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STABILITY PARAMETERS OF COMMERIAL MAIZE (*Zea mays* L.) HYBRIDS

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Many authors showed the possibility of developing highly yielding and stable hybrids. The assumption was that commercial maize hybrids were characterized not only by the level of average yield bat also by their stability.

Fifteen commercial maize hybrids of medium late and late FAO maturity groups (400-700) were used in the present study. The two-year four-replicate trials were set up in six locations according to the randomized complete-block design. Stability parameters were determined after the method of EBERHART and RUSSEL (1966), in which the genotype was considered stable if it had a high average yield, a coefficient of regression of approximately 1.0 and deviation from regression as small as possible.

The obtained results show that early maturity hybrids responded better to more modest growing condition and had a greater deviation from

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regression, while late maturity hybrids had a coefficient of regression closer to unity and they generally better responded to improved growing conditions.

*Key words***:** stability parameters, commercial hybrids, maize

INTRODUCTION

In the contemporary agriculture, the man is not interested in the organism that will adjust well to the given agroecological conditions in order to continue the species, but in the organism with a genetic potential of high yielding potential and at the same time with the good stability and adaptability.

A great number of authors dealt with this topic, starting form the defining the problem to the selection of the statistical model that would the most really encompass the problem and provide results that would help breeders to make decisions. Hence we find numerous definitions of stability and adaptability but the following ones prevail:

- Stability is the ability of a genotype to have always the uniform yield regardless of environmental effects (ROMER, 1917, cit. BECKER, 1981)
- Adaptability (FINLY and WLKINSON, 1963) is the ability of a variety to provide stable and high yield under different environmental conditions.

There was a huge controversy over defining the desirability of adaptability and stability even after several decades of research work on this problem. In accordance to certain definitions, FEDERER and SCULLY (1993) state that selection of stable genotypes would lead to the choice of commercially quite unusable genotypes. Their conclusion is that even the most desirable genotype according to contemporary criteria, would be unstable. Correspondingly, HELMS (1993) obtained similar results with oat - selection for yield and stability (with the application of several parameters) showed that the individual selection for yield resulted in low stability, while selection for stability only resulted in low yields. In support of this a study of SPRAGUE and FEDERER (1951) can be mentioned; the authors concluded in the study that genotypes of broad adaptability generally had a lower yield, while those genotypes of a high yield had narrow adaptability. Therefore, the main aim of breeders is to improve yields of new varieties and at the same time not to disturb or reduce stability. The yield and stability are regulated by different genes that provide tandem selection for both traits with simultaneous difficulties due to their inverse correlation. Many authors presented possibilities of the development of maize hybrids of high yielding and excellent stability, RUSSELL, (1974), VASILJ and MILAS, (1981), SAVIĆ and IVANOVIĆ, (1985), BOKAN *et al*., (1995), JOCKOVIĆ *et al.*, (1995).

Several models for genotype adaptability and stability analyses have been developed for the last 70 years (YATES and COCHAN, 1938, FINLAY and WILKINSON, 1963). The most often applied model in literature is the one after EBERHART and RUSSELL, (1966), based on the regression coefficient b_i and standard deviation from regression Sdi^2. This model was used in the present study for evaluation of commercial ZP maize hybrids stability.

Although many authors dealt with this topic, there is not yet a consensus in defining stability or the stability concept most adequate for the application in plant breeding. Some authors criticise such a regression approach (FREEMAN and PREKINS, 1997, cit. KANG, 1990). LIN *et al.* wondered whether Sdi^2 from mean squares characterized stability (KANG, 1990).

Although the practical application of the statistics of stability in yield trials has not been clearly defined and set, it is obvious that the integration of stability performances and yields is necessary in order to select highly yielding and stable genotypes. Both, stability performances and yields should be simultaneously considered in order to reduce the effect of the GxE interaction and to select genotypes more precisely and exactly.

Some researchers (GAUCH and ZOBEL, 1997), state that the majority of studies carried out nowadays are based on the models developed a half a century ago. As a result of the use of PCs many processing procedures, previously almost not possible, today become accessible and therefore more studies are necessary to explain and improve this topic.

MATERIALS AND METHODS

The assumption was that the commercial hybrids differ not only in yields but also in stability.

The following 15 commercial ZP maize hybrids (FAO 400-700) were used in the present study: ZP-42a, ZP-480, NS-501, ZP-570, ZP-580, ZP-533, ZP-599, ZP-633, ZP-677, ZP-701, ZP-732, ZP-704, ZP-735, NS-640, ZP-753.

