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Identification of Potential Tropical Maize Inbred Lines with Early Maturity for Drought-Prone Environments

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ABSTRACT

The present study was undertaken during October, 2020–January, 2021 at Maize Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, Telangana state, India to identify potential inbred lines and hybrids with early maturity and high yield through combining ability analysis and heterosis. Six lines and four testers were crossed in L×T design to obtain 24 crosses. Evaluation of these crosses and their parents for combining ability revealed significant differences due to lines, testers and their crosses indicating the existence of wider variability among the material used in the study. Maize line MGC 434 (91 days), two testers GP-170 and PFSR-56 (91 days), and one hybrid MGC-445×PFSR-132 (83 days) were identified as early duration genotypes. Four lines MGC-444 (-3.13), MGC-440 (-2.71), MGC-439 (-1.96) and MGC-445 (-0.46) with significant negative GCA effects were identified as best general combiners for early maturity. Eight hybrids, MGC-439×BML-14 (-4.99), MGC-445×PFSR-56 (-4.65), MGC-461×PFSR-56 (-3.65), MGC-445×PFSR-132 (-3.60), MGC-434×BML-14 (-2.32), MGC-439×GP-170 (-2.10), MGC-440×PFSR-56 (-2.07) and MGC-440×GP-170 (-1.01) with significant negative SCA effects were considered as best cross combinations with early maturity. The inbred parents and cross combinations with early maturity identified in the study can be utilized for development of hybrids suitable to drought prone environments.

KEYWORDS: Maize, early maturity, general combining ability, specific combining ability

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1. INTRODUCTION

Globally, maize is being cultivated in more than 203.5 mha in 170 countries under varied agro-climatic conditions with a production of 1163.5 mt and productivity of 5.7 t ha^{-1} (Anonymous, 2022). It contributes 40% annually (>840 m tons) to the world food basket (Prasanna et al., 2021). In the world, maize is predominantly used as feed (>60%) and only 17% as food and rest for the industrial purposes (Anonymous, 2021a). In India, maize is the third most important food crop among the cereals, contributes nearly 9% to the national food grain production. It is cultivated in an area of 9.5 mha and with productivity of 3000 kg ha^{-1} (Anonymous, 2021b). Nearly 80% of total maize is grown in *kharif* season, which is predominantly a rainfed crop with medium and long duration hybrids/ varieties.

The past few years have seen dramatic changes in the production and productivity of maize in India. The adoption of single cross hybrids has revolutionized the maize production. Consequently, its production has registered an annual growth rate of 6.4% (2016–2020), the highest among food crops and surpassing the 4% growth rate for agriculture in general and 4.7% for maize in particular (Erenstein et al., 2022). The demand for maize is increasing consistently and hence, it is important to enhance its productivity through development of hybrids suitable to various agro-ecosystems.

Since most of the maize is cultivated under rainfed conditions, it undergoes drought stress at various physiological stages particularly between tassel emergence and early grain-filling period (2 to 22 days) after anthesis, due to consequent effects on male–female flowering synchronization, and reduction in grain setting and kernel size (Bolanos et al., 1993), causes considerable reduction in yield and sometimes complete barrenness. In order to improve the yield of maize per hectare, there is need to develop hybrids which should have high genetic gain, including reduction in breeding cycle time, widely adapted, responsive to improved production practices and adjustable in the existing cropping pattern (Atlin et al., 2017; Andorf et al., 2019; Bailey-Serres et al., 2019). Further, obtaining sufficient information on breeding values and genetic parameters of chose genotypes is essential for systematic introgression of exotic lines into local germplasm in target environments (Nelson and Goodman, 2008; Dermail et al., 2023)

Early maturing hybrids play a vital role in enhancing the productivity of maize, which may prevent yield losses by escaping the terminal droughts (Drought escapers), as well as disease and insect attacks (Pest and disease avoiders) to considerable extent due to their short life cycle (Ullah et al., 2017; McMillen et al., 2022). To achieve this, it is important to select suitable parents for hybridization and to develop promising hybrids with early maturity and high yield. (Chavan et al., 2022).

This can be achieved by having information on the nature of combining ability of the parents and their performances in specific crosses i.e., general combining ability and specific combining ability (Sprague and Tatum, 1942) respectively and by assessing the magnitude of the heterosis and breeding strategy effective for developing hybrids (Renkow and Byerlee, 2010; Edmeades et al., 2017; Zaidi et al., 2019). Hence, the present study was undertaken to identify potential inbred lines and promising early maturing maize hybrids to drought prone environments by estimating the combining ability and heterosis for early maturity and grain yield in selective genotypes of maize.

