Scientific Papers. Series A. Agronomy, Vol. LVI, 2013
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

RESULTS REGARDING DROUGHT RESISTANCE OF SAME MAIZE HYBRIDS IN SOUTH PART OF ROMANIA CONDITIONS

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Abstract

Cultivating the most adequate hybrids, well adapted to specific environmental conditions, resistant to main abiotic (frost, drought) and biotic (insects and diseases) stress factors, with superior yielding ability and high quality potential facing all requirements under different cultivation areas, is recognized as major purpose in obtaining high economical performances for major crops, especially in maize.

The aim of this research is studying yielding potential and quantification of 14 hybrid drought tolerance in field crops, under dry year conditions, 2012. The experiments were carried out in Romanian Plain, under both dry-land at Caracal, and irrigation at Brăila.

In 2012, in Southern of Romania, the cumulated rainfall during June and August was under multiannual average, insufficient for covering the corn water requirements. Thus, conditions were favorable to select the genotypes with a good drought resistance. The drought was very severe in Caracal, where the tested genotypes yielded, on an average, only 2.01t kernel ha^{-1}, as compared to 8.08 t kernel ha^{-1}in Brăila. The highest yield was obtained by the hybrid GW 8.7 t kernel ha^{-1}, with 11.53 t kernel ha^{-1}, under irrigation with 700 mm/ha, in Brăila, followed by GW 49003 and GW 48002 with 10.58 and 10.05 t kernel ha^{-1}, respectively. On average experiments, the hybrid GW 8691 emphasized by yield, achieving 7.04 t kernel ha^{-1}. The yielding results are correlated with the water utilization degree. The water utilization degree during the entire vegetation period was different at all 14 hybrids and for each location apart. Among the two testing trials, the first place was occupied by the hybrids GW 8002 and GW 9003 with 13,0 and 12,8 kg kernel/mm water, respectively. The results are part of Ph.D. thesis.

Key words: *drought, hybrids, maize adaptability, yielding.*

INTRODUCTION

Maize is grown on over 2.5 million hectares, representing more than 25% from total arable land of Romania. The largest areas cultived with maize are situated in plain regions, where drought is very frequent.

Prolonged drought, occuring during the flowering and grain filling period (July-August), which generally are enhanced by heat and low relative moisture, are the most damageable for maize (Bîlteanu, 1998; Cristea et al. 2004). Climate changes are increasingly felt during the last past decades, especially regarding alternations between high temperatures and low rainfall levels. In this case, the plant physiological mechanisms are disturbed and the yielding potential significantly decreases (Banziger, 2007; Tollefson, 2011). This type of drought causes an increased frequency of barren plants and incomplete seed setting. Based on these considerations, identifying maize hybrids with genetically improved characteristics and high level of adaptability in order to have low yielding losses is indeed relevant.

According to European legislation, Romania allows for commercialization on its territory any corn hybrid registered in EU countries, even if it has not been tested under Romanian conditions and registered in Romanian Official Catalogue. Under these circumstances, the Romanian farmers are not covered by the risks arising from the cultivation of some hybrids un-adapted to specific conditions or exceeded by the new ones.

The aim of the research was to understand the general and specific market requirements and to provide a contribution by obtaining hybrids with superior yielding performances, drought resistant, improved quality and a higher level of stability.

MATERIALS AND METHODS

The experiments were carried out in 2012 in two different locations, representative for the Romanian Plain, one in Southwestern area, Agricultural Research-Development Station (ARDS) Caracal, and the other one, in the Southeastern one, Agricultural Research-Development Station (ARDS) Brăila.

The experimental design was random blocks, in three replications, with a sowing area of 20 m^{-1}, of which 15 m^{-1} were harvested and the cultivation technology was similar to that applied to the field crops. The plant density was 45,000 pl/ha under dryland in Caracal and 65,000 pl/ha under irrigated conditions, in Brăila. The sowing was done on April, 27^{th}.