The four-replicate trails were set up according to a randomized block design in six locations during 1997. : Becej, Z. Polje with irrigation, Z. Polje dry land farming, Bijeljina, Pancevo, S. Mitrovica and in six locations during 2000. : Becej, Z. Polje with irrigation, Z. Polje dry land farming, Pancevo, Zarkovci and Adasevci. Totally 12 environments. The elementary plot size amounted to 8.736 m^2 – plant density was 54900 $p\cdot ha^{-1}$

The stability parameters of grain yield were estimated after EBERHART and RUSSELL (1966), with the model presented with the following equation:

$$Y_{ij} = m + B_i I_j + \delta_{ij}$$

Y_{ij} - an average yield of the i^{th} genotype in the j^{th} environment
m - an average yield of the i^{th} genotype in all environments
B_i - regression coefficient to the environmental index indicating a genotypic response to environmental changes
I_j - environmental index as a mean of all genotypes in the j^{th} environment reduced by a grand mean
δ_{ij} - deviation from regression of the i^{th} genotype in the j^{th} environment

RESULTS AND DISCUSSION

As assumed, the commercial ZP maize hybrids differ by both yield and stability parameters (Tab. 1.). According to mean values over locations the following can be concluded:

The highest yield was recorded in Bečej '97 (13.222 t·ha^{-1}), then Zemun Polje with irrigation '97 (12.982 t·ha^{-1}) and Zemun Polje dry land farming '97 (12.244 t·ha^{-1}) (Fig. 1.). The lowest yield was detected in the location Žarkovac '00. Although all locations were not the same, the differences in yields over years are obvious. This can be explained by the difference in the precipitation sum. Namely, the first year (1997.) was favorable, and irrigation was not necessary, while the second year (2000.) was arid and irrigation was necessary especially in the grain filling period. It is clearly observable in the yield (10.972 t·ha^{-1}) obtained in the location Zemun Polje '00, which evidently deviates from yields obtained in other locations in the second year of investigation.

Moreover, as assumed, medium late and late maturity hybrids significantly differed by yields from medium and medium early maturity hybrids.

Table 1: Analysis of Variance for grain yield

Source of variation	df	SS	MS	F
Locations	11	5462.149	496.559	99.513**
Rep. (locations)	36	179.635	4.990	5.122**
Treatments	14	116.383	8.313	8.532**
Loc x Treat	154	362.288	2.353	2.415**
Error	504	491.052	0.974	
Total	719	6611.539	9.195	

Coefficient of variation = 10.79

Hybrids of FAO maturity group 400 poorly respond to more favorable growing conditions, which can be observed in both, the Table of Analysis of Variance where they are ranked at the bottom of the table with the average yield of 8.499 t·ha^{-1}, i.e. 8.603 t·ha^{-1} in ZP-42a, i.e. ZP-480, respectively, and Figure 1. Average yields over environments of the late maturity hybrid ZP-753 and the medium early hybrid ZP 480 are presented in Figure 1. in which their different responses to improved quality of environments are clearly observable.

All this is confirmed by results obtained in the second year (2000.) of investigation. The second year was arid and a poorer response of hybrids ZP-480, ZP-42a, and ZP-533 to irrigation than of hybrids ZP-723, ZP-753 and ZP-701 is observable.

The hybrid ZP-677 with the average yield of 9.816 t·ha^{-1} ranked the first in all 12 environments, and was followed by ZP-580, ZP-704, ZP-735 and ZP-701 provided that the hybrid ZP-735 had increased grain moisture at harvest.

