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CRITICAL THRESHOLDS OF PRODUCTIVITY ANALYSIS DUE TO INFLUENCES OF GENETICS

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ABSTRACT

A maize micro-trial network (8 locations) was organized in 2017 by the Romanian Maize Producers Association (APPR) to asses yield capacity and stability of most recent and popular 110 maize hybrids with different FAO maturity groups, from 250-290 till over 500, commercialised by seed industry companies operating in Romania. The aim was to establish critical thresholds of maize productivity analysis and to select and recommend the highest yielding and most adapted maize hybrids, commercialised by the maize seed companies, in different soil and climatic conditions from South and South east of the country, both in irrigated and non-irrigated conditions (drought and heat) for the protection and profit maximization of Romanian farmers from these geographic areas.

Year 2017 was very favourable for maize crop so that 6 locations were classified without water stress (average grain yield/location was from over 9000 kg/ha till over 12500 kg/ha). Only two locations were classified with water stress: Caracal (average grain yield/location limited to 4800 kg/ha) and Berezeni, with moderate water stress (average grain yield/location around 7800 kg/ha). Variation coefficient values for both grain yield and grain moisture at harvest were under 10% in most situations, showing a reasonable quality of the data taken into analysis. F values and significance for genotype from ANOVA applied to maize hybrids trials in APPR network, 2017 were in all cases significant for $P<0.001$, suggesting that there were notable significant differences among tested maize hybrids. Grain yield stability, was described by regression lines between average grain yield in locations with water stress vs. average grain yield in locations without water stress for main FAO maturity groups on the market. Recommendations issued were broadcasted at the level of farmers under the form of a recommended list with the scope to better orient farmers in the multitude of the products offered by the market and to assist them for choosing the most efficient hybrids for their activity area.

Keywords: maize hybrids, productivity, recommended list.

INTRODUCTION

Maize is the third agricultural crop worldwide as cropping area (after wheat and rice) and on the first place if grain production is considered. It is utilized in human food, animal feed, raw material in different industries (plastics, packing materials, insulating materials, adhesives, chemical products, explosives, paints, abrasive pastes, colorants, insecticides, pharmaceuticals, organic acids, solvents, artificial silk, antigen, soaps and more recently to produce fuels to replace gasoline and diesel).

Due to this particular economic importance, maize breeding programs were developed both at the population level (recurrent selection, varieties, synthetics and crossing among varieties) and programs based on hybrids obtained by crossings among inbred lines (the most important effort actually), in the great maize worldwide cropping area, but particularly in North America and Europe. These breeding programs led to obtaining significant genetic gains concerning yield potential, but also for some other physiological and agronomical traits of great importance; these genetic gains should be further maintained and developed, particularly in the context of the current climatic changes, by significant breeding efforts of the adaptation capacity of this agricultural crop to the new adverse climate changes.

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Studies showed that in temperate areas maize breeding multi locational testing in different climatic conditions conducted to an increasing of 73 kg/ha/year in conditions of medium stress (Duvick, 1977). In tropical areas conventional breeding produced a genetic gain of a 144 kg/ha/year in drought conditions (Edmeades et al., 1999).

Multi locational and multi annual testing of the elite germplasm is used by maize breeding programs and represents a randomised sample of the variation of maize hybrid potential for stress tolerance in multiple target environments. Testing environments should be established according to the probability of drought and heat manifestation when duration and intensity of the stress cannot be controlled by irrigation. A good example of such testing strategy is the utilization of selection index for stability (DRIND), proposed by Mandache in 2013, which is based on an unbalanced set of yield data obtained in two testing categories of locations:

- LWS – low level of water stress (relative optimal conditions for plant growing development and relative high level of grain yield);
- HWS – high level of water stress (drought and heat conditions and relative low level of grain yield) (Martura et al., 2016).

Developed modern breeding programs are performing testing and characterization of newly released maize hybrid and those from advanced testing stages in locations where the level of water stress is controlled by drip irrigation and were several level of water stress are created by precisely controlling irrigation rate and vegetation phase submitted to water stress. There are also systems of controlling natural rain falls by utilization of covering systems with glass or plastic but the most used procedure is to place the testing location in areas known as arid.

Scope of the paper

The scope of this paper was the selection and recommendation of the highest yielding and most adapted maize hybrids, commercialised by the maize seed companies operating on Romanian territory, in different soil and climatic conditions from south and south east of the country, both in irrigated and non-irrigated conditions (drought and heat) for the protection and profit maximization of the Romanian farmers from these geographic areas.

MATERIAL AND METHODS

Testing locations

Maize hybrid testing was carried out in the research network of the Romanian Maize Producers Association (APPR) in eight locations from south and south east Romania, one of the most important maize cropping areas in Romania.

Table 1. Locations of APPR research testing network used for maize hybrid testing in 2017

Location	County	Geographical coordinates			Cropping conditions
		Latitude	Longitude	Altitude (m)	
Caracal	Olt	44°06’52”N	24°24’15”E	90	Non irrigated
Furculeşti	Teleorman	43°90’75”N	25°19’88”E	86	Non irrigated
Fundulea	Călăraşi	44°27’27”N	26°31’46”E	66	Non irrigated
Vâlcelele	Călăraşi	44°25’12”N	27°13’21”E	43	Non irrigated
Berezeni	Vaslui	46°22’30”N	28°08’51”E	50	Non irrigated
Mircea Vodă	Brăila	45°04’12”N	27°25’36”E	29	Non irrigated
Mircea Vodă	Brăila	45°04’06”N	27°25’14”E	29	Irrigated
Mihail Kogălniceanu	Ialomiţa	44°66’87”N	27°67’97”E	20	Irrigated

Six from eight locations where in non-irrigated conditions and only two in conditions of irrigations, but in Mircea Vodă, where trials had been planned with and without irrigation, irrigations were not necessary.

