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VARIABILITY OF SEED TRAITS OF FERTILE AND STERILE VARIANTS OF THE MAIZE HYBRID COMBINATION ZP 434

VARIJABILNOST OSOBINA SEMENA FERTILNE I STERILNE VARIJANTE HIBRIDNE KOMBINACIJE KUKURUZA ZP 434

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ABSTRACT

The introduction of sterile forms of parental inbreds in the production of hybrids maize seed has led to the improvement of production methods and to the facilitation of seed crop control. The aim of the present study was to compare utility values of the F1 generation between seeds produced by the use of standard inbreds and seeds produced from plants with cytoplasmic male sterility inherited maternally. Significant differences were detected in all observed traits compared to the version of the hybrid combination. The share of large seed fractions was higher in the fertile than in the sterile version, while the SR to SF ratio was uniform in the sterile version. The weight of 1000-seed was greater in the sterile form (325.7 g), while the first count and germination were equal amounting to 97.2 %. The first count (95.7 %) and germination (94.5 %) were also high in the fertile version.

***Key words**: sterility, hybrid, maize, seed traits.*

REZIME

U proizvodnji hibridnog semena kukuruza najvažniji zadatak je proizvodnja kvalitetnog semenskog materijala. Jedna od mera u toku oplodnje semenskog kukuruza je zakidanje metlica. To je težak i odgovoran posao koji iziskuje puno vremena i angažovanje velikog broja radnika uz kontrolu stručnih lica. Uvođenjem sterilnih formi roditeljskih linija u dobijanju semenske robe hibrida kukuruza unapredila se tehnologija proizvodnje i omogućilo lakšu kontrolu semenskih useva. Cilj rada je da se uporede kvalitativne osobine F1 generacije između semena koje je dobijeno upotrebom standardnih linija i semena čija roditeljska komponenta majke ima osobinu citoplazmatične muške sterilnosti. Poređene su: masa 1000 semena, enerija klijanja, klijavost i frakcioni sastav. Značajne razlike utvrđene su kod svih posmatranih osobina u odnosu na verziju hibridne kombinacije. Fertilna verzija u odnosu na sterilnu imala je veće učešće krupnih frakcija, dok je kod sterilne ujednačen odnos SO i SP. Masa 1000 semena veća je kod sterilne forme 325 7g, kao i energija i klijavost koje su u oba slučaja 97,2%. Fertilna verzija je takođe imala visoke vredenosti energije (95,7%) i klijavosti semena(94,5%).Veću varijabilnost u ispoljavanju kvalitativnih osobina semena ispoljila je fertilna varijanta hibridne kombinacije. Dobijene razlike u ispoljavanju fizičko-mehaničkih osobina u korist sterilne verzije opravdavaju uvođenje u semensku proizvodnju hibrida sa citoplazmatičnom muškom sterilnošću.

***Ključne reči**: sterilnost, hibrid, kukuruz, osobine semena.*

INTRODUCTION

The seed production of hybrid combinations for furhter multiplications means providing all conditions necessary for good quality seed production with the application of all cropping practices. Parental inbreds have a very significant importance in producing high quality hybrid maize commercial seed. For that purpose, production procedures are prescribed in accordance with regulations and breeders' instructions. The occurrence of male sterility in maize was utilised to develop sterile versions of parental components in seed production. Detasseling is a measure that is applied in maize hybrid production to prevent self-pollination in crosses. Using sterile female compontnes saves time and money and also prevents uncontrolled self-pollination that occurs as a result of inadequate detasseling.

The extensive application of cytoplasmic male sterility in the production resulted in studies on its effects on yield and other agronomic traits of maize. Many scientists have studied plant sterility and its effects on the improvement of qualitative traits of seeds *(Weingartner et al., 2004; Munsch, 2008)* and concluded that sterility increased yield. *Jovanović et al., (2016)* emphasised the effects of the relationships of fertile and sterile versions of hybrids on yield in the maize seed production.

