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AVERAGE YIE F ZPCC 341 DUE TO DIFFERENT PERCENTAGE OF FER AND STERILE PLANTS PARTICIPATION

VISINA PR NOG PRINOSA ZPSC 341 U ZAVISNOSTI OD PROCENT CEŠĆA FERTILNIH I STERILNIH BILJAKA

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ABSTRACT

The aim of the study was to the changes in grain yields in relation to the sterile to fertile plants ratio.Total of 21 mixtures of 0, 5, 10 up to 100 % e plants mixed with the sterile variant of the hybrid ZPSC 341 was made. Because of reliability of the experiment the original fertile hybrid ZPSC 341 was used as a check three times. Effects of fertile, i.e. sterile cytoplasm of the observed hybrid on yield and yield variations were studied. The extent of dependence of the percentage of fertile plants on yield was determined. Furthermore, the sterile to fertile hybrid variant ratio resulting in the highest yield was established. The analysis of results indicate that the highest average yield (13.273 t ha^{-1}) was obtained with 90 % fertility, while the lowest average yield (11.510 t ha^{-1}) was gained with 10 % fertility.

Key words: *cytoplasmic male sterility, maize, yield.*

REZIME

U radu su prikazani rezultati ogleda ZPSC 341 hibrida proizvedenog u 2015 godini. Cilj istraživanja bio je da se izvođenjem ogleda na određenoj lokaciji i primenom statističke analize, odredi optimalan odnos muški sterilne (cms-S osnova) i muški fertilne komponente komercijalnog hibrida ZPSC 341, kako bi se u komercijalnoj proizvodnji postigao maksimalan prinos. Ogled je postavljen na lokaciji Bijeljina u tri ponavljanja po slučajnom blok sistemu. Napravljena je 21 smeša sa po 0, 5, 10 do 100% fertilnih biljaka pomešanih sa sterilnom varijantom hibrida ZPSC 341. Kao kontrola, radi pouzdanosti eksperimenta u ogled je uključen orginalni fertilni hibrid ZPSC 341 kao standard tri puta (ZPSC 341 iz ručne oplodnje, ZPSC 341 F1 i ZPSC 341 iz recipročnog ukrštanja). Posmatran je prinos, variranje prinosa i uticaj na prinos učešća fertilne odnosno sterilne citoplazme ispitivanog hibrida. Statistička obrada podataka obuhvatila je analizu varijanse po slučajnom blok sistemu, regresionu i korelacionu analizu prinosa zrna i procenta fertilnih biljaka u hibridu ZPSC 341, kako bi se utvrdile promene prosečnog prinosa zrna u odnosu na procenat učešća sterilnih i fertilnih biljaka. Utvrđeno je u kojoj meri postoji zavisnost procenta fertilnosti na prinos odnosno koji odnos sterilne i fertilne varijante hibrida je ostvario najveći prinos. Analiza rezultata je pokazala da je najveći prosečan prinos bio sa 90% fertilnosri (13,273 t ha^{-1}) za razliku od hibrida sa 10% fertilnosti koji je imao najmanji prosečan prinos (11,510 t ha^{-1}).

Ključne reči: *citoplazmatična muška sterilnost, kukuruz, prinos.*

INTRODUCTION

Maize, due to its morphology, is a plant very suitable for the production of hybrid seed in large quantities, because hybridisation is relatively easily achieved by sowing parental components in alternate rows and by detasseling, i.e. removal of pollen-producing flowers (tassels) from female plants immediately after their exsertion. In such manner the following is achieved: pollen of solely male parents (which are not detasseled) circulates in the field, and hybrid seed is produced on female (detasseled) plants.

In order to achieve total hybridisation it is necessary to remove all tassels in female rows in due time (prior to pollen shed). This requires a large labor force, who have to be engaged in a relatively short period of time (10 to 30 days). Besides the provisions of detasselers it is necessary to provide appropriate control and super quality control of the work performed.

The machine cutting off tassels is the simplest solution to the problem of detasseling in maize hybrid seed production. Experiments with detasseling machines, cutters, had been performed by many researchers (*Dungan and Wudworth, 1939; Borgeson, 1943; Kiesslbach, 1945; Bauman, 1959; Hunter et al., 1973*), and obtained results were summarised by *Huey (1971)* and *Trifunović (1975)*. *Huey (1971)* states that mechanical cutters of tassels are not usable under poor weather conditions, do not solve the problem of removing tassels on tillers and plants lagging in growth, and at the same time it is not possible to reduce the average number of leaves lost per plant bellow 2-3 even with the most careful work.

