Original scientific paper
10.7251/AGSY1404235S

THE EFFECT OF CYTOPLASMIC MALE STERILITY ON MORPHOLOGICAL TRAITS OF MAIZE INBRED LINE

Milan STEVANOVIC, Jovan PAVLOV, Goran STANKOVIC, Zoran CAMDZIJA, Sofija BOZINOVIC, Milos CREVAR, Jelena VANCETOVIC

Maize Research Institute, “Zemun Polje”, Belgrade, Serbia
*Corresponding author: mstevanovic@mrizp.rs

Abstract

In order to reduce costs from detasseling the production of hybrid maize seed is increasingly based on using cytoplasmic male sterility (CMS). It is very important to investigate the influence of the specific type of sterility on morphological traits of inbred lines since they are unstable due to its nature. In this study we used seven maize inbred lines developed at Maize Research Institute „Zemun Polje“ and each of these seven lines were investigated in five variants: with normal cytoplasm (N), with C type sterile cytoplasm (CMS-C), the fertile counterpart C (RfC), with S type sterile cytoplasm (CMS-S), the fertile counterpart S (RfS). We found that genotype, location and type of line have significant influence on morphological traits. The position of main ear in lines with sterile cytoplasm and there fertile counterpart were higher comparing to lines with normal cytoplasm. The greatest plant height was observed in RfC lines, while all other lines had similar plant height. The highest percentage of lodged and broken plant was observed in inbred lines with normal cytoplasm, while the smallest value of this parameter was found in lines with C type sterile cytoplasm. This can lead us to conclusion that introduction of new genes have influence on morphological traits of maize inbred lines.

Key words: *maize, citoplasmic male sterility (CMS), inbred lines, morphological traits, position of main ear, plant height*

Introduction

The cytoplasmic male sterility (CMS) is widely used procedure for producing hybrid seeds in many important field crops, due to this technique is very cost effective, so using CMS hybrids we can decrease time and costs in seed production. For the breeding programs and production of modern maize hybrids special attention is given to the morphological traits of maize. There is a tendency to make hybrids that will have low plant height in order to increase plant density per unit (Russell, 1984). Maize breeders and producers have tendency to produce hybrids in which main ear is lower-positioned, because this will reduce lodging and brokening of plants (Meghji et al., 1984; Duvick et al., 2004). The icreasment of lodged and broken plants is not desirable, because it leads to reduction in grain yield. Due to all named reasons, it is very important to determine whether the use of CMS and the introduction of new genes affect the morphological traits of maize hybrids.

In the last forty years, there are not so many investigations related to the effect of cytoplasmic male sterility on morphological traits of maize hybrids. Scientific interest for this research field was reduced in seventies years of the last century due to infection of maize hybrids with the fungus *Helminthosporium maydis* (Vančetović et al., 2007). From this reason, the use of CMS in the maize hybrids production is considered to be risky. Considering everything above, the investigation of the influence of the CMS on the morphological traits of maize should be continued in order to investigate how new, modern inbred lines are behave if in seed production we use their sterile analogues.

The main aim of this study was comparison of morphological traits of original inbred lines and their CMS and Rf variants in order to understand whether use of CMS and the introduction of new genes affect the morphological traits of maize.

Materials and Methods

In this study we used seven maize inbred lines developed at Maize Research Institute „Zemun Polje“ that belongs to different maturity groups (FAO 300-500). The lines were named as ZPL-1, ZPL-2, ZPL-3, ZPL-4, ZPL-5, ZPL-6 i ZPL-7. CMS and Rf versions of lines were obtained by conversion of inbreds with normal cytoplasm at Maize Research Institute „Zemun Polje“.

Trials were set up according to the randomised split-plot design in the period of two years (2010 and 2011). All trials were set up under conditions of dry land farming. Sowing was always done on the optimum dates with the application of common cropping practices. Trials were set up on three locations:Zemun Polje, Školsko dobro (a location within trial fields of the Maize Research Institute Zemun Polje) and Srbobran. The trial performed on location Školsko dobro in 2011. was discarded. The trial was setup in three replications in five sets (blocks), where each of those sets presented one of the type of observed inbreds:

I block – N (normal) cytoplasm, i.e. original inbred lines
II block – CMS-C inbreds
III block – RfC inbreds
IV block – CMS-S inbreds
V block – RfS inbreds .

