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Original scientific paper

EFFECT OF DIFFERENT PROPORTIONS OF EXOTIC GERMPLASM ON GRAIN YIELD AND GRAIN MOISTURE IN MAIZE

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Two main questions in programs introgressing exotic maize germplasm into temperate materials are the choice of available exotic sources to work with, and the proportion of exotic germplasm that should be incorporated into adapted germplasm. The objective of this study was to compare effects of different proportions of tropical maize inbred line NC298 in hybrids male parent on grain yield and grain moisture content, using method of orthogonal polynomials.

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Methods of direct crosses and backcrosses were used to form four hybrid groups (six hybrids each) containing 0, 25, 50 and 75 percent of tropical exotic germplasm, respectively, by their male parent (or one half of mentioned proportions in the corresponding hybrids).

The linear components of the germplasm proportions sum of squares, were significant ($p<0.01$) for both grain yield and moisture content and the cubic effect ($p<0.05$) for grain yield only. Results in this study clearly suggested backcross foundation populations with an adapted line to be appropriate selection sources for both grain yield and grain moisture content.

Key words: germplasm, maize, orthogonal polynomials, temperate germplasm.

INTRODUCTION

The results of many researchers are supporting a use of exotic maize germplasm in temperate breeding (WELLHAUSEN, 1956; GOODMAN, 1965; HALLAUER, 1978; GEADELMANN, 1984; BECK *et al.*, 1991; GOODMAN and CARSON, 2000). There are many of available sources of different types of exotic germplasm, from racial accession through the inbred lines. GOODMAN (1998) reported slight increase in the use of both temperate exotic germplasm (from 0.8% in 1984 to 2.6% in 1996) and tropical exotic germplasm (from 0.1% in 1984 to 0.3% in 1996) in U.S. maize breeding. The similar situation has remained until now, not only in U.S. corn seed industry, but also in the European southeastern corn breeding programs.

The barriers and possible difficulties to using tropical maize germplasm in temperate breeding programs has been described by many authors (FRANCIS, 1972; LONNQUIST, 1974; GOODMAN, 1985; HAWBAKER *et al.*, 1997; HALLAUER, 2003). Such difficulties (assuming longterm breeding programs to meet anticipated goals) together with „pressure of industry“ may have a major influence on a lack of success in commercial implementation of exotic germplasm, but „not a lack of excellent sources of tropical maize germplasm“ (GOODMAN *et al*., 2000).

The two main questions in programs of an exotic maize germplasm introgression into temperate materials are the choice among available tropical exotic sources and proportion of tropical exotic germplasm that should be incorporated into adapted germplasm. The objective of this study was to test effects of different proportions of the tropical exotic maize inbred line NC298 in hybrids male parent (Mo17 and NS796) on grain yield and grain moisture content using method of orthogonal polynomials.

MATERIALS AND METHODS

As a source of tropical exotic germplasm, NC298 100% tropical germplasm yellow, flint inbred line (by dr. M.M. GOODMAN, 1991) was chosen. Two inbred lines, Mo17 and NS796 bred out from Lancaster population and local variety Vukovarski zuban, respectively (STOJAKOVIC *et al.*, 2001) were used for the male parent component. Both male (temperate) lines and NC298 (tropical exotic) combine well with Reid Yellow Dent heterotic group. Using methods of direct crosses and backcrosses (between NC298 and both male lines, Mo17 and NS796), four male groups with 0, 25, 50 and 75 percent of tropical exotic germplasm, respectively, were formed (VASIĆ *et al*., 2006; Table 1). Each line or combination within each male group was tested with three common female inbred-testers that belong to the Reid Yellow Dent heterotic group (NS568, B109 and NS416). Each male parent group consisted of six hybrids with the same proportion of exotic germplasm (3 x 2, female and male parents, respectively).

Table 1. Inbred lines and their combinations obtained to fit appropriate proportions of exotic germplasm (used as hybrids male parent)

Male group	Lines and combinations	Proportion of exotic germplasm (NC298)
1	NS796 Mo17	0
2	(NS796x NC298) x NS796 (Mo17 x NC298) x Mo17	25
3	NS796 x NC298 Mo17 x NC298	50
4	(NS796x NC298) x NC298 (Mo17 x NC298) x NC298	75

The proportion of exotic germplasm in each hybrid combination was one half of the proportion containing the corresponding male parent. The inbreds NS568, NS416 and NS796 were selected at Institute of Field and Vegetable Crops, Novi Sad, while both Mo17 and B109 are of U.S. origin.

Twenty eight entries (24 tested hybrids and four check hybrids) were grown in two-row plots, creating a density of 53.333 plants/ha. All plots were over planted and thinned in the fifth leaf stage to obtain final density. Plots were arranged in a randomized complete block design with two replications in each of five environments (E; locations - year combination). In 2002 and 2003, hybrids were grown at Novi Sad and Srbobran (in 2002 only) and Osjek (Croatia) in 2003, only. In 2003, location Srbobran was discarded because of a severe windstorm and hail damage after pollination. Finally, four environments were included into the data analysis. The standard maize growing technology was applied under dry land conditions. Harvesting was done by combine. Data were collected for grain yield (adjusted to the 14% moisture and expressed in t/ha) and grain moisture (%).

