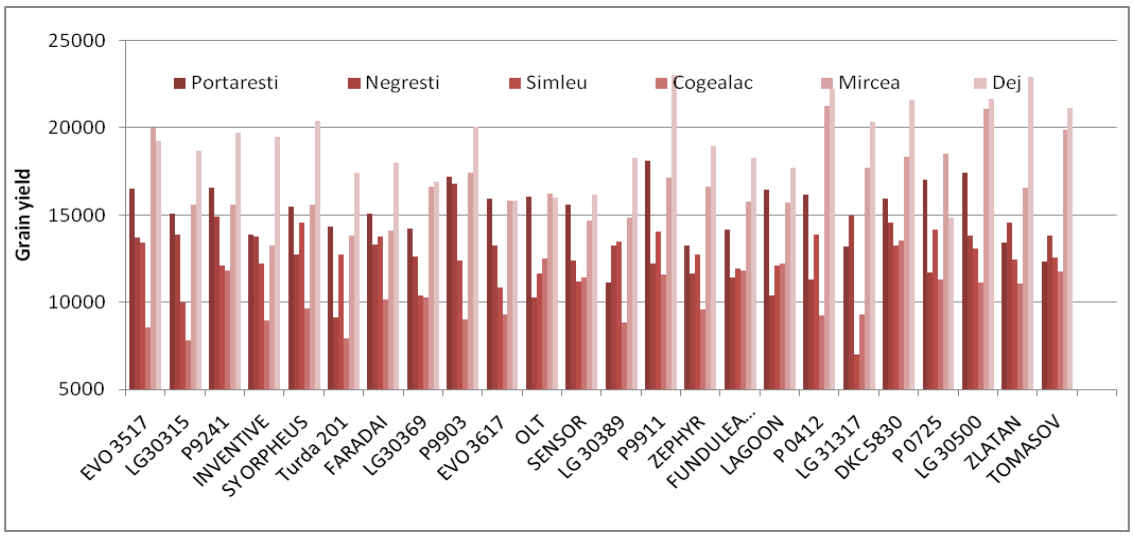

Figure 2. The grain yield for studied maize hybrids, in 2019 year

The analysis of variance regarding the grain yield (Table 3) shows that the highest influence (p>0.1%) due to location, followed by year, the interaction between location and year, being very significant. The interaction between hybrid and location or year are significant at level of p=5%.

Table 3. Analysis of variance for the grain yield (date obtained in 2018 and 2019 years, for twenty four maize hybrids)

Source	Degrees of freedom	Sum of squares	Mean square	F	P
Year (A)	1	44663271.390	44663271.390	95.2480***	0.0000
Location (B)	5	549102767.538	109820553.508	234.2010***	0.0000
Hybrids (C)	23	134439545.434	5845197.628	38.9457***	0.0000
A x B	5	76108961.603	15221792.321	32.4617***	0.0000
A x C	23	20279711.749	881726.598	5.8748*	0.0000
B x C	115	146177925.934	1271112.399	8.4692*	0.0000
A x B x C	115	88051766.091	765667.531	5.1015*	0.0000
Total	289	1060373373.636			

The results presented in Figures 3 and 4 show that the thousand grain weight (TGW) of the studied hybrids are different by year and by location. In 2018 year the TGW was lower than 2019 year, for all hybrids. This is normal, taking into consideration the climatic conditions in 2018 year.

In 2018 year some hybrids registered higher value of this characteristics in Mircea Vodă, Negreşti and Dej locations. The hybrids with good TGW values were P 0412, Olt, DKC 5830 and Fundulea 376. In 2019 year the higher values of TGW were registered the same locations like in 2018 year, the hybrid Olt having the highest values in almost all location. This hybrid is followed by LG 30389, P 0412 and DKC 5830.

Frequency and normal distributions of TKW for Hap II and Non-Hap II haplotypes are presented in Figure 7.