One of important discoveries is that nitrogen requirements of such plants is lower during the growing season. The amounts of nitrogen that would be absorbed by pollen are, in sterile plants, is redirected into ears that have greater capability of absorption at the time of kernel filling *(Hirel et al., 2005).* The end results of availability of greater amounts of nitrogen to sterile forms is a greater number of kernels per ear *(Vega et al., 2001)*.

MATERIAL AND METHOD

Seed produced according to all standards prescribed by regulations and breeders' procedures and instructions was used in the trial *Regulation on control of the seed production of the agricultural crops (Official Gazette of the Republic of Serbia, issue 60/2006).*

Seed used in the trial was produced from the hybrid combination ZP 434 in the following two ways: 1) production with fertile inbreds of both components - the hybrid version whit

fertile cytoplasm and 2) production with the sterile female component and the fertile male component - the hybrid version whit sterile cytoplasm. The female to male component ratio amounted 4:2.

After harvest, kernels were shelled, cleansed and dried. Samples drawn from such material for the analysis of data sized 25 kg. Seed was processed in the laboratory according to its size and shape into four fractions: SR (small rounded), SF (small flat), MSR (medium small rounded), MSF (medium small flat). Sizing and sorting were done by the Carter Day equipment, alongside with sieves with rectangular and round meshes (ø 6.3-8.4 and 8.4-11). The weight of 1000 seed, early germination, germination and percentage share of fractions in the seed material were determined for each seed fraction. The weight of 1000 seed was obtained by seed weighing, 100 x 10, first count and germination were established by the standard method (between filter paper), setting 100 seeds in four replications, at altering temperature 20/30 ^{o}C and altering light (16:8 h light : dark). Seeds were germinated in the germinator room with humidity of 60 % and light intensity of 1600 lx, after the methods given in the ISTA Rules (2015) and National Regulations (47/87).

All data were analysed by descriptive statistics and the two factorial analysis of variance using the statistical program IBM SPSS 2010.

Table 2. Descriptive statistics

Production version			Percentage fraction	Weight of 1000seed	First count	Germination
Fertile	Mean		24.9986	304.4361	95.7847	96.4722
	95 % Confidence interval for mean	Lower Bound	23.4539	296.4133	94.9612	95,9963
		Upper Bound	26.5433	312.4589	96.6083	96,9482
	Variance		87.934	2372.107	24.995	8.349
	Std. Deviation		9.37729	48.70428	4.99953	2.88944
	Minimum		8.60	220.30	63.00	86.00
	Maximum		48.00	398.10	100.00	100.00
Sterile	Mean		24.9993	325.7868	97.2632	97.2895
	95 % Confidence interval for mean	Lower Bound	22.8125	317.1920	96.9262	96.9676
		Upper Bound	27.1862	334.3817	97.6001	97,6114
	Variance		186.202	2876.301	4.420	4.035
	Std. Deviation		13.64559	53.63116	2.10246	2.00869
	Minimum		2.30	216.00	88.00	91.00
	Maximum		58.80	426.30	100.00	100.00

RESULTS AND DISCUSSION

The analyses of data on effects of two production technologies of hybrid seed on morphological and physiological traits of seed show certain differences. The production method, i.e. hybrid version, were not significant for the variation of fraction percentage, but affected remaining three traits (Table 1). Fractions, the second factor, affected all observed traits, $p<0.05$. The joint action of the hybrid variant and the seed fraction was significant only for the percentage of certain fractions in the total seed material ($F=15.296$, $p<0.05$).

Mean values of all seed traits observed over versions of the hybrid combination show that they were higher in the sterile version (Table 2). According to data for the sterile version weight of 1000 seed, early germination and germination amounted to 325.7 g, 97.2 % and 97.3 %, respectively. Variations in the expression of traits in the sterile variant were significantly lower than in the fertile variant (2.1 % for first count and 2.0 % for germination).