An analysis of variance for two-way data tables was conducted to estimate the significance and magnitude of genotype (G) x environment (E) interactions. These analyses assumed that genotypes and environment effects were fixed and random, respectively. Results for the G x E mean squares level of significance were not shown here. For the statistical analyses in this study, the mean values of 24 tested hybrids over environments for both grain yield and grain moisture content (under assumption of potential biases based on the significant G x E interaction for grain moisture content) were used.

An analysis of variance for Repeated Measure Design (RMD) together with testing of the linear, quadratic and cubic effects of the equally spaced germplasm proportion intervals for grain yield and grain moisture was done by EDWARDS (1979).

RESULTS AND DISCUSSION

The highest yielding hybrid group was that with 25% of exotic (NC298) germplasm in male parent (7.40 t/ha). The second ranking hybrid group regarding to grain yield (7.26 t/ha) did not have any portion of exotic germplasm (Table 2). The mean values for the other two hybrid groups were 6.62 t/ha and 6.53 t/ha for the groups that contained 50% and 75% of exotic germplasm in male parent, respectively.

Positive linear relationship was apparent between grain moisture (%) and proportion of exotic germplasm. Two of the totally four hybrid groups that contained 0% and 25% of exotic germplasm, showed the lowest grain moisture values, 23.03% and 23.53%, respectively (Table 2).

Table 2.: Mean values for grain yield and grain moisture content of maize hybrids containing different proportion of exotic germplasm (NC298) in their male parent

Group*	NC298 proportion in male	Grain yield t/ha	Rank	Grain moisture %	Rank
1	0	7.26±0.12	2	23.03±0.52	4
2	25	7.40±0.10	1	23.53±0.47	3
3	50	6.62±0.21	3	25.45±0.44	2
4	75	6.53±0.11	4	27.45±0.68	1

*See Material and Methods for the within group hybrids structure

Using the similar genetic material, VASIĆ *et al*., (2006), reported that the differences between mean values for both grain yield and grain moisture were significant ($p<0.1$, $p<0.05$ or $p<0.01$) for all compared proportions of exotic germplasm except for the 0% vs. 25% including both traits and for the 50% vs. 75% for grain yield, only.

The analysis of variance of RMD design showed significant mean square values ($p<0.01$) for germplasm proportions for both grain yield and grain moisture (Table 3).

Table 3. RMD+ analysis of variance and orthogonal comparison of germplasm propotions for grain yield and grain moisture content

Sources of variation	df	Mean Squares (MS)	
		Grain yield (GY)	Grain moisture (GM)
Hybrids (H)	5	0.081	2.715
Germplasm (G)	3	1.168**	24.348**
Linear	1	2.646**	69.130**
Quadratic	1	0.079	3.375
Cubic	1	0.778*	0.539
H x G	15	0.133	21.237
R^2 GY vs. Germplasm		0.661**	
R^2 GM vs. Germplasm			0.803**

RMD+ (Repeated Measure Design); *p<0.05; **p<0.01

On the same time, the linear components were significant (p<0.01) for both traits and the cubic effect (p<0.05) for grain yield only. It seems that significant non-linear effect was effected by inconsistent grain yield trend over different germplasm proportions (Table 2). The validity of the model used in this study has been supported by the significant (p<0.01) R^2 values for both traits (trait vs. germplasm). The observed values were 0.661 and 0.803 for grain yield and grain moisture content, respectively (Table 3).

VALES *et al.* (2001) observed the quadratic effect (p<0.01) after three cycles of S1 recurrent selection for grain yield in EPS7 population of maize, while EPS6 population under the same procedure showed the linear response, only. The authors pointed out that S1 recurrent selection to improve grain yield could be continued in EPS6 because of the linear response. In EPS7, it is not clear whether selection should be continued or not because of the quadratic effect observed. Results in this study clearly suggested backcross foundation populations with an adapted line to be appropriate selection sources for both grain yield and grain moisture content. These results are in agreement with conclusions of many authors using field data (HALLAUER, 1978; CROSSA and GARDNER, 1987; NELSON and GOODMAN, 2008), or theoretical genetic and computer simulation studies (HO and COMSTOCK, 1980; DUDLEY, 1982).

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UTICAJ RAZLIČITIH PROPORCIJA EGZOTIČNE GERMPLAZME NA PRINOS ZRNA I UDEO VODE U ZRNU KUKURUZA

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I z v o d

Inkorporacija egzotične germplazme u genetički materijal umerenog klimata nameće dva osnovna pitanja: izbor i proporciju odgovarajućih egzotičnih izvora. Cilj ovog istraživanja je bio poređenje efekata različitog udela tropske linije kukuruza NC298 u očinskoj komponenti hibrida, na prinos zrna i udeo vode u zrnu, primenom metode ortogonalnih polinoma.

Metodom direktnih i povratnih ukrštanja dobijene su četiri grupe hibrida (po šest hibrida u svakoj) koje su sadržale 0, 25, 50 i 75 procenata tropske germplazme, u njihovoj očinskoj komponenti (ili jednu polovinu pomenutih procenata u odgovarajućim hibridima). Sume kvadrata linearne komponente, bile su značajne ($p<0.01$) za prinos zrna i za udeo vode u zrnu, dok su sume kvadrata kubnog efekata bile značajne ($p<0.05$) samo za prinos zrna. Rezultati ovih istraživanja jasno ukazuju da su početne populacije nastale povratnim ukrštanjem sa adaptiranom linijom pogodan izvor za selekciju na prinos zrna i udeo vode u zrnu.

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