Every plot in one replication was assembled in 4 rows, where each row possessed 12 hills at the distance of 40 cm. Hand sowing was performed and four plants were sowed per hill. The inter-row distance was 70 cm. The elementary plot size and sowing density were 7.28 m^2 and 71,429 plants ha^{-1}, respectively. At the 5-leaf stage, thinning to two plants per hill was performed.

The following traits were measured:

Plant height (cm)

Main ear height (cm)

Percentage of lodged and broken plant

Immediately after fertilization a random sample of 20 plants was used to determine plant height and position of main ear. The percentage of lodged and broken plant was determined before harvesting, and in this step all plants that were broken above node where the main ear is positioned were treated as broken, while lodged plants were ones that are inclined at more than 30 degrees from the vertical.

Statistical analysis of data included analysis of variance - ANOVA randomized block design (RCB) for the factors G (genotype) and L (location) by the factor T (the type of inbreds) as a split-plot of G and L. The software used for analysis of variance was the MSTAT (MSTAT Development Team, 1989). It also has been used the least significant difference test (LSD) for the comparison of the original inbreds and their counterparts. Both tests are applied to the significance level of 5 and 1%.

Results and Discussion

The analysis of variance for the traits plant height, main ear position and percentage of broken and lodged plants for all locations are presented in the Table 1. It was shown that genotype (G) and location (L), as well as their interaction (GxL), had very significant influence on all three traits. Type of inbreds (T) had very significant influence on main ear height and plant height, while there was no statistically significant correlation observed for the trait percentage of broken and lodged plants. The interaction of genotype and type of inbreds (GxT) very significantly affected all three investigated traits. Interaction of location and type of inbreds (L x T) showed very significant effect on main ear position and plant height, while there was no influence on percentage of broken and lodged plants. The interaction of genotype, location and type of inbreds (G x L x T) had significant influence on main ear position and percentage of broke and lodged plants, while there was no effect on plant height.

Table 1. The significance of mean squares from the ANOVAfor traits plant height. main ear position and percentage of broken and lodged plants

Trait		Main ear position (cm)	Plant height (cm)	% of broken and lodged plants
Source of variation	Degrees of freedom	Mean square	Mean square	Mean square
Repetition (R)	2	30.023 ns	216.603 ns	9.518 ns
Genotype (G)	6	177778.625 **	39864.032 **	569.614 **
Location (L)	4	346.055 **	8944.838 **	1742.770 **
G x L	24	236.218 **	555.937 **	89.781 **
Error (E-1)	68	36.522	72.137	19.397
Type of inbreds (T)	4	451.863 **	635.572 **	37.351ns
G x T	24	141.657**	352.685 **	44.854 **
L x T	16	702.205 **	302.583 **	30.059 ns
G x L x T	96	29.696 *	64.872 ns	27.256 *
Error (E-2)	280	21.366	51.631	19.683
Total	524			

*; ** - Statisticaly significant on level 0.05 i 0.01. respectively

LSD-test between inbred lines showed the highest main ear position in inbreds with RfC and C type of cytoplasm (81.23 cm and 81.1 cm, respectively) for both investigated levels of significance (5% i 1%).The lowest position of main ear was observed in inbreds with normal cytoplasm, 76.33 cm (Tab. 2). The last finding lead us to conclusion that introduction of new cytoplasmic genes into inbred lines results in increasing of main ear position. The highest plant height was observed in RfC inbreds (195.2 cm), while the lowest plant height was determined in RfS inbreds (188.4 cm) for both significance levels. The differences between inbreds with normal and sterile cytoplasm for this trait were marginal, which is consisted with research Rojc et al. (1984). For the significance level of 5%, the highest percentage of broken and lodged plants was observed in inbreds with normal and sterile S type cytoplasm (7.209 and 7.071%, respectively), while for the significance level of 1% no significant differences between investigated inbreds for this trait was observed. The lowest percentage of broken and lodged plants was found in inbred lines with C type of CMS, so we can conclude that in this case introduction of new genes leads to increased resistance on lodging. Previous researches

of Rojc et al. (1984) showed opposite results. They have shown that sterile hybrids have for 1% higher number of broken and lodged plants comparing to their fertile analogues. Our results are giving support that use of CMS in modern inbred lines may give benefit for breeders and seed producers, so the future investigation in this field is of great importance.