Weather conditions of 2017 where extremely favourable for maize production (Table 2). Irrigations were applied only in location Mihail Kogălniceanu, where the rainfalls in the period April-September were lower and a relative water deficit was registered.

Table 2. Soil and weather characterization of the APPR testing location used in 2017

Location	Type of soil	April - September rainfall (mm)	Irrigation (mm)
Caracal	Chernozem	200	-
Furculeşti	Chernozem	428	-
Fundulea	Chernozem	419	-
Vâlcelele	Chernozem	320	-
Berezeni	Chernozem	300	-
Mircea Vodă	Chernozem	380	-
Mihail Kogălniceanu	Silt-Loam	282	260

The lowest April-September rainfall were registered in Caracal, while moderated water stress manifested in Berezeni, with reduced April-September precipitation of only 300 mm.

The crop management applied to maize hybrid testing locations from APPR network in 2017 ensured in general optimal maize requirements, as well as the protection of the plant emergence. The main technological measures are presented for each location in Table 3.

Table 3. Main crop management measures applied to maize hybrids testing locations (APPR network)

Crop management	Caracal	Furculeşti	Fundulea	Vâlcelele	Berezeni	Mircea Vodă	Mihail Kogălniceanu
Planting date	April 29	April 7	April 14	April 14	April 19	April 30	April 13
Seed treatment	Nuprid AL 600 FS	Nuprid AL 600 FS	Nuprid AL 600 FS	Nuprid AL 600 FS	Nuprid AL 600 FS	Nuprid AL 600 FS	Nuprid AL 600 FS
Herbicides (pre-emergent/ vegetation)	Gliphosat + Adengo/ Nisshin	Frontier Forte 1.2 l/ha/ Titus 0.5 l/ha	Frontier 1.5 l/ha/ Elumis 1.5 l/ha	Bandera 1.1 l/ha/ Temsa 1.1 l/ha	Adengo 0.35 l/ha / Buctril 0.4 l/ha	Gliphosat 3 l/ha + Adengo 0.3 l/ha/ Crew 0.8 l/ha	Adengo 0.35 l/ha
Plant population (plants/ha)	65000	68000	68000	80000	68000	68000	70000
Preceding crop	wheat	wheat	corn	corn	corn	soybean	corn
Soil treatment	-	Picador 5 kg/ha (insecticide)	-	-	-	Force 15 kg/ha (insecticide at planting)	Picador 32 kg/ha and Mospilan 100 g/ha (insecticides)
Fertilization	Complex NPK 20-20-0, 250 kg/ha. Ammonium Nitrate, 200 kg/ha.	N a.i. 50 kg/ha. P_2O_5 a.i. 50 kg/ha.	Complex NPK 20-20-0, 200 kg/ha. Urea, 250 kg/ha.	Complex NPK 20-20-0, 200 kg/ha.	Complex NPK 20-20-0, 200 kg/ha. Urea, 250 kg/ha.	Complex NPK 20-20-0, 300 kg/ha. Urea, 250 kg/ha.	N a.i. 164 kg/ha. P_20_5 a.i. 104 kg/ha. K_2O a.i. 48 kg/ha.
Harvest date	September 1st	August 29	September 22	September 24	September 19	September 28	October 5

Location classification

On the basis of climatic data and of the information received from trial responsible from each location, but particularly on the basis of location average grain yield, 2017 experimental locations were classified function of the level of water stress (Table 4).

Variation coefficients computed from grain yield and grain moisture at harvest are presented in the same table.

Agricultural year 2017 was very favourable for maize crop in most of the testing locations which were, accordingly, classified without water stress. In six testing locations average grain yield/location was over 9000 kg/ha, reaching in some locations values over 12500 kg/ha. Only two locations could be classified as affected by water stress: Caracal, where average grain yield/location was limited to 4800 kg/ha and Berezeni, with moderate water stress, where average grain yield/location was around 7800 kg/ha.

Variation coefficient values for both grain yield and grain moisture at harvest were under 10%, with the exception of Berezeni, where the variability coefficient values were slightly over 10%. This situation showed a reasonable quality of the data taken into analysis.

Table 4. Location classification and data quality (variation coefficients)

Location	FAO<400				FAO>400				Water stress classification
	Average grain yield		Average grain moisture		Average grain yield		Average grain moisture		
	kg/ha	CV (%)	%	CV (%)	kg/ha	CV (%)	%	CV (%)	
Caracal	4734	9.9	13.15	4.4	4802	9.2	16.07	5	Water stress
Furculești	9040	7	12.53	2.9	9027	5.5	13.57	4.4	Low water stress
Fundulea	9866	7.4	13.95	3.4	10369	6.8	16.51	5.4	Low water stress
Vâlcelele	12155	6.9	14.43	6.4	12706	7.3	17.18	9.9	Low water stress
Berezeni	7595	12.5	11.86	6.3	7485	11.8	13.89	5.1	Moderate water stress
Mircea Vodă	9669	5.2	14.19	2.8	10004	9.6	15.61	3	Low water stress
Mircea Vodă	10085	8.3	13.84	1.9	10622	9.9	15.40	2.8	Low water stress
Mihail Kogălniceanu	11716	7.4	12.26	3.1	12467	6.2	17.34	5.1	Low water stress

Experimental parameters applied to maize hybrid trials from APPR network, 2017

A total number of the most recent and popular 110 maize hybrids with different FAO maturity groups, from 250-290 till over 500, commercialised and recommended by the seed industry companies operating in Romania, were selected to be tested in small plot research hybrid trials. Experimental design was completely randomised blocs in 3 replication; hybrids where grouped in 2 experiments: 60 hybrids with FAO maturity less than 400, and a number of 50 maize hybrids FAO higher than 400.

