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Average yield of hybrid ZPSC 341 due to different percentage of fertile and sterile plants in seed production in location Vojvodina

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ABSTRACT

The aim of the study was to determine the changes in grain yields in yield trials related to the sterile and fertile ratio of female parent in seed production. Total of 21 mixtures of 0, 5, 10, etc. 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. Effects of fertile, i.e. sterile male cytoplasm in female parent 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 (16.024 t ha^{-1}) was obtained with 80% fertility of female plants, while the lowest average yield (13.892 t ha^{-1}) was gained with 15% fertility, although the difference was not significant.

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). 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.

Material and methods

The objective of the study was to perform yield trials 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 female plants ratio from previous seed production. Total of 21 seed mixtures, from 0, 5, 10, etc. up to 100%, from seeds produced by fertile seed production and seeds produced from cytoplasmatic male sterile production of hybrid ZPSC 341 was made. Because of reliability of the experiment, the original fertile hybrid ZPSC 341 was used as a check three times (hand-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 Bečej. 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 m^2.

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.

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 female parent plants (according to Hadživuković, 1991).

Results and discussion

Table 1 shows that the most yielding hybrid (16.054 t ha^{-1}) had 80% of fertile plants, while the hybrid had15% of fertile was the least yielding (13.892 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 Bečej (15.024 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 Bečej were higher by over 1.0 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% interval of confidence for mean yield	
			Lower limit	Upper limit
1	ZP341Hand	14.284	11.770	16.797
2	ZP341F1	15.160	12.940	17.381
3	ZP341Rec.	14.471	12.107	16.834
4	0%	16.008	14.047	17.969
5	5%	14.398	12.198	16.599
6	10%	15.612	12.275	18.948
7	15%	13.892	7.763	20.021
8	20%	14.493	13.811	15.175
9	25%	14.978	12.994	16.962
10	30%	14.591	11.236	17.945
11	35%	15.019	13.980	16.059
12	40%	14.989	12.076	17.901
13	45%	14.753	12.906	16.599
14	50%	15.611	13.527	17.696
15	55%	14.328	12.331	16.326
16	60%	14.009	10.203	17.815
17	65%	14.694	9.480	19.908
18	70%	15.862	11.696	20.028
19	75%	15.448	14.808	16.088
20	80%	16.054	12.015	20.092
21	85%	15.031	11.430	18.633
22	90%	15.975	15.253	16.697
23	95%	15.382	13.418	17.345
24	100%	15.532	13.909	17.155

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 (Tabaković et al., 2015., Pavlov et al, 2015).

Results point out that different ratios of sterile to fertile female parent in the seed mixture used in sowing do not significantly affect achieved yields (r=0.082).

Furthermore, we were not able to determine a relative importance of each independent variable for depended variable - yield (Table 2). 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 0.7 % (R^2).

Table2. Values of parameters of squares regression model and coefficient of determination

Location	β_0	β_1	β_2	R^2
Bečej	$-7E-06X^2$	0.0028X	10.219	0.007

According to the coefficient of determination, 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 Bečej (0.007) is presented in Figure 1.

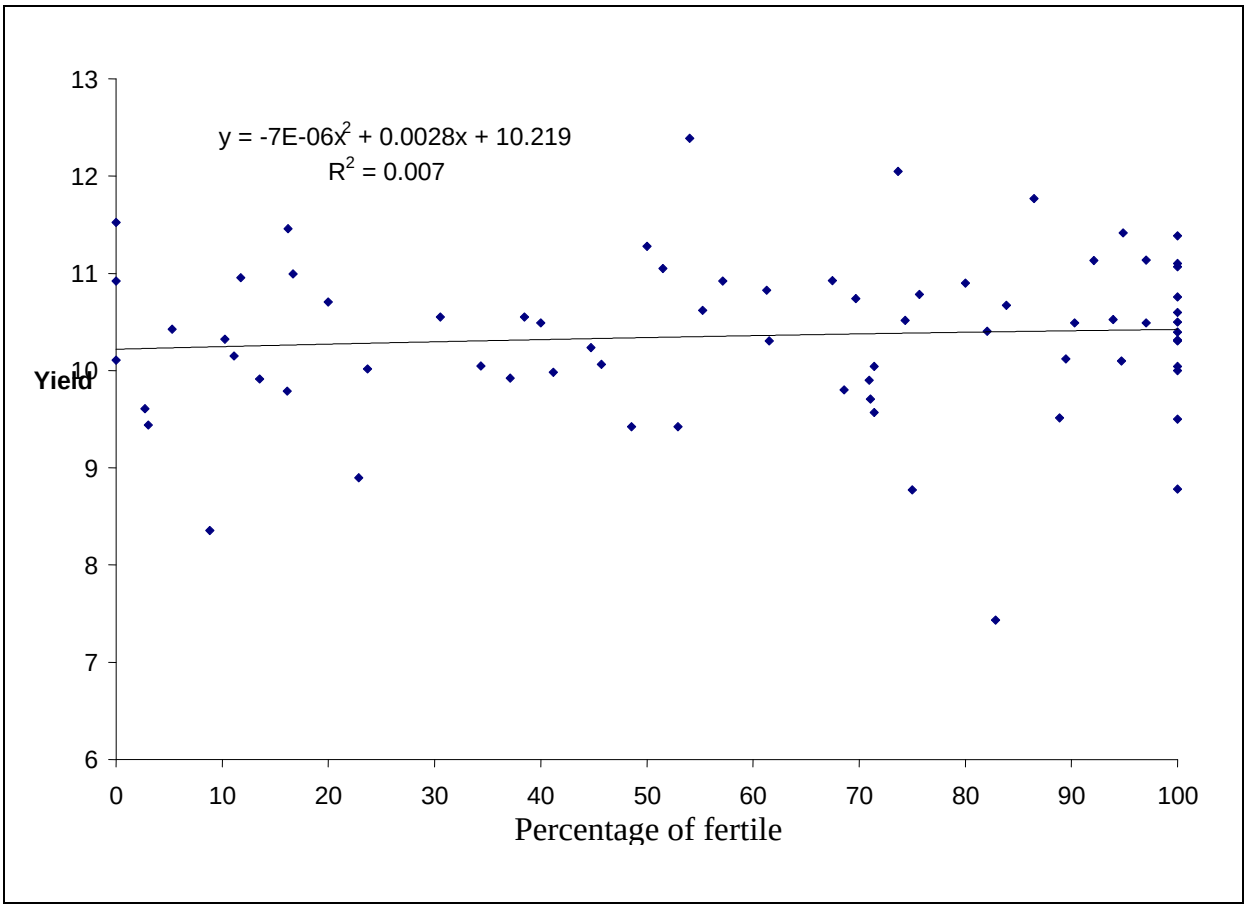

Fig. 1. Calculated squares regression equation for the location of Bečej

Figure 1 does not show regularity of effects of percentage of fertile and sterile plants on yields.

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 16.024 t ha^{-1}.
- The lowest recorded yield amounted to 13.892 t ha^{-1}.
- The most favourable ratio of fertile to sterile variant was 80% of fertile to 15% of sterile plants.
- The least favourable ratio was with the 15% of fertile plants (13.892 tha^{-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.

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