RESPONSES OF TROPICAL ELITE MAIZE ACCESSIONS FROM LATIN AMERICA WITH TWO BRAZILIAN TESTERS

Manoel Xavier dos Santos [1]*, Linda Maria Pollak [2], Hélio Wilson Lemos de Carvalho[3], Cleso Antônio Patto Pacheco[1], Elto Eugenio Gomes e Gama[1], Paulo Evaristo de Oliveira Guimarães[1], Ramiro Vilela de Andrade[1], Luciano Lourenço Nass[4]

INTRODUCTION

Maize genetic biodiversity is great and the importance of genetic resources has long been emphasized for increasing the genetic base of cultivated maize by their use in breeding programs (Brown, 1953; Salhuana & Sevilla, 1995). The use of maize genetic resources, however, is still limited due to the lack of agronomic information, poor adaptation, tendency for root and stalk lodging and time required to obtain improved cultivars (Brown, 1975; Uhr & Goodman, 1995). Despite these problems a few breeders have worked with exotic populations and reported an increase in yield when crossing exotic with adapted populations due to the genetic diversity between the parental populations

Information about heterotic patterns, essential to maximize the use of genetic resources in breeding programs, has been increasing in recent years for tropical regions. The Latin American Maize Project (LAMP) provided an excellent oportunity to select the best tropical accessions for participating countries (Salhuana & Sevilla, 1995), and now each country can utilize selected accessions as new gene pools for developing improved varieties and hybrids.

The objectives of this study were to: (i) identify among tropical elite maize accessions from the LAMP those that could contribute to increased levels of heterosis with the best heterotic pattern from Brazil; and (ii) incorporate the selected accessions into breeding programs.

MATERIAL AND METHODS

The Latin American Maize Project (LAMP) was an international project funded by Pioneer Hi-Bred International, Inc., to systematically evaluate maize genetic diversity for use in present and future breeding programs. The twelve countries involved evaluated more than 12,000 landrace accessions from the Americas (Salhuana & Sevilla, 1995). Because of differences in environments and growing seasons among the twelve countries the project was divided into five homologous areas (HA) according to altitude and latitude. Brazil was included in HA 1 which included tropical regions located between 0^o to 23^o N or S latitudes with altitudes below 1,200 meters above sea level (masl).The project was also divided into five stages of evaluation. Brazil evaluated 1,340 and 352 accessions, in the first and second stages, respectiveley. After the second stage the best 5% were selected for the third stage.

In the third stage, seeds of the best 5% were interchanged among countries with the same HA in order to make testcrosses. In this stage in Brazil, testcrosses using the testers BR 105 and BR 106 were made with five accessions from Bolivia, seven from

[1]Embrapa Milho e Sorgo, C.P. 151 – CEP 35701-970 – Sete Lagoas, MG.
[2] USDA-ARS Crop Genetics Research Unit, Iowa State Univ., Ames, IA 50011
[3] Embrapa Tabuleiros Costeiros, C.P. 44 – CEP 49025-040 – Aracaju, SE
[4] Embrapa Recursos Genéticos – C.P. 02372 – CEP 70849-970 – Brasília, DF
Corresponding author xavier@cnpms.embrapa.br

Guatemala, fifteen from Mexico, two from Paraguay, fourteen from Peru, five from Venezuela, seven from the United States, and seventeen from Brazil.

In 1991, the 72 crosses plus 9 checks were planted in a 9x9 simple lattice design at Sete Lagoas-MG (latitude 19^{o}47'45"S and longitude 44^{o}14'48"W), Goiânia-GO (latitude 16^{o}40'43"S and longitude 49^{o}15'14"W), Propriá-SE (latitude 10^{o}12'40"S and longitude 36^{o}50'25"W) and Janaúba-MG (latitude 15^{o}48'09"S and 43^{o}18'32"W). The common check in each experiment was the tester (BR 105 or BR 106) which was repeatedly interplanted in each incomplete lattice block. The means for these testers were considered as the superior parents for calculating heterosis estimates.

Data were recorded at four locations for plant height (cm), ear height (cm), number of broken stalks (B) and root lodging (R), ear number per plot, and yield measured as ear weight (Y) in t há $^{-1}$. Data for 50% male and female flowering were only observed in Sete Lagoas-MG and Propriá-SE. Yield data were adjusted to 14.5% moisture based on grain moisture samples taken on the same day of harvest. Data for broken stalks and root lodging (B+R) were transformed to $\sqrt{B+R+1}$. Prolificacy was calculated using an ear index (EI - ear number per plot over final stand).

Adjusted treatments means were used for the combined analysis over the four locations. This analysis was done based on a randomized complete block design since lattice efficiency of each experiment was low. Location was considered as a random model effect and treatments were considered as fixed effects. Adjusted mean yield values were used for estimating heterosis in relation to the superior parent. LSD was calculated as $t_{5\%}\sqrt{2MS(TxL)/r}$.