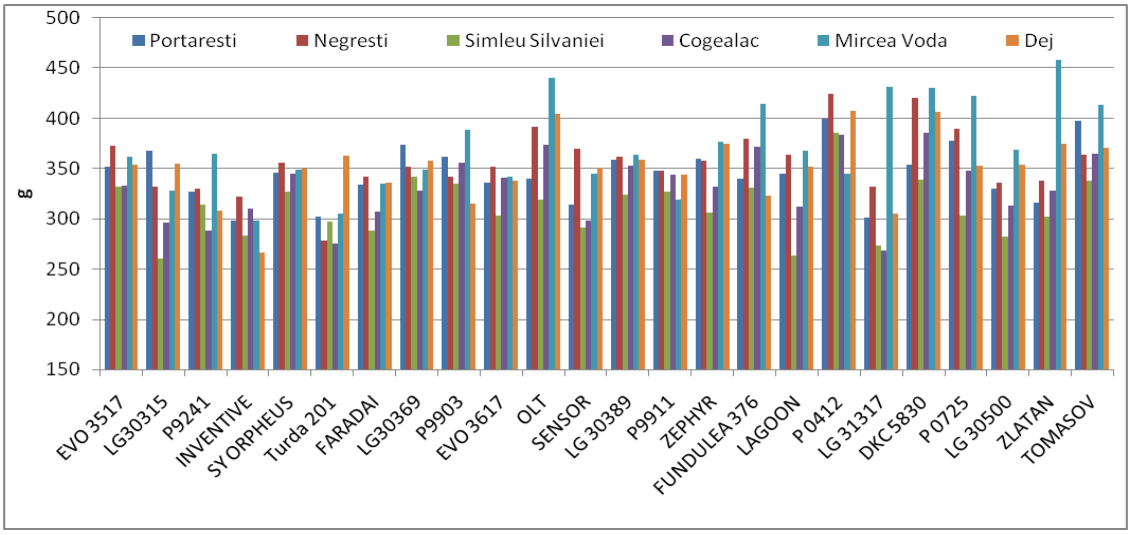

Figure 3. The thousand grain weight, for studied maize hybrids, in 2018 year

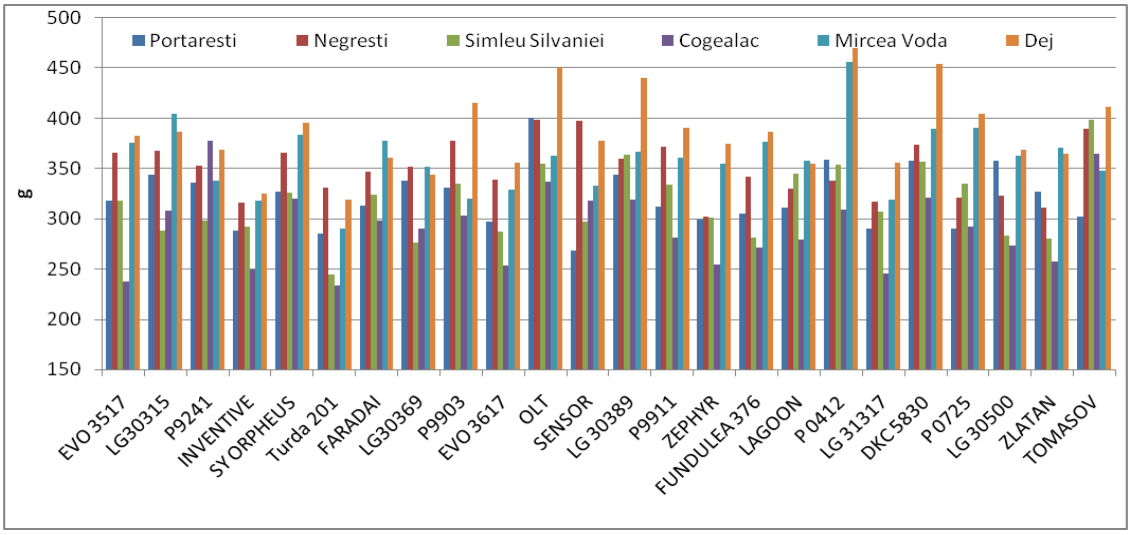

Figure 4. The thousand grain weight, for studied maize hybrids, in 2019 year

The results regarding hectoliter mass of the twenty four hybrids, presented in Figures 5 and 6 show that in 2018 year were registered lower values comparing with 2019 year. The highest values of hectoliter mass were in both years in Mircea Vodă location, followed by Cogealac and Portăreşti. The lowest values were registered in Dej location, for almost all hybrids, in both years.

In 2018 year the highest value of hectoliter mass was registered by Inventive hybrid, followed by P 9241, SY Orpheus, LG 30369, Faradai, LG 31317 and DKC 5830. In 2019 year, also the hybrid Inventive was situated on the first place, followed by SY Orpheus, Faradai and Turda 201.

