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SIGNIFICANCE OF AGRO-ECOLOGICAL CONDITIONS ON TRAIT FORMATION OF MAIZE HYBRID SEED

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Abstract

Traits of the F_1 generation of maize hybrid seed were observed in four SC combinations produced in two locations. Agro-ecological conditions for the production of hybrid seed in these locations during three years differed. The coefficient of variation for germination energy and seed germination was 0.71% in ZP 341 during the first year. Produced seed of all observed hybrids was of satisfactory quality. The analysis of data shows that seed germination and energy (2.56% CV) varied the most in the hybrid combination ZP 434 in the three-year experiment. According to the location assessment, established differences in traits were greater, and the coefficient of variation for both locations amounted to $0.9 \leq 3.21$. The effect of agro-ecological conditions differed over locations during the same production season. According to obtained results, agro-ecological conditions have an essential role on the formation of traits of hybrid seed. Based on gained results, the level of expression of the two observed traits in all four hybrids was high under all agro-ecological conditions. Moreover, effects of the factors (hybrid and location) on germination energy and seed germination were high.

Key words: *maize, location, germination, variability.*

Introduction

The necessary and appropriate number and arrangement of plants in a commercial maize hybrid crop can be provided primarily by sowing seeds of good physiological and physico-mechanical traits.

With regard to both scientific and technological research, germination represents a physiological trait of maize hybrid seed that depends on remaining physiologcal traits of embryos and seeds, but also on the environmental conditions under which the research is carried out. Seed germination is a complex biochemical, physiological and morphological process in the formation of a new plant. According to Ujević and Kovačević (1972), the process of seed germination is proceeded through three stages. Germination is a process encompassing enzyme activation, degradation of insoluble reserve materials, translocation and mobilisation of soluble substances and growth-inducing reactions. The studies preformed by McDonalda et al. (1994) point out that the most active water intake by seeds occur during the first six hours of imbibition and that is more pronounced in the embryo than in the endosperm. Physico-mechanical and physiological traits of maize hybrid seed depend on agro-ecological conditions during the seed formation and maturation. Shien and Mc Donald (1982) observed the influence of a seed size and shape in two maize inbred lines on seed quality and established that there is no dependence on a seed size. There are numerous studies published in our country relating to the significance of the seed size and shape and their effects on germination (Đukanović et al. 2003; Pajić et al. 1997). According

to results obtained by Chassot (2000), in the no-tillage system, the air and soil temperatures are probably the main physiological stress factor during the early maize plant development. Stone et al. (1999) determined that the soil temperature directly affected meristematic tissues of radicles and shoots.

All traits of maize hybrid seeds depend on a genotypic combination and the interaction of this combination and agro-ecological conditions during the growing season of the seed crop. Lee et al. (2002) showed significant differences in tolerance of genotypes to low temperatures; these differences were manifested during various developmental stages of roots and above-ground plant parts.

The research programme encompassed experimental studies of traits of the F_1 generation of maize hybrid seed, mathematical and statistical processing, evaluation and the analysis of obtained experimental data.

Material and Methods

Seed of the following hybrid combinations, produced in two locations, Banat1 (L1) and Banat2 (L2), was used as a material in this study: ZP 341, ZP 434, ZP 684 and ZP 704. The material was produced by the application of similar cropping practices. Production locations differed in ecological and agro-ecological conditions.

Production trials were established for each hybrid combination according to standards prescribed in the *Regulation on control of the seed production of agricultural crops* (Official Gazette of RS, issue 60/2006).

Agro-ecological conditions were monitored during the production process, while data were obtained from the nearest hydrometeorological stations.

Working samples of 1000 g each were drawn from the natural seed material (25-30 kg) and used for the analysis of germination energy and seed germination.

The determination of seed physiological traits (germination energy and germination) was done at the standard temperature regime and filter paper: t=20/30^{o}C ((16:8) light : dark (L:D) photoperiod, white light at higher temperatures), germination energy for 4 days and germination for 7 days.

Each of obtained parameters was processed by the statistical analysis by the application of the descriptive statistics for parameters at the annual level (the period from 2006 to 2010). Differences among four observed maize hybrids in two locations in Bačka were established by the analysis of variance for the factorial trial set up according to the randomised block design and by the LSD test at the probability levels of 5% and 1% (Hadživuković, 1973). In order to draw objective conclusions on effects of observed parameters on tested maze seed traits and the possibility to apply parametric tests (ANOVA and LSD-test), homogeneity of variance was tested by the Levene′s test.

Results and Discussion

Results of the three-year study on the impact of a location and a year of production on physiological traits, energy and germination, point out to the minor variability of observed traits. Germination and energy values were above 90%, while the coefficient of variation (CV) did not exceed 4%. The influence of the production location was higher than the effect of the production year. Furthermore, the differences among hybrid combinations were also determined. The least variation was in the hybrid combination ZP 704 during the first year of production (G1, Table 1).

