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Faculty of Agriculture in Osijek

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ORIGINAL SCIENTIFIC PAPER

Effects of different types of cytoplasm on thenumber of kernels per row of maize inbred lines

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Abstract

The aim of the present study was to determine effects of both, different types of cytoplasm (*cms*-C, *cms*-S and fertile) and environmental factors on the number of kernels per row. Twelve maize inbred lines were tested in two locations in Zemun Polje (Selection field and Školsko dobro) in 2013 and 2014. The three-replicate comparative trials were set up according to the randomised complete block design within each type of cytoplasm. Each plot within the replicate consisted of four rows. Fertile versions of inbred lines were sown in two border rows and they were pollinators for their sterile counterparts. Statistic-biometric data processing was based on mean values per replicate and encompassed the analysis of variance. Gained results showed significant differences in the number of kernels per row among inbred lines in dependence on the type of cytoplasm, year and the location. The average number of kernels per row ranged from 15.6 (L_6) to 25.9 (L_9). Depending on the type of cytoplasm, the higher average number of kernels per row was detected in *cms*-C cytoplasm (20.4), than in fertile cytoplasm (20.0) and *cms*-S cytoplasm (19.8). In both years of investigation, the variation of average values of the number of kernels per row was very significant ($P \leq 1\%$). The average value of the number of kernels per row registered in inbred lines in 2014 (21.30) was significantly higher than the one recorded in 2013 (18.83). Comparing observed locations, a higher average number of kernels per row was determined in the location Zemun Polje-Selection field (20.58) than in the location Zemun Polje-Školsko dobro (19.55) (Table 1). Gained results point out to effects of different types of cytoplasm on the number of kernels per row.

Key words*:* cytoplasmic male sterility, inbred lines, number of kernels per row

Introduction

The advantages of using hybrids in agricultural production are known and numerous. The increase of yields and product quality are the most important. However, the production of hybrid maize seed faces many obstacles. In order to accomplish total hybridisation between two parents, it is very important not to allow self-pollination of the female component.

Control-pollination of the female component plant in the production of hybrid seed can be achieved in one of the following ways: by detasseling (manually or mechanically), by the application of chemicals that prevent pollen formation or its dispersal and by the use of male sterility.

Since manual detaselling is a very hard work that requires many labourers in a relatively short period of time (10-30 days), the necessity for mechanical detasseling has been imposed. 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.

Experiments with the application of chemicals for preventing the formation or dispersal of pollen have not yielded satisfactory results yet.

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.

Kaeser et al. (2003) consider 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 of the labour-intensive mechanical emasculation of parental lines.

Today, in practice, many hybrid seeds are based on male sterile inbred lines and are produced by applying the main *cms* types, *cms*-C and *cms*-S (the type *cms*-T is susceptible to maize leaf pathogens).

Since it is necessary to achieve yields as high as possible in the hybrid seed production, to cheapen the production, to make it high-quality and less risky, it is necessary to study the effects of the type of cytoplasm and its interaction with a genotype on the yield and some morphological traits for the needs of production.

Material and Methods

Twelve inbred lines, mainly from the breeding fond of the Maize Research Institute, Zemun Polje, that are also parental components of elite ZP hybrids, were used in the comparative trails set to study effects of the type of cytoplasm on the number of kernels per row in maize inbred lines.

There were three groups of 12 same inbred lines that were studied: the first group had classical fertile genetic base; the second group had incorporated cytoplasmic sterility of the C type (*cms*-C), while the third group had cytoplasmic sterility of the S type (*cms*-S).

The trials were performed under the dry-land farming in two locations of Zemun Polje (Selection field and Školsko dobro) during the two subsequent years (2013 and 2014). The seed material for trials was obtained from technical isolation, so called hand pollination. The three-replicate comparative trials were set up according to the randomised complete block design within each type of cytoplasm. Each plot within the replicate consisted of four rows. Fertile versions of inbred lines were sown in two border rows and they had a role of a pollinator for their sterile counterparts. Sowing was done manually in the optimum period (the second half of April) at the inter-row distance of 70 cm, and the inter-hill distance of 40 cm. The elementary plot size was 5.6 m². Four seeds were sown in 12 hills per each row. At the 5-leaf stage, plants were thinned out to two plants per hill, i.e. 40 plants remained for studying, which corresponds to the density of approximately 70,000 plants per hectare. In

order to avoid the effect of border plants, plants from 10 inner hills were used for the analysis of agronomic traits.

The following parameters were observed immediately prior to the harvest: the total number of plants, the number of lodged plants (whereby plants whose stalks and the ground form an angle smaller than 45º), the number of broken plants (whereby the criterion of the broken nodus under the upper ear determines this parameter).

Harvest is done at the stage of full (physiological) maturity. Yields of harvested ears for each inbred per replication was measured for each elementary plot during the harvest. Samples of 20 average ears were drawn and measured at the laboratory. The number of kernels per row was observed and recorded. After shelling of the submitted sample of all replicates, cobs were measured and the grain moisture percentage was determined by use of the moisture meter.

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 of applying parametric tests (ANOVA and LSD-test), homogeneity of variance was tested.

