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Original scientific paper

STABILITY PARAMETERS FOR GRAIN YIELD OF MAIZE HYBRIDS (*Zea mays* L.*)*

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Stability parameters for grain yield were evaluated in 11 maize hybrids of FAO 300-700 maturity groups (ZPSC 330M, ZPTC 404, ZPSC 42A, ZPSC 480, ZPSC 539, ZPSC 599, ZPSC 580, ZPSC 677, ZPSC 633, ZPSC 704 and ZPSC 753) at three different locations in Central Serbia over a two-year period. The hybrids were tested in two separate trials including 50,000 and 65,000 plants/ha, respectively. The stability parameters were estimated using the EBERHART and RUSSELL regression model (1966).
There were no significant differences (except in the ZPTC 404 hybrid) between the values of the regression coefficient (bi) for grain yield and the mean value. The ZPSC 599 hybrid of the group of hybrids with a medium

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growing season gave high yields and less favourable values of stability parameters at most locations and over most years as compared to the long-season hybrids. The late maturity hybrids (FAO 600 and 700) as compared to the early maturity ones generally exhibited unfavourable values of stability parameters, i.e. a specific response and better adaptation to more favourable environmental conditions, and produced higher average yields. The yield of these hybrids could not have been jeopardized by the yield of the early maturity hybrids.

Key words: maize, grain yield, stability parameters

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INTRODUCTION

A modern approach to maize breeding involves not only the necessity to increase yield potential but also hybrid selection and evaluation under different environmental conditions aimed at recommending hybrids for a specific geographical region that would satisfy yield and stability requirements. Some 60% of yield increases of maize hybrids result from an improved genetic basis of new hybrids and 40% are attributed to production improvements. Yield increases of modern cultivars i.e. hybrids are induced by enhanced yield stability rather than by improved yield potential due to the fact that yield potential can be easily reduced by increasing the number of plants per unit area if stability genes are incorporated (STEVOVIĆ *et. al.* 1997, VASIĆ *et al.* 1997, FASOULA and FASOULA 1997).

Given the fact that selection is generally undertaken under favourable environmental conditions when yield potential is highlighted, it is unlikely that such hybrids will act similarly under heterogeneous conditions. Therefore, BABIC *et al.* (2008) underline the need to develop genotypes that, apart from producing high yields, show high adaptability in that they ensure reliable production under different environmental conditions. These authors also report the impossibility of clearly defining smaller growing regions. The objective of the study was to evaluate the yield of maize hybrids with different growing seasons (FAO 300-700 maturity group) by analysis of variance and regression analysis. As the selected hybrids belong to different maturity groups, it is necessary to establish whether the number of plants per unit of area can induce changes in the hybrid response to environmental factors.

Intensive maize cultivation necessitates identification not only of yield components and other agronomically important traits, but also of stability parameters in order to make objective evaluation of their actual values.

Short-season hybrids generally exhibit lower genetic yield potential, but more favourable values of stability parameters as compared to medium-late hybrids (SAVIĆ and IVANOVIĆ 1985, DELIĆ and PETROVIĆ 1995, ĐUROVIĆ 2000).

The obtained results point to the possibility of using short-season hybrids instead of medium-late ones, given the balance between yield and stability parameters.

MATERIALS AND METHODS

A total of 11 two-way maize hybrids of the FAO 300-700 maturity group (the first numeral standing for a specific maturity group) were selected, including: FAO 300: ZPSC 330M, FAO 400: ZPTC 404, ZPSC 42A and ZPSC 480; FAO 500: ZPSC 539, ZPSC 599 and ZPSC 580; FAO600: ZPSC 677 and ZPSC 633, FAO 700: ZPSC 704 and ZPSC 753.

The hybrids were examined in parallel field trials during 1995 and 1996 at three locations in West Serbia: Parmenac (alluvial soil), Mojsinje (vertisol) and Tavnik (pseudogley). The trials were established according to a randomized block design at two different densities of 50,000 and 65,000 plants/ha, each in four replications. The hybrids were independently randomized at each density. Following the harvest period, the yield of maize ears (60 plants) was measured and yield per ha at 14 % moisture was calculated. The obtained results were subjected to a factor analysis of variance using F and LSD tests and the stability parameters were evaluated by the regression analysis method (EBERHART and RUSSELL, 1966).