The plot was represented by 4 rows with 4.8-7.8 m length, 70 to 75 cm apart, function of the experimental planter used, from which only central rows were harvested; thus, a great part of inter-genotypic competition which appears in this kind of hybrid experiments was eliminated.

Plant population was around 68,000 plants/ha. Planting was generally made at optimal planting time;

Plot harvest was made with experimental combines measuring both yield/plot (kg) and grain moisture (%). Data obtained from the combines were used to calculate yield/ha (yield per plot / harvested plot area) as were as to bring the moisture of the hybrids at the standard grain moisture of 15%.

Data interpretation

Grain yield and harvest moisture were submitted to analysis of variance (ANOVA) applied to individual experiments in every location using the statistical program, Expe-R, from Research Institute Arvalis from

France. To evaluate the precocity of the hybrids as well as to estimate the stability of the grain yield of maize hybrids, linear regression equations and lines (Ceapoiu, 1968) between average yield over locations with water stress and average yield of the location without water stress for each maturity group respectively were calculated and represented in graphs and tables. For correct comparisons, the data were presented by grouping hybrids in several maturity groups FAO: 250-290, 300-340, 350-390, 400-440, 450-490, over 500.

RESULTS AND DISCUSSION

In the conditions of the year 2017 in yield trials with no apparent water stress, the yield averaged over all hybrids from each maturity groups showed an increase with increased lateness up to the group FAO 450-500 (Table 5).

Maximum yield of the best hybrid in each group showed the same increasing trend, highest maximum yield being registered in the latest maturing group.

Table 5. Average and maximum yields in hybrids from each maturity group, in trials classified as exposed to no water stress or with significant water stress

FAO group	Number hybrids tested	No water stress		Water stress	
		Average	Maximum	Average	Maximum
250-290	6	9902	10742	**6343**	7086
300-340	26	10144	11544	6159	**7729**
350-390	34	10567	12528	6165	7529
400-440	18	10814	12019	6163	6987
450-490	20	**10954**	12489	6063	7404
>500	6	10426	**12882**	5932	7427
TOTAL	110				

In contrast, the highest average yield was found in the earliest maturity group (FAO 250-290) and the highest maximum yield In the FAO group 300-340. The results suggest that farmers should prefer a particular maturity group taking into account the probability of water stress, along with other advantages related with differences in earliness.

Large differences were found among hybrids belonging to the same maturity group. F values and their significance, obtained from the analysis of variance in each location and trial separated were in all cases significant for $P< 0.001$, suggesting that there were notable significant differences among tested maize hybrids (Table 6).

Consequently, the analysis of grain yield and moisture data was made for each location and trial (data not shown), as well as on the average of the two categories of locations, without water stress and with water stress. Generally, it is not recommended to compute yield averages over all locations, taking all category of stress together, but grouping instead the locations function of water stress present in each location.

Table 7 presents average grain yield and harvest moisture of the maize hybrids FAO maturity 250-290 in two categories of stress conditions from 2017 testing, six locations with low water stress or without water stress and only two locations with high and moderate water stress. *ES Creative*, *AS 201* and *SY Arioso* gave the highest yield and lower moisture at harvest.

On the basis of these averages, regression line between the average of the locations with water stress and averages of the locations without stress was graphical represented in Figure 1 for estimating yield stability and select maize hybrid with superior performances in both water stress conditions. In this early FAO maturity group, 250-290, the data suggested that hybrid *SY Arioso* was the most stable being situated on the stability graph over the regression line in the right-upper quart of the graph, showing superior performances in both categories of locations, with and without water stress. Maize hybrid *ES Creative* gave also remarkable average performances in water stress conditions with an average reasonable yield of about 10000 kg/ha in optimal conditions.

Table 6. F values and significance for genotypes (tested maize hybrids) from ANOVA applied to maize hybrids yield trials in APPR network, in 2017

Location	FAO group	F value	P %	Significance
Caracal (non irrigated)	< 400	2.98	0.00	***
Caracal (non irrigated)	> 400	4.16	0.00	***
Furculeşti (non irrigated)	< 400	4.79	0.00	***
Furculeşti (non irrigated)	> 400	8.23	0.00	***
Fundulea (non irrigated)	< 400	3.32	0.00	***
Fundulea (non irrigated)	> 400	7.38	0.00	***
Vâlcelele (non irrigated)	< 400	3.26	0.00	***
Vâlcelele (non irrigated)	> 400	6.24	0.00	***
Berezeni (non irrigated)	< 400	2.53	0.00	***
Berezeni (non irrigated)	> 400	3.24	0.00	***
Mircea Vodă (non irrigated)	< 400	21.48	0.00	***
Mircea Vodă (non irrigated)	> 400	10.45	0.00	***
Mircea Vodă (irrigated)	< 400	6.90	0.00	***
Mircea Vodă (irrigated)	> 400	6.93	0.00	***
Mihail Kogălniceanu (irrigated)	< 400	4.45	0.00	***
Mihail Kogălniceanu (irrigated)	> 400	10.33	0.00	***

Consequently, the analysis of grain yield and moisture data was made for each location and trial (data not shown), as well as on the average of the two categories of locations, without water stress and with water stress. Generally, it is not recommended to compute yield averages over all locations, taking all category of stress together, but grouping instead the locations function of water stress present in each location.

