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EFFECTS OF DIFFERENT TYPES OF CYTOPLASM ON THE KERNEL ROW NUMBER OF MAIZE INBRED LINES

Snežana V. JOVANOVIĆ[1]*, Goran TODOROVIĆ[1], Nikola GRČIĆ[1], Ratibor ŠTRBANOVIĆ[2], Rade STANISAVLJEVIĆ[2], Josip BRKIĆ[3], Goran KRIZMANIĆ[3]

[1]Maize Research Institute, Zemun Polje, Belgrade, Serbia
[2]Institute for Plant Protection and Environment, Belgrade, Serbia
[3]Agricultural Institute Osijek, Osijek, Croatia
*Corresponding author: jsnezana@mrizp.rs

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 kernel row number of 12 maize inbreds lines. The trial with inbred lines was set up in two locations (Zemun Polje-Selection field and Zemun Polje-Školsko dobro) in 2013 and 2014. Moreover, the three-replicate 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 included the analysis of variance. According to this analysis, significant differences in the kernel row number were established among inbred lines in dependence on the type of cytoplasm, year and the location. The average kernel row number ranged from 10.3 (L_9) to 15.8 (L_5 and L_7). The variation of the kernel row number, related to the source of cytoplasm, was very significant. Differences ($Lsd_{0.01}$) in the kernel row number were not determined in inbred lines L_5, L_8, L_{10} and L_{12} in regard to the type of cytoplasm: *cms*-C, *cms*-S and fertile. The average kernel row number significantly ($P \leq 1\%$) varied in regard to the year of investigation. A higher average value (13.75) was established in 2014 than in 2013 (13.31). The kernel row number per year very significantly varied ($Lsd_{0.01}$) in all inbreds, but the differences were not significant in the inbreds L_2, L_3, L_8, L_9 and L_{12}. Gained results point out to effects of different types of cytoplasm on the kernel row number.

Key words: *cytoplasmic male sterility, inbred lines, kernel row number*.

INTRODUCTION

According to the distribution and the scope of production, maize is, next to wheat, the most essential field crop in our agricultural production. The development of new hybrids of high genetic potential is one of the most important factors of the maize production increase. Many traits of maize plant and ear that are interesting and important for selection are quantitative in nature, meaning that they are determined by a great number of genes whose effects are modified by environmental conditions. In studying these traits it is essential to establish their genetic background and modes of their inheritance in order to successfully apply breeding methods. Due to its morphology, maize is a plant very suitable for the production of large quantities of hybrid seeds, because hybridisation is relatively easily achieved with sowing parental components in alternate rows and tasselling of male inflorescence on female plants immediately after their emergence. It such a way, only pollen of a male (not detasselled) parent is distributed in the field, hence the seed produced on female (detasselled) plants are hybrid seed. In order to utilise seed superiority within the aforementioned scope, it is necessary to accomplish the full hybridisation between parental components. Failure to achieve the complete hybridisation, the female component, which, as a rule has low yield, occurs in produced seeds and reduces the total yield per area unit, and, consequently results in incomplete utilisation of heterosis. The complete hybridisation may be achieved if detasselling in rows with female plants is done in due time (before pollen release). This operation needs engagement of a large number of workers in a relatively short period of time (10-30 days). Besides manpower, it is necessary to provide control and super control of the quality of performed work, which means engagement of a many qualified workers. Since the beginning of the hybrid maize seed production, mechanical topping of tassels has been imposing as the simplest solution to the problem of detasseling. Experiments with mechanical topping have been performed by numerous researches (Dungan and Wudworth, 1939; Bogeson, 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) has stated that mechanical toppers were not usable under poor weather conditions, and that they did not solve the problem of detasseling on tillers and underdeveloped plants, while leaf loss could not be reduced below 2-3 leaves even with the most attentive operation. The possibility of efficient detasseling problem solving in the hybrid maize seed production has 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 detasseling, 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 nitrogen ha^{-1}, 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) 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. In recent years, many hybrid seeds based on male sterile inbred lines have been produced with major *cms* types, *cms*-C and *cms*-S (*cms*-T 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

The total of 12 maize inbred lines were used to study the effect of the type of cytoplasm on the kernel row number. Inbred lines were classified into the following three groups: 1) inbreds with the *cms*-C type cytoplasm, 2) inbreds with the *cms*-s type cytoplasm and 3) inbreds with fertile cytoplasm. Seeds of these materials (inbred lines) for this study were produced in the technical isolation, so called manual pollination. Sowing of all trials was always performed on the optimum dates (the third decade of April) with the application of common cropping practices. Two comparative trials were set up under dry-farming conditions in two locations (Zemun Polje - Selection field and Zemun Polje - Školsko dobro) in 2013 and 2014. The tree-replication trials were set up according to the randomised block design. Each plot within the replication consisted of four 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 was 70 cm. The elementary plot size was 5.6m². Thinning to two plants per hill was done at 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 their possible late break of stability in two observed *cms* types can point out to a more suitable *cms* type for the seed production under conditions of our country.A total number of both, lodged and broken plants, was great in all replications immediately prior to harvest. 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 maturity. Yields of fresh ears for each inbred per replication and each elementary plot were measured at harvest. An average sample of 20 ears was separately measured with the technical balance in the laboratory. After shelling of the average sample, cobs were weighed, while the moisture metre was used to establish grain moisture percentage for each replication.

