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EFFECTS OF DIFFERENT TYPES OF CYTOPLASM ON PLANT HEIGHT OF MAIZE INBRED LINES

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Abstract

The aim of the study was to determine effects of both, different types of cytoplasm (*cms*-C, *cms*-S and fertile) and environmental factors, on the plant height of 12 maize inbred lines. The trial with inbred lines was set up in two locations (Zemun Polje - Selection field and Zemun Polje - Školsko dobro) in 2008 and 2009. Very significant differences in the plant height among inbred lines in dependence on the type of cytoplasm and the location were established by the analysis of variance. The average plant height varied from 161.8cm (L_{11}) to 220.5cm (L_1). In relation to the type of cytoplasm (*cms*-C, *cms*-S and fertile), the average values of the plant height very significantly varied ($P \leq 1\%$). The plant height in inbred lines with fertile cytoplasm was very significantly higher ($Lsd_{0.01}$) (187.6cm) than in inbred lines with sterile *cms*-C (181.1cm) and *cms*-S (180.2cm) types of cytoplasm. Varying of average values of the plant height was very significant ($P \leq 1\%$) in both years of investigation and locations. In 2008, the average plant height of inbred lines (173.98cm) was significantly lower than the average values recorded in 2009 (191.94cm). Very significantly higher values of the plant height were determined in the first location, Selection field (189.25cm) than in the second location, Školsko dobro (176.67cm).

Key words: *Cytoplasmic male sterility, inbred lines, plant height*

Introduction

Maize hybrids are the product of the cross between inbred lines derived in the process of selection by controlled self-pollination of selected genotypes until homosigosity is reached. In the hybrid maize seed production it is necessary to perform deta sseling on the female component in order to avoid self-pollination and reduction in heterosis of F_1 generation hybrids.

It is necessary that complete hybridisation between parental components is achieved otherwise heterosis will not be expressed in the F_1 generation. If complete hybridisation is not achieved self-pollinated female component will occur in produced seed and heterosis will not be fully used, while total yield per area unit will be reduced.

In the production of hybrid maize seed, it very often happens that complete hybridisation between parental components cannot be achieved during deta sseling even by the best producers. In order to achieve complete hybridisation it is necessary to remove all tassels in female component rows prior to pollen release. This job requires a great number of workers who should be engaged in a relatively short period of time (10-30 days). In addition to these workers, it is necessary to provide appropriate control and super control of quality of the job done, which means engagement of a large number of skilled workers.

Mechanical topping in the production of hybrid maize seed has been imposing from the beginning of this production. Experiments with mechanical topping had been performed by numerous researches (Dungan and Wudworth, 1939; Borgeson, 1943; Kiesslbach, 1945; Bauman, 1959; Hunter *et al*., 1973 and many others), while results of their studies were summarised by Huey (1971) and Trifunović (1975). Huey (1971) stated that mechanical toppers were not usable under poor weather conditions, and that they did not solve the problem of deta sseling on tillers and under developed plants, while leaf loss could not be lower than 2-3 even with the most attentive operation.

The possibility of successful solving problem of deta sseling in the hybrid maize seed production occurred when cytoplasmic male sterility in maize was discovered. The use of male sterile versions of the female component thoroughly eliminates the need to perform deta sseling, reduces the number of workers necessary for control, effectively improves production quality and significantly reduces costs and accompanying risks, and ultimately, in this way, the seed production becomes very attractive for producers.

The first description of male sterility was provided by Rhoades (1931). Further researches showed that cytoplasmic factors were responsible for sterility.

Cytoplasmic male sterile plants of the female component do not consume nutrients and energy to form and shed pollen, but to form the grain. Fertile pollen is a great recipient of mineral nitrogen, much more than any other part of the plant. It was estimated that sterile plants may save approximately 10-30 kg ha^{-1} of nitrogen, which is, instead of being used to form pollen, directed into female reproductive organs, thus resulting in the grain yield increase.

Kaeser *et al.* (2003) considers cytoplasmic male sterility (*cms*) a trait interesting for the maize seed industry, because it leads to lower costs of the hybrid seed production by eliminating the labour-intensive mechanical emasculation of parental lines.

In recent years, many hybrid seeds based on male sterile inbred lines have been produced with major *cms* types, *cms*-C and *cms*-S, replacing *cms*-T, which is susceptible to maize leaf pathogens.

The main goal in the commercial maize production is the highest possible grain yield, along with other favourable agronomic traits. Increasingly strong competition in the market of maize seed requires studies on the effect of the type of cytoplasm and its interaction with a genotype on yield and some morphological traits for the purpose of the production.

Material and Methods

Material and methods in performing field trials

Total of 12 maize inbred lines with three different types of cytoplasm was observed: 1) inbreds with the *cms*-C type, 2) inbreds with the *cms*-s type and 3) inbreds with fertile cytoplasm.

Two trials were set up in two locations (Zemun Polje - Selection field and Zemun Polje - Školsko dobro) in 2008 and 2009. The tree-replication trials were set up according to randomised block design. Each plot within the replication consisted of 4 rows. Fertile versions of inbred lines were sown in two border rows and these inbreds had a role of a pollinator for their sterile counterparts. Each row consisted of 12 hills with 4 seeds each. The within-row hill distance amounted to 40 cm, while the inter-row distance amounted to 70 cm. The elementary plot size was 5.6m².

The trial was set up under rainfed conditions. Cropping practices common for maize were applied during the growing season.

Thinning to two plants per hill was done in the 5-leaf stage. In order to avoid the effect of border plants, only plants from 10 inner hills were used in the analysis of agronomic traits.

