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VARYING OF AVERAGE YIELDS OF THE COMMERCIAL HYBRID ZPSC 341 OVER DIFFERENT LEVELS OF PERCENTAGE PARTICIPATION OF FERTILE PLANTS

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Abstract

The aim of the study was to determine the optimal ratio of male sterile (cms-S) to male fertile components of the hybrid ZPSC 341, in order to obtain the maximum yield in the commercial production. The present study encompassed observance of effects of different proportions of fertile to sterile plants on grain yield of the hybrid ZPSC 341. The three-replicate trial was set up according to the randomised block design. Twenty one mixtures with 0, 5, 10, …up to 100% of fertile plants mixed with the sterile variant of the hybrid ZPSC 341 were made. The original fertile hybrid ZPSC 341 was three times included into the trial as a check (hand-pollinated ZPSC 341, ZPSC 341 F1 and reciprocally crossed ZPSC 341), so as to control reliability of the trial. Yield, variations in yields and effects of fertile and sterile cytoplasm of the hybrid on yields were observed. The effect of the percentage of fertility, i.e. of sterile to fertile variant ratio on yield was determined. Gained results show that the highest average yield (16.071 t ha^{-1}) was achieved with 90% of fertility, in contrast to the hybrid with 30% of fertility in which the lowest yield (14.112 t ha^{-1}) was recorded.

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

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 a way 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 great many workers, 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 others), and obtained results were summarised by Huey (1971) and Trifunović (1975). H u e y (1971) states that mechanical cutters of tassel 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.

Material and methods

In order to determine the optimal ratio of sterile to fertile variant of the hybrid ZPSC 341 in the commercial production, 21 mixtures with 0, 5, 10, up to 100% of fertile plants mixed with the sterile variant of the hybrid ZPSC 341 were made. The original fertile hybrid ZPSC 341 was three times included into the trial as a check (hand-pollinated ZPSC 341, ZPSC 341 F1 and reciprocally crossed ZPSC 341), in an attempt to control reliability of the trial.

Material and methods of setting up field trials

The three-replicate trial was set up according to the randomised block design in the location of Pančevo in 2013. 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 (from April 5 to May 1). 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.

Methods of experimental data processing

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 (according to Hadživuković, 1991).

Results and discussion

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-% interval of confidence for mean yield	
			Lower limit	Upper limit
1	Hand-pollinated ZP341	14.980	13.637	16.322
2	ZP341F1	13.952	13.744	14.159
3	ZP341Rec.	14.718	12.232	17.204
4	0%	14.260	12.369	16.150
5	5%	14.590	13.687	15.494
6	10%	14.235	13.328	15.142
7	15%	14.294	12.489	16.098
8	20%	15.137	14.045	16.230
9	25%	14.903	12.764	17.043
10	30%	14.112	12.743	15.481
11	35%	14.669	14.286	15.051
12	40%	14.515	13.711	15.320
13	45%	14.435	12.901	15.970
14	50%	14.503	10.921	18.085
15	55%	14.916	14.562	15.270
16	60%	15.279	13.604	16.953
17	65%	15.237	14.029	16.446
18	70%	14.713	11.857	17.569
19	75%	14.804	11.850	17.758
20	80%	14.925	14.632	15.217
21	85%	15.151	12.749	17.552
22	90%	16.071	15.625	16.517
23	95%	15.435	14.694	16.175
24	100%	15.269	13.678	16.860

Table 1 shows that the most yielding hybrid (16.071t ha^{-1}) had 90% of fertile plants, while the hybrid ZPSC 341F1 was the least yielding (13.952 t ha^{-1}).

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

The conclusion made by comparison of average yields (14.796 t ha^{-1}) obtained in the location of Pančevo and yields of hybrids ZP 360 and ZP 434 (14.160 and 14.260 t ha^{-1}) recorded by Videnović et al. (2000) in the location of Sombor, is that achieved average yields were approximately equal.

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%).
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.
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=0.390).

Table 2. Correlation coefficient of yield and fertility percentage

Ordinal number	Location	r_{xy}
1	Pančevo	0.390

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 15.2 % (R^2).

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

Location	β_0	β_1	β_2	R^2
Pančevo	-4E-05X^2	0.0118X	10.049	0.152

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 Pančevo (0.152) is presented in Figure 1.

Figure 1. Calculated squares regression equation for the location of Pančevo.