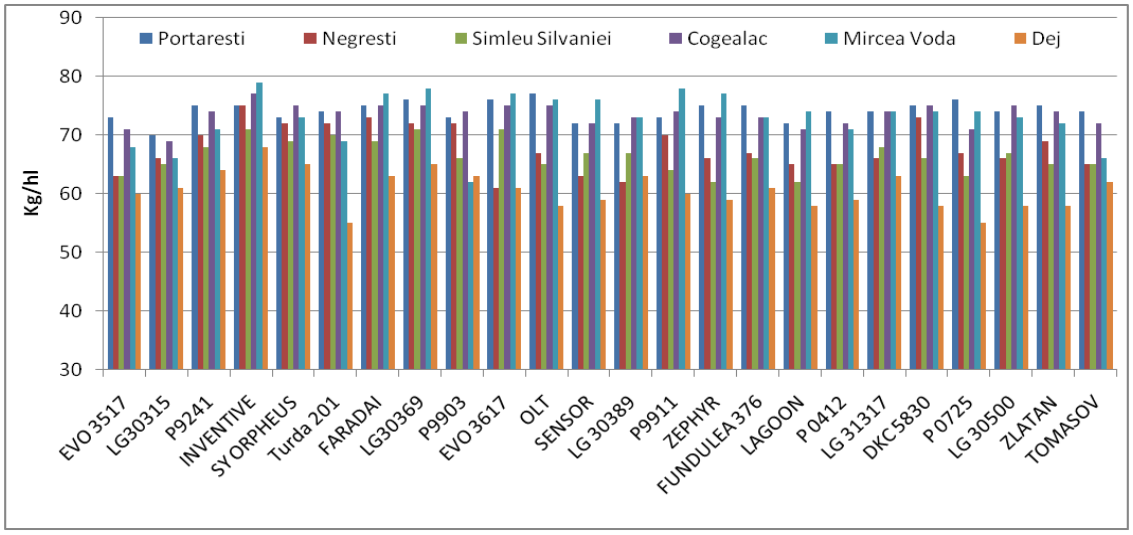

Figure 5. The hectoliter mass, for studied maize hybrids, in 2018 year

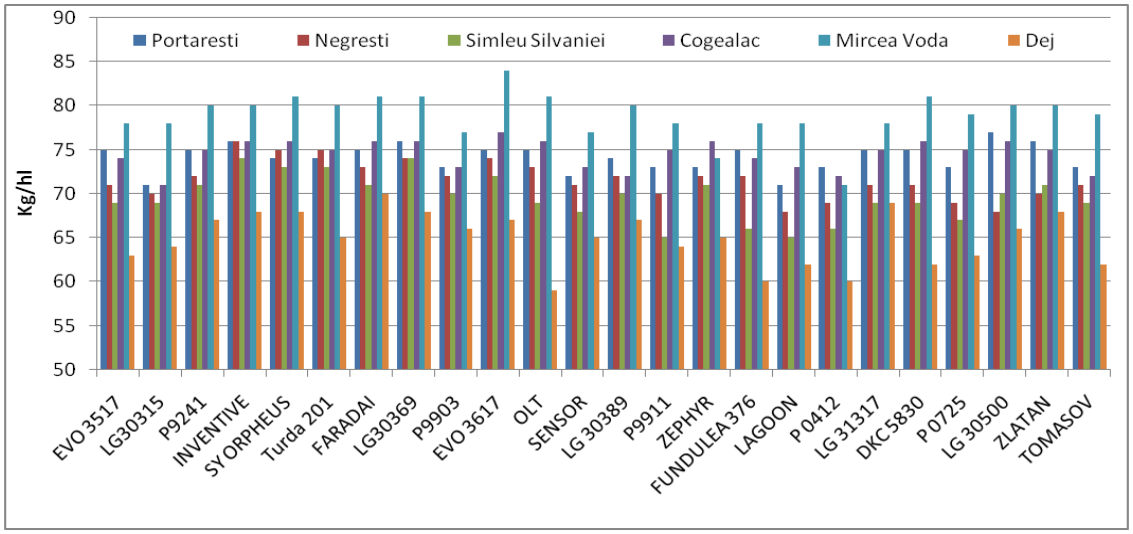

Figure 6. The hectoliter mass, for studied maize hybrids, in 2019 year

Referring to the vegetation period of the hybrids (period from emergence to maturity) the results presented in Figures 7 and 8 show that there are differences by location and by year. There are not high differences between hybrids.

In 2018 year the highest number of days for the vegetation period of hybrids it was registered in Mircea Vodă location, followed by Şimleu Silvaniei and Negreşti. The shorter vegetation period it was registered in Portăreşti, Dej and Cogealac locations.

In 2019 year, Mircea Vodă and Şimleu Silvaniei locations are very closely, regarding the vegetation period of the hybrids, followed by Negreşti location. In the other three locations (Dej, Portăreşti and Cogealac) the hybrids registered the shorter vegetation period. In both years it was registered almost the same difference between the shorter and longer vegetation period of the hybrids, this being of around 40 days. Regarding the hybrids it was a difference of 5 days, between the hybrid with shorter and the hybrid with

longer vegetation period, in both years. The longer vegetation period registered by hybrids was around 135-143 days. The shorter vegetation period was around 105-115 days. The highest difference between hybrids was given by location. Taking into consideration the grain yield released by hybrids, it seams that the vegetation period of the hybrids has not influence on this. It was released high grain yield in location with high vegetation period, also with a short one.

