Tropical Maize Synthetics Improvement For Moistute-Stress Tolerance For Small-Sacle Farmers

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Introduction

In tropical regions drought, low natural soil fertility, biotic stress like leafborer, among other effects are major constraints to maize production. The northeastern region comprises 18,28% of the Brazil total area, contributes with 5,32% of the national maize production, and has the highest incidence of drought or lack and irregularity of rainfall distribution. Most of the maize produced in this region comes from small farms and drought has been the main constraint responsible for severe yield losses. Maize is the most important food crop in the region and the need to increase its production cannot be overemphasized. As pointed out by Ceballos and Pandey (1991 a, b) in marginal areas maize is generally cultivated as staple food, using low agronomic inputs, limited financial support and low use of resources.

Therefore, small scale farmers in the tropical areas are often the people hardest hit by drought and other adverse natural conditions. Water stress tolerant germplasm are expected to be very useful to small scale farms who grow maize in areas frequently affected by drought. Drought stress occur with different intensity at any plant development stage from germination to physiological maturity and flowering is the most critical stage in maize for drought stress (Bolaños and Edmeades 1993).

A selection program for non-biotic stress tolerance should put emphasis on the importance of evaluation in stress and non stress environments. The pre-flowering stress treatment allowed for manifestation of the genetic variability for e.g., ears per plant, kernel weight, etc. Therefore severe water stress treatment will reduce genetic variation for grain yield (Bolaños and Edmeades, 1997).

There is strong agreement that selection for yield under drought stress is less efficient than under non stress conditions, mainly because of reduction in heritability of yield under stress (Rosielle and Hambling, 1981; Blum, 1988; Johnson and Geadelmann, 1989), then selection would be better under both the stress and non stress environments.

The type of progenies evaluated affect the rate of improvement and the ability to discriminate among genotypes for stress tolerance. Thus, selfed progenies as showed by many research results on yield improvement, are preferred over non inbred progenies, because heritability increases with levels of inbreeding (Bolaños and Edmeads, 1997; Lamkey and Hallauer, 1987).

The objectives of this study were to present the genetics parameters estimates for ear yield used in selection in inbred progenies trials under water stress and non-stress conditions as part of a recurrent selection program for drought tolerance in two heterotic tropical maize synthetics.

Materials and Methods

The Syndent was synthesized by the recombination of 13 elite dent type inbred lines of Tuxpeño germplasm (CIMMYT) and the Synflint through the recombination of 15 flint type inbred lines from Caribbean and Cateto germplasm (CIMMYT), in 1995. Selection began in 1996 and underwent 3 cycles of full sib recurrent selection scheme in the rainfed seasons at Sete Lagoas, MG, Brazil. Each cycle of full-sib selection required one year to complete.
In 1998 were obtained 200 S1 from each synthetic and the S1 families were prescreened under mild drought at Sete Lagoas, they were also selected for desirable plant characteristics where the selects ones were advanced to S2 by self pollination.
The superior 144 S2 progenies of each synthetic were grown for yield evaluation at the experimental station of Janaúba, located in North region of MG State, altitude 516 masl, latitude 15º 47´S and longitude 43º 18´W, where stress could be managed by irrigation during the hot rain-free season under two water regimes (environments). Each of the two 144 progeny sets were evaluated using a lattice design 12 x 12 with a tester (experimental double-cross hybrid) and 2 replications, in single-row plots of 5 m long and spaced 0,90 x 0,20 m between row and plant within the rows, respectively. The water regimes were classified in two types, a well-watered (NS) and a moderated stress (WS) where irrigation was suspended two weeks prior to anthesis and was reinitiated two weeks after flowering to ensure that kernels set under this stress would be filled. Data were collected for ear yield (kg $plot^{-1}$). Statistical analyses of variance followed procedures described by Falconer (1989). Each experiment was analyzed separately as lattice design, and broad-sense heritability of ear yield and predicts responses of yield to selection were calculated as:
Broad-sense heritability $h^2=\sigma^2_g / (\sigma^2_g + \sigma^2_e / r)$. where
σ^2_g =Genetic variance; σ^2_e = Error variance and r = nº of replication (Hallauer and Miranda Filho,1981).
Predicted response to selection in percentage was $R\%=(h \times \sigma_g)/M_{yield} \times 100$, assuming a standardized selection differential of 1.0.
Analysis for genotype distribution was performed based on a water stress index based on yield under drought condition to identify the most tolerant progenies to the moisture stress imposed in the experiments. The environment index or water stress index (WSI) was calculated by the equation:

