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AGRONOMIC PERFORMANCE OF TROPICAL × TROPICAL AND TROPICAL × TEMPERATE SINGLE-CROSS MAIZE HYBRIDS IN IBADAN, NIGERIA

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ABSTRACT

The productivity of tropical maize could be improved by the introgression of beneficial alleles from temperate germplasm. Ten tropical × temperate and two temperate × temperate single cross hybrids were developed and evaluated for their performance alongside four tropical × tropical hybrids. The tropical × temperate hybrids were developed by crossing the temperate inbred lines B73 and Mo17 as males to the tropical inbred lines 4001, 4008, 9613, 9432 and KU1409. The experimental design was randomized complete block with three replicates. Data were collected on seedling emergence, flowering traits, grain yield and yield components and subjected to analysis of variance. Significant genotypic differences were observed among the hybrids for all measured traits. The tropical × tropical crosses had significantly higher grain yield, ear width, kernel weight and kernel depth than the crosses involving the tropical × temperate inbred lines. However, the tropical × tropical hybrids had lower emergence percentage, but higher emergence index and emergence rate index than the tropical × temperate hybrids. Grain yield ranged from 3.38 (Mo17 × B73) to 6.02 t/ha (4001 × 4008) and was in the order temperate × temperate < tropical × temperate < tropical × tropical hybrids. On average, tropical × B73 hybrids had higher grain yields than tropical × Mo17 hybrids. Four of the tropical × temperate hybrids (4001 × B73, 4008 × B73, KU1409 × B73 and 9432 × Mo17) had grain yields equal to or above the overall average. These hybrids have considerable potential and could be exploited to improve and broaden the grain yield of tropical maize.

Key words: B73 inbred, Genetic variability, Maize grain yield, Tropical × temperate hybrids

INTRODUCTION

Maize (*Zea mays* L.) is one of the most widely cultivated cereal grain crops in sub-Saharan Africa, where it accounts for up to 70% of the daily human calorie intake with a consumption averaging about 72 kg per capita (Martin *et al*., 2000; FAOSTAT, 2014). Therefore, increased grain production and yield is required to meet the demand for maize within the limits of available land and environmental conditions in tropical Africa (Pingali and Pandey, 2001). To achieve this goal, and given the diversity of crop growing environments in tropical Africa, there is the need to develop maize varieties and hybrids with enhanced yield potential and improved adaptation to major stresses (Menkir *et al*., 2006).

Improvement in crop plants involves intercrossing among existing elite genetic materials which usually results in a progressive depletion of genetic variability and could restrict breeding flexibility as new production challenges emerge. Maize grain yield improvement could be achieved by introducing new variability into existing germplasm thereby widening the genetic base. This could be accomplished by the introgression of beneficial alleles from exotic into adapted germplasm. Exotic germplasm includes any genetic material with restricted immediate usefulness without selection for adaptation and needs improvement (Carena and Hallauer, 2001; Dhliwayo *et al*., 2009; Hallauer *et al*., 2010). In a review, Efron (1985) noted the lack of adaptation of exotic germplasm to tropical climate and its susceptibility to diseases and insect pests among the reasons for the limited use of exotic germplasm for improving grain yield and other agronomic traits in tropical Africa. The author opined that exotic germplasm could however be used to enhance heterosis of tropical maize hybrids in Africa. According to Goodman (1999), proven inbred lines are the most promising sources of exotic germplasm because they possess numerous desirable attributes fixed through several generations of inbreeding and selection and should be free from most deleterious recessive alleles. Wen *et al.* (2012) have suggested that the incorporation of lines from the germplasm enhancement maize (GEM) project with unique alleles and clear heterotic patterns into tropically adapted lines could be of benefit in enhancing heterosis for grain yields.