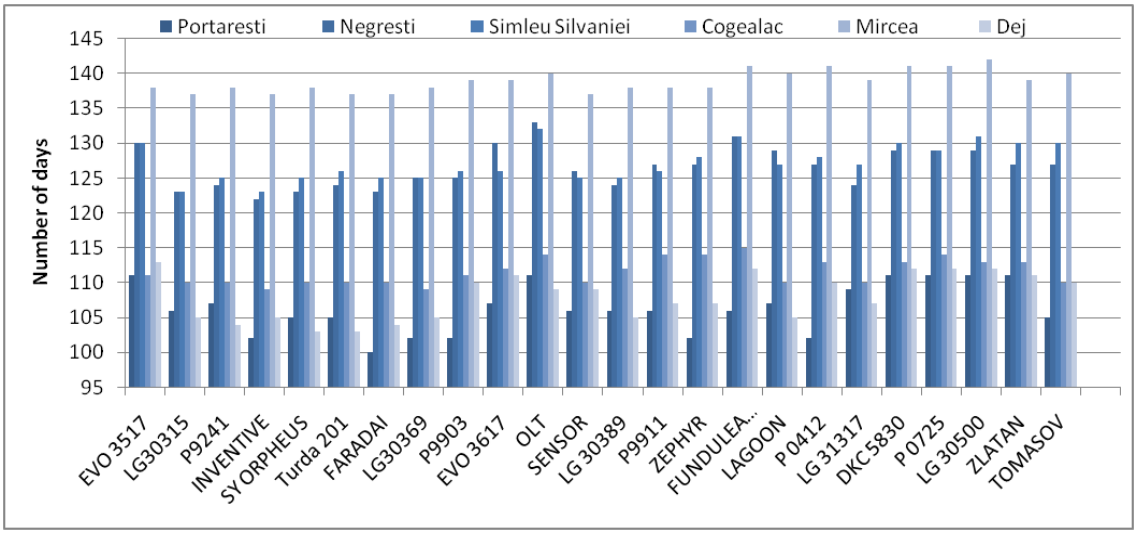

Figure 7. The vegetation period for studied maize hybrids, in 2018 year

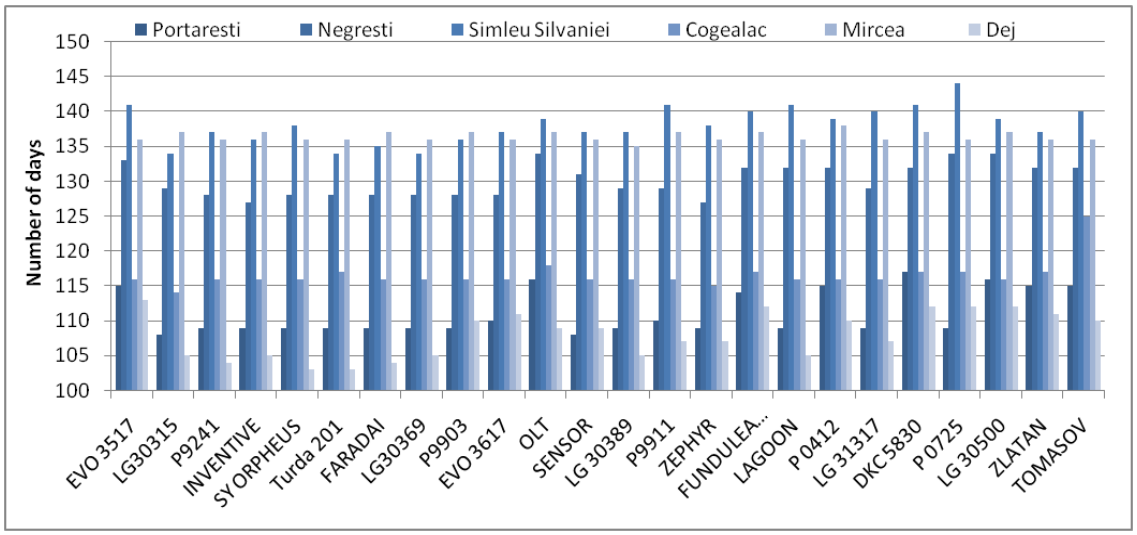

Figure 8. The vegetation period for studied maize hybrids, in 2019 year

The resistance to diseases is of a great importance for the stability of the grain yield. The pathogen *Fusarium* spp. has a strong negative impact on the grain yield, but also on its quality.

The results referring to the resistance, of the studied hybrids to this pathogen (Table 4) show that there are differences between locations, in both years, this depending by the climatic conditions, in each location. In 2018 year the conditions were favorable to the attack in Şimleu Silvaniei location, where some hybrids have showed sensitivity. Also, in Cogealac location the attack degree was a little higher, comparing with other locations. In 2019 year the conditions for the development of the attack of pathogen were quite good in Portăreşti and Negreşti locations.

In these locations, some hybrids showed sensitivity in both years (Zephyr) or sensitivity in one year and mid resistance in the other year (EVO 3517, Turda 201, EVO 3617, LAGOON). Most of hybrids have a good resistance (middle resistant), some of them being resistant in both situations, in favorable or unfavorable conditions (LG 30500, P 9911, Olt).

Table 4. The behavior of maize hybrids regarding the resistance to the pathogen *Fusarium* spp.