The possibility for an effective solution to the problem of detasseling in hybrid seed production has emerged with the discovery of cytoplasmic male sterility in maize. Using the sterile male version of the female component completely eliminates the need for detasseling, then the number of workers needed for control tasks is minimised, production quality is improved and costs and associated risks are significantly reduced, and finally, in this way, the seed production becomes very attractive for producers.

The first description of male sterility was given by *Rhoades (1931)*. Further investigations showed that sterility was caused by cytoplasmic factors.

Considering that the highest possible yields, with other favourable agronomic traits, are the principal aim of commercial production and in the light of increasingly strong competition in

the seed maize market, it is necessary to evaluate the effect of maize sterility on grain yield of ZPSC 341, one of leading hybrids at the Maize Research Institute, Zemun Polje, and to determine the optimal ratio of sterile to fertile component for the need of commercial production of this hybrid ZPSC 341.

MATERIAL AND METHOD

The objective of the study was to perform trails in a certain location and to apply the statistical analysis in order to determine the changes in grain yields in relation to the sterile to fertile plants ratio. Total of 21 mixtures of 0, 5, 10, up to 100 % of fertile plants mixed with the sterile variant of the hybrid ZPSC 341 was made. Because of reliability of the experiment the original fertile hybrid ZPSC 341 was used as a check three times (had-pollinated ZPSC 341, ZPSC 341 F_1 and reciprocally crossed ZPSC 341).

The three-replicate trial was set up according to the randomised block design in the location of Bijeljina. The elementary plot consisted of two rows with 0.7-m inter-row distance, 10 hills per row, 0.37-m inter-hill distance and 2 plants per hill. The size of elementary plot amounted to 5.18 m².

The trial was set under conditions of dry-land farming. Sowing was performed at the optimum time. Standard maize cropping practices were applied.

The total number of plants, separately of fertile and sterile plants, was recorded for each elementary plot during the growing season when pollination was completed.

Harvest was done in the time of full maturity. The yield of fresh ear maize was measured at harvest for each hybrid per replicates and each elementary plot. The submitted sample consisting of five ears was measured with the technical balance in the laboratory.

Statistical data processing encompassed the following: analysis of variance according to the randomised block design, regression and correlation analyses of grain yield and percentage of fertile plants in the hybrid ZPSC 341, so as to determine changes in grain yields in relation to the percentage ratio of sterile to fertile plants (*Hadživuković, 1991*).

RESULTS AND DISCUSSION

Table 1 shows that the most yielding hybrid (13.273 t ha^{-1}) had 90 % of fertile plants, while the hybrid had 10 % of fertile was the least yielding (11.510 t ha^{-1}).

According to the stated, it may be concluded that edaphic and climatic conditions in the given location had a crucial effect.

If the average yields gained in the location of Bijeljina (12.415 t ha^{-1}) are compared with the yields of the hybrids ZP 360 (14.160 t ha^{-1}) and ZP 434 (14.260 t ha^{-1}) recorded by *Videnović et al. (2000)* in the location of Sombor it can be concluded that the yields recorded in the location of Bijeljina were lower by 2.0 t ha^{-1}.

Furthermore, studies of the most recent the 5th and the 6th generation of ZP hybrids carried out by *Jovanović et al. (2007)* show that the highest yields in Serbia were recorded in the following hybrids: ZP 684 (9.50 t ha^{-1}), ZP 544 (9.23 t ha^{-1}) and ZP 434 (9.21 t ha^{-1}). The hybrids ZP 341 (10.02 t ha^{-1}) and ZP 434 (9.50 t ha^{-1}) were the most yielding in the region of Banat, while the highest yield in the region of Srem was achieved with the hybrid ZP 434 (11.34 t ha^{-1}). Moreover, based on long-term studies on medium late maturity hybrids with a shorter growing season carried out by the group of researches, it was concluded that given hybrids had significantly lower grain moisture content (16-18 %).

Table 1. Average yield and its variation interval for the check and different levels of fertility percentage

Ordinal number	% Fertility	Average yield t ha^{-1}	95 %-ni interval of confidence for mean yield	
			Lower limit	Upper limit
1	ZP341Hand-pollinated	12.339	7.936	16.741
2	ZP341F1	11.716	9.620	13.812
3	ZP341Rec.	12.353	10.822	13.885
4	0	12.507	10.568	14.446
5	5	12.248	11.180	13.316
6	10	11.510	9.880	13.432
7	15	12.241	9.880	15.194
8	20	12.068	9.550	14.681
9	25	12.486	11.786	13.186
10	30	11.987	9.170	14.803
11	35	12.747	10.465	15.030
12	40	12.992	9.803	16.181
13	45	13.143	10.306	15.980
14	50	12.753	9.098	16.408
15	55	12.648	12.061	13.234
16	60	13.184	9.901	16.467
17	65	11.956	7.101	16.810
18	70	12.353	11.583	13.123
19	75	12.452	10.324	14.579
20	80	11.947	10.126	13.768
21	85	12.538	9.239	15.836
22	90	13.273	10.974	15.572
23	95	12.481	9.071	15.891
24	100	12.043	9.126	14.960

Based on everything stated, it may be concluded that the 5th generation of ZP hybrids (FAO 300-400) expressed exceptional yielding and yield stability. Additionally, these hybrids are characterised by a shorter growing period and significantly lower grain moisture at harvest, which is great advantage due to reduced costs of maize drying and storage.