Results and discussion

The grain yield is an important and complex trait consisting of a greater number of components of quantitative nature with polygenic genetic base. The number of kernels per row is one of the yield components. It is a quantitative trait that varies under effects of genetic factors, environmental factors, and to a smaller extent, their interaction. This trait is very important for maize grain yield.

The average number of kernels per row of inbred lines ranged from 15.6 (L6) to 25.9 (L9) (Table 1). In dependence on the type of cytoplasm, the highest average number of kernels per row (20.4) was established in inbreds with cms-C cytoplasm, while this number was somewhat lower in inbreds with fertile cytoplasm (20.0) and cms-S cytoplasm (19.8). The variation of average values of the number of kernels per row of all inbred lines was very significant (P≤1%) in both years of investigations. The average number of kernels per row (21.30) was very significantly higher in 2014 than in 2013 (18.83). Furthermore, a very significantly greater number of kernels per row was obtained in the first location, Zemun Polje-Selection field (20.58) than in the second location, Zemun Polje-Školsko dobro (19.55), (Table 1).

If obtained values for the number of kernels per row are compared with ones achieved by Sečanski et al. (2013), it can be concluded that the gained values for this trait were approximately equal ranging from 16.1 to 28.8.

According to studies carried out by Todorović (1996), the average values for the number of kernels per row were greater in hybrids than in inbreds in both years of investigation, ranging from 15.14 to 28.63 in inbreds vs. 25.30 to 35.53 in hybrids.

Average values of the number of kernels per row were significantly higher in hybrid combinations than in parental inbred lines in the study performed by Grčić (2016), which points out that heterosis for this trait was very pronounced.

According to everything stated it can be concluded that the number of kernels per row is a very important trait that affects yield and varies under genetic factors, i.e. depends on the genetic background of the trait, then varies under environmental factors, to a smaller extent, and under effects of their interactions.

Table 1. Average values for the number of kernels per row over inbred lines, years, type of cytoplasm and locations

Year (Y)	Location (L)	Cytoplasm (C)	Inbred lines (I)												LSD test	
			1	2	3	4	5	6	7	8	9	10	11	12	5%	1%
G_1	L_1	C_1	22.9	21.4	23.5	21.1	15.3	13.7	18.4	13.4	23.3	16.4	12.8	23.7		
		C_2	24.5	21.4	24.1	19.0	23.1	19.0	23.8	18.3	25.7	24.5	13.5	8.0		
		C_3	25.8	24.5	27.2	20.4	19.0	20.7	24.7	22.3	33.2	11.9	11.3	20.0		
	L_2	C_1	15.8	18.9	14.3	15.5	22.4	12.6	17.6	19.4	23.8	17.0	17.8	20.9		
		C_2	21.6	18.4	15.9	12.7	15.7	15.2	16.8	14.3	22.9	21.4	11.4	8.6		
		C_3	19.2	20.5	16.5	16.7	16.4	14.3	16.5	18.9	26.4	14.1	20.4	13.5	**5.060**	**6.878**
G_2	L_1	C_1	22.8	22.8	17.6	23.6	14.9	13.3	23.8	15.2	24.5	29.0	26.8	28.2		
		C_2	21.7	20.1	12.5	20.0	19.4	16.0	24.7	15.9	27.2	27.9	27.2	19.4		
		C_3	17.6	20.6	19.3	22.6	12.8	12.1	23.6	13.4	25.2	18.9	27.2	22.8		
	L_2	C_1	23.1	22.0	18.3	25.0	16.9	18.4	19.4	22.6	27.1	27.8	28.2	25.6		
		C_2	22.1	18.4	16.9	21.8	18.0	15.6	21.8	17.3	27.3	31.1	26.7	23.4		
		C_3	22.3	19.8	20.1	23.4	14.4	16.6	21.2	16.4	24.6	18.9	27.6	23.5		
Average for inbreds			**21.6**	**20.7**	**18.8**	**20.2**	**17.3**	**15.6**	**21.0**	**17.3**	**25.9**	**21.6**	**20.9**	**19.8**	**1.09**	**1.44**
Average for cytoplasm			C_1		**20.4**		C_2		**19.8**		C_3		**20.0**			

			F test
Average for years	G_1	**18.83**	G_2	**21.30****	** P≤1%
Average for locations	L_1	**20.58****	L_2	**1.55**	

C_1 - cms-C cytoplasm
C_2 - cms-S cytoplasm
C_3 - fertile (N) cytoplasm
* ≤ 0.05
**≤ 0.01

Conclusion

Based on two-year studies of maize inbred lines with different types of cytoplasm it can be concluded that the analysis of variance shows highly significant differences among genotypes in the number of kernels per row, as a yield component, and significant effects of year, location and their interaction. The average number of kernels per row of inbred lines varied from 15.6 (L_6) to 25.9 (L_9). The highest number of kernels per row (20.4) was recorded in the inbred lines with *cms*-C cytoplasm, while the lowest number (19.8) was detected in inbred lines with *cms*-S cytoplasm. The average number of kernels per row was very significantly higher (21.30) in 2014 than the number obtained in 2013 (18.83). The average number of kernels per row was higher in the first location (20.58), than in the second location (19.55).

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