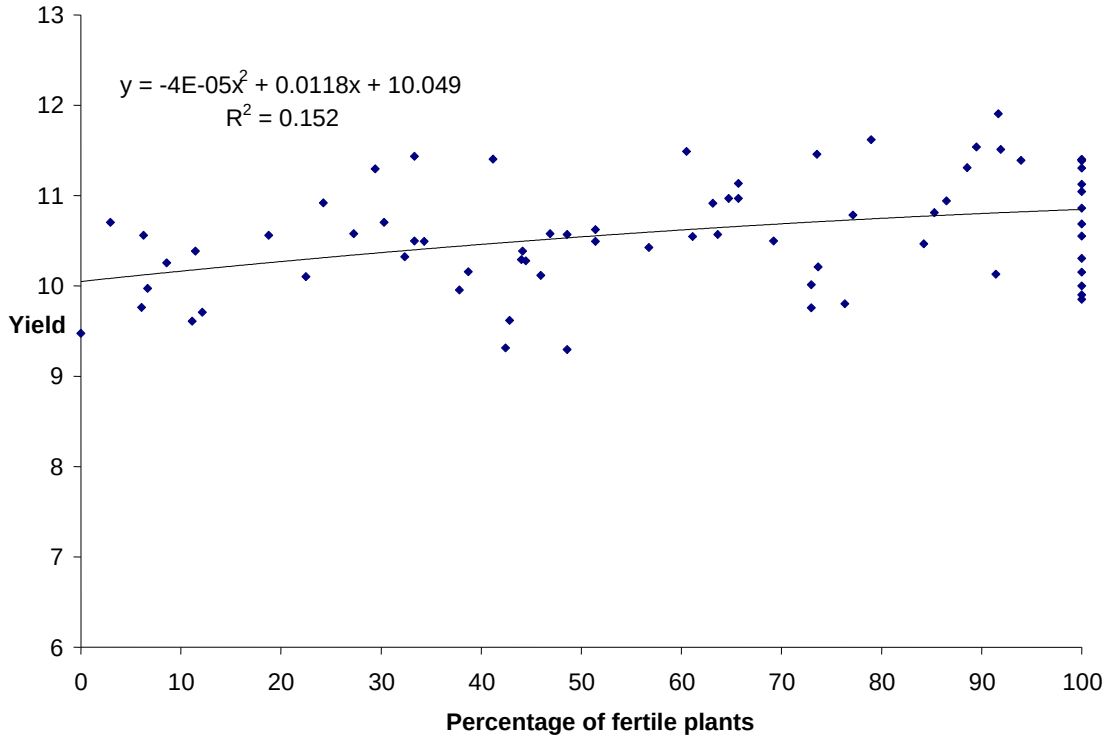

Figure 1 does not show regularity of effects of percentage of fertile and sterile plants on yields, which points out to the possibility of their independence.

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.

According to obtained results, the following may be concluded:

The location statistically significantly affected maize grain yield;
Environmental conditions significantly affected yield variation
The highest recorded yield amounted to 16.071 t ha^{-1}
The lowest recorded yield amounted to 13.952 t ha^{-1}
The most favourable ratio of fertile to sterile variant was 90% of fertile to 10% of sterile plants;
The least favourable ratio was with the participation of 30% of fertile plants (14.112 t ha^{-1})
Although correlation coefficients were positive, there was no statistical significance of yield and percentages 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.

References

Bauman, L. F. (1959): Progress report on genetic control of male sterility Proc of 6th Ann. Hybrid corn Industry-Res. Conf., pp. 13-18.

Borgeson, C., (1943): Methods of detasseling and yield of hybrid seed corn. Jour. Amer. Soc. Agron., 35: 919-922.

Dungan, G. H. and Woodworth, C. M. (1939): Loss resulting from pulling leaves with tassels in detasseling corn. Ag J., 31: 872-875.

Hadživuković, S. (1991): Statistički metodi s primenom u poljoprivrednim i biološkim istraživanjima. Drugo izdanje. Poljoprivredni fakultet, Novi Sad. (Statistical method with applications in agricultural and biological research).

Huey, J. R. (1971): Experiences and results of mechanical topping versus hand detasseling in 1971. Proc. of 26th Corn. Res. Conf. pp. 144-147. Amer. Seed Trade Assoc.

Hunter, R. B., Mortimore, C. G., and Kannenberg, L. W. (1973): Inbred maize performance following tassel and leaf removal. Agronomy Journal 65: 471-472.

Jovanović, Ž., Tolimir, M., Kaitović, Ž., (2007): ZP hibridi kukuruza u proizvodnim ogledima 2006. godine. Zbornik naučnih radova 2007. Vol. 13. br. 1-2. str.53-60. (ZP maize hybrids in the production trials in 2006).

Kiesselbach, T. A. (1945): The detasseling hazard of hybrid seed corn production. Jour. Amer. Soc. Agron. 37: 806-811.

Rhoades, M. M., (1931): The cytoplasmic inheritance of male sterility in Zea mays. J. Genet. 27:71-93.

Trifunović, V., (1975): Proučavanje sterilnosti polena materinskih linija kukuruza s obzirom na dobijanje hibridnog semena. Arhiv za poljoprivredne nauke. 28 (104): 59-107. (The study of pollen sterility of maternal maize lines with regard to obtaining hybrid seed).

Videnović, Ž., Jovanović, Ž., Kresović, B., Tolimir, M. (2000): Effects of agroecological conditions on zp maize hybrid yield in Serbia. Genetika, Vol. 32, No. 3. str. 397-405.