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 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 kernel row number is one of the yield components. It is a quantitative trait that varies under effects of genetic factors, environmental factors, to a lower extent, and their interaction. This trait is very important for maize grain yield. The average kernel row number of inbred lines ranged from 10.3 (L_9) to 15.8 (L_5 and L_7) (Table 1). In dependence on the type of cytoplasm, the highest average kernel row number (13.6) was established in inbreds with *cms*-S cytoplasm, while this number was somewhat lower in inbreds with fertile (13.5) and *cms*-C cytoplasm (13.4). Variation of average values of the kernel row number of all inbred lines was very significant ($P \leq 1\%$) in both years of investigations. The average kernel row number (13.31) was very significantly lower in 2013 than in 2014 (13.75). Furthermore, a very significantly greater kernel row number was obtained in the first location, Zemun Polje-Selection field (13.55) than in the second location, Zemun Polje-Školsko dobro (13.52), (Table 1). If obtained values are compared with ones achieved by Todorović (1996), it can be concluded that the gained values for the kernel row number were approximately equal ranging from 12.91 to 15.73. The kernel row number 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 carried out by Todorović (1995), the average values for the kernel row number were greater in observed hybrids than in observed inbreds, ranging from 11.84 to 17.88 vs. 13.26 to 19.12.Average values of the kernel row number 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 kernel row number is a very important trait that affects yield and varies under genetic factors, environmental factors, to a smaller extent, and under effects of their interaction.

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

Year	Location	Cytoplasm	Inbred lines (I)												LSD test	
(Y)	(L)	(C)	1	2	3	4	5	6	7	8	9	10	11	12	5%	1%
Y_1	L_1	C_1	11.6	12.1	14.6	14.6	14.2	13.8	15.0	12.7	10.5	11.8	11.3	11.4	1.284	1.745
		C_2	12.8	11.5	15.8	15.2	16.9	16.0	16.0	15.3	10.6	12.9	12.1	9.9		
		C_3	13.1	12.0	15.6	15.0	16.9	17.1	16.4	17.3	10.6	9.2	11.4	11.3		
	L_2	C_1	11.8	12.5	13.3	13.6	16.3	14.5	15.3	16.3	10.3	12.0	12.1	11.1		
		C_2	12.3	11.9	13.4	13.6	16.6	14.7	15.5	15.3	10.4	12.9	10.5	9.9		
		C_3	11.6	12.3	13.5	13.7	15.8	14.2	15.1	17.2	10.5	10.5	12.7	1.8		
Y_2	L_1	C_1	14.1	11.7	14.5	15.5	14.9	15.6	16.3	14.7	10.0	13.7	12.8	11.7		
		C_2	13.8	11.6	13.8	15.3	17.1	15.6	16.8	15.9	10.0	13.4	12.5	11.0		
		C_3	13.7	11.4	14.0	15.4	14.0	14.3	16.1	13.9	10.0	12.2	12.7	11.0		
	L_2	C_1	13.3	11.9	14.1	15.6	15.3	17.5	15.5	15.7	10.0	13.4	12.9	11.6		
		C_2	13.7	10.9	14.0	14.6	16.4	15.7	16.1	15.7	10.0	14.2	12.7	11.2		
		C_3	13.4	11.6	15.1	15.1	15.0	17.5	16.2	15.8	10.5	12.2	13.2	11.7		
Average for inbreds			12.9	11.8	14.3	14.8	15.8	15.5	15.8	15.5	10.3	12.4	12.2	11.0	0.35	0.46
Average for cytoplasm			C_1	13.4			C_2	13.6			C_3	13.5				
															F test	
Average for years			Y_1			13.31			Y_2			13.75**			** P≤1%	
Average for locations			L_1			13.55			L_2				13.52			

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 the following conclusions may be drawn:

An inbred line, type of cytoplasm, year and the location significantly affect the kernel row number.

The highest kernel row number (15.8) was recorded in the inbred lines L_5 and L_7. The lowest kernel row number (10.3) was recorded in the inbred line L_9.

The highest (13.6), i.e. lowest (13.4) average kernel row number was detected in inbreds with *cms*-S cytoplasm, i.e. C type cytoplasm, respectively.

The average kernel row number was significantly lower in the first year (13.31) than in the second year (13.75).

The average kernel row number was higher in the first location (13.55), than in the second location (13.52).

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