Table 7 presents average grain yield and harvest moisture of the maize hybrids FAO maturity 250-290 in two categories of stress conditions from 2017 testing, six locations with low water stress or without water stress and only two locations with high and moderate water stress. *ES Creative*, *AS 201* and *SY Arioso* gave the highest yield and lower moisture at harvest.

Table 7. Average grain yield and harvest moisture of the maize hybrids from FAO maturity 250-290 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
AS 201	6	10742	107	6	13.0	2	5878	92	2	11.1
ES Creative	6	10180	101	6	13.5	2	7086	111	2	11.5
KWS 2370	6	9625	96	6	12.6	2	6275	99	2	11.2
Mas 24.C	4	9846	98	4	13.7	2	6464	102	2	11.7
SS Avicii	6	9538	95	6	14.4	2	5956	94	2	13.7
SY Arioso	6	10480	104	6	12.9	2	6402	101	2	11.4

On the basis of these averages, regression line between the average of the locations with water stress and averages of the locations without stress was graphical represented in Figure 1 for estimating yield stability and select maize hybrid with superior performances in both water stress conditions. In this early FAO maturity group, 250-290, the data suggested that hybrid *SY Arioso* was the most stable being situated on the stability graph over the regression line in the right-upper quart of the graph, showing superior performances in both categories of locations, with and without water stress. Maize hybrid *ES Creative* gave also remarkable average performances in water stress conditions with an average reasonable yield of about 10000 kg/ha in optimal conditions.

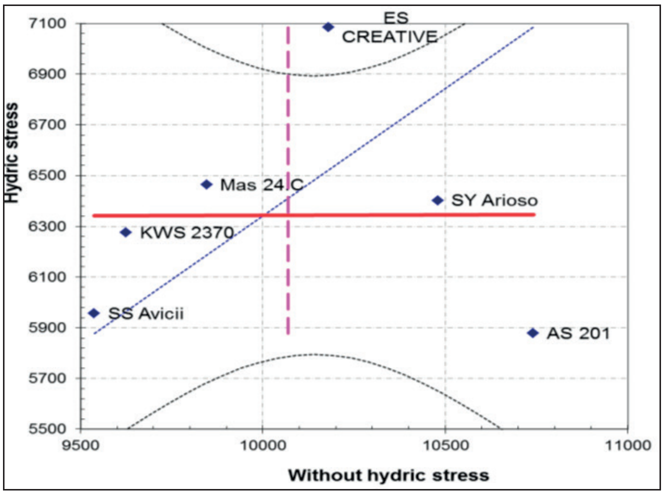

Figure 1. Grain yield stability of the maize hybrid FAO maturity 250-290, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

In Table 8 average grain yields and harvest moisture in the two stress categories of 2017 testing locations, with and without water stress, of the maize hybrids grouped in FAO maturity 300-340 are shown. Maize hybrids *KSB 5432/Korvinus, LG 30.315, Mas 34.B, P 9486* and *Kamponi CS* out yielded significantly the average of the experiment and had also lower grain harvest moisture, both in stress water and optimal conditions (without water stress) locations. These hybrids are placed in stability graph among the most stable maize hybrids from this maturity group, being situated in upper right part of the graph (Figure 2).

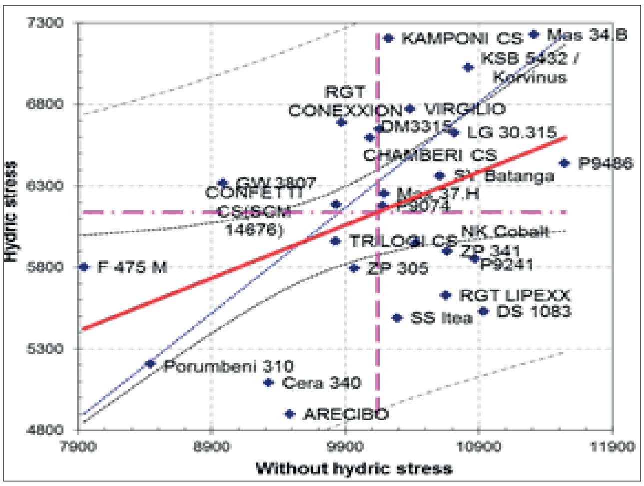

Figure 2. Grain yield stability of the maize hybrid FAO maturity 300-340, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