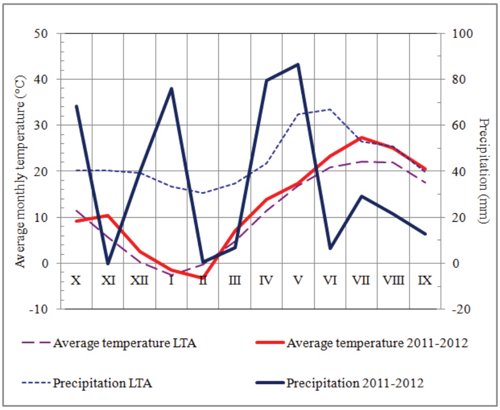

Figure 1. Rainfall and temperature registered at ARDS Caracal, in agricultural year 2011-2012, compared with multiannual average

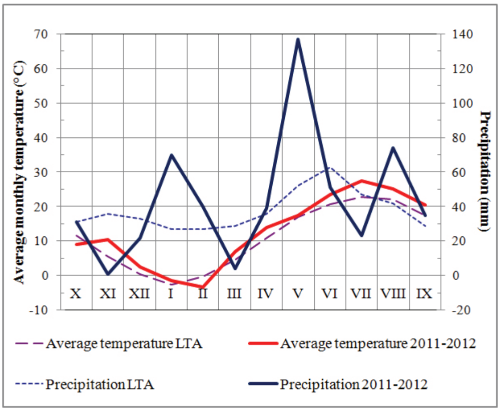

Figure 2. Rainfall and temperature registered in ARDS Brăila in agricultural year 2011-2012, compared with multiannual average

The following determinations were performed: emergence time, silking time, physiological maturity time, sum of useful unit degree of temperature, drought resistance, lodging (%), breaking (%), diseases resistance (rots and smut), *Ostrinia* resistance, "stay green" feature, plant height, ear cob insertion (cm), tassel length (cm), number of tassel branches, the leaves number, peduncle length (cm), number of husk leaves, ear cob length (cm), rachis width (cm), rows of kernels, kernel depth (cm), kernel yield, kernel/ear cob ratio, moisture (at harvest) (%), SVW and TKW. Some of them are presented in this paper.

Climatically, the year 2012 was very dry, thus monthly temperatures average, was bigger than multiannual average, with 0.5°C in Brăila and with 2.4°C in Caracal. În both testing centers, in June-August was very hot; in July, average temperature was with 3.6°C higher in Brăila and with 5.3°C higher in Caracal then multiannual average, at which added a lot of days with more then 40°C .

RESULTS AND DISCUSSIONS

Generally, in Romania and especially in southern part of the country, the agricultural year 2011-2012 was unfavorable for corn, fact that led to very low yields achieving. Under dryland, at ARDS Caracal, the yielding level has ranged between 0.89 t kernels ha^{-1} at genotype GS-4/12 and 3.2 t kernels ha^{-1} at Unimeza, a semi-early hybrid, with an average of 2.01 t kernels ha^{-1}, that means 1/5 from the potential of the genotypes (Table 1).

In Caracal, good results were also registered by the following hybrids: GW 9003 which accomplished a level of 3.07 t kernels ha^{-1}, followed by Efrat with 2.9 t kernels ha^{-} and GW 8691 with 2.5 t kernels ha^{-1}.

The yield level, in Caracal, was strongly influenced by rainfall repartition. The Figures 1 and 3 show that the total rainfall quantity was very ununiform distributed, with no rain in February, March and June, especially.

The high yield differences were determined by the rainfall registered during June-August, period of maximum consumption for maize. At ARDS Caracal, the total rainfall during this period was only 57.4 mm and was distributed as follows: 6.7 mm in June, 29.2 mm in July and 21.6 mm in August, while the multiannual average for this period is 170.6 mm (67 mm in June, 52.9 in July and 50.7 mm in August). This explains the yielding level in 2012 in Caracal, but in the same time, this condition had allowed to select the hybrid more tolerant to drought from the tested germoplasm.

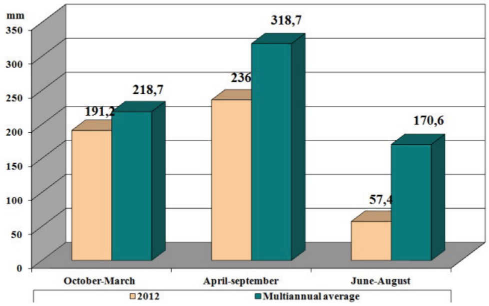

Figure 3. Rainfall registered under different periods in ARDS Caracal

At ARDS Brăila the rainfall was also un-uniform distributed, compared with the multiannual average, (Figure 2), but the heat and drought were not so intense. Thus, for the multiannual average of 152 mm during June-August (with 63 mm in June, 47 mm in July and 42 mm in August) in 2012 year, 148 mm (with 51 mm in June, 23 mm in July and 74 mm in August, Figure 4) were registered, at which is added the amount of 700 mm provided by irrigation.

