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THE EVALUATION OF COMBINING ABILITIES FOR GRAIN YIELD OF ZP MAIZE INBRED LINES USING THE LINE × TESTER ANALYSIS

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Abstract

This study was performed with the aim to determine general (GCA) and specific combining abilities (SCA) of ZP maize inbred lines by the application of the inbred × tester analysis. Furthermore, the proportion of additive and non-additive (dominance and epistasis) genetic variance in the formation of maize grain yield was established. Results obtained on GCA and SCA pointed out to weak variation, provided that only the tester Z2 showed significant values of GCA (1.30**), due to which its use in maize selection was proposed, while there were no significant values of SCA. The GCA/SCA ratio, which is less than unity in both locations, showed a greater proportion of non-additive variance in the yield formation in both locations. The highest contribution in expression of grain yield in the locations of Zemun Polje and Školsko dobro went to testers (68.84%) and interactions (lines × testers) (46.81%), respectively.

Key words: *maize, combining abilities, inbred × tester analysis*

Introduction

Maize grain yield is a complex trait and the most important aim of breeders is to developed varieties and hybrids of high genetic potential and yielding. Maize, as an agricultural species, has become very important with the discovery of the phenomenon of heterosis, as a basis of modern breeding. Heterosis represents hybrid vigour of F_1 generation derived from crosses of distant maize inbred lines (Shull, 1909). A further step in modern breeding has been made by the discovery and defying of general and specific combining abilities (Sprague and Tatum, 1942). General combining ability (GCA) is an average performance of an individual in a particular series of crosses, while specific combining ability (SCA) is a performance of a parent X in a cross to a parent Y, where the average value of this combination can deviate from the average value of general combining abilities of these parents in comparison to some other parents (Borojević, 1981).

The estimation of combining abilities of maize inbred lines contributes to revealing of genetic backgrounds of unknown and/or insufficiently studied genotypes. Obtained data can be used in the development of new hybrids. Observed genotypes with higher values of combining abilities, can result in improved hybrids when they are crossed to other materials from the maize germplasm collection.

Material and methods

Five inbred lines (A1, A2, A3, A4, A5) and three testers (Z1, Z2, Z3) from the collection of the Maize Research Institute, Zemun Polje, as well as, their 15 hybrids were used in the present study. Female components, five inbred lines, were of the BSSS background, while testers originated from the Lancaster background. Crosses (hybrids) for the trial were performed in 2009. The two-replicate trial was set up according to the randomised block design (RCBD) in two locations during 2010. Two rows for each genotype were sown, hence there were 20 plants per row and the density amounted to 67,000 plants ha^{-1}. The row distance was 0.75 m. The row length was 4 m, while the elementary plot size amounted to 6 m^2 (1.5 m x 4.0 m). Identical cropping practices were applied in both locations. Yield ha^{-1} in t was calculated at 14% moisture.

Combining abilities were estimated by the inbred × tester analysis suggested by Kempthorne (1957), and applied by Singh and Chaundhary (1976). This analysis was performed in the Excel programme.

Results and discussion

Results on the initial analysis of variance showed statistically highly significant (P=0.01) differences for genotypes (treatments) (data not shown). The sum of squares of genotypes (treatments) further partitioned to sum of squares of parents (inbred lines and testers), parents vs. crosses, crosses, inbred lines (female component), testers (male components) and finally inbred lines × testers. Obtained results showed statistically significant (P=0.05) differences for parents (inbred lines and testers) and testers (location of Školsko dobro) and statistically very significant (P=0.01) differences for crosses and testers (location of Zemun Polje). Statistically very significant difference was also observed (P=0.01) for parents vs. crosses on both locations (data not shown).

Average grain yields of maize inbred lines and their GCA values pointed to weak variations (Table 1). The best GCA ranking inbred line was A1 (location of Zemun Polje), but its value was not significant. A highly significant difference was established for testers Z1 and Z2 by the test of significance. Moreover, the tester Z2, i.e. Z1 (location of Zemun Polje) proved to be the best, i.e. the poorest general combiner, respectively (Table 1). The tester Z2 was also the best general combiner in the location of Školsko dobro, although its GCA value did not exceed the level of significance.