Table 8. Average grain yield and harvest moisture of the maize hybrids from FAO maturity 300-340 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
Arecibo	6	9483	93	6	14.89	2	4900.0	79.805	2	13.59
Cera 340	6	9328	92	6	14.59	2	5094.0	82.9637	2	12.95
Chemberi CS	4	10083	99	4	13.78	2	6594.5	107.402	2	12.49
Confetti CS (SCM 14676)	4	9834	97	6	14.08	2	6186.3	100.754	2	11.64
DM 3315	4	10157	100	4	13.45	2	6650.2	108.31	2	12.09
DS 1083	6	10935	108	6	13.68	2	5529.8	90.0621	2	11.90
F 475M	6	7943	78	6	14.34	2	5801.8	94.4914	2	13.56
GW 3807	6	8983	89	6	13.66	2	6315.8	102.862	2	13.59
Kamponi CS	6	10227	101	6	13.97	2	7204.6	117.338	2	12.74
KSB 5432/Korvinus	6	10823	107	6	13.26	2	7024.8	114.41	2	11.81
LG 30.315	6	10717	106	6	12.96	2	6627.1	107.933	2	11.46
Mas 34.B	4	11315	112	4	13.50	2	7229.3	117.741	2	11.52
Mas 37.H	4	10192	100	4	13.73	2	6552.8	101.837	2	11.80
NK Cobalt	6	10428	103	6	14.36	2	5950.6	96.9154	2	12.13
P 9074	4	10180	100	4	13.43	2	6178.8	100.632	2	11.79
P 9241	4	10869	107	4	13.75	2	5852.3	95.3138	2	12.65
P 9486	6	11544	114	6	13.92	2	6437.7	104.848	2	12.33
Porumbeni 310	6	8442	83	6	13.29	2	5208.8	84.8336	2	11.68
RGT Conexxion	6	9870	97	6	12.94	2	6691.6	108.983	2	11.19
RGT Lipexx	6	10653	105	6	13.12	2	5628.0	91.6605	2	11.47
SS Itea	6	10289	101	6	13.10	2	5490.9	89.4284	2	12.13
SY Batanga	6	10608	105	6	13.35	2	6362.1	103.617	2	11.44
Trilogi CS	6	9827	97	6	14.35	2	5959.8	97.065	2	13.91
Virgilio	4	10384	102	4	13.05	2	6770.0	110.26	2	12.02
ZP 305	6	9967	98	6	16.29	2	5794.8	94.3772	2	16.46
ZP 341	6	10664	105	6	15.51	2	5900.7	96.1032	2	15.59

Average results in the two categories of water stress of the maize hybrids from FAO maturity group 350-390 are presented in Table 9 and Figure 3. A relative large series of hybrids among which the most notorious *P 9537, P 9903, Phileaxx, ES Method* and *SY Zephir* produced superior grain yield in both location categories, stress water and optimal conditions and reasonable grain moisture at harvest. It is notable the relative high number of superior hybrids, with high grain yield, lower grain moisture at harvest and yield stability in this group of maturity which is particularly important for the maize cropping area from south and south east Romania.

Table 9. Average grain yield and harvest moisture of the maize hybrids from FAO maturity 350-390 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
AS 334	6	10559	100	6	14.95	2	6473.6	105.0570	2	12.23
Basmati CS	6	11082	105	6	14.53	2	6664.7	108.1580	2	13.17
Bio Vestas	6	10853	103	6	12.71	2	5631.1	91.3849	2	11.44
Cera 350	4	11184	106	4	14.11	2	6539.4	106.1250	2	14.23
Cera 360	6	9258	88	6	13.34	2	5652.8	91.7369	2	12.50
Cera 380	6	10382	98	6	14.63	2	5233.6	84.9330	2	13.74
DKC 4555	6	11104	105	6	13.50	2	6167.8	100.0950	2	12.30
DM 3014 CR	4	9405	89	4	14.10	2	5901.5	95.7721	2	12.25
DM 4035	2	12528	119	2	15.00	2	5768.7	93.6176	2	13.87
DS 1071	6	10915	103	6	14.09	2	5844.7	94.8499	2	13.19
DS 2845	4	9480	90	4	13.69	2	5235.7	84.9679	2	12.59
ES Faraday	6	10499	99	6	13.57	2	6885.6	111.7420	2	11.89
ES Method	6	10993	104	6	14.38	2	7529.0	122.1850	2	12.65
ES Mylord	6	10211	97	6	14.10	2	5951.2	96.5784	2	12.59
GW 3159	6	9420	89	6	14.52	2	5039.9	81.7895	2	13.04
GW 9003	6	10263	97	6	14.64	2	6343.6	102.9470	2	13.61
Kamparis	6	10696	101	6	13.70	2	6597.2	107.0620	2	12.29
KWS 4484	6	11189	106	6	14.19	2	6341.1	102.9060	2	12.38
KXB 5438/Karpatis	6	11172	106	6	12.91	2	5823.0	94.4988	2	11.23
LG 30.369 "Limanova"	6	10802	102	6	14.07	2	6946.0	112.7240	2	12.43
LG 30.389	6	10862	103	6	13.82	2	6457.6	104.7970	2	12.15
LG LZM 366/57	6	10996	104	6	13.75	2	6997.4	113.5570	2	12.78
Loubazi CS	6	10015	95	6	14.02	2	5682.2	92.2143	2	12.81
Martor - DKC 4555	6	10873	103	6	13.66	2	5501.2	89.2764	2	12.42
NK Thermo	6	10610	100	6	13.03	2	6249.6	101.4210	2	12.13
P 9537	6	11406	108	6	13.85	2	7280.9	118.1590	2	12.89
P 9903	6	11772	111	6	13.86	2	6107.2	99.1105	2	14.01
Phileaxx	6	11812	112	6	14.08	2	6476.7	105.1080	2	12.31
Portile CS	4	9529	90	4	13.45	2	5751.9	93.3448	2	12.49
SY Iridium	6	10472	99	6	14.17	2	6820.9	110.6930	2	12.15
SY Photon	6	11199	106	6	12.55	2	6609.4	107.2610	2	11.84
SY Ulises	6	10271	97	6	13.98	2	6442.7	104.5550	2	12.84
SY Zephir	6	11525	109	6	14.38	2	6622.2	107.4680	2	12.42
Turda Star	3	5930	56	3	13.30	2	3939.1	63.9250	2	11.68