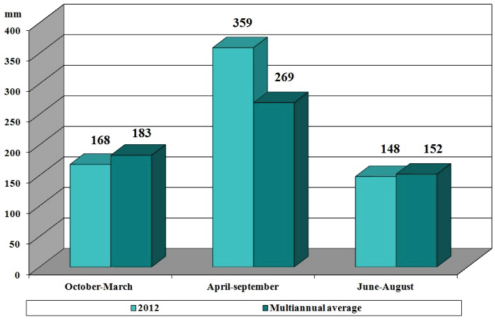

Figure 4. Rainfall registered under different periods in ARDS Brăila

This situation allows to obtain an average yield of 8.08 t kernels ha^{-1} with the maximum level registered by GW 8691 hybrid, consisting of 11.53 t kernels ha^{-1}. Good results were also achieved by GW 9003 hybrid and the GW 8002 hybrid, with 10.58 t kernels ha^{-1} and 10.46 t kernels ha^{-1}, respectively.

Table 1. Kernel yield achieved by maize hybrids tested at ARDS Caracal, and ARDS Brăila in 2012

No	Hybrid	CARACAL		BRĂILA		Average	
		t/ha	%	t/ha	%	t/ha	%
1	GW 8691	2.54	126	11.53	147	7.04	140
2	GW 9003	3.07	153	10.58	135	6.82	135
3	GW 8002	2.15	107	10.46	133	6.31	125
4	UNIMEZA	3.21	160	8.83	113	6.02	119
5	EFRAT	2.73	136	8.78	112	5.76	114
6	GW 8008	1.42	71	9.22	118	5.32	106
7	GW 8037	2.58	129	7.59	97	5.09	101
8	STATUS	1.41	70	8.63	68	5.02	100
9	GW 8653	1.54	76	8.22	106	4.88	97
10	GW 8194	1.86	92	7.70	98	4.78	95
11	KONSUR	1.13	56	8.06	103	4.59	91
12	GS-2/12	2.18	107	535	68	3.77	75
13	GS-3/12	1.44	72	3.95	50	2.70	54
14	GS-4/12	0.89	44	4.18	53	2.53	50
Average		2.01	100	8.08	100	5.04	100
LDS 5%		*0.16*	*8*	*0.48*	*6*	*0.32*	*6*

Even though the water requirements were supplemented by irrigation, the high temperatures recorded during pollination stage affected considerably the yielding potential for all the hybrids tested in this research. Most of them, especially GS-4/12 and GS-3/12, recorded a 50% decreasing level beneath the experience average On experiment average of the two locations placed under different climatic conditions of Romanian Plain, one can highlight the semi-early hybrid GW 8691, with an average yield of 7.04 t kernels ha^{-1}, followed by GW 9003 and GW 8002 with 6.82-6.31 t kernels ha^{-1}, outyielded with 25-39.5% the average of the experiment.

The yielding correlated distribution recorded by those 14 hybrids tested in two locations, under dry-land at Caracal and under irrigated land at Brăila, revealed a strong connection, provided statistically as significantly distinct one (Figure 5). Thus, good results under both testing conditions were achieved by the following five hybrids: GW 8691, GW 9003, GW 8002, Unimeza and Efrat. Besides them, GW 8037 hybrid is suitable for severe heat and drought conditions. The third group consists of the late hybrid Konsur and semi-late hybrids: GW 8653, Status and GW 8008 which kept their higher yielding potential only under irrigated conditions, fact demonstrated by the testing activities during past years (Schitea, 2010).

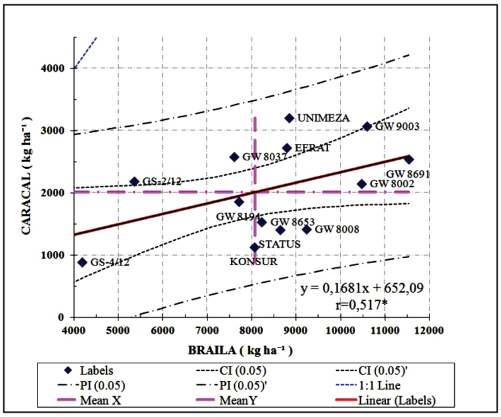

Figure 5. Relationship between the kernel yield under both dryland and irrigation, in 2012

The data presented in Figures 6-7 emphasize the way of water utilization by the tested hybrids, expressed by the achieved yield, kernel mm^{-1} water. The report depends on total rainfall and rainfall registered during vegetation period in Caracal and Brăila at which, 700 mm from irrigation has added in Brăila. This revealed the fact that a high capacity of water utilization, feature determined by genetically potential of drought tolerant genotypes connected with the environmental conditions (Tollenaar, 1999).