Hybrid	2018						2019					
	Portărești	Negrești	Cogealac	Mircea Vodă	Șimleu Silvaniei	Dej	Portărești	Negrești	Cogealac	Mircea Vodă	Șimleu Silvaniei	Dej
1	6.8	6.0	4.5	6.0	4.2	6.5	6.0	5.0	6.9	6.8	6.6	7.0
2	7.8	7.4	5.8	7.7	5.8	7.6	6.9	5.6	7.3	6.4	6.9	7.3
3	7.5	7.0	5.5	7.5	4.9	7.9	6.4	6.4	6.5	6.7	7.0	7.6
4	6.9	7.5	5.7	6.9	5.0	7.3	4.9	5.4	6.0	5.7	6.7	6.9
5	6.0	7.3	6.6	7.0	5.8	6.8	5.8	5.2	7.4	6.9	6.5	7.3
6	8.0	7.9	6.0	7.0	6.0	7.4	4.9	4.8	6.7	5.5	7.2	6.6
7	6.8	8.0	6.5	7.9	5.6	8.0	6.0	5.7	7.8	5.9	6.5	7.0
8	7.7	7.7	6.9	7.7	6.2	7.7	5.5	4.8	7.5	7.7	6.8	7.2
9	6.9	7.8	5.9	8.0	6.0	7.9	6.9	6.9	6.2	7.5	7.0	7.6
10	5.6	6.8	4.8	5.9	4.7	6.7	5.8	5.2	6.9	6.0	6.8	6.5
11	7.9	8.0	6.9	7.3	6.3	6.8	7.0	5.7	7.9	6.9	6.5	6.2
12	5.8	6.0	4.7	5.9	4.8	7.3	6.0	6.0	7.8	5.3	7.0	6.8
13	7.8	7.8	6.9	8.0	5.3	8.0	4.6	6.9	6.9	6.8	7.3	7.2
14	7.6	8.0	6.5	7.8	5.9	7.9	7.4	6.4	7.5	7.0	7.6	7.8
15	6.0	6.8	5.0	7.3	4.4	7.6	4.8	4.9	7.0	6.6	6.4	6.9
16	7.7	7.9	6.7	7.6	5.8	7.8	6.8	5.2	7.6	6.4	6.0	6.7
17	6.4	7.0	5.8	7.8	5.5	7.9	7.2	4.4	7.8	6.0	7.0	6.4
18	6.9	7.8	5.9	8.0	6.7	8.0	6.6	6.0	6.8	6.9	7.4	7.7
19	7.5	8.0	6.0	7.8	5.9	7.7	5.0	6.3	7.2	6.5	6.5	7.9
20	7.0	7.8	6.8	7.6	5.9	7.9	6.5	6.8	7.7	7.0	7.3	7.4
21	6.7	7.5	5.9	8.0	6.7	7.8	7.3	5.2	6.8	6.8	7.6	6.3
22	7.0	6.9	6.0	7.6	6.8	8.0	7.0	6.7	7.2	7.2	6.6	7.6
23	6.5	7.2	6.8	7.9	6.7	7.6	5.9	7.0	7.0	6.5	6.4	7.4
24	6.0	6.8	6.4	7.2	6.4	7.8	4.3	6.5	7.4	6.8	6.2	7.8

Note of attack degree	Resistance class
1.0-2.9	Very sensitive
3.0-4.9	Sensitive
5.0-6.9	Middle resistant
7.0 -8.0	Resistant

CONCLUSIONS

In the maize breeding programs, from different seed companies or research institutes or stations, there are developing hybrids with high genetic potential for the grain yield. For these hybrids, the reaction to different ecological environments is very important.

The tested maize hybrids proved a high genetic potential for the grain yield, in different soil and climatic conditions.

Some analyzed characteristics were different by locations and by years. The thousand grain weight has an important role in obtaining good grain yield.

The hectoliter mass is different by locations but has not a high influence on the released grain yield.

The vegetation period of the hybrids was high influenced by location but did not played an important role in the level of the grain yield.