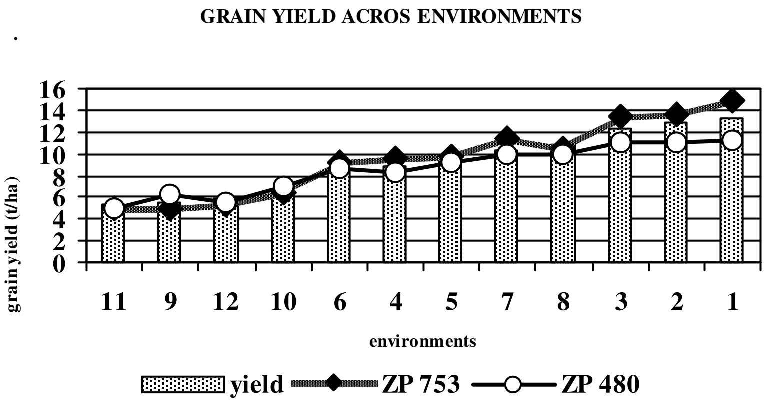

Fig 1: Grain yield across environments

Table 2: Stability parameters

Genotype	Yield	rank	reg.coef. b_i	rank	S_{di}^2
ZP 42a	8,499	15	0.91936	5	-0.1401
st. 500	8,932	10	0.89893	9	0.3957**
ZP 480	8,603	13	0.75809**	15	-0.0392
ZP 533	8,520	14	0.76299**	14	-0.0213
ZP 599	8,930	11	1.03582	2	0.2037*
ZP 570	9,121	8	0.90493	8	0.0976
ZP 580	9,581	2	1.18894	12	0.237*
ZP 633	9,239	7	0.95038	3	0.6085**
ZP 677	9,816	1	1.09345	6	0.1127
st. 600	8,780	12	0.99555	1	0.5504**
ZP 701	9,402	6	1.08110	6	0.3861**
ZP 753	9,492	5	1.19745*	13	0.0243
ZP 732	9,184	9	1.17177*	11	0.2921*
ZP 735	9,497	4	1.10408	10	0.2141*
ZP 704	9,509	3	0.93713	4	-0.0512

$\sum bi/_{br.hib.} = 0.9999$ Se $_{bi}$ =0.06911548 Total = 1646.347

Table 3: *Environmental index*

O. no.	Environment	Loc. Sum	Env. index
1	Becej I	198.325	4.0753
2	Z.Polje-irrigation I	193.915	3.7813
3	Z.Polje-dry land farming I	183.664	3.0979
4	Bijeljina I	132.926	-0.2846
5	Pancevo I	145.928	0.5822
6	S.Mitrovica I	127.908	-0.6192
7	Becej II	154.320	1.1416
8	Z.Polje- irrigation II god	161.883	1.6458
9	Z.Polje- dry land farming II	84.003	-3.5462
10	Pancevo II	96.672	-2.7016
11	Zarkovci II	79.733	-3.8308
12	Adasevci II	87.070	-3.3417

Table 2 presents the regression coefficient and the deviation from regression. It is clearly observable that medium early and medium maturity hybrids have values of the regression coefficient below, while late maturity hybrids have these values above unit.

According to the method of EBERHART and RUSSELL the genotype is stable if its yield is high, the regression coefficient is around unit and the deviation from the regression is as smaller as possible. Based on these parameters hybrids ZP-677, ZP-570, ZP-42a and ZP-704 could be considered stable. Also, the highest potential under favorable growing conditions could be detected in the hybrid ZP-753, then hybrid ZP-732 but especially the hybrid ZP-753 whose regression coefficient is significantly bigger than one and the deviation from regression is not different from zero. Furthermore, according to these parameters it can be concluded that hybrids ZP-480 and ZP-533 are better for less favorable growing conditions. Table 3 shows location sums and environmental indices by which the locations Bečej '97, Zemun Polje irrigation '97, Zemun Polje dry land farming '97, Bečej '00 and Zemun Polje irrigation '00 are distinguished as qualitative environments.

CONCLUSION

It was confirmed that commercial ZP maize hybrids differed by both, average yield levels, and stability parameters. It was observed that late maturity hybrids had a positive response to improved growing conditions, while medium early hybrids had more uniform yield and a poorer response to improved growing conditions, which is in accordance with previously performed studies, SAVIĆ N. and IVANOVIĆ, (1985), PETROVIĆ *et a*l.(1988), DELIĆ and PETROVIĆ (1995).

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PARAMETRI STABILNOSTI KOMERCIJALNIH HIBRIDA KUKURUZA (*Zea mays* L.)

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I z v o d

Mnogi autori su pokazali mogućnost stvaranja prinosnih, a istovremeno stabilnih hibrida. Predpostavljeno je da se komercijalni hibridi kukuruza razlikuju ne samo po prosečnom prinosu već i po stabilnosti.

Petnaest komercijalnih ZP hibrida kukuruza, srednje ranih, srednje kasnih i kasnih FAO grupa zrenja (400-700) je bilo uključeno u ovo ispitivanje. Ogled je bio postavljen u šest lokacija, dve godine i četiri ponavljanja po kompletno randomiziranom blok dizajnu. Parametri stabilnosti su odredjeni po metodu EBERHART I RUSSEL (1966), po kojem se genotip smatra stabilnim ako ima visok prosečan prinos, koeficijent regresije oko jedinice i devijaciju od regresije što je moguće manju.

Dobijeni rezultati pokazuju da srednje rani I srednje kasni hibridi imaju veću devijaciju od regresije i daju bolji odgovor u lošijim sredinama, dok kasni hibridi imaju koeficijent regresije blizu jedinice i generalno daju bolji odgovor na poboljšanje uslova gajenja.

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