On the two testing centers average, the GW 9003 hybrid was the first regarding the water utilization capacity (13.5 kg kernels/mm water), followed by the GW 8691 hybrid, with 13.1 kg kernels/mm water and the Unimeza hybrid with 12.7 kg kernels/mm water.

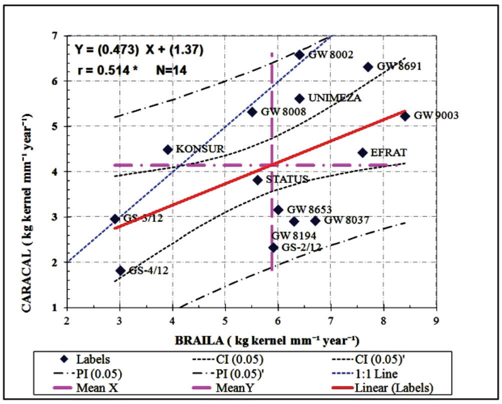

Figure 6. Water use efficiency in Caracal (yearly rainfall) and Brăila (yearly rainfall + 700 mm irrigation)

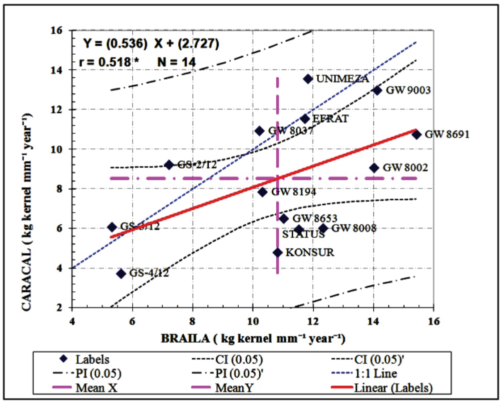

Figure 7. Water use efficiency in Caracal (rainfall from vegetation period) and Brăila (rainfall from vegetation period +700 mm irrigation)

The water utilization degree for the entire vegetation stage ranged between 3.8-13.6 kg kernels/mm water at Caracal and 5.3-15.4 kg kernels/mm water at Brăila, with an average of 8.1 kg kernels/mm water.

The water utilization degree was different at each genotype and ranged between 1.8-6.6 kg kernels/mm water at Caracal and 2.9-8.4 kg kernels/mm water at Brăila. This calculation was related at annual water amount (only rainfall at Caracal, rainfall plus 700 mm provided by irrigations, at Brăila) with an average of 5 kg kernels/mm water for those two locations and hybrids, respectively.

Correlated distribution for the coefficient of water efficiency in the two testing conditions, allow a complete characterization of the tested hybrids, as statistically significant correlation (Figures 6-7).

Concerning the main morphological characteristics (Table 2) the drought reduced especially the plant height, the ear cob length, rows of kernel and TKW.

Regarding the other characteristics such as kernel depth, rachis width, the differences among tested hybrids were small, and no significant trend of them in relation with drought was registered. The other morphological traits presented in Table 2 show high variation limits of the genotypes tested above. For instance, number of husk leaves varied between 6.5 at GW 9003 hybrid and 12 at status hybrid.

