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VARIATION OF MORPHOLOGICAL AND PHYSIOLOGICAL TRAITS OF MAIZE HYBRID SEED OVER GROWING LOCATIONS

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Abstract

Physiological and morphological traits of seed and their variability in dependence on the growing location were studied in 2014. The analyses were carried out on hybrid seed of three commercial hybrid combinations produced in three locations. The following seed traits were observed under laboratory conditions: germination energy, total germination and 1000-seed weight. The highest, i.e. lowest values of germination and germination energy were recorded in the hybrid H3, i.e. H1, respectively. The greatest 1000-seed weight was detected in the hybrid H3. With regard to the growing location, the highest values of germination and germination energy were recorded in the location B (97.166%), while the location A was most suitable for the expression of 1000-seed weight. The greatest 1000-seed weight amounted to 394.67 g. The hybrid combination × location interaction significantly affected all three traits. The highest energy and germination were recorded in the hybrid H1 in the location B. The hybrid combination H2 and the location C had the highest effect on 1000-seed weight. This trait mostly varied in the hybrid combination H3 in the location C. Average values of germination energy, total germination and 1000-seed weight very significantly depended on the hybrid combination and the growing location.

Key words: *hybrid, location, seed trait*

Introduction

Hybrid maize seed is produced under diverse agro-ecological and agro-technological conditions and therefore traits of such seed depend on many factors: genotypic combinations of parental inbreds, coincidence of flowering times of parental inbreds, duration of pollination in seed crops, duration of seed filling, duration of maturation of formed and filled seed, moisture content in physiologically mature seed at harvest, seed maturation, seed infection by disease-causing agents, presence of pests. It was determined that numerous factors affect the process of maize seed germination both, individually and interactionally, while obtained results refer to seed as an entity (*Antonić et al., 2003, Dačić et al., 1997, Sabovljević et al., 1997.*). Agro-ecological conditions depend not only on meteorological and edaphic conditions in a region but also on applied cropping practices in the production of seed crops. Furthermore, all traits of hybrid maize seed depend on a genotypic combination and interactions of this combination with agro-ecological conditions during the growing season of seed crops. *Lee et al. (2002)* presented important differences in cold tolerance related to a genotype. These differences manifested in different rates of the root development but also in development rates of the above-ground shoots. Based on the stated, traits of produced hybrid maize seed depend on procedures absolutely controlled by humans, on ecological conditions influenced, to a certain extent, by humans, on traits of parental inbreds and on interactions among all stated factors.

The aim of the present study was to observe effects of growing locations on physiological and morphological traits of maize seed: germination energy, total germination and 1000-seed

weight, as well as, their variatons in relation to the production region in the year of investigation.

Material and Methods

The study was carried out with three commercial single-cross combinations of maize of different FAO maturity group (FAO 300, FAO 400 and FAO 600) derived at the Maize Research Institute, Zemun Polje.

Hybrid seed of the F1 generation for each hybrid combination was produced in three locations, during 2014: SC341(H1) - Sanad (A), Žarkovac (B) and Feketić (C), SC427 (H2) - Sanad (A), Žarkovac (B) and Sivac (C), SC666 (H3) - Sanad (A), Žarkovac (B) and Feketić (C). In the production of seed crops, all standard and prescribed cropping practices and procedures were applied in due time and in the right way in each of locations. Harvest of seed ears was done by maize pickers. Husking was performed immediately prior to artificial drying. After drying, ears were shelled and the natural seed material was cleaned. Submitted samples of 25-30 kg were drawn out of natural seed material for each hybrid combination and each production location. Non-destructive methods were applied to study hybrid maize seed. Seeds were observed and evaluated as entities. Total germination, germination energy and 1000-seed weight were determined under laboratory conditions according to the Regulation on Seed Testing Quality of Agricultural Crops 47/87 and ISTA Rules (currently valid edition). The standard method for total germination and germination energy was applied (t_1=20/30^{o}C and (16:8) light : dark photoperiod). The first, i.e. final count were done on the forth, i.e. seventh day, respectively.