Previous studies (Tallury and Goodman 1999; Goodman *et al.* 2000; Chen *et al.*, 2013) as well as molecular data involving the use of SSRs and SNPs (Liu *et al.*, 2003; Yan *et al.*, 2009; Ortiz *et al.*, 2010) have revealed the potentials of tropical maize germplasm in broadening the genetic base of temperate hybrid maize breeding, which could also aid the adaptability of new hybrids (Fan *et al.*, 2003). There could also be some favourable alleles unique to temperate germplasm for the improvement of tropical maize. Worku *et al*. (2016) demonstrated that the productivity of tropical inbred lines could be increased by the inclusion of temperate germplasm in breeding populations. Reports (Kim *et al.*, 1987; Menkir *et al.*, 2006) have shown the potential utility of exotic germplasm in improving grain yield and other agronomic traits in tropical adapted lines. Improvement in the performance of hybrids could be achieved faster by integrating the good plant type and agronomic characteristics of exotic inbred lines into adapted tropical inbred lines (Menkir *et al.*, 2006). These reports demonstrated the comparative potentials of adapted × exotic backcrosses and adapted lines. There is hardly any documented report on the direct assessment of F_1 hybrids between adapted and exotic germplasm in tropical maize breeding. Such reports could provide information on which cross populations should be selected for improvement either by selfing, backcrossing or backcrossing before selfing. The temperate inbred lines B73 and Mo17 are respectively among the most recycled female and male maize inbred lines in the US (Baker, 1984; Smith, 1988) and their hybrid and its relatives are widely cultivated in the Corn Belt (Lu and Bernardo, 2001). Furthermore, the genetic map of maize is based on recombinant inbred lines developed from the B73 × Mo17 hybrid (Swanson-Wagner *et al.*, 2006). This study was therefore carried out to evaluate the performance of F_1 hybrids of selected tropical inbred lines crossed to the temperate inbred lines B73 and Mo17.

MATERIALS AND METHODS

Generation of planting materials

Sixteen maize genotypes comprising of four tropical × tropical hybrids, ten tropical × temperate hybrids and two temperate × temperate reciprocal cross hybrids were used for the study. The tropical × temperate hybrids were generated by crossing the two temperate inbred lines B73 and Mo17 as males to five tropical inbred lines (4001, 4008, 9432, 9613 and KU1409) developed by the International Institute of Tropical Agriculture (IITA), Ibadan in an incomplete diallel. Seeds for all the hybrids were generated in the nursery during the 2013/2014 dry season.

Field evaluation

The sixteen maize hybrids were evaluated under rain-fed conditions during the 2014 and 2015 main cropping seasons at the Teaching and Research Farm of the University of Ibadan (7°26' N, 3°54' E), Ibadan, Nigeria. The soil at the experimental site is sandy-loam with 15.20 g/kg organic carbon, 0.98 g/kg total nitrogen, 14.79 mg/kg available P (Bray-1), 0.26 cmol/kg K and a pH(H_2O) of 6.1. The experimental design was a randomised complete block with three replicates. Plots consisted of three rows that were 5.00 m long. Within and between row spacing were 0.25 m and 0.75 m, respectively. Planting was done on the flat. Two seeds were planted per hill and later thinned to one to give a plant population density of approximately 53,333 plants per hectare. Fertilizer in the form of NPK 15-15-15 was applied at the rate of 300 kg/ha at two weeks after planting (WAP). This provided 45 kg N/ha, 20 kg P/ha and 36 kg K/ha. The fertilizer was top-dressed with urea at the rate of 25 kg N/ha at 5 WAP. Plots were kept weed free with herbicide application complemented with hand weeding.

Data collection

Seedling emergence and flowering traits

Seedling emergence which represented the number of emerged seedlings at a given time was monitored from 4 to 10 days after planting (DAP). Total number of emerged seedlings was therefore computed as the numbers of emerged seedlings at 10 DAP. Data on seedling emergence was used to calculate emergence percentage (E%), emergence index (EI) and emergence rate index (ERI). The E% was computed as proportions of numbers of emerged seedlings at 10 DAP to number of seeds planted, expressed as percentage. The EI, estimate of the rate of emergence, was calculated using the formula of Mock and Eberhart (1972).

$$EI = \sum [(N_x) \times (DAP)/\text{Seedlings emerged 10 DAP}]$$

where N_x is the number of seedlings emerged on day *x*.

The ERI, an estimate of the total number of days for the attainment 100% emergence, was calculated as the proportion of EI to E% multiplied by 100.

Days to anthesis (DA) and days to silking (DS) were recorded as number of days from planting to when 50% of plants in a plot shed pollen or show silk extrusion, respectively. Anthesis – silking interval (ASI) was derived as the difference in days between DS and DA.