The 12 observed inbred lines encompass the majority of maize germplasm that is used in the seed production of the Maize Research Institute. The comparison of probable pollen restoration into two observed *cms* types can point out to more suitable *cms* type for the seed production under conditions of our country.

Immediately prior to harvest, a total number of both, plants and lodged and broken plants, was great in all replications. Broken plants were all those plants that were broken below the upper-ear bearing node, while lodged plants were those in which the angle between the stalk and the ground was less than 45º.

Harvest was done at full ripeness.

Methods of experimental data processing

Statistical-biometrical data processing is based on means per replication. Differences among analysed maize inbred lines with various sources of cytoplasm (C, S and fertile), in two locations and during two years as well as their interactions were determined by the analysis of variance for the factorial trial set up according to the randomised block design, as wall as by the LSD test at the probability levels of 5% and 1% (Hadživuković 1991). In order to draw objective conclusions on effects of observed factors on tested traits of maze inbred lines and the possibility to apply parametric tests (ANOVA and LSD-test), homogeneity of variance was tested.

Results and Discussion

The average plant height of inbred lines ranged from 161.8cm (L_{11}) to 220.5cm (L_1) (Table 1). In dependence on the type of cytoplasm (*cms*-C, *cms*-S and fertile) these values very significantly ($P \leq 1\%$) varied. Inbred lines with fertile cytoplasm were on the average very significantly ($Lsd_{0,01}$) higher (187.6cm) than inbreds with sterile *cms*-C type (181.1cm) and *cms*-S type (180.2cm).Variation of average plant heights of all inbred lines was very significant ($P \leq 1\%$) in both years of investigations and both locations. The average plant height (173.98cm) was very significantly lower in 2008 than in 2009 (191.94cm). Furthermore, a very significantly greater plant height was obtained in the first location, Selection field (189.25cm) than in the second location, Školsko dobro (176.67cm), (Table 1).

Table 1. Average plant heights over inbred lines, years, type of cytoplasm and locations

Year	Location	Cytoplasm	Inbred lines (I)												LSD test	
(G)	(L)	(C)	1	2	3	4	5	6	7	8	9	10	11	12	5%	1%
G_1	L_1	C_1	219.6	182.6	188.6	190.3	184.7	163.1	162.6	164.9	182.0	170.0	149.2	176.6	14.833	20.161
		C_2	224.5	176.5	191.3	188.7	200.0	178.5	163.9	172.7	197.4	166.2	145.4	167.2		
		C_3	231.1	198.5	194.7	201.6	196.7	182.1	173.0	180.7	209.2	181.8	165.9	195.8		
	L_2	C_1	215.2	158.5	154.3	171.7	177.3	154.2	146.9	156.2	175.9	155.6	144.1	174.2		
		C_2	202.1	156.2	153.6	170.9	168.1	155.8	140.2	147.4	182.2	155.5	146.5	167.2		
		C_3	212.5	164.3	151.2	177.9	172.2	161.1	145.6	152.2	213.9	153.2	156.3	173.2		
G_2	L_1	C_1	227.7	199.4	194.4	197.2	207.4	190.4	177.7	180.0	212.2	191.5	168.7	192.6		
		C_2	221.9	191.7	193.3	199.8	196.6	185.6	178.7	180.0	171.7	187.5	173.4	186.2		
		C_3	232.7	204.0	206.6	207.0	205.0	194.4	180.1	173.5	180.1	183.6	179.2	196.2		
	L_2	C_1	222.2	189.2	193.9	206.2	203.7	149.7	167.5	176.5	197.4	183.1	162.1	182.4		
		C_2	211.6	177.8	181.8	197.7	190.0	181.5	166.3	176.0	207.8	187.6	177.0	196.6		
		C_3	225.2	189.7	185.9	214.9	203.8	194.1	168.6	178.0	214.7	185.2	173.5	194.7		
Average for years			220.5	182.4	182.5	193.7	192.1	174.2	164.3	169.8	195.6	175.1	161.8	183.6	3.22	4.25
Average for cytoplasm			C_1		181.1		C_2		180.2		C_3		187.6		1.61	2.13
															F test	
Mean for years				G_1			173.98			G_2			191.94**		** P≤1%	
Mean for locations				L_1			189.25**			L_2			176.67			

C_1 -cms-C cytoplasm

C_2 -cms-S cytoplasm

C_3 -fertile (N) cytoplasm

* ≤0,05

**≤ 0,01

If obtained values are compared with ones achieved by Sečanski (1999), it can be concluded that the heights were approximately equal ranging from 169 cmto 185cm.

The plant height does not depend only on genetic background of the trait, but also on many environmental factors and cropping practices (sowing density, soil type, presence of diseases and pest, meteorological conditions...).

According to two-year studies Todorović (1995), stated that the plant height was greater in observed hybrids than in observed inbreds, ranging from 194.30cm to 253.50cm vs. 165.60cm to 189.50cm.

Similar results were obtained in the study carried out by Radanović *et al*. (2015), which means that heterosis for this trait was very pronounced.
According to everything stated it can be concluded that the plant height is a very important trait that indirectly affects yield and is related to the duration of the growing season.

Conclusion

Based on two year studies of maize inbred lines with different types of cytoplasm the following conclusions may be drawn:

1. An inbred line, type of cytoplasm, year and location significantly affect the plant height.
2. The highest plant height was recorded in the inbred line L_1 (220.5cm).
3. The lowest plant height was recorded in the inbred line L_{11} (161.8cm).
4. The highest, i.e. lowest average plant height was detected in inbreds with fertile cytoplasm (187.6cm), i.e. cytoplasm S type (180.2cm), respectively.
5. The average plant height was significantly lower in the first year (173.98cm) than in the second year (191.94cm).
6. The average plant height was higher in the first location (189.25cm) than in the second location (176.67cm).

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