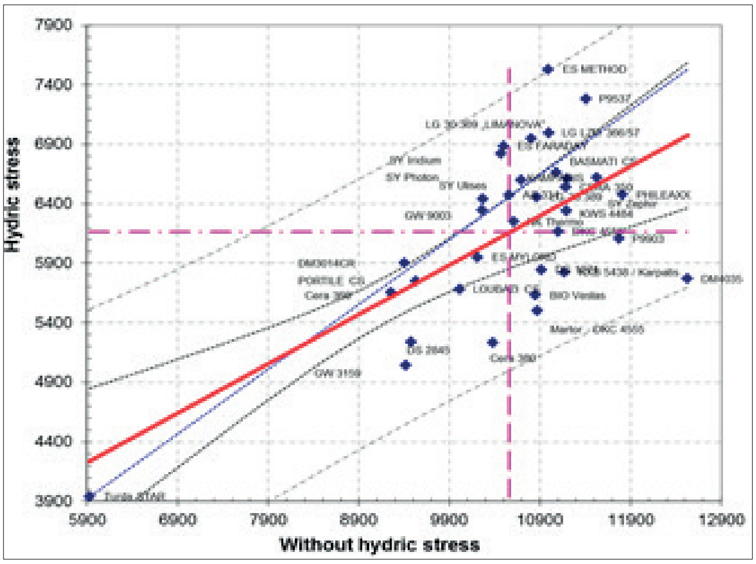

Figure 3. Grain yield stability of the maize hybrid FAO maturity 350-390, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

The following maturity group analyzed, 400-440, is also a key FAO maturity group for maize cropping area in Romania. Grain yield and harvest moisture data collected for the maize hybrids tested in this FAO maturity group and averaged over the two categories of water stress, are presented in Table 10 and Figure 4. Hybrids *P 0023, DM 4315, P 9911, SY Dartona, ZP 427* produced high and stable grain yield (reasonable harvest average moistures) and consequently are placed on the stability graph among the most stable genotypes.

Table 10. Average grain yield and harvest moisture of the maize hybrids from FAO maturity 400-440 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
Anadon	6	11144	103	6	18.08	2	6231.9	101.1190	2	13.15
Balasco	6	9868	91	6	14.58	2	6232.4	101.1260	2	13.80
Cera 420	6	9143	85	6	15.66	2	4491.6	72.8803	2	13.41
DM 4315	6	11693	108	6	14.14	2	6973.7	113.1540	2	12.54
DS 1326	6	10602	98	6	15.08	2	5911.6	95.9213	2	13.77
ES Cortes	6	10516	97	6	14.44	2	6124.8	99.3794	2	16.11
Kapitolis	6	11226	104	6	14.44	2	6580.0	106.7670	2	12.28
KXB 4381/Kollineas	6	11418	106	6	14.54	2	6424.0	104.2350	2	11.93
P 0023	6	12019	111	6	14.48	2	6986.5	113.3620	2	12.52
P 9911	6	11879	110	6	14.93	2	9280.1	101.9010	2	12.02
Palizi CS (CSM 14758)	6	11007	102	6	14.95	2	5967.7	96.8319	2	11.78
Porumbeni 427	6	10287	95	6	13.10	2	5690.8	92.3377	2	11.64
RGT Lexxtour	6	10546	98	6	14.76	2	6595.5	107.0170	2	13.77
SS Extasia	6	10971	101	6	14.81	2	6241.6	101.2750	2	13.52
SUR 405	4	10141	94	4	13.72	2	6031.9	97.8735	2	11.55
SY Dartona	6	11142	103	6	13.84	2	6340.2	102.8760	2	10.58
ZP 427	6	10894	101	6	14.54	2	6235.6	101.1780	2	12.54
ZP Dalmac	6	10149	94	6	15.85	2	5589.4	90.6926	2	12.69

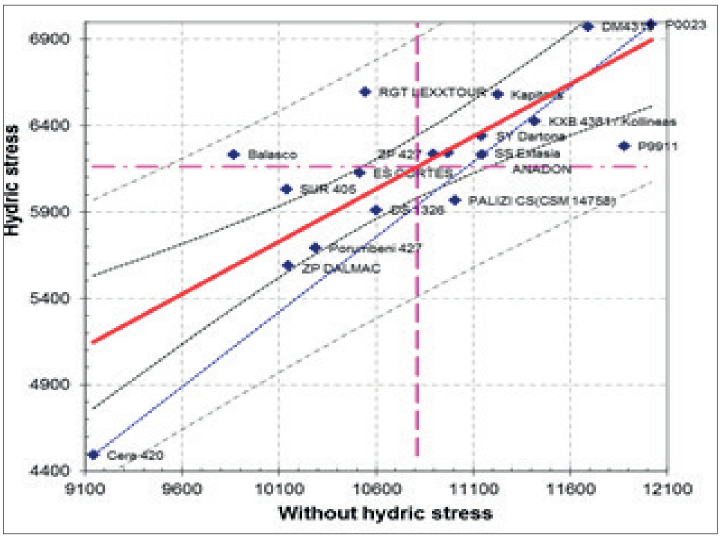

Figure 4. Grain yield stability of the maize hybrid FAO maturity 400-440, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

Table 11 and Figure 5 contain data regarding average grain yield and harvest moisture obtained in the two categories of locations, water stress and optimal conditions as well as stability of the maize hybrid tested in FAO maturity group 450-490, also an important maturity group for some cropping maize areas in Romania.