The corresponding values in the fertile version amounted to 5 % and 2.9 %, respectively. Percentage of fractions and weight of 1000 seed were more uniform in the fertile than in the sterile version.

The magnitude of confirmed differences in means between the two production methods of seeds was significant (Table 3). Differences in values weight of 1000 seed, first count and germination ($p<0.05$) were significant, while differences in the percentage share of separated fractions were not significant ($p=0.999$).

The share of four seed fractions in the fertile version was 17.5 % for small fractions (SR and SF) and 32 % for medium small fractions. This relationship in the sterile version was somewhat different, and share of small fractions ranged from 10.8 % to 16.6 %, while this interval was 29.6-32.8 % for medium small fraction (Figures 1, 2).

Table 1. Two factorial analysis of variance

Source	Mean Square				F				Partial Eta Squared			
	Percen-tage	Weight of 1000 seed	First count	Germi-nation	Percen tage	Weight of 1000seed	First count	Germi-nation	Percen - tage	Weight of 1000seed	First count	Germi-nation
V	0,00	33,708.53	161.63	49.39	0.00	129.08*	12.48*	11.12*	0.00	0.31	0.04	0.04
F	8.919,13	231,195.99	147.31	170.64	219.15*	885.32*	11.37*	38.44*	0.70	0.90	0.11	0.29
VF	622,52	721.73	22.66	3.78	15.29*	2.76*	1.75	0.85	0.14	0.03	0.02	0.01
E	40,70	261.14	12.95	4.44								

V – version; F – fraction;E - errorp<0,005

Table 3. Differences in means (LSD test)

Traits	Fertile version (I)	Sterile version (J)	Mean Difference (I-J)	Std. Error	95 % Confidence Interval for Differences	
					Upper Bound	Lower Bound
Fraction %	1	2	-0.001	0.742	-1.461	1.459
Weight of 1000 seed	1	2	-21.351*	1.879	-25.050	-17.652
First count	1	2	-1.478*	0.418	-2.302	-0.655
Germination	1	2	-0.817*	0.245	-1.299	-0.335

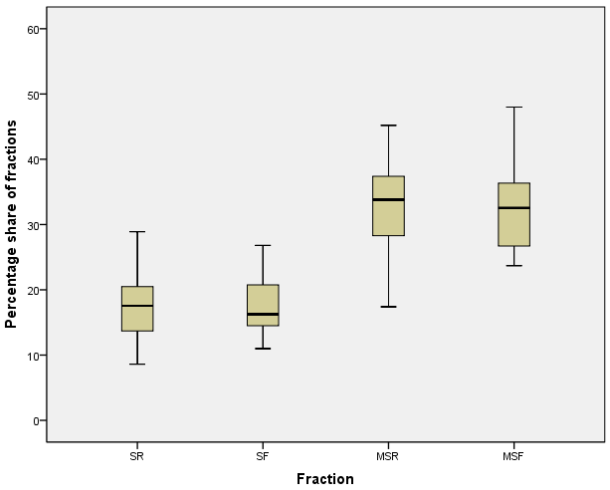

Fig. 1. Percentage share of seed fractions over the hybrid version whit fertile cytoplasm

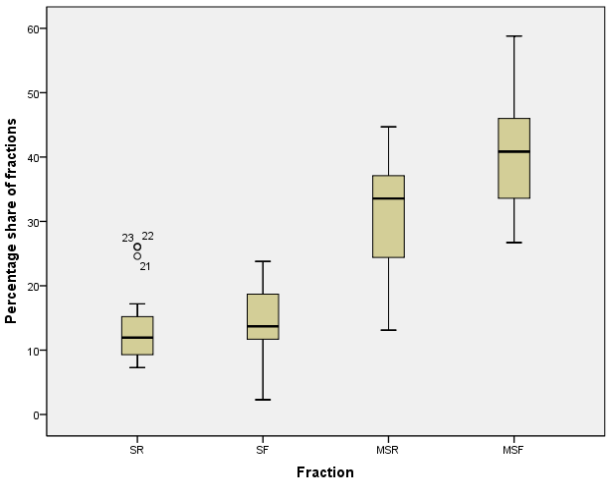

Fig. 2. Percentage share of seed fractions over the hybrid version whit sterile cytoplasm