RESULTS AND DISCUSSION

Analysis of variance of the means from the crosses with the tester BR 105, combined across four locations (TABLE 1), showed highly significant differences among treatments for all traits ($P \leq 0.01$). For treatments x locations interaction, significant differences were found ($P \leq 0.01$) for yield (YI), ear height (EH) and square root of broken stalks + root lodging (B+R), but no significant differences were detected for the plant height (PH) and ear index (IE). The crosses with the tester BR 106 (TABLE 2) also showed significant differences among treatments ($P \leq 0.01$) for all traits, but for treatments x locations interaction significant differences were only found for YI($P \leq 0.05$) and B+R ($P \leq 0.01$). The four environments where the treatments were evaluated could be classified as HA 1 despite the distance of 1,500 miles between the two furthest locations. Within HA 1, Propriá-SE and Janaúba-MG could represent one subregion, while Sete Lagoas-MG and Goiânia-GO could be included in another subregion. Within these subregions there are large differences in soil type, altitude, and climatic conditions. The first subregion has hot days and high night temperatures with irregularly distributed rainfall, while the second has more moderate climatic conditions and lower night temperatures. Thus, a treatments x locations interaction should be expected for traits that are affected by environment. Even for analysis by grouping subregions, significative differences were found due to treatments x locations interactions for traits Y and B+R (data not shown). Similar results have been shown in tropical regions within environments that are considered more uniform with adapted, improved maize populations (Naspolini et al., 1981; Gama et al., 1982; Santos et al., 1994). Large climatic variability is a problem in tropical regions. For this reason, it is usually recommended to select genotypes for specific environmental conditions to avoid losses in time and to more efficiently use limited financial resources.

Mean values for yield with BR 105 tester ranged from 4.4 t ha^{-1} to 7.7 t ha^{-1}, while these means for the checks ranged from 5.7 t ha^{-1} to 8.0 t ha^{-1}. The best cross (SE 032 x BR 105) produced 7.7 t ha^{-1} while the double cross commercial check BR 201 produced 6.8 t ha^{-1}. There was large variability for PH (231 to 267 cm) and EH (119 to 162 cm).

With the tester BR 106 the range of variation for yield was from 4.1 t ha^{-1} to 7.4 t ha^{-1} while the commercial check BR 201 produced 6.6 t ha^{-1}. For the other traits the crosses with BR 106 showed similar trends as the crosses with BR 105, but means were lower with tester BR 106 due to having a lower mean values for these traits or due to the elite accessions having a dent endosperm.

Because yield is the primary agronomic trait of interest, and since these elite accessions have never been improved in their native countries, heterosis will be discussed only for yield. The high-parent heterosis with the tester BR 105 showed estimates that ranged from -28% to 26%. In crosses with BR 106, the high-parent heterosis ranged from -35% to 17%. The differences among these heterotic responses with the testers can be explained due to endosperm types of the accessions. More than 90% of the elite accessions had dent endosperm and crosses with dent x flint have shown higher heterosis than dent x dent. The best cross (8.4 t ha^{-1}) showed a heterosis of 14% relative to the superior parent and 73% relative to mid-parent. Depending on the improvement level and genotypes tested, heterosis can vary and have low or high values.

From a practical point of view and considering the limited financial resources for maize breeding programs in public institutions, among the elite accessions the following were selected for further work in Brazil: SE 032 and PE 001 with the tester BR 105, and PE 011 and Pasco 014 with tester BR 106.

REFERENCES

BROWN, W.L. Sources of germplasm for hybrid corn. p. 11-19. *In* W. Heckendorn and J. Gregory (ed.) **Proc. 8th Corn Industry-Research Conf., 8th,** Chicago, IL., 2-3 Dec. 1953. Am. Seed Trade Assoc., Washington, DC, 1953.

GAMA, E.E.G.; VIANA, R.T.; NASPOLINI FILHO, V.; MAGNAVACA, R. Heterosis for four characters in nineteen populations of maize. **Egyptian Journal Genetics Cytology,** v. 13 p. 69-80, 1982.

NASPOLINI FILHO, V.; GAMA, E.E.G.; VIANA, R.T.; MORO, J.R. General and specific combining ability for yield in a diallel cross among 18 maize populations. **Brazilian Journal of Genetics,** v. 4, p. 571-577, 1981.

SALHUANA, W.; SEVILLA, R. **Latin American Maize Project (LAMP). Stage 4 results from homologous area 1 and 5.** ARS Special Publication, Beltsville, 1995.

SANTOS, M.X.; PACHECO, C.A.P.; GUIMARÃES, P.E.O.; GAMA, E.E.G.; SILVA, A.E.; OLIVEIRA, A.C. Diallel among twenty eight varieties of maize. **Brazilian Journal of Genetics,** v. 17 p. 277-282, 1994.

UHR, D.V.; GOODMAN, M.M. Temperate maize inbreds derived from tropical germplasm: I. Tescrosses yield trials. **Crop Science,** v. 35 p. 779-784, 1995.

TABLE 1. Mean squares of the combined analysis of variance for trials with tester BR 105 over four environments for yield (Y), plant height (PH), ear height (EH), ear index (EI) and square root of broken stalks + root lodging + 1 (B+R).

Source	MEAN SQUARES					
	d.f	Y	PH	EH	EI	B + R
Locations (L)	3	209.80	54,856	53,113	0.94	184.79
Treatments (T)	80	3.72**	1,358**	903**	0.02**	1.49**
T x L	246	1.24**	379	206**	0.01	0.56**
Mean effective error	256	0.52	298	142	0.01	0.36
CV%		11.25	6.88	8.06	9.49	20.90
Overall mean		6.50	250	148	1.04	2.89

** Significant at 0.01.

TABLE 2. Mean squares of the combined analysis of variance for trials with tester BR 106 over four environments for yield (Y), plant height (PH), ear height (EH), ear index (EI) and square root of broken stalks + root lodging+ 1 (B+R).

Source	MEAN SQUARES					
	d.f	Y	PH	EH	EI	B + R
Locations (L)	3	340.80	70,477	68,635	1.43	236.42
Treatments (T)	80	4.42**	1,515**	1,302**	0.02**	0.78**
T x L	246	1.24*	262	231	0.01	0.59**
Mean effective error	256	0.90	250	216	0.01	0.45
CV%		15.41	6.46	10.28	10.08	24.60
Overall mean		6.10	245	143	0.96	2.74

* , ** Significant at the 0.05 and 0.01 level, respectiveley.