Maize hybrids *KSB 6456/KWS Durango, KXB 5453/Kollegas, P 0216, RGT Mexini, SY Senko* gave the highest average grain yields in both location categories and they are favourably positioned on the stability graph, being classified as maize hybrids with remarkable productivity and yield stability.

Table 11. Average grain yield and harvest moisture of the maize hybrids from FAO maturity 450-490 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
AS 54	6	10382	95	6	16.79	2	4730.6	78.0239	2	15.30
Cera 450	6	10384	95	6	19.69	2	5208.5	85.9059	2	18.44
DKC 5141	6	10925	100	6	14.67	2	5911.4	97.5002	2	14.38
ES Debussy	6	11123	102	6	14.79	2	6357.3	104.8540	2	14.95
F 423	6	7934	72	6	18.02	2	4988.1	82.2718	2	17.26
Gasti CS	6	11999	110	6	17.90	2	6300.6	103.9190	2	15.74
Iezer	6	9243	84	6	18.11	2	5109.3	84.2705	2	16.19
Infini CS	6	11491	105	6	16.85	2	6254.4	103.1570	2	15.36
KSB 6456/KWS Durango	6	12489	114	6	16.30	2	6898.4	113.7790	2	15.37
KXB 5453/Kollegas	6	12140	111	6	16.08	2	7404.1	122.1190	2	15.24
LG 30.500	6	12334	113	6	16.40	2	5703.9	94.0767	2	15.18
LG LZM 465/22	6	10655	97	6	13.92	2	5513.4	90.9344	2	13.65
Mas 45.M	6	10813	99	6	15.06	2	6051.0	99.8023	2	14.35
Mas 55.N	6	11295	103	6	18.29	2	6246.9	103.0330	2	16.95
P 0216	6	11933	109	6	14.70	2	7231.6	119.2750	2	13.74
P 0412	6	11507	105	6	16.52	2	6258.3	103.2200	2	16.34
Por 458	6	9194	84	6	14.94	2	5537.3	91.3292	2	14.65

Porumbeni 461	6	9766	89	6	16.43	2	6077.1	100.2320	2	16.09
RGT Mexini	6	11934	109	6	15.80	2	6862.3	113.1830	2	14.48
SY Senko	6	11531	105	6	15.46	2	6614.1	109.0890	2	14.27

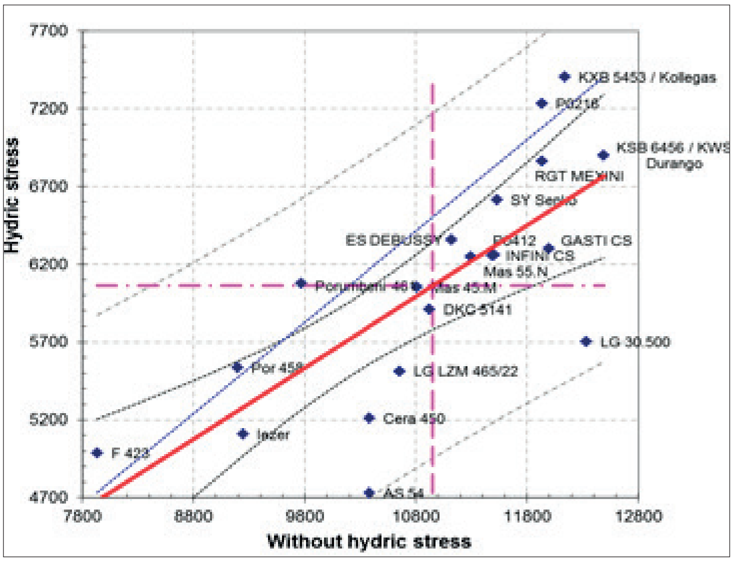

Figure 5. Grain yield stability of the maize hybrid FAO maturity 450-490, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

The results of the hybrids tested in the FAO maturity group over 500, that are less and less used for grain yield in south and south east Romania, presented in Table 12 and Figure 6, showed that maize hybrid *DKC 5830* is placed most favourably on the stability graph.