The seed size was followed by the percentage of separated fractions, hence seed produced on the sterile basis had more extreme values for all fractions. Seeds of the fertile version were smaller, weighted of 1000 seed varied from 249.9 g to 366.6 g, while these values ranged from 265.5 g to 396.3 g in the sterile version. *Kaeser (2002)* has established insignificantly higher yields of sterile cytoplasm hybrids than of fertile counterpart.This author's results pointed out to the increased yields due to the increased number of seeds and weight of 1000 seed. *Stamp et al., (2000)* have also recorded higher yields in hybrids with sterile cytoplasm due to a greater seed weight and an increased number of kernels per ear.

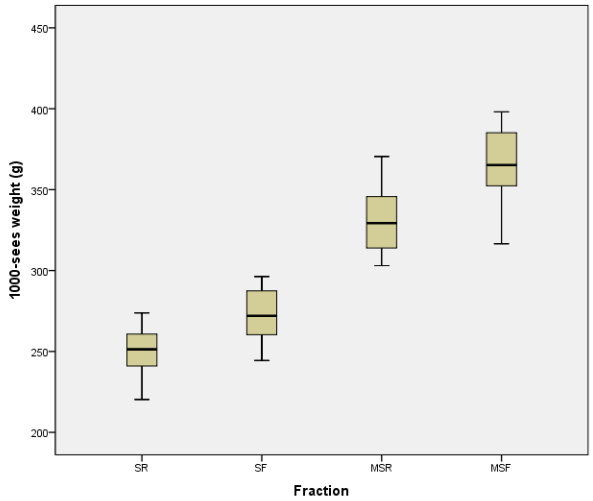

Fig. 3. Weight of 1000 seed over the hybrid version whit fertile cytoplasm

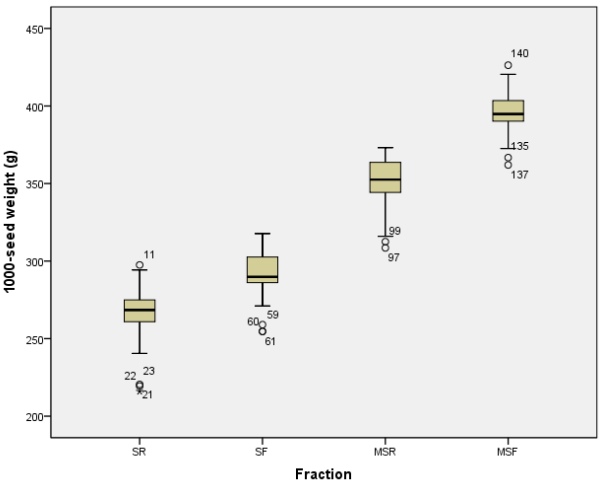

Fig. 4. Weight of 1000 seed over the hybrid version whit sterile cytoplasm

The variation in the third trait, early germination-first count was greater in the fertil cytoplasm version of the hybrid and amounted to 2.5>SD<6.5. On the other hand, this variation in the sterile cytoplasm version of the hybrid was bellow 2.5 %. All differences as shown by comparisons of means were significant (Figure 5, 6). A genotypic combination and synchronicity of flowering of parental inbreds had the primary effect on the expression of traits in seed crops *(Tabaković et al., 2016).*

Seed germination is a trait that was more uniform than the first count in all four fractions and the standard deviation did not exceed 3.5 %. The lowest value of MSF fraction of 78 % was recorded in the fertile variant, while the maximum germination value of 100 % was detected in all studied variants (Figure 7, 8).