RESULTS

The analysis of variance revealed significant grain yield differences between certain hybrids and locations. The lowest average yield was produced by ZPSC 330 M, and the highest by ZPSC 599 at a density of 50,000 plants/ha and 65,000 plants/ha, respectively (Tabs. 1 and 2).

There were no significant differences between the regression coefficients (50,000 plants/ha) of all hybrids and the average in the first year of observation. The regression coefficient was found to be highest in ZPSC 599 (1.285) and lowest in ZPSC 330 M (0.746). The regression coefficient of ZPSC 580 was closest to the average (1.007). The highest and significant deviation from regression was exhibited by ZPSC 677 (1.558). Half of the other hybrids showed significant values, whereas the other half showed negative values.

Coefficients of determination were high and quite uniform in all hybrids, ranging from 0.971 to 1.000.

The b_i values in the second year of observation did not differ significantly from the mean value. ZPSC 599 had the highest regression coefficient, whereas the lowest value was determined in ZPSC 733. The regression coefficient of ZPSC 539 was closest to the mean value.

The lowest and non-significant deviation from regression in the second year was observed in ZPSC 330M, ZPTC 404 and ZPSC 580. Similarly to the previous year, coefficients of determination were quite uniform and high. The values of the standard error of the regression coefficient average indicate the identical heterogeneity of b_i in both years (Table 1).

Table 1. Average grain yield (t/ha) and stability parameters at a density of 50,000 plants /ha

Year	1995			
Hybrid	Yield	$b_i \pm SE$	S^2d_i	R^2
ZPSC330M	8.53	0.746 ± 0.085	0.200*	0.987
ZPTC 404	9.94	0.823 ± 0.143	0.713**	0.971
ZPSC 42A	10.86	0.907 ± 0.000	-0.077	1.000
ZPSC 480	10.01	0.879 ± 0.043	-0.007	0.998
ZPSC 536	10.52	1.069 ± 0.023	-0.057	0.999
ZPSC 599	12.62	1.285 ± 0.102	0.329**	0.994
ZPSC 580	11.05	1.007 ± 0.000	-0.077	1.000
ZPSC 677	11.74	1.185 ± 0.206	1.558**	0.971
ZPSC 633	11.19	1.073 ± 0.121	0.488**	0.987
ZPSC 704	11.58	1.120 ± 0.010	-0.73	0.999
ZPSC753	10.95	0.907 ± 0.079	0.168*	0.992
Average	10.82	1.000		
Lsd 0.05	0.640	SEb = 0.097		
0.01	0.849			

Year	1996			
Hybrid	Yield	$b_i \pm SE$	S^2d_i	R^2
ZPSC330M	6.65	0.951 ± 0.053	0.010	0.997
ZPTC 404	7.25	0.876 ± 0.057	0.020	0.996
ZPSC 42A	7.66	0.892 ± 0.091	0.126*	0.989
ZPSC 480	7.53	0.876 ± 0.012	-0.046	0.999
ZPSC 536	7.99	0.980 ± 0121	0.259**	0.985
ZPSC 599	8.81	1.213 ± 0.081	0.089*	0.995
ZPSC 580	8.03	1.052 ± 0.067	0.045	0.996
ZPSC 677	9.21	1.134 ± 0.086	0.108*	0.994
ZPSC 633	9.19	1.023 ± 0.096	0.146**	0.991
ZPSC 704	8.56	1.148 ± 0.128	0.291**	0988
ZPSC753	8.22	0.855 ± 0.189	0.702**	0.953
Average	8.10	1.000		
Lsd 0.05	0.501	SEb = 0.100		
0.01	0.668			

The highest regression coefficient in the first year (Table 2) was found in ZPSC 677 (1.285), whereas ZPTC 404 had the lowest value (0.569), which was highly significantly different from the mean value. ZPSC 633 was closest to the average value. With the exception of ZPSC 580 insignificantly deviating from regression, most of the other hybrids showed significant deviation from regression. The values of the coefficients of determination were quite uniform and high, ranging from 0.902 to 0.999 in all hybrids.