Yield and yield related traits

Ear length (cm) was measured on 10 top ears as the length of ears (with husk removed) and the average per ear based on the number of ears measured. Ear width (cm) was measured on 10 top ears, using an electronic 6" digital calliper (Pittsburgh®, Item #47257, made in China), as the diameter of ears (with husk removed) taken at the middle portion of the ear and the average per ear based on the number of ears measured. Cob width (cm) was measured on 10 top ears, using an electronic digital calliper, as the diameter of the cob of shelled ears taken at the middle portion of the cob and the average per cob based on the number of ears measured. This was used only in the estimation of kernel depth. Kernel depth (cm) was estimated as half the difference between ear and cob widths. Kernel rows was recorded as average number of kernel rows on 10 top ears. Kernel weight (g) was measured as the weight of 1000 kernels adjusted to 150 g/kg moisture content. It was estimated by weighing a representative 200 kernels and multiplying by 5. Number of kernels was recorded as number of kernels on ear per plant after shelling and estimated indirectly through the relationship between weight of 200 kernels, weight of total number of kernels and number of ears harvested per plot. Grain moisture content was determined with a portable Dickey-John moisture tester (Model 14998, Dickey-John Corporation, Auburn USA) as the percent moisture content of shelled kernels. All ears in a plot were harvested, shelled and the weight, moisture content of shelled grains and number of plants at harvest used to estimate grain yield (t/ha) adjusted to 150 g/kg moisture content.

Data analyses

Data were subjected to analysis of variance using the PROC. GLM procedure in SAS (SAS Institute Inc., 2003). Means were separated using Least Significant Difference (LSD) at $p \leq 0.05$. Comparison among hybrid types was done using a single degree of freedom contrast.

RESULTS

Seedling emergence and flowering traits

Hybrids differed significantly for E%, EI, ERI, DA, DS. Also, significant hybrid differences were observed within each category of hybrids for these traits except ASI which did not differ among the Tropical × Tropical hybrids, as well as DA and DS for which the Temperate hybrids did not show significant differences. However, the interactions between hybrids and years were not significant for any of the traits. Single degree of freedom contrast indicated significant differences between the Tropical × Tropical and Temperate × Temperate hybrids, as well as between the Tropical × Tropical and Tropical ×

Temperate hybrids for the seedling emergence and flowering traits. The contrast between Tropical × Temperate and Temperate × Temperate hybrids were significant for the seedling emergence traits only. However no significant differences were detected between the Tropical × B73 and Tropical × Mo17 hybrids for the seedling emergence and flowering traits (Table 1). The Tropical × Tropical hybrids had lower E%, but higher EI and ERI than the Tropical × Temperate hybrids, indicating that the latter group of hybrids germinated and emerged earlier than the former. On average, the E%, EI and ERI were 90.9, 4.2 and 4.7, respectively suggesting the planting materials were of good quality. The DA and DS ranged from 50.8 to 56.0 (mean: 52.2) and 52.5 to 57.3 (mean: 54.4) days, respectively. The ASI across hybrids was on average less than 2 days. Flowering was significantly earlier in the Tropical × Temperate hybrids than in Tropical × Tropical hybrids (Table 2).

Table 1: Mean squares from analysis of variance of the effects of years and hybrid on seedling emergence and flowering traits of 16 single cross maize hybrids evaluated across two years in Ibadan, Nigeria

Source of variation	DF	Emergence percentage	Emergence Index	Emergence rate index	Days to anthesis	Days to silking	ASI
Rep(Year)	4	27.588	0.548*	0.052	21.458***	30.344***	0.958***
Hybrid	15	448.410***	3.626***	0.134***	13.660***	11.294***	0.600***
Tropical ×Tropical	3	153.035***	0.890***	0.143**	4.778*	5.444*	0.111
Temperate ×Temperate	1	1855.551**	18.476***	0.161***	0.083	0.750	1.333***
Tropical ×Temperate	9	86.336***	0.379***	0.061***	7.481***	6.252***	0.548***
Tropical ×B73	4	68.556***	0.224**	0.016***	8.533***	4.883***	0.783**
Tropical ×Mo17	4	123.929***	0.570***	0.091***	8.033***	8.917***	0.450*
Tropical ×B73 versus Tropical ×Mo17	1	7.086	0.117	0.237	1.067	1.067	0.000
Tropical ×Tropical versus Temperate ×Temperate	1	1779.360***	0.065**	14.027***	40.500***	24.500***	2.000***
Tropical ×Tropical versus Tropical ×Temperate	1	289.426**	0.438***	2.700**	121.905***	96.090***	1.543***
Tropical ×Temperate versus Temperate ×Temperate	1	3618.618***	0.627***	29.618***	1.736	3.803	0.400
Year × Hybrid	15	1.102	0.005	0.002	0.205	0.160	0.042
Error	60	13.995	0.216	0.026	0.747	0.977	0.158

*, **, ***: significant respectively at 0.05, 0.01, 0.001 probability levels

Table 2: Means of seedling emergence and flowering traits of 16 single cross maize hybrids maize hybrids evaluated across two years in Ibadan, Nigeria