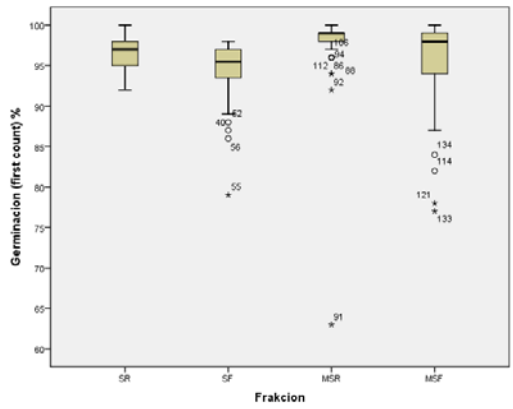

Fig. 5. Means of the early germinacion (first count) over the hybrid version whit fertile cytoplasm

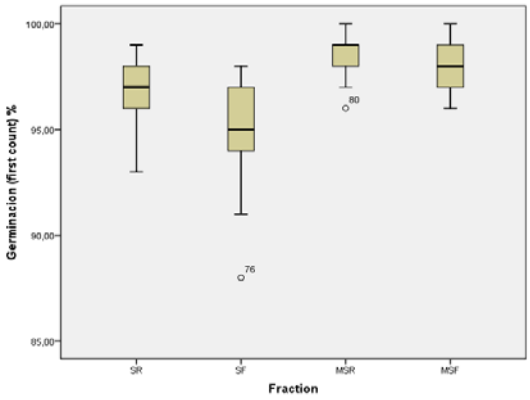

Fig. 6. Means of the early germinacion (first count) over the hybrid version whit sterile cytoplasm

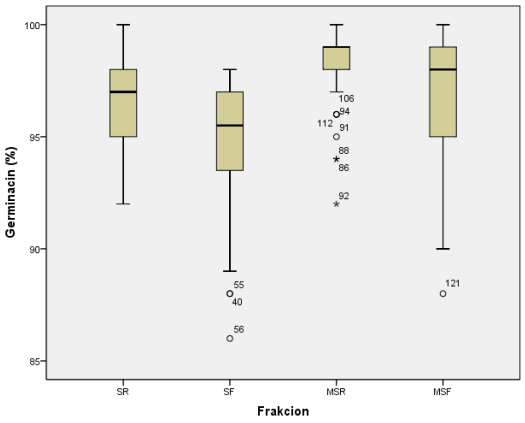

Fig. 7. Means of seed germination over the fertil cytoplasm version of the hybrid

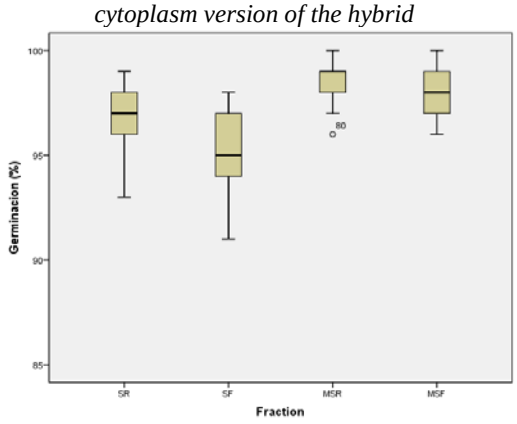

Fig. 8. Means of seed germination overthe hybrid version whit sterile cytoplasm

CONCLUSION

According to obtained results, the following conclusion may be made that sterile variants are better than fertile ones was proven. The advantage of introductions of sterile forms into seed production is, first of all, in reliable technology of production of good-quality seed material, and then the economic effect cannot be ignored. Besides these advantages, all gained results proved significant differences in relation to morphological and physiological seed traits. The weight of 1000 seed of the sterile version wass higher by even 21 g than of the fertile version, while the differences in the first count and germination were greater by 1.5 % and 0.817 %, respectively. The partial effect of hybrid combination version is the greatest for the weight of 1000 seed (η=0.31). Mass introduction of sterile forms could significantly contribute to the improvement of production technology and maintenance of seed material quality.

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