Table 1. Average values and variations for germination energy and seed germination over years of production

Year		Germination energy (ek)				Seed germination (uk)			
		ZP341	ZP434	ZP684	ZP704	ZP341	ZP434	ZP684	ZP704
G1	Average	97.51	97.41	96.55	95.32	97.5	97.46	96.50	95.31
	CV	0.71	1.13	0.42	0.14	0.71	1.13	0.43	0.14
G2	Average	96.50	95.23	95.35	96.74	96.5	95.25	96.23	98.00
	CV	0.71	2.56	0.14	0.14	0.71	2.56	1.13	0.01
G3	Average	92.22	94.25	94.71	94.57	91.7	94.71	94.74	94.85
	CV	0.28	0.84	0.42	1.55	0.42	0.14	0.42	1.98

The production location L2 caused the greatest variation in the hybrid combination ZP 341, while the combination ZP 684 with the coefficient of variation of 0.9% in the location L1 had the least differences in values of traits presented in Table 2.

Table 2. Average values and variations for germination energy and seed germination over locations of production

Location		Germination energy (ek)				Seed germination (uk)			
		ZP341	ZP434	ZP684	ZP704	ZP341	ZP434	ZP684	ZP704
L1	Average	94,80	95,47	95,33	95,07	94,80	95,47	95,33	95,53
	CV	2,99	2,47	0,90	1,60	2,99	2,47	0,90	2,32
L2	Average	95,67	95,73	95,67	95,93	95,67	96,07	96,27	96,53
	CV	3,21	1,86	0,99	0,76	3,21	1,29	1,10	1,33

Observed factors have a smaller or a greater statistically significant effect on germination energy and seed germination, as well as on their partial effect of action. Hence, both factors and their interaction too affect changes in germination energy and seed germination. It was determined that many factors affected the process of maize seed germination either individually and or in interactions, while the obtained results referred to the seed as a whole (Dačić et al. 1997, Sabovljević et al. 1997, Tabaković et al. 2015.).

The year of production is a factor that affected both energy and germination in all hybrid combinations. Moreover, the interaction of the two factors was significant. The significance of the location on the expression of seed germination was observed in the hybrid combinations ZP 434, ZP 684 and ZP 704, while energy varied under the effect of this factor only in the hybrid combination ZP 704 (Table 3).

The partial effect of the year on the physiological traits was the highest in ZP 341 ($\eta 2$= 0.817, $\eta 2$=0.779). On the other hand, this effect of the location was small in all hybrid combinations and ranged from $\eta 2$= 0.001 to $\eta 2$=0.4639, while the interaction of factors with its partial effect caused the greatest variation in seed germination in ZP 434 ($\eta 2$=0.480) (Table 3).

The year of production as a factor had a significant effect on energy and germination in all hybrid combinations. Furthermore, the interaction of two factors was significant. Effects of the location on seed germination were significant in the following three hybrid combinations ZP 434, ZP 684 and ZP 704, while energy varied under the influence of this factor only the hybrid combination ZP 704 (Table 3).

The partial effect of the year on physiological traits was the greatest in ZP 341 ($\eta 2$= 0.817, $\eta 2$=0.779), while it was small in remaining hybrid combinations ranging from $\eta 2$= 0.001 to

η2=0.4639. In addition, the partial effect of the interaction of factors was greatest on seed germination in ZP 434 (η2=0.480) (Table 3).

Table 3. Statistical significance of differences for energy and seed germination (F and LSD test)

Hybrids		Germination energy			Seed germination		
		Year	Location	Interaction	Year	Location	Interaction
ZP 341	F-test	53.75*	0.02	2.69	42.39*	0.02	2.35
	LSD 0,01	1.456	1.629	3.256	0.976	1.091	2.182
	LSD 0,05	1.917	2.146	4.286	1.185	1.236	2.873
	Partial Eta Squared of value	0.817	0.001	0.183	0.779	0.001	0.164
	Levene′s test F		2.542			1.520	
	p-level		0,0000			0.0000	
ZP 434	F-test	13.07**	0.260	10.21**	12.63**	1.653**	11.08**
	LSD 0,01	0.876	0.980	1.960	0.784	0.876	1.756
	LSD 0,05	1.154	1.290	2.580	1.032	1.154	2.308
	Partial Eta Squared of value	0.521	0.011	0.460	0.513	0.064	0.480
	Levene′s test F		1.959			0.893	
	p-level		0.0001			0.0643	
ZP 684	F-test	5.478**	0.543	0.348	12.40**	8.71**	1.111
	LSD 0,01	1.735	1.940	3.881	0.876	0.980	1.960
	LSD 0,05	2.284	2.554	5.108	1.154	1.290	2.580
	Partial Eta Squared of value	0.4706	0.0798	0.4491	0.6362	0.4639	0.7237
	Levene′s test F		3.680			1.199	
	p-level		0.0005			0.0006	
ZP 704	F-test	2.851**	1.295**	0.766	14.817*	3.750**	3.050**
	LSD 0,01	1.095	1.224	2.448	0.803	0.898	1.796
	LSD 0,05	1.441	1.611	3.222	1.057	1.182	2.365
	Partial Eta Squared of value	0.192	0.051	0.060	0.553	0.135	0.203
	Levene′s test F		1.531			3.797	
	p-level		0.052			0.053	

Conclusion

All stated factors affect expression of traits of maize hybrid seeds to a different extent and in different ways: directly; more or less indirectly, through greater or smaller interactions and in altering ways;

Average values and variations of traits of maize hybrid seed represent a resultant of actions of all mentioned factors in all stated ways of their actions.

Results of the analysis of variance, i.e. values of the F-test and probabilities of these values, point out that the effect of certain factors is not the same for the expression of all seed traits and all hybrid combinations.

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