The attack of the pathogen *Fusarium* spp. can produce some loss on the grain yield but the highest influence has on the grain quality. There are differences between locations, in both years, this depending by the climate,

which create good conditions for the pathogen developing. Also, there are differences between hybrids, some of them showing a very good resistance.

The grain yield released by the hybrids in all six locations, in both years has showed that even they were developing in very different conditions of environment, the hybrids produced a good yield. This it means that all hybrids are good commercial hybrids.

REFERENCES

Baute, T., Hayes, L., Mcdonald, I., Reid, K., 2002. *Agromomy guide for field crops*. Publication 811, The Ontario Ministry of Agriculture, Food and Rural Affairs.

Bărbulescu, A., 2000. *Achievements and perspectives in pest and diseases control*. Probl. Prot. Plant., XXVIII: 69-136.

Cristea, M., Căbulea, L., Sarca, T., 2004. *Monograhpic study of maize crop*. Editura Ceres, Vol. 1: 374-376.

Cristea, M.S., Cristea, S., Zala, 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, No. 1: 10183-10189.

Dalle Mulle, E., and Ruppanner, V., 2010. *Exploring the global food supply chain markets, companies, systems*. In: Companion Publication to Seeds of Hunger, Back - grounder No. 2 - THREAD Series.

Dudoiu, R., Cristea, S., Lupu, C., Popa, D., Oprea, M., 2016. *Micoflora associated with maize grains during storage period*. AgroLife Scientific Journal, Vol. 5, No. 1: 63-68.

FAOSTAT, 2014. *The statistics division of FAO*. http://faostat3.fao.org/home/index.html; http://faostat.fao.org/ (last retrieved on May 2014).

Grassini, P., Eskridge, K., Cassman, K., 2013. *Distinguishing between yield advances and yield plateaus in historical crop production trends*. Nat. Commun., 4, article number: 2918. http://dx.doi.org/10.1038/ncomms3918

Gurian-Sherman, D., 2009. *Failure to yield. Evaluating the performance of genetically engineered crops*. Union of Concerned Scientists.

Horhocea, D., Ciocăzanu, I., Iordan, H.L., Ciontu, C., 2020. *Experimental results obtained for the commercial and perspective maize hybrids, created at NARDI Fundulea*, An. INCDA Fundulea, Vol. LXXXVIII: 1-13.

Iordan, H.L., Biţică, A.R., Băduţ, C., 2016. *The selection of genotypes with a faster loss of water from the grain - a priority in the corn breeding program at NARDI Fundulea*. An. INCDA Fundulea, Vol. LXXXIV: 26-34.

Lackey, Y.R., 2008. *Corn energy value - A comparison of harvesting corn an shelled dried corn, high moisture corn, high moisture cob corn (cob meal) and corn silage*. Ministry of Agriculture Food and Rural Affairs, http://www.omafra.gov.on.ca/english/livestock/beef/news/vbn1108a2.htm.

Le Buanec, B., 2008. *Evaluation of the seed industry during the past 40 years*. SEED News Magazine, Main subject of July/August-XII n 4.

Matsuoka, Y., Vigouroux, Y., Goodman, M., Sanchez, G.J., Buckler, E., Doebley, I., 2002. *A single domestication for maize shown by multilocus microsatellite genotyping*. PNAS 99 (9): 6080-6084.

Petcu, E., Martura, T., Ciocăzanu, I., Iordan, H.L., Băduţ, C., Urechean, V., 2018. *The effect of water stress induced with peg solution on maize seedlings*. Romanian Agricultural Research, 35: 21-28.

Popescu, M., Mocuta, D., Cristea, S., 2018. *Trend on maize market evolution in Romania*. Innovation management and education excellence through vision 2020, Proc. Papers, Vol. I-XI: 1680-1688.

Shewry, P., 2007. *Improving the protein content and composition of cereal grain*. J. Cereal Sci., 46: 239-250.