Table 2. The main morphological characteristics of maize hybrids tested in 2012

Hybrid	FAO grupe	Σ^0C Entire vegetation stages	Plant height (cm)	Ear cob insertion (cm)	Number of leaes	Number of husk leaves	Ear cob length (cm)	Rachis width (cm)	Rows of kernels	Kernel depth(cm)	SVW	TKW
GW 9003	370	3064	230	90	16.5	6.5	19.0	2.4	12-14	1.1	63.4	296
KONSUR	590	3055	210	86	15.0	7.3	17.0	2.3	14-16	1.0	68.3	334
GW 8008	450	2951	240	95	14.5	7.0	19.1	2.1	14	1.0	65.0	208
GW 8194	340	2942	230	95	15.0	8.5	18.5	2.3	14-16	1.0	62.0	259
GW 8653	330	3019	260	110	17.0	8.3	18.3	2.3	14-16	1.1	71.0	234
GW 8002	380	2995	225	95	17.0	9.0	16.0	2.2	12-14	1.1	68.1	306
GS-2/12	290	2972	230	96	17.0	9.0	18.0	2.4	14-16	1.0	71.0	271
GS-3/13	300	2952	220	90	16.5	10.0	16.2	2.1	14	1.0	70.7	257
GW 1691	400	2951	210	80	15.0	11.5	16.0	2.4	14	0.9	73.5	282
UNIMEZEA	350	3078	220	90	15.0	10.0	17.0	2.2	12-14	1.0	77.1	309
STATUS	480	3063	190	70	15.0	12.0	16.0	2.1	12-14	0.9	76.2	252
EFRAT	290	2947	210	75	14.1	12.0	16.2	2.3	14-16	0.9	74,1	283
GW 8037	280	3005	270	125	16.2	8.0	18.5	2.3	14-16	1.1	70.0	247
GS-4/12	280	2929	240	90	16.0	8.5	16.5	2.4	16-18	1.1	72.5	246

Between the vegetation period and moisture at harvesting, a very strong correlation was emphasized (Figure 9).

Breeding maize for sustainable agriculture implies releasing hybrids with high yielding ability and low moisture at harvest. Fast grain dry-down rate hybrids may be harvested in grain and the crop may be immediately stored, with low costs. These issues might be solved by growing maize hybrids with a shorter period of vegetation, but important quantity of maize would be lost by incomplete utilization of favorable thermal resources on more than 50% from total maize area from Southern and Western Romania.

The tested hybrids belong to different FAO maturity groups, those between 280–590 (Table 2). The drought and heat especially, led to a shortening of vegetation period, causing forced maturation of the late genotypes. Due to very high temperatures during yield formation under both dryland and irrigation, a high number of sterile plants was among tested genotypes was recorded (Figure 8). This highlights once again, the opportunity of performed researches.

These data demonstrate that releasing maize hybrids with increased resistance to drought and heat had been necessary for both irrigated and dryland area from Southern plains, with environmental conditions similar to those of Caracal and Braila. Subsequently, a field trials research was developed according to the following principles:

- hybrids released under irrigated conditions should be tested in both optimal and water stress conditions, aiming the promotion of those with superior mean performance;
- hybrids released under dryland conditions (drought tolerant) should be tested, also, under irrigations in order to select those with economic yielding potential suitable for such environments.

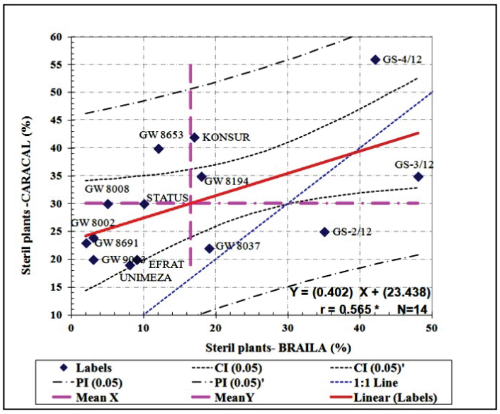

Figure 8. Relationship concerning the degree of steril plants in dry and irrigated land

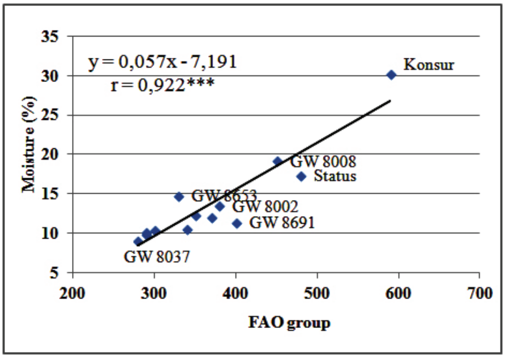

Figure 9. Relationship between the group of maturity and moisture

CONCLUSIONS

The maize hybrids tested in 2012, represent a new germplasm with a large variability regarding yielding and adaptability.

Hybrids Unimeza, GW 9003, Efrat, GW 8691 and GW 8002 revealed the highest heat and drought tolerance. These hybrids have good adaptability level, being able to use the irrigation water.

The semi-early GW 8037 hybrid revealed itself only under heat and drought conditions.

Hybrids GW 8008, Konsur, Status and GW 8653 are recommended only to crop in optimal water conditions.

ACKNOWLEDGEMENTS

Golden West Company, E. Constantinescu (PhD, ARDS Caracal), R. Coşoveanu (PhD, ARDS Brăila).

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