Hybrids	Emergence percentage	Emergence Index	Emergence rate index	Days to anthesis	Days to silking	ASI
Tropical × Tropical						
4001 × 4008	88.63	4.47	5.08	55.0	56.2	1.2
KU1409 × 4008	83.86	4.31	5.15	53.8	55.0	1.2
KU1409 × 9613	95.37	4.11	4.32	55.2	56.2	1.0
4001 × KU1414	92.86	4.38	4.71	56.0	57.3	1.3
Mean	90.18	4.32	4.82	55.0	56.2	1.2
Tropical × Temperate						
4001 × B73	90.35	4.19	4.64	52.8	54.3	1.5
4008 × B73	96.03	4.10	4.27	54.0	55.0	1.0
9432 × B73	96.30	4.05	4.21	50.8	52.8	2.0
9613 × B73	98.55	4.13	4.19	52.8	54.3	1.5
KU1409 × B73	91.94	4.10	4.47	51.8	53.2	1.4
Mean	94.63	4.11	4.36	52.5	53.9	1.5
4001 × Mo17	91.94	4.37	4.72	52.8	54.5	1.7
4008 × Mo17	87.30	4.24	4.86	53.8	55.3	1.5
9432 × Mo17	99.08	4.15	4.19	51.7	52.7	1.0
9613 × Mo17	94.71	4.23	4.47	50.8	52.5	1.7
KU1409 × Mo17	96.70	4.03	4.17	51.8	53.3	1.5
Mean	94.94	4.20	4.48	52.2	53.7	1.5
Temperate × Temperate						
B73 × Mo17	62.83	4.52	7.38	52.8	54.2	1.4
Mo17 × B73	87.70	4.29	4.90	52.7	54.7	2.0
Mean	75.27	4.41	6.14	52.8	54.4	1.7
Grand Mean	90.88	4.23	4.73	53.1	54.5	1.4
CV (%)	4.11	3.78	9.83	1.63	1.81	28.09
LSD (0.05)	4.32	0.18	0.54	1.00	1.14	0.46

ASI: Anthesis-silking interval

Grain yield and yield components

Significant hybrid effects were observed for grain yield and yield-related traits. Similarly, grain yield and yield-related traits manifested significant within hybrid group differences except yield-related traits of Temperate × Temperate hybrids. Comparatively, grain yield and yield-related traits differed significantly between the Tropical × Tropical and Temperate × Temperate, as well as between Tropical × Tropical and Tropical × Temperate hybrids types except for kernel rows. However, comparison between Tropical × Temperate and Temperate × Temperate hybrids for these traits were only significant for grain yield and kernel weight. Contrast between Tropical × B73 and Tropical × Mo17 crosses were significant for the grain yield and yield-related traits except kernel weight (Table 3). Grain yield among the hybrids ranged from 3.38 (Mo17 × B73) to 6.02 t/ha (4001 × 4008). All the four Tropical × Tropical hybrids had above average grain yields, while only four of the Tropical × Temperate hybrids (4001 × B73, 4008 × B73, KU1409 × B73 and 9432 × Mo17) had grain yields equal to or above the average (4.47 t/ha). However, seven of the Tropical × Temperate hybrids (4001 × B73, 4008 × B73, 9432 × Mo17, KU1409 × B73, 9613 × B73, KU1409 × Mo17 and 4001 × B73) had yields greater than 4.00 t/ha. The grain yield of the Tropical × Tropical hybrid 4001 × 4008 was significantly higher than for all other hybrids, while the grain yield of the highest yielding Tropical × Temperate hybrid (4001 × B73) was comparable to those of the other Tropical × Tropical hybrids. The Tropical × B73 hybrids out-yielded Tropical × Mo17 hybrids by 12.7%, while the Tropical × Tropical hybrids were on the average 21.4% higher yielding than the Tropical × B73 hybrids. The range in ear width was from 3.68 (4008 × Mo17) to 4.61 cm (4001 × B73) with a mean of 4.23 cm. The Tropical × Tropical hybrids had significantly higher ear width than the Tropical × Temperate hybrids. Although the ear width of the Tropical × Mo17 hybrids and Temperate × Temperate hybrids were comparable, these were significantly lower than those of Tropical × B73 hybrids. Kernel depth ranged from 0.83 (B73 × Mo17) to 1.09 cm (KU1409 × 4008) with a mean of 0.93 cm. The Tropical × B73 hybrids had higher kernel depth than either of the Tropical × Mo17 or Temperate × Temperate hybrids (Table 4). The range in ear length was from 12.2 (9432 × B73) to 16.3 cm (4001 × 4008) cm with a mean of 14.4 cm. The ear length of Tropical × Tropical hybrids (15.3 cm) and Tropical × Mo17 hybrids (15.0 cm) were comparable and higher than either that of Tropical × B73 (13.2 cm) or the Temperate × Temperate hybrids (13.7 cm). Kernel rows ranged from 12.2 (4008 × Mo17) to 16.5 (9432 × B73) with a mean of 14.0. The Tropical × B73 hybrids had higher kernel rows than the Tropical × Mo17 and Tropical × Tropical hybrids. Kernel number ranged from 335.4 (9432 × B73) to 526.6 (4008 × B73) with a mean of 415.0. Although Tropical × B73 crosses had comparable kernel number with Tropical × Tropical hybrids, significantly lower kernel number was observed for Tropical × Mo17 crosses. Kernel weight ranged from 162.4 (B73 × Mo17) to 243.7 g (4001 × 4008) with a mean of 203.7 g. The Tropical × Tropical hybrids had significantly higher kernel weight than all other hybrid combinations. The kernel weight of Tropical × B73 crosses was comparable to that of Tropical × Mo17 crosses (Table 4).