Table 1. GCA values for inbred lines and testers for grain yield

Genotype	Zemun Polje		Školsko dobro	
	Mean	GCA	Mean	GCA
A1	7.5	0.78	6.2	-0.25
A2	6.4	-0.38	6.0	0.53
A3	6.1	-0.12	6.6	-0.08
A4	6.1	-0.13	6.8	0.17
A5	5.1	-0.15	3.8	-0.37
Z1	5.2	-1.01*	3.8	0.30
Z2	7.4	1.30**	5.7	0.50
Z3	5.2	-0.30	5.5	-0.79
SE GCA inbreds	-	0.3915	-	0.3915
SE(Gi-Gj) inbreds	-	0.5536	-	0.5536
SE GCA testers	-	0.3032	-	0.3032
SE (Gi-Gj)testers	-	0.4288	-	0.4288
LSD inbreds 0.05	-	1.1482	-	1.1482
LSD inbreds 0.01	-	1.5607	-	1.5607
LSD testers 0.05	-	0.8894	-	0.8894
LSD testers 0.01	-	1.2089	-	1.2089

Two good general combiners do not necessarily give the best SCA result (Borojević, 1981). This statement was also confirmed by the SCA value of the hybrid A2 x Z1 (0.22) and A2 x Z3 (0.46) on location of Zemun Polje, hybrid A3 x Z3 0.34 on second location (Table 2), where the combination of parents with negative GCA values resulted in a hybrid with positive SCA values. The combination of a parent with negative and a parent with positive GCA values, A1 x Z1 (1.06), A3 x Z2 (0.60) and A4 x Z2 (0.61) at Zemun Polje and the combination of A1 x Z2 and A2 x Z3 at the location of Školsko dobro resulted also in positive SCA values. The values of SCA were the highest in these hybrids, although they did not exceed the level of significance. The combinations of parents with positive and negative GCA values resulting with positive SCA values are in accordance with results gained by Wali (2010) and Živanović et al (2010). The potentiality of the cross from a high x low combination is attributed to the interaction between dominant alleles from a good general combiner and a recessive allele from a poor combiner (Senthil and Bharathi, 2009). By the combination of parents with positive GCA values both parents gave a negative SCA value: A1 x Z2 at Zemun Polje and A2 x Z1 and A2 x Z2 at Školsko dobro.

Table 2. SCA values for hybrids for grain yield

Genotype	Zemun Polje		Školsko dobro	
	Mean	SCA	Mean	SCA
A1 x Z1	11.9	1.06	11.6	-0.18
A2 x Z1	9.9	0.22	11.9	-0.71
A3 x Z1	9.5	-0.44	11.9	-0.05
A4 x Z1	9.5	-0.43	12.3	0.10
A5 x Z1	9.5	-0.41	12.5	0.84
A1 x Z2	12.5	-0.70	13.1	1.12
A2 x Z2	11.3	-0.69	12.3	-0.46
A3 x Z2	12.8	0.60	11.9	-0.30
A4 x Z2	12.8	0.61	12.5	0.10
A5 x Z2	12.4	0.18	11.4	-0.46
A1 x Z3	11.2	-0.35	9.7	-0.94
A2 x Z3	10.9	0.46	12.6	1.18
A3 x Z3	10.5	-0.15	11.2	0.34
A4 x Z3	10.4	-0.19	10.9	-0.21
A5 x Z3	10.9	0.23	10.2	-0.37
SE SCA	-	0.6185	-	0.6781
SE (Sij-Skj)	-	0.8746	-	0.9589
LSD 0.05	-	1.8140	-	1.9888
LSD 0.01	-	2.4656	-	2.7032

The proportion of non-additive variance in the yield prevailed in this study, which is observable from Table 3 (GCA/SCA ratio is less then unity). These results are in accordance with Shams (2010) and Wali (2010).

Table 3. Components of genetic variance for grain yield

	Zemun Polje	Školsko dobro
Additive variance		
Va(F=1)	0.2049	0.0328
GCA variance	0.1024	0.0164
Dominant variance		
Vd(F=1)	0.1043	0.2408
SCA variance	0.1043	0.2408

GCA/SCA	0.9820	0.0681

The highest proportional contribution to grain yield at Zemun Polje goes to testers, while the proportional contribution of inbred × tester interaction was predominant at Školsko dobro (Table 4).

Table 4. The proportional contribution of inbreds, testers and their interactions in expression of grain yield (%)

Average contribution of	Zemun Polje %	Školsko dobro %
Inbreds	12.10	12.93
Testers	68.84	40.26
Inbred × testers interaction	19.15	46.81

Conclusion

Results obtained on GCA and SCA showed weak variations, provided that only the tester Z2 showed significant GCA values (1.30**); crosses to this tester had the highest results and it was suggested for further use in maize selection; on the other hand, there was no combination with inbreds lines that had a significant SCA value. Female components showed weak variations, which was an indicator of huge genetic closeness of the initial material. The GCA/SCA ratio pointed out to a greater proportion of non-additive variance in the grain yield formation in both locations. The highest contribution in the grain yield formation at the location of Zemun Polje was observed in testers (68.84%), while the corresponding contribution in the location of Školsko dobro was observed in the inbred × tester interaction (46.81%).

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