Tabela 2. The least significant difference test for mean values for main ear position. plant height and percentage of broken and lodged plants

	Main ear position (cm)				Plant height (cm)				% of broken and lodged plants			
Rank	Type	Value	0.05	0.01	Type	Value	0.05	0.01	Type	Value	0.05	0.01
1	RfC	81.23	A[1]	A[1]	RfC	195.2	A[1]	A[1]	N	7.209	A[1]	A[1]
2	C	81.10	A	A	N	192.2	B	B	S	7.071	A	A
3	RfS	79.43	B	B	C	192.2	B	B	C	6.870	AB	A
4	S	78.10	C	B	S	190.7	B	BC	RfC	6.750	AB	A
5	N	76.33	D	C	RfS	188.4	C	C	RfS	5.702	B	A
		Lsd	1.256	1.655		Lsd	1.952	2.572		Lsd	1.205	1.588

1 – Statistically significant values are ones that have no common letter

Conclusions

The effect of CMS on morphological traits in seven maize inbred lines developed at Maize Research Institute “Zemun Polje” was observed in the present study. Each of - them was investigated in five variants: with normal cytoplasm (N), with C type sterile cytoplasm (CMS-C), the fertile counterpart C (RfC), with S type sterile cytoplasm (CMS-S) and the fertile counterpart S (RfS). It was shown that genotype, locality and type of inbreds had very significant influence on plant height, main ear position and percentage of broken and lodged plants. The least significant difference test for mean values showed that for both significance levels (5 and 1 %) lowest position of main ear was observed in inbreds with normal cytoplasm. We could conclude that introduction of new cytoplasmic genes leads to increased position of main ear, which is not preferred trait. LSD test was also showed the greatest plant height was determined in inbreds with RfC germplasm for both significance levels. The differences between inbreds with normal and sterile cytoplasm for this trait were marginal. The highest percentage of lodged and broken plant was observed in inbred lines with normal cytoplasm, while the smallest value of this parameter was found in lines with C type sterile cytoplasm. In this case, we could conclude that introduction of new genes results in increasing resistance on lodging. Our results are giving support that use of CMS in modern inbred lines may give benefit for breeders and seed producers, so the future investigation in this field is of great importance.

References

Duvick, D.N., Smith, J.S.C., Cooper, M. (2004): Long-term selection in a commercial hybrid maize breeding program. pp. 109-151. In: Plant Breeding Reviews: Long Term Selection: Crops, Animals, and Bacteria, Vol. 24, Part 2 (ed. J. Janick), John Wiley & Sons, Oxford, UK.

Meghji, M.R., Dudley, J.W., Lambert, R.J., Sprague, G.F. (1984) Inbreeding depression, inbred and hybrid grain yields, and other traits of maize genotypes representing three eras. Crop Science, 24: 545-549.

MSTAT Development Team (1989); MSTAT-C: A microcomputer program for the design, management and analysis of agronomic research experiments. MSTAT Development Team, Michigan State University, East Lansing.

Rojc, M., Parlov, D., Tomičić, B., Sever, J., Majhen, J. (1984) The possibility of application of cytoplasmic male sterility in BC maize hybrids (Mogućnost korišćenja muške sterilnosti kukuruza u hibridnim kombinacijama BC kreacija). Agricultural News (Poljoprivredne Aktuelnosti), 20 (1-2/84): 195-203.

Russell, W.A. (1984) Agronomic performance of maize cultivars representing different eras of breeding. Maydica, 29: 375-390.

Vančetović J., Vidaković, M., Branković-Radojčić, D. (2007) The importance and use of CMS in maize hybrids production (Značaj i korišćenje CMS u proizvodnji hibrida kukuruza). In: Basis for sustainable development, Serbian Genetic Society, Belgrade, pp. 55-83.