The regression coefficient in the second year was highest in ZPSC 704 (1.178) and lowest in ZPSC 480 (0.863). ZPSC 580 and ZPSC 330M were closest to the average value. ZPSC 580 and ZPSC 599 showed non-significant deviation from regression. The values of the coefficient of determination were quite similar, ranging from 0.961 to 0.999.

Table 2. Average grain yield (t/ha) and stability parameters at a density of 65,000 plants /ha

Year		1995		
Hybrid	Yield	$b_i \pm SE$	S^2d_i	R^2
ZPSC330M	8.69	0.703 ± 0.121	0.547*	0.971
ZPTC 404	10.28	0.569** ± 0.011	-0.102	0.999
ZPSC 42A	10.78	0.866 ± 0.035	-0.053	0.998
ZPSC 480	11.14	0.822 ± 0.045	-0.018	0.997
ZPSC 536	12.09	1.175 ± 0.090	0.252*	0.994
ZPSC 599	12.68	1.205 ± 0.112	0.447**	0.992
ZPSC 580	10.79	0.813 ± 0.076	0.151	0.991
ZPSC 677	12.39	1.285 ± 0.146	0.842**	0.987
ZPSC 633	11.27	1.097 ± 0.361	5.685**	0.902
ZPSC 704	12.10	1.234 ± 0.202	1.708**	0.974
ZPSC753	12.46	1.231 ± 0.039	-0.040	0.999
Average	11.33	1.000		
Lsd 0.05		SEb = 0.097		
0.01				

Year		1996		
Hybrid	Yield	$b_i \pm SE$	S^2d_i	R^2
ZPSC330M	7.03	0.967 ± 0.071	0.093*	0.995
ZPTC 404	7.69	0.899 ± 0.181	0.876**	0.961
ZPSC 42A	8.64	0.886 ± 0.164	0.711**	0.967
ZPSC 480	8.57	0.863 ± 0.006	-0.046	0.999
ZPSC 536	8.63	0.925 ± 0.095	0.207**	0.989
ZPSC 599	9.55	1.148 ± 0.061	0.058	0.997
ZPSC 580	8.54	0.972 ± 0.052	0.028	0.997
ZPSC 677	10.3	1.135 ± 0.091	0.186**	0.994
ZPSC 633	9.57	1.103 ± 0.029	-0.024	0.999
ZPSC 704	9.38	1.178 ± 0.022	-0.034	0.999
ZPSC753	8.94	0.925 ± 0.158	0.658**	0.971
Average	8.81	1.000		
Lsd 0.05	0.501	SEb = 0.102		
0.01	0.664			

The standard error of b_i in the first year indicated that these parameters showed somewhat higher heterogeneity as compared to the second year (Table 2).
ZPSC 330M and all of the FAO 400 hybrids gave lower average yields but higher stability at both densities as compared to the other hybrids tested. At a density of 50,000 plants, ZPSC 753 produced lower average yields than hybrids in higher maturity groups, but showed higher stability as compared to the other hybrids. As for ZPSC 580, its performance in the second year was identical to that of the hybrids of the lower maturity groups.

DISCUSSION

The established values of the regression coefficient for grain yield in all hybrids (excepting ZPTC 404 in 1995) were not significantly different from the mean value and indicated that all of the tested hybrids exhibited adaptability to agro-environmental conditions in terms of the parameter concerned. The significantly different value of b_i in ZPTC 404 in the first year suggested that the hybrid had higher-than-average stability as compared to the other tested hybrids. As for the medium-early hybrids, ZPSC 599 produced higher grain yields in all trials in both years and at both densities as compared to the late hybrids, but also showed higher values of the regression coefficient and mostly significant deviation from regression. Stability parameters indicated that this hybrid exhibited a specific response to the particular agro-environmental conditions, i.e. better adaptation to more favourable environments. In terms of stability parameters, ZPSC 539 was comparable to the shorter-season hybrids and its grain yields produced at certain locations were characteristic of the later hybrids.