Table 3: Mean squares from analysis of variance of the effects of years and hybrid on grain yield and yield-related traits of 16 single cross maize hybrids evaluated across two years in Ibadan, Nigeria

Source of variation	DF	Grain yield (t/ha)	Ear width (cm)	Kernel depth (cm)	Ear length (cm)	Kernel rows	Kernel number	Kernel weight (g)
Rep(Year)	4	0.098	0.028***	0.004***	1.144*	1.080***	227.349	291.989
Hybrid	15	4.335***	0.499***	0.031***	7.723***	9.805***	19111.389***	5172.731***
Tropical ×Tropical	3	0.813*	0.039**	0.028***	3.020***	1.751***	2404.675**	764.949***
Temperate ×Temperate	1	0.021*	0.003	0.030	0.052	0.314	1777.063	109.022
Tropical ×Temperate	9	2.402***	0.561***	0.023***	8.372***	15.043***	27980.000***	3646.183***
Tropical ×B73	4	2.806***	0.254***	0.019***	6.278***	3.699***	47388.000***	4161.704***
Tropical ×Mo17	4	1.588***	0.248***	0.023***	0.978***	1.836***	5002.049***	4038.925***
Tropical ×B73 versus Tropical ×Mo17	1	4.040**	3.042***	0.040**	46.323***	113.245***	42261.23***	13.132
Tropical ×Tropical versus Temperate ×Temperate	1	34.512***	1.188***	0.101**	40.500***	2.859	20123.170*	38636.060***
Tropical ×Tropical versus Tropical ×Temperate	1	25.780***	2.129***	0.113***	121.905***	5.767	18310.510*	22280.240***
Tropical ×Temperate versus Temperate ×Temperate	1	7.237***	0.011	0.010	1.736	0.003	3052.612	11184.730***
Year × Hybrid	15	0.020	0.001	0.000	0.050	0.026	130.487	13.447
Error	60	0.168	0.007	0.001	0.375	0.216	905.629	139.482

*, **, ***: significant respectively at 0.05, 0.01, 0.001 probability levels

Table 4: Means of grain yield and yield related traits of 16 single cross maize hybrids evaluated across two years in Ibadan, Nigeria

Hybrids	Grain yield (t/ha)	Ear width (cm)	Kernel depth (cm)	Ear length (cm)	Kernel rows	Kernel number	Kernel weight (g)
Tropical × Tropical							
4001 × 4008	6.02	4.48	0.94	16.3	13.7	464.8	243.73
KU1409 × 4008	5.20	4.54	1.09	15.0	14.3	449.2	218.36
KU1409 × 9613	5.51	4.40	0.98	14.7	13.1	434.9	238.99
4001 × KU1414	5.28	4.58	0.96	15.2	13.2	418.0	238.66
Mean	5.50	4.50	0.99	15.3	13.6	441.7	234.94
Tropical × Temperate							
4001 × B73	5.36	4.61	0.96	14.3	15.7	510.3	198.19
4008 × B73	5.01	4.32	0.90	14.3	15.3	526.6	178.74
9432 × B73	3.61	4.10	0.86	12.2	16.5	335.4	203.03
9613 × B73	4.21	4.30	1.00	12.8	15.7	455.6	175.46
KU1409 × B73	4.48	4.54	0.98	12.4	14.4	350.2	241.35
Mean	4.53	4.37	0.94	13.2	15.5	435.6	199.35
4001 × Mo17	4.21	4.02	0.84	15.3	13.1	419.3	189.65
4008 × Mo17	3.35	3.68	0.83	15.5	12.2	343.9	183.26
9432 × Mo17	4.67	4.00	0.98	14.7	13.4	368.3	239.04
9613 × Mo17	3.67	3.75	0.88	14.7	12.9	399.6	172.80
KU1409 × Mo17	4.19	4.17	0.91	14.6	12.3	381.6	207.33
Mean	4.02	3.92	0.89	15.0	12.8	382.5	198.42
Temperate × Temperate							
B73 × Mo17	3.47	4.10	0.83	13.7	14.3	403.8	162.43
Mo17 × B73	3.38	4.14	0.93	13.8	14.0	379.4	168.46
Mean	3.42	4.11	0.88	13.7	14.2	391.6	165.44
Grand Mean	4.47	4.23	0.93	14.35	14.00	415.04	203.72
CV (%)	9.15	1.96	2.77	4.27	3.32	7.25	5.80
LSD (0.05)	0.47	0.10	0.03	0.71	0.54	34.75	13.64

DISCUSSION

In the present study, the agronomic performance of some tropical × tropical, tropical × temperate and temperate × temperate single-cross maize hybrids was evaluated. The hybrid types evaluated exhibited significant genotypic differences for all the measured traits. These differences could be attributed to variation in the genetic backgrounds of the inbred parents of the hybrids. Within hybrid group differences for some of the traits indicated the existence of genetic variability among the hybrids regardless of the similarity in the genetic background of the parental inbreds

The tropical × temperate hybrids germinated and emerged earlier than either the tropical × tropical or temperate × temperate hybrids. Furthermore, the tropical × temperate and temperate × temperate hybrids flowered two days earlier than the tropical × tropical hybrids. In the study by Bosch *et al*. (2003), 100% tropical × tropical hybrids flowered four days earlier than B73 × tropical hybrids in the temperate climate of Spain.

Four of the tropical × temperate hybrids (4001 × B73, 4008 × B73, KU1409 × B73 and 9432 × Mo17) had grain yields equal to or above the average. Three of these crosses involved the temperate inbred line B73. Furthermore, the average yield of crosses with B73 was significantly higher than the crosses with Mo17. These results suggest that B73 could have good combining ability with tropical inbred lines and be a veritable source of useful alleles to improve the performance of tropical germplasm. In addition, the results of the present study showed significant differences among the three groups (tropical × tropical, tropical × temperate and temperate × temperate) of hybrids for grain yield. This is consistent with the findings of Bosch *et al*. (2003). In their study, Bosch *et al*. (2003) reported that the average grain yield of temperate × tropical hybrids containing 50% tropical material was significantly higher than that of 100% tropical × tropical hybrids but lower than the mean grain yield of the 100% temperate hybrids in the Spanish temperate Mediterranean climate. These findings reveals that the adapted tropical germplasm contain more useful alleles than the exotic temperate lines. In order to increase the probability of isolating useful lines from these crosses, there is therefore the need for at least one generation of backcrossing to the adapted tropical lines before selection is initiated Dudley (1982). It is however interesting to note that although the Tropical × Temperate cross 9432 × B73 exhibited below average grain yield, the cross 9432 × Mo17 had above average grain yield. This finding shows the importance of crossing the temperate inbred lines to the same set of tropical inbred lines when their potential utility is being compared. Similar findings were reported by Kraja *et al*. (2000). These authors therefore suggested that comparison of the potential utility of any set of exotic lines should only be made when they have been assessed using a common tester.

CONCLUSIONS

The single-cross hybrids included in this study exhibited significant genetic differences for all the measured traits. Among and within hybrid group differences were found for most of the traits. The Tropical × B73 crosses out-yielded Tropical × Mo17 crosses by 12.7% suggesting that B73 could have good combining ability with tropical inbred lines and be a veritable source of useful alleles to improve the performance of tropical germplasm. Four Tropical × Temperate crosses (4001 × B73, 4008 × B73, KU1409 × B73 and 9432 × Mo17) had grain yields equal to or above the average. The utility of these hybrids in improving and broadening the grain yield potential of tropical maize germplasm should be further exploited via backcrossing and selection in order to increase the possibility of isolating useful lines from the crosses.

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