Table 12. Average grain yield and harvest moisture of the maize hybrids from FAO maturity over 500 (APPR testing network, 2017)

Hybrid	Locations without hydric stress					Locations with hydric stress				
	Grain yield (15% moisture)			Harvest moisture		Grain yield (15% moisture)			Harvest moisture	
	No. loc.	kg/ha	% (experiment average)	No. loc.	%	No. loc.	kg/ha	% (experiment average)	No. loc.	%
AS 5M43	6	11598	111	6	17.75	2	5864	99	2	16.42
DKC 5830	6	12882	124	6	17.09	2	7064	119	2	17.01
F 376	6	8495	81	6	17.79	2	4518	76	2	16.39
Martor - DKC 5830	4	12075	116	4	15.90	2	7427	125	2	16.36
Olt	6	8638	83	6	18.56	2	5217	88	2	18.33
Paltin	6	8868	85	6	16.37	2	5500	93	2	16.29

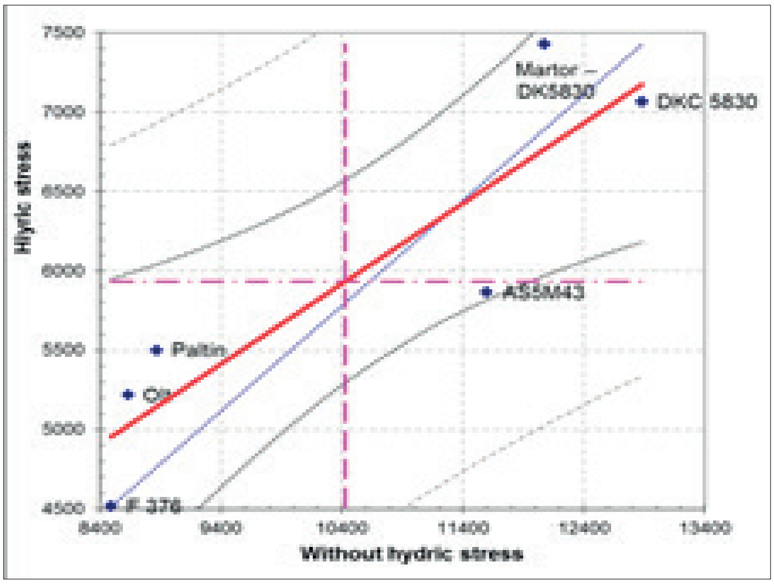

Figure 6. Grain yield stability of the maize hybrid FAO maturity over, represented by regression line between average grain yield in locations with water stress vs. average grain yield in locations without water stress (APPR testing network, 2017)

Data from Table 13 show relatively low values for determination coefficients and for regression equation slopes between grain yield and harvest moisture. This relationship is normally known to be significant, but the maize hybrids tested in this recommended trials are a selection of the most adapted and high performing maize genotypes, which broke down this positive correlation between yield and harvest moisture. Another reason for this lack of correlation between yield and harvest moisture could be late harvesting with very low moisture. This situation could be corrected following the strict recommendation that average harvest moistures should be between 20 and 30%, when real maturity differences might be detect more precisely.

Relationship between optimal and water stress conditions has not been examined, since 2017 was a very favourable year for maize and water stress location were very limited (practically one location with full water stress and one location with moderate water stress).

Table 13. Determination coefficients and regression equations computed for different maturity groups between grain yield and harvest moisture

FAO	Without water stress		With water stress	
	R^2	Regression	R^2	Regression
250-290	0.11170	y=10370-86.15x	0.0510	y=6402-16.57x
300-340	0.06550	y=9775+27.3x	0.0010	y=6105+2.57x
350-390	0.01250	y=10784-12.4x	0.0019	y=6107+3.12x
400-440	0.00013	y=10766+4.99x	0.0006	y=6138+2.62x
459-490	0.03480	y=10558+37.66x	0.2275	y=5438+59.52
500-600	0.38130	y=12706-651.49x	0.0455	y=6377-127.19x

CONCLUSIONS

APPR maize hybrid testing network, conducted in 2017, produced quality data, which allowed releasing pertinent recommendation for the farmers from South and South east Romania maize cropping area, regarding selection of the most suitable maize hybrids for the specific conditions on each farm. Inter-genotypic competition was controlled in a great extent by using several replications and advanced experimentation methods and techniques. Statistical interpretation and results presentation used allowed a correct discrimination among hybrids and the selection of the best performing.

Climatic conditions of 2017 were very favourable for maize crop and consequently the level of the average yield obtained reached very high levels. From the eight testing locations used, only two could be classified as affected by advanced water stress (Caracal) or moderate water stress (Berezeni).

On the basis of grain yield and harvest moisture data and grain yield stability in different conditions of water stress, hybrids with superior performances, were recommended to be used in production: *SY Arioso* and *ES Creative*, FAO maturity group 250-290; *KSB 5432/Korvinus, LG 30.315, Mas 34.B, P 9486, Kamponi CS*, FAO maturity group 300-340; *P 9537, P 9903, Phileaxx, ES Method, SY Zephir, LG LZM 366/57, LG 30.369 "Limanova", ES Faraday, Basmati CS, Kamparis,* FAO maturity group 350-390; *P 0023, DM 4315, P 9911, SY Dartona, ZP 427* FAO maturity group 400-440; *KSB 6456/KWS Durango, KXB 5453/Kollegas, P 0216, RGT Mexini, SY Senko* FAO maturity group 450-490 and *DKC 5830* FAO maturity group over 500.

Seed companies give a particular interest for the FAO maturity groups with the largest impact for South and South east Romania, 300-340 and 350-390 FAO group, where frequency of the products with superior performances was also higher.

The results obtained as well as the recommendations issued on the basis of these results were broadcasted at the level of farmers under the form of a recommended list; the scope to this list was to better orient farmers in the multitude of the products offered by the market and to assist them for choosing the most efficient hybrids for their activity area.

Due to practical and economical importance of this activity it is highly recommended the continuation and the improvement of this type of independent testing performed by APPR or any other farmer association, by increasing the number of locations and multi annual testing, as well as increasing the quality of the trials. It is also recommend to extend this testing network in the western part of the country, another important area for maize cropping in Romania.

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