$$WSI= (Y_{H_2O} - Y_{DROUGHT}) / (\overline{Y}_{H_2O} - \overline{Y}_{DROUGHT})$$

Results and Discussion

For the trait ear yield, results of the combined analysis of variance showed high significant differences (P<0.01) among the progenies for both synthetics, and the environments x progenies interactions showed statistically high significant (P<0.01) and significant (P<0.05) for the Synflint and the Syndent, respectively (Table 1).

Table 1. Combined analysis mean square results for ear yield (kg $plot^{-1}$), for the two synthetics, evaluate at two water conditions, at Janaúba, MG, in 1999.

		Synflint	Syndent
SV	DF	MS	
Environment (E)	1	328.8177**	191.7071**
Progeny (P)	143	0.7079**	0.9494**
E x P	143	0.3157**	0.2851*
Mean Error	266	0.1933	0.3017
CV%		20.08	21.68
Mean (kg $plot^{1}$)		2,19	2.53

*,** significant at P<0.01.and P<0.05 levels, respectively.

Ear yield means (Table 2) were higher for both synthetics at the non water stress condition (NS), and the Syndent yielded relatively more (66,64%) than Synflint (63,00%) related to the tester. The Syndent performed better than the Synflint material at this stress condition (WS), where the Syndent and the Synflint yielded 52,23% and 38,26% of the tester, respectively.

Table 2. Broad-sense heritability (h^2) genetic variance (σ^2_g), error variance (σ^2_e) and predicted response to selection (R), for ear yield (kg $plot^{-1}$), for two moisture stress environments, at Janauba, MG, in 1999.

Experiments	h^2	σ^2_g	σ^2_e	R%	Yield
		(kg $plot^{1})^2$		(kg $plot^{1}$)	Mean
Synflint (WS)	0,382	0,054	0,196	0,144(10,05)	1,433
Synflint (NS)	0,752	0,289	0,171	0,466(15,82)	2,945
Syndent(WS)	0,607	0,157	0,270	0,309(15,79)	1,956
Syndent (NS)	0,635	0,235	0,204	0,386(12,41)	3,110
Tester (NS)					4,675
Tester (WS)					3,744

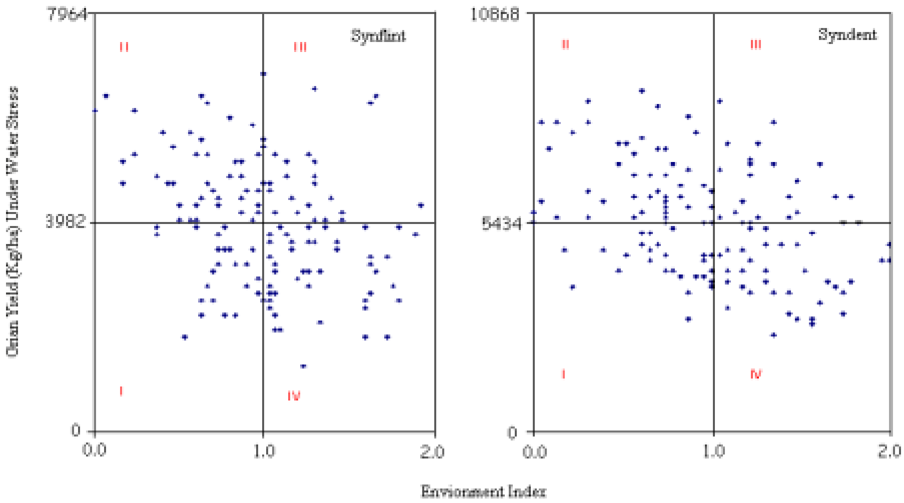
WS= With water stress NS= No water stress Tester = Experimental double cross hybrid.