Applied the statistical method of the two-factorial analysis of variance and confirmed the effect of the hybrid combination and the location on physiological and morphological traits that were the objective of the present study (*Tabaković et al., 2015; Pavlov et al., 2015).*

Results presented in Table 2 point out that different ratios of sterile to fertile components in the seed mixture used in sowing do not significantly affect achieved yields (r=0.249).

Table 2. Correlation coefficient of yield and fertility percentage

Ordinal number	Location	r_{xy}
1	Bijeljina	0.249

Furthermore, we were not able to determine a relative importance of each independent variable for depended variable - yield (Table 3). Insignificant effects of various ratios of fertile to sterile components are noticeable through low regression coefficients (ß). Their contribution to the changes in yields amounts to only 6.2 % (R^2).

Table 3. Values of parameters of squares regression model and coefficient of determination

Coefficient	β_0	β_1	β_2	R^2
Value	-0.0002X²	0.0234X	8.425	0.062

According to the coefficient of determination, a small percentage dependence can be observed, pointing to the fact that a high percentage of variance affecting yield variation was not encompassed.

The coefficient of determination for the location of Bijeljina (0.062) is presented in Figure 1.

Figure 1 does not show regularity of effects of percentage of fertile and sterile plants on yields, which points out to the possibility of their independence.

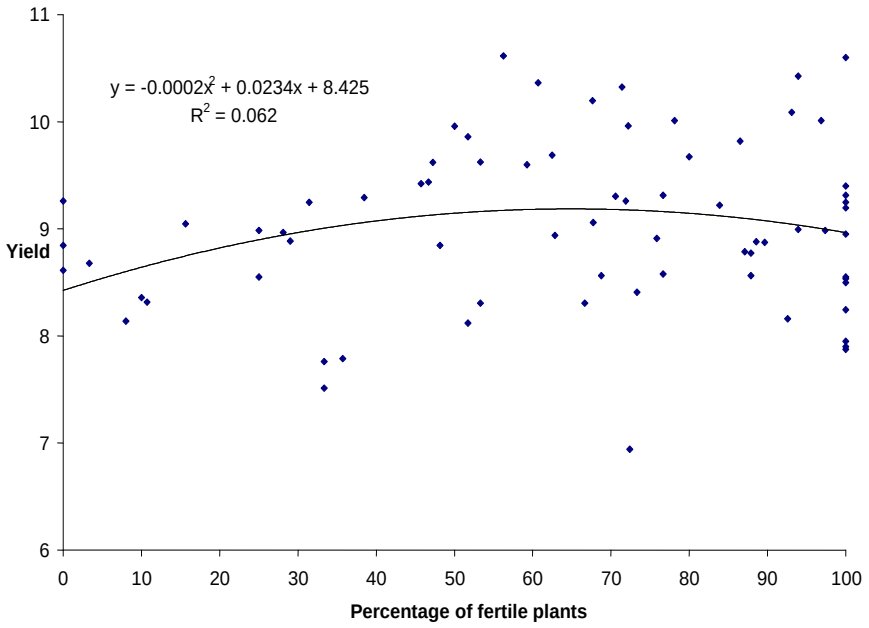

Fig. 1. Calculated squares regression equation for the location of Bijeljina

CONCLUSION

Issues related to the commercial seed production of the hybrid ZPSC 341 and effects of different percentages of fertile and sterile plants on yield of this hybrid were observed in this study.

Based on the results leads to the conclusion that the grain yield was significantly influenced by the location and had environmental conditions. The obtained average yields were: highest 13.273 t ha^{-1} and the lowest 11.510 t ha^{-1}. As for the relationship of fertile and sterile variants in the crop, proved to be the most favorable with 90 % share of fertile plants, a most unfavorable relationship was with a 10 % share of fertile plants. Correlation coefficients were positive but there was no statistical significance in yield and percentage of fertile and sterile plants.

Although obtained results do not show the optimal ratio of sterile to fertile variants of the hybrid ZPSC 341 for its commercial production, there are sufficient reasons to assume that the previously applied 75 % to 25 % ratio of fertile to sterile variants is the optimal one for the commercial production of the hybrid ZPSC 341.

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