Each of obtained parameters was statistically processed by descriptive statistics for parameters at the annual level. Differences among analysed maize hybrids as well as their interactions were evaluated by the analysis of variance. Gained experimental data were processed by the appropriate mathematical and statistical methods using the statistic package STATISTICA 10.0 for Windows.

Results and Discussions

Table 1 illustrates data of means of qualitative and quantitative seed traits. In all three hybrids and in each of three locations standards prescribed by the Regulation on Seed Testing Quality of Agricultural Crops were met, except for H1 in the location A (germination energy was bellow 90%). Results obtained in the fields and the laboratory confirmed better germination and germination energy at higher temperatures (*Sabovljević et al.,* 1997; *Rosić*, 1959; *Popović*, 1982; *Pinnel*, 1949). According to Živanović et al. (2012), Marić et al. (2013) daily temperatures in the stage of germination and emergence should be 8-10^{o}C for germination and 10-12^{o}C for emergence in order to have successful maize production. The expression of germination energy and total germination in this study was uniform, with variations less than 2.1%, while the third observed trait was characterised by a significantly greater variation in relation to both factors. The analysis of the first factor (hybrid combination) shows that the hybrid H3 had the highest mean for germination energy and germination of 96.9%, while 1000-seed weight amounted to 432.6 g in the hybrid H2. Furthermore, the analysis of different groups of hybrids points out to the effect of a hybrid combination on germination and germination energy (*Tabaković et al., 2015*). The best conditions for germination energy and total seed germination were registered in the location B with the mean of these traits amounting to 97.2%. The highest mean value of 1000-seed weight (394.6 g) was estimated in the location A. *Shien* and *Mc Donald* (1982) determined the influence of seed size, shape and treatment on seed quality of two inbred lines.

Table 1. Means and variations of seed traits ($S\overline{x}, \overline{X}$)

	H1			H2			H3			$\overline{X}$,$S\overline{x}$		
	ge	g	sw	ge	g	sw	ge	g	sw	ge	g	sw
A	85.0 ±2.4	87.1 ±1.6	364.2 ±13.5	94.1 ±0.4	94.1 ±0.4	443.7 ±49.2	97.1 ±0.4	97.1 ±0.4	376.0 ± 10.1	92.0 ±2.1	92.7 ±1.6	394.6 ±17.1
B	98.4 ±0.3	98.4 ±0.3	322.2 ±12.8	96.8 ±0.5	96.8 ±0.5	403.2 ±43.1	96.3 ±0.8	96.3 ±0.8	350.7 ± 12.9	97.2 ±0.6	97.2 ±0.6	358.7 ±16.6
C	97.7 ±0.4	97.7 ±0.4	308.7 ±14.2	96.2 ±0.5	96.2 ±0.5	451.0 ±36.4	97.5 ±0.4	97.5 ±0.4	373.4 ± 10.2	97.1 ±0.4	97.1 ±0.4	377.7 ±22.0
	93.4 ±2.4	94.4 ±1.9	331.7 ±15.1	95.7 ±0.6	95.7 ±0.6	432.6 ±14.8	96.9 ±0.5	96.9 ±0.5	366.7 ±11.4	$\overline{X}$.$S\overline{x}$		

A, B, C - location, H1, H2, H3 - hybrid combination, ge - germination energy, g - total germination, sw - 1000-seed weight, $\overline{X}$-mean, $S\overline{x}$-standard error

The effect of hybrid combinations and locations on studied physiological and morphological traits was determined by the two-factorial analysis of variance (Table 2). The statistically significant difference among observed groups of hybrids and locations was estimated at the $p<0.05$. Moreover, the influence of interactions of factors on the expression of seed traits was also determined ($F=23.25$, $p<0.05$, $F=19.12$, $p<0.05$). An effect size measure was done by partial eta-squared. The eta-squared values ($\eta=0.535$, $\eta=0..486$) point to great effects of hybrid combinations and locations on trait variances. The highest partial effect was estimated for the hybrid combination on 1000-seed weight ($\eta=0.542$).