2. MATERIALS AND METHODS

The present study was undertaken during October – January, 2020–2021 at Maize Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad, India

2.1. Experimental material used in the study

The experimental material for the present study comprised of six inbred lines MGC-434, MGC-439, MGC-440, MGC-444, MGC-445, MGC-461; four testers *viz.*, BML-14, GP-170, PFSR-56, PFSR-132. All the six lines were obtained from CIMMYT Regional Centre, Hyderabad whereas the four testers were developed through pedigree method of selection at AICRP on maize, Maize Research Centre, PJTSAU, Rajendranagar, Hyderabad (Table 1). These six lines and four testers were crossed in L×T fashion during *rabi* 2020–21 and obtained 24 single cross hybrids.

2.2. Field plot technique

The experimental material consisting of 24 single cross hybrids and their 10 parents (6 lines and 4 testers) with two checks (DHM-117 and NK624) were sown in randomized block design in three replications during *kharif,* 2021 and 2022 at Maize Research Centre, PJTSAU, Rajendranagar, Hyderabad.

The genotypes were sown following hand dibbling with one seed per hill at a spacing of 60 cm between rows and 20 cm between plants. Each experimental plot consisted of 4 rows of 5 m length. Further, the crop was managed with recommended fertilizer dose (180 N, 60 P_2O_5, and 40 K_2O kg ha^{-1}). The complete dose of P_2O_5, K_2O and one-third of the nitrogen was applied as a basal dose, and rest of the nitrogen was applied as top dressing in two equal splits, one at knee high stage and the other at tasseling stage. To obtain a healthy crop, all the recommended plant protection measures were followed during crop growth period.

Table 1: Details of selective maize genotypes used in the present study

Sl. No.	Identity	Source	Pedigree
Lines			
1	MGC- 434	CIMMYT, Regional Centre, Hyderabad	(CLQG2508-B*8/POB45c9F22-18-3-1-B*4-1-B*9)-B-4-BB
2	MGC- 439		(PobBTS-BBB-52/CML451)-B*4-5-B*4
3	MGC- 440		((CLQ-RCYQ28xP390Am/CMLc4F218-B-1-B)-B-7-2-B*6-B1-BBB/(CLQ-RCYQ28xP390Am/CMLc4F218-B-1-B)-B-7-2-B*6-B2-BBB)-B-9-B-2-BB
4	MGC-444		(PobBTS-BBB-52/CML451)-B*4-2-B*4
5	MGC- 445		(POP351C0-HS274-1-1-B*4-2-B*6/Composite18-B(Fat)-BB-3-B)-B-7-B-1-2-B
6	MGC- 461		RTSyn16HG(A)-7-1-1-B-B2
Testers			
1	BML-14		COIB96 K-1-#-1-2-xb-xb-1-2-xb-xb-2-xb-xb-xb
2	GP-170		EY Syn-B-#-34-B-1-B
3	PFSR-56		BPPTI-38×CM-119
4	PFSR-132		BPPTI-29×CM-210
Checks			
1	DHM-117	Developed at Maize Research Centre, PJTSAU Rajendranagar, Hyderabad	BML-6×BML-7
2	NK-6240	Hybrid from Syngenta	Popular in Telangana

2.3. Statistical analysis

The observations for yield attributing traits were recorded on five random plants per treatment in all the genotypes in each replication. The plants were selected from the middle rows to minimize error due to the border effect. The observations pertaining to maturity related characters were recorded on plot basis and the maize genotypes were classified based on days to 50% tasselling and days to maturity according to Badu-Apraku et al. (2012). Replication wise mean value for all the characters were subjected to statistical analysis for computing mean, general combining ability (GCA), specific combining ability (SCA), gene action and heterosis. The adopted design was Randomized Block Design (RBD) replicated thrice. The analysis of variance for each character was carried out as per the standard statistical procedure described by Panse and Sukhatme (1985) to test the differences between the genotypes for all the characters. The combining ability was estimated based on the method of Kempthorne (1957). The estimates of general and specific combining ability effects and their variances were obtained by using covariance of half-sibs and full sibs.

3. RESULTS AND DISCUSSION

The present study was carried out to identify potential parents and elite cross combinations with early maturity in selective maize genