Biblid: 1821-4487 (2018) 22; 1; p 46- 48
UDK: 633.15

Original Scientific Paper
Originalni naučni rad

TRAIT DISPERSION OF HYBRID MAIZE SEED UNDER DIFFERENT PRODUCTION CONDITIONS

DISPERZIJA OSOBINA HIBRIDNOG SEMENA KUKURUZA U ODNOSU NA RAZLIČITE USLOVE PROIZVODNJE

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ABSTRACT

This paper presents the results of an analysis of maize seed production. A total of six hybrids were selected from two maturity groups (FAO 300 and FAO 600) produced in three locations (L1, L2, L3). The following commercially important seed traits and their variability were analyzed: 1000-seed mass and germination. The average 1000-seed mass of all the parameters examined amounted to 342.8 g, whereas the minimum and maximum masses recorded were 285.7 g and 370.5 g, respectively. In the FAO 300 hybrids, a 60:30 ratio of large to small seed fractions was recorded. Conversely, this ratio in the FAO 600 hybrids was not uniform. Seed germination of the hybrids examined was high (above 90 %). The highest effect on trait variability was recorded in the hybrid combination (η^2 = 0.889 – seed mass, and η^2 = 0.456 - germination). Trait variations across locations and hybrid combinations are important for obtaining high yields and realizing the maximum potential of seed material.

Key words*: genotype, location, maize seed, 1000-seed mass, germination*

REZIME

U radu su prikazani rezultati analize proizvodnje semenskog kukuruza. Iz proizvodnje su odabrani sledeći hibridi: ZP 333, ZP 341, ZP 360, ZP 600, ZP 606 i ZP 666; dve grupe zrenja (FAO 300 i 600), proizvedenih na tri lokaliteta (L1, L2, L3). Analize su rađene na osobine semena koje su važne komercijalne karakteristike - apsolutna masa semena i klijavost, a koje zavise od uslova proizvodnje i vremenskih uslova godine, te je njihova varijabilnost manja ili veća u zavisnosti od ovih faktora. Varijabilnast i korelacija dve pomenute osobine su posmatrani na semenu proizvedenom u 2015. godini. Seme je podeljeno prema masi na krupnu (8,5-11 mm) i sitnu frakciju (6,5-8,5 mm). Prosečna masa 1000 semena za sve posmatrane parametre iznosila je 342,8 g, minimalana 285,7 g i maximalna 370,5 g. Hibridi grupe zrenja 300 karakterisali su se većim procentom krupne frakcije: odnos za hibride iz ove grupe bio je 60% krupne i 30% sitne frakcije. Grupa zrenja 600 nema ujednačen odnos frakcija između hibrida. Klijavost za sve posmatrane hibride bila je visoka - iznad 90%, uz mali broj uzoraka čija vrednost je bila ispod standardizovanog procenta. Varijabilnost u ispoljavanju osobina između lokaliteta bila je veoma značajna (p< 0,05). Najveći efekat na varijabilnost osobina imala je hibridna kombinacija (η^2=0,889 na masu i η^2=0,456 na klijavost) a zatim interakcija hibridne kombinacije sa lokalitetom (η^2=0,621 na masu i η^2=0,623 na klijavost). Frakcija nije imala statističke značajnosti u ispoljavanju klijavosti semena (η^2=0,020).

Variranje osobina prema lokalitetu i hibridnoj kombinaciji značajno je za postizanje visokih prinosa i ispoljavanje maksimalnog potencijala semenskog materijala.

Ključne reči*: genotip, lokalitet, semenski kukuruz, masa 1000 zrna, klijavost.*

INTRODUCTION

As reproductive material and a final commercial product, seeds are characterized by different shapes, sizes and masses. Plant production yields greatly depend upon these morphological traits of seed. The shape and size of maize kernels are important factors in seed processing and industrial grain processing. The morphological traits of seed primarily depend on the hybrid combination, sowing period, flowering time, pollination, seed filling, agroecological conditions, as well as other biotic and abiotic factors. The seed shape and size are variable traits closely linked to the quality of seed. In seed production, seeds are classified by size into large and small, and by shape into round and flat seeds. According to many authors, round seeds have a greater mass and lower germination (*Đukanović et al., 2008*). The germ of round seeds is exposed to greater impacts and damages (*Opra et al., 1997*). Due to a smaller specific area, round seeds are more suitable for cleaning, treating and handling. The predominant type of maize kernel is the dent type of flat and polyhedral shape.

In addition to the shape and size of seed, proper seed germination is also of paramount importance. Germination is a physiological trait which depends on numerous factors. Stress, including particularly increased salt concentrations (*Gebremedhn and Berhanu, 2013*) and low temperatures (*Tobeh and Jamaati-e-Somarin, 2012*), significatly affects the expression of this trait. Plants express their traits in a different manner, depending on the duration of stress exposure (*Gupta and Sheoran, 1983*). As a response to stress, maize, as well as other plant species, uses protective mechanisms (*Bohnert et al., 1995*), which results in various rates of plant growth (*Gill et al., 2003*).

In order to obtain high yields, seed material used in seed and commercial production should possess uniform morphological and physiological traits.

MATERIAL AND METHOD

Seeds of six genotypes from two FAO maturity groups (300 and 600), produced as seed material at locations in Srem (L1), Bačka (L2) and Banat (L3) in 2015, were used in the experiment. Seed production in all the locations was performed in keeping with the standards and regulations of seed maize production (Regulation- Sl.G.RS 60/2006 and ISTA Rules 2017). After harvest, maize ears were dried to a moisture content of 14 %, prior to shelling and processing. During processing, seeds were pre-conditioned and separated into two fractions (small (SSF) - 6.5-8.4 mm and large (LSF) - 8.5-11 mm). One-kilogramme samples of cleaned and processed seeds were taken for laboratory tests. Seed mass was determined in 10 x 100 seeds, whereas germination was established using standard laboratory methods (including filter paper on day 7 after placing the seed for germination, with a moisture of 60 % as well as varying light (16/8 h) and temperature (20/30 ^{o}C). The intensity of light was 1600 lx, whereas the seed germination was performed in a germination room. The number of germinated seeds was determined by percentage calculation.

The data obtained were analysed using the methods of statistical description and correlation. In order to evaluate the effect of the parameter values impartially, the parametric ANOVA and LSD tests were employed.

All statistical calculations were performed using the IBM SPSS 20 statistical software.

RESULTS AND DISCUSSION

The results obtained show significant differences between the factors analyzed. A hybrid combination certainly determines the level of variations in the traits examined (F = 17.637 for germination, F = 167.945 for mass; $p < 0.05$). Furthermore, the second factor, i.e. location, was also found to be statistically significant ($p < 0.05$) (Table 1).

Table 1. Statistical significance of differences between the hybrid groups and locations

Source	Dependent Variable	F	Partial Eta Squared (η^2)
Hybrid	germination	17.637*	0.456
	1000-seed mass	167.945*	0.889
Location	germination	7.587*	0.126
	1000-seed mass	25.208*	0.324
HxL	germination	17.333*	0.623
	1000-seed mass	17.171*	0.621

HxL- hybrid x location, p<0.05

In relation to the 1000-seed mass, variations within a hybrid combination were recorded depending on genetic factors, biochemical and physiological abilities of the plant, temperature, moisture, and the duration and rate of seed filling, which results in different seed sizes (*Sadras and Egli, 2008*). The hybrids of the FAO maturity group 600 exhibited a more uniform 1000-seed mass with a standard deviation of 30-40. The largest seed (370.47 g) within this group was recorded in the hybrid ZP 666. The standard deviation of the second group of hybrids (40-54) indicates a lesser uniformity of seed within the hybrid combinations (Table 2). The seed mass of this group of hybrids is smaller and ranges from 285.72 g to 328.33 g. The statistical significance of the differences recorded is minute mostly due to uniform production conditions. This is in accordance with numerous studies examining the effects of production conditions on seed mass, which argue that the formation of mass and the number of kernels actually depend on agroecological conditions (Borrás *and Gambín, 2012; Baoyuan et al., 2016*), particularly the time of flowering.

Table 2. Means of seed germination and 1000-seed mass

Hybrid	Germination (%)	SD - standard deviation	1000-seed mass (g)	SD- standard deviation	LSF (%)	SSF (%)
ZP 333	91.14	6.49	293.56	39.86	61.29	38.71
ZP 341	94.62	6.08	328.33	48.71	64.37	35.63
ZP 360	96.75	6.08	285.72	53.91	66.80	33.20
ZP 600	93.04	2.60	317.27	38.11	35.92	64.08
ZP 606	96.74	1.36	362.49	40.02	48.00	52.00
ZP 666	97.60	1.19	370.47	30.22	48.81	51.19
Total	95.68	3.80	342.84	48.05		
	r	R Squared	Eta	Eta Squared		
GxH	0.27	0.07	0.52	0.27		
WxH	0.42	0.18	0.58	0.34		

GxH - germination x hybrid; WxH - 1000-seed masst x hybrid

The means of seed germination ranged from 91 % (ZP 333) to 98 % (ZP 666) (Table 2). The results obtained indicate high values, whereas the deviations within the hybrid combinations were minute. This physiological trait showed the smallest differences in ZP 666 and the highest in ZP 333, which is quite in contrast with the level of germination (Figure 1).

The level and rank of seed mass and germination equally depend on the hybrid combination (η^2 - 0.268, η^2 - 0.337 respectively), whereas the correlations were more significant in seed mass (r = 0.424).

The relationship between the FAO 300 fractions is uniform (LSF:SSF = 60:30). This relationship in the second group of hybrids is less uniform. The greatest differences (LSF:SSF = 60:30) were recorded in ZP 600 (Table 2).

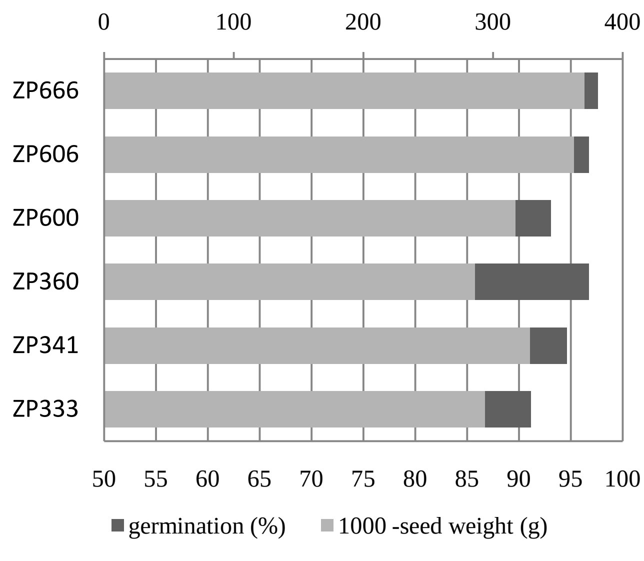

Fig. 1. Means of seed germination and 1000-seed mass across the hybrid combinations

In a number of previous studies, it has been argued that the agroecological conditions of production contribute to a lesser or greater dispersion in the expression of traits (*Tabaković et al., 2016*). The location, as a factor analysed in this study, was important for the differences in seed germination and seed mass. Stress conditions during the production process affect the germination index and the length of root and germ. Adaptation to stress conditions is the adjustment of metabolism via enzyme modulators important for physiological processes (*Yan et al., 2001; Ehsanpour and Amini, 2003*). In this study, the highest germination (97.15 %), with the smallest deviation between the means (SD 1.58 g), was recorded in the location L1. The largest seeds of all the hybrids (351.0 g) were recorded in the location L3, whereas the least variations in the seed mass were determined in the location L2 with a standard deviation of 43.6 g (Table 3). The seed mass values obtained depended on the limiting factors during the early stages of grain filling (*Gambín et al., 2006*) and kernel growth rate (*Sala et al., 2007*).

Table 3. Means of germination and mass across the locations

Location	Germination (%)	SD-standard deviation	1000-seed mass (g)	SD-standard deviation
L1	97.14	1.58	344.30	52.32
L2	95.93	3.54	333.75	43.61
L3	93.86	4.87	351.00	47.33
Total	95.67	3.79	342.84	48.05
	r	R Squared	Eta	Eta Squared
GxL	-0.35	0.12	0.35	0.12
WxL	0.05	0.00	0.14	0.02

CONCLUSION

A hybrid combination is an essential prerequisite for the level of trait expression. The agroecological conditions of locations in this study proved non-significant for the formation of seed mass ($p > 0.05$). However, these conditions exerted sigificant effects on the germination od seed ($F = 9.864$), which were recorded not only in the hybrid combinations, but also in each hybrid individually. Correct evaluations of the trait differences recorded under different agroecological conditions enable a successful selection of hybrid combinations and sowing locations.

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Received: 26. 02. 2018. Accepted: 14. 03. 2018.