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Stability of the Expression of the Maize Productivity Parameters by AMMI Models and GGE-Biplot

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Introduction

Maize (*Zea mays* L.) (2n=20), belongs to the family *Poceaceae*. Diversified uses of maize worldwide include: grain, starch products, maize oil and forage for animals. Maize in the world sowed of 185 million hectares, average yield were 5.62 t ha^{-1} while total production was over 1.04 billion tonnes. Maize cultivars are grown in approximately 1.10 million hectares annually in Serbia and national average yield was 7.52 t ha^{-1} (Ikanović *et al.*, 2018). Hybrid seeds demanded by maize growers are provided by mostly national or international seed companies in Serbia. The aims of this study were to identify superior experimental hybrids with number of rows of grains as well as to select the best location for testing hybrids, year, locations and treatments (with sulfonylurea), developed in the maize breeding program of the domestic company of Serbia by using and comparing AMMI and GGE biplot methods.

Table 1. The additive main effects and multiplicative interactions analysis of variance for tested maize lines

Sources of variation	DF	Number of rows of maize grains		
		SS	SS (%)	MS
Genotype (G)	5	590.27	53.50	118.05**
Year (Y)	1	5.28	0.48	5.28**
Locality (L)	1	25.09	2.27	25.09**
Treatment (T)	3	3.51	0.32	1.17ns
G x Y	5	2.91	0.26	0.58 ns
G x L	5	20.27	1.84	4.05**
IPCA1 (100%)	5	20.3	100.00	4.05 ns
IPCA2 (0%)	3	0.0	0.00	0.00 ns
G x T	15	28.47	2.58	1.90*
Y x L	1	2.17	0.20	2.17 ns
Y x T	3	19.73	1.79	6.58 ns
L x T	3	3.20	0.29	1.07 ns
G x Y x L	5	1.27	0.12	0.25 ns
G x Y x T	15	65.66	5.95	4.38**
G x L x T	15	56.02	5.08	3.73**
Y x L x T	3	3.51	0.32	1.17 ns
G x Y x L x T	15	33.97	3.08	2.26*
Error	192	242.00	21.92	1.26 ns
Total	287	1103.33	100.00	-

Results and Discussion

The results also show that the sums of the squares of the first and second major components (PC1 and PC2) constitute 100% of the sum of the squares of the interaction G×L. Also, the first PC1 axis belongs to all 100%, which points to the significance of the genotype in the total variation and significance of the genotype for overall interaction with other observed sources of variability, Table 1. The combined ANOVA showed differences among environments (E) and genotypes (G) to be significant indicating that they were diverse. However, genotype by environment interactions for grain yield was not significant.

Conclusions

Results from this study have suggested that AMMI analysis is very applicable for the analysis of maize lines and different years, locality, treatment and their interaction. The genotype share in the total phenotypic variance for the number of rows of grains was 53.50%, and the interaction was 21.15%. The results also show that the sums of the squares of the first and second major components (PC1 and PC2) constitute 100% of the sum of the squares of the interaction G×L. Also, the first PC1 axis belongs to all 100%, which points to the significance of the genotype in the total variation and significance of the genotype for overall interaction with other observed sources of variability.

Value of phenotypic expression and the stability of the genotype L-5 coincides with the ideal genotype, followed by L-6, L-4, etc. Even in the applied treatments, the genotype L-5 is the closest to the ideal genotype, both in terms of stability and in terms of shown expression.

Materials and Methods

Plant material. The research was carried out at two sites: in Zemun Polje (44°52´N, 20°19´E, 81m asl) and in Pančevo (44°52´14´´N, 20°38´25´´E, 77m asl) during 2010 and 2011 and the basic plant materials consists of six lines of maize (L-1, L-2, L-3, L-4, L-5 and L-6). The types of soil in Pančevo and Zemun Polje is chernozem. Examines were based on a completely random block system, in three reps, with 20 plants in each repetition. Each genotype was planted in one row with ten houses with two plants each, so that the size of the elementary plot was 2.8 m^2. The density of crops was 74.280 plants per hectare. Sowing and harvesting were done manually and in the experiment, standard maize cultivation technology was applied except for variants with treatment (Božović, 2018).

Treatments. The experiments were four sub-treatments with Sulfonylurea herbicides: T_1- Control was without herbicide, treatment was done only with water; T_2-active substance Nicosulfuron, and the Motivell preparation in the amount of 1.25 l ha^{-1} (6.3 ml per treatment); T_3-active substance Rimsulfuron, and the Tarot preparation in the amount of 60 g ha^{-1} (0.3 g per treatment); T_4- Active substance Forasulfuron, and the Ekvip preparation in the amount of 2.5 l ha^{-1} (12.6 mL per treatment).

Data analysis. The AMMI model was used to assess the G × E interaction, and it can be represented by the following formula (Gauch & Zobel, 1996): $Y_{ger} = \mu+\alpha_g+\beta_e+\Sigma_n\lambda_n\gamma_{gn}\delta_{en}+\varrho_{ge}+\varepsilon_{ger}$
Meteorological data. In first year in Pančevo average monthly temperature was 17.44 ºC and in second year 19.53 ºC. In Zemun Polje in first year average monthly temperature was 18.51 ºC and in second year 19.57 ºC.

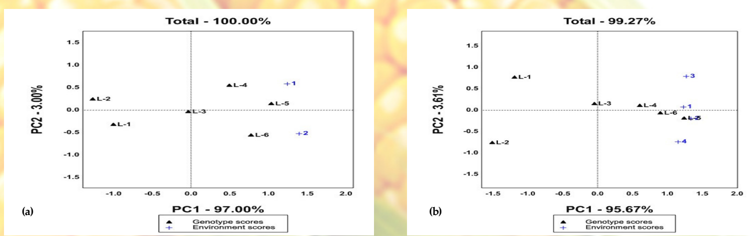

Figure 1. This is a figure, present GGE biplot representation. (**a**) GGE biplot representation of stability of expression for the number of rows of grain of lines of maize based on locality and (**b**) based on the treatment.

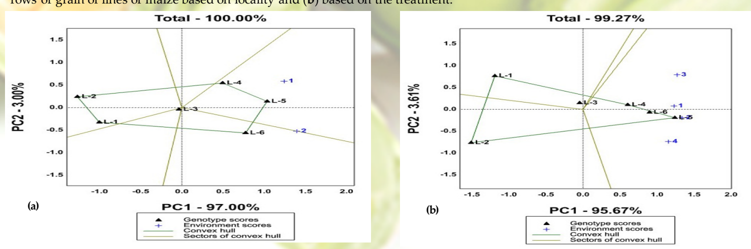

Figure 2. This is a figure present GGE-biplot. GGE-biplot view for the number of rows of grain of lines of maize, according to the "wich-won-where" model based on the locality and (**b**) based on the treatment.

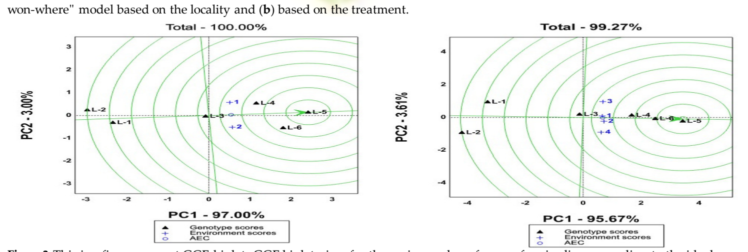

Figure 3. This is a figure present GGE-biplot. GGE biplot view for the grain number of rows of maize lines according to the ideal genotype model based on the locality and (**b**) based on the treatment.