The lower yields of most of the early and medium-early hybrids were accompanied by generally favourable values of stability parameters i.e. by their better adaptation to unfavourable conditions.

Many authors suggest that hybrids giving higher average yields are better adapted to favourable agro-environmental conditions and do not show a linear tendency due to significant deviations from regression, or in other words low-yielding hybrids perform better under worse conditions and their response can be predicted with higher certainty due to relatively low deviation (SAVIĆ *and* IVANOVIĆ 1985, PETROVIĆ *et al.* 1988, YUE *et al.* 1990 *and* 1997, JOCKOVIĆ *et al.* 1995, BOĆANSKI *et al.* 2000, BABIĆ *et al.* 2006).

The hybrids of lower maturity groups show a higher adaptability potential, but a low response to the environment and, hence, a frequent inability to make use of favourable conditions (TROYER 1995, BOKAN *et al.* 1995, BABIĆ *et al.* 2006).

CONCLUSION

There were significant differences in grain yield between certain hybrids and locations. The average grain yield was lowest in ZPSC 330M and highest in ZPSC 599 at both plant densities.

The values of the regression coefficient of grain yield were not (except in one case) significantly different from the mean value, suggesting that the tested hybrids were adapted to the environmental conditions in terms of this parameter.

Among the medium-season hybrids, ZPSC 599 exhibited higher yields and more unfavourable values of stability parameters as compared to the long-season hybrids.

The FAO 600 and 700 maturity hybrids generally had unfavourable values of stability parameters for all traits tested, i.e. they showed a specific response and better adaptation to more favourable environmental conditions, but their yield was rarely jeopardized by the yield of any early-maturing hybrid.

ZPSC 330M and all FAO 400 hybrids gave lower average yields and showed higher stability at both densities as compared to the other tested hybrids. At a density of 50,000 plants/ha^{-1}, ZPSC 753 produced lower average yields than did the hybrids of the higher maturity groups and showed higher stability as compared to the other tested hybrids. At a density of 65,000 plants/ha^{-1}, the performance of ZPSC 580 was identical to that of the hybrids in the lower maturity groups.

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PARAMETRI STABILNOSTI PRINOSA ZRNA HIBRIDA KUKURUZA (*Zea mays* L.)

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I z v o d

Tokom dve godine u tri različita lokaliteta centralne Srbije procenjeni su parametri stabilnosti prinosa zrna 11 hibrida kukuruza (ZPSC 330M, ZPTC 404, ZPSC 42A, ZPSC 480, ZPSC 539, ZPSC 599, ZPSC 580, ZPSC 677, ZPSC 633, ZPSC 704 i ZPSC 753) FAO grupa zrenja 300 – 700. Hibridi su testirani u dva nezavisna ogleda sa 50 000 i 65 000 biljaka/ha. Za procenu parametra stabilnosti primenjena je metoda regresione analize Eberhart i Russell (1966).

Vrednosti regresionog koeficijenta (b_i) za prinos zrna nisu se (izuzev kod hibrida ZPTC 404) značajno razlikovali u odnosu na srednju vrednost. Iz grupe hibrida srednje dužine vegetacije hibrid ZPSC 599 je u najvećem broju lokaliteta i godina postigao visoke prinose uz nepovoljnije vrednosti parametara stabilnosti u odnosu na hibride duže vegetacije. Hibridi kasnijih grupa zrenja (FAO 600 i 700) u poređenju sa ranijim su, uglavnom, imali nepovoljne vrednosti parametara stabilnosti odnosno specifičnu reakciju i bolju adaptaciju na povoljnije uslove sredine uz više prosečne prinose. Nivo prinosa ovih hibrida nije mogao biti ugrožen prinosom hibrida ranijih grupa zrenja.

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