The efficiency of selection under water and non water stress conditions for increasing ear yields under water stress is determined by the broad-sense heritabilities (h^2) of ear yield under water stress and non stress conditions (Falconer, 1989).
Broad-sense heritability estimates calculated for ear yield under no water stress exceeded those under water stress, and were of 0.382 (kg $plot^{-1})^2$ with stress and 0.752 (kg $plot^{-1})^2$ without stress for Synflint, but of similar trends for Syndent with 0.607 (kg $plot^{-1})^2$ with stress and 0.635 (kg $plot^{-1})^2$ without stress (Table 2). Betran et. al. (1997) and Bolaños & Edmeads (1997) found similar results (h^2>0.50) testing inbred lines of different endogamy levels, derived from CIMMYT germplasm under selection for drought resistance. As expected genetic variance estimates were higher in water stress condition than for non-water stress for both synthetics, mainly for Synflint material. The genetic variance under non-stress condition exceeded those of with stress by 81.31 % and 33.19 % on average for Synflint and Syndent, respectively. Therefore, gains in selection can only be possible when the genetic variation for tolerance to water stress, through whatever mechanism, can be observed (Bolaños and Edmeades, 1997). Thus, better genetic gains can be obtained with the Synflint material.
Error variance was a little higher under stress than without stress for both synthetics.

Predicted response of ear yield to selection estimates presented a trend of higher values (kg plot-1) under non-stress treatment.

Larger predicted selection gains (0.466 kg plot-1) was found for Synflint and lower gain (0,386 kg plot-1) for Syndent, both at the non-stress condition.

To identify superior endogamy progenies for the moisture stress imposed in the experiments, an analysis for genotype distributions was performed based on a water stress index (WEI) and yield under drought condition (Figures 2 and 3). According to the yield under water stress (ordinate) and the environment index (abscissa) we can place the progenies in four groups. Group 1, characterized by low EI and yield, was composed of 31 progenies (22%) and 24 progenies (17%) for Syndent and Synflint, respectively, and were classified as low yieldings and non-responsive to drought.



Figures 2 and 3. Ear yield as function of *environment index* or *Water Stress Index – WSI*, for 144 S2 progenies trials each across two replications from 2 tropical synthetics under two water regimes at Janaúba, Brazil, 1999.

Group 2, characterized by low EI and high yield, was composed of 48 progenies (33%) and 47 progenies (32.5%) for Syndent and Synflint, respectively, and were classified as high yieldings and non-responsive to drought.

Group 3, characterized by high EI and yield, was composed of 22 progenies (15%) and 26 progenies (18%) for Syndent and Synflint, respectively, and were classified as high yieldings and responsive to drought

Group 4, characterized by high EI and low yield, was composed of 43 progenies (30%) and 47 progenies (32.5%) for Syndent and Synflint, respectively, and were classified as low yieldings and responsive to drought

Genotypes of group 3 interact in a positive direction with our objective. We then select the progenies in group 3 for recombination for continuing our breeding selection second phase.

Rosielle and Hambling (1981) pointed out that usually selection is made under non-moisture stress conditions, with water supplementation, where heritability and genotypic variance for yield and, therefore, potential selection gains for non-stress conditions are high.

The results found in this study showed the need in modifying this scheme of selection with these two synthetics for yield improvement in this specific drought environment. Selection gains under low water can be considerably enhanced if secondary traits other then yield are used when evaluating progenies in drought stress selection experiments. Selection under water stress conditions using topcross progenies and other traits related with drought besides yield should be a better strategy. These two synthetics could be released for farmers whose yields are reduced drastically by drought occurring near flowering and during grain filling periods.

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