Table 2. Two-factorial analysis of variance and partial eta-squared

Factor	Seed trait	d.f.	Mean squares	F-test	Partial eta-squared
hybrids	germination	2	49.411	9.882*	0.196
	energy	2	81.378	9.309*	0.187
	1000-seed weight	2	78756.908	47.852*	0.542
location	germination	2	192.144	38.429*	0.487
	energy	2	258.411	29.560*	0.422
	1000-seed weight	2	9718.047	5.905*	0.127
hybrids * location	germination	4	116.294	23.259*	0.535
	energy	4	167.161	19.122*	0.486
	1000-seed weight	4	3630.965	2.206	0.098

Additional comparisons using the $LSD_{0,05}$ test (Table 3) indicated that means for all three traits differed significantly over hybrids, except in germination energy between the second and the third hybrid. The significant differences in germination energy were also detected between the locations A and B and A and C. On the other hand, significant differences in 1000-seed weight were recorded only between locations A and C.

Table.3 Significance of differences at the 0.05% probability level

Seed trait		(I) hybrid	(J) hybrid	Difference between means (I-J)	95% confidence interval		(I) location	(J) location	Difference between means (I-J)	95% confidence interval	
					Lower limit	Upper limit				Lower limit	Upper limit
g	LSD	1	2	-1.30*	-2.44	-0.15	1	2	-4.40*	-5.54	-3.25
			3	-2.56*	-3.71	-1.41		3	-4.36*	-5.51	-3.21
		2	1	1.30*	0.15	2.44	2	1	4.40*	3.25	5.54
			3	-1.26*	-2.41	-0.11		3	0.03	-1.11	1.18
		3	1	2.56*	1.41	3.71	3	1	4.36*	3.21	5.51
			2	1.26*	0.11	2.41		2	-0.03	-1.18	1.11
ge	LSD	1	2	-2.00*	-3.51	-0.48	1	2	-5.10*	-6.61	-3.58
			3	-3.26*	-4.78	-1.74		3	-5.06*	-6.58	-3.54
		2	1	2.00*	0.48	3.51	2	1	5.10*	3.58	6.61
			3	-1.26	-2.78	0.25		3	0.03	-1.48	1.55
		3	1	3.26*	1.74	4.78	3	1	5.06*	3.54	6.58
			2	1.26	-0.25	2.78		2	-0.03	-1.55	1.48
sw	LSD	1	2	-100.90*	-121.74	-80.06	1	2	35.97*	15.13	56.81
			3	-34.97*	-55.81	-14.13		3	16.95	-3.88	37.79
		2	1	100.90*	80.06	121.74	2	1	-35.97*		-15.13
			3	65.93*	45.08	86.77		3	-19.02	-39.86	1.82
		3	1	34.97*	14.13	55.81	3	1	-16.95	-37.79	3.88
			2	-65.93*	-86.77	-45.08		2	19.02	-1.82	39.86

g-total germination, ge- germination energy, sw- 1000-seed weight

Conclusion

Studies on physiological and morphological seed traits showed that these traits are commercially important. An appropriate number and arrangement of plants in mercantile crops of maize hybrids are primarily provided by sowing seeds of good physiological, physical and mechanical traits. Our studies pointed out that variations in seed traits depended not only on genetically predetermined limits, but also on different production conditions. Effects of hybrid combinations and locations were great on all traits. According to obtained results, germination energy and total germination were more dependent on production conditions, i.e. locations (η=0,487 and η=0,422, respectively), while 1000-seed weight depended more on genetic performances of a hybrid combination (η=0,542). The significance of a hybrid combination and a location was confirmed by the analysis of variance, while the significance of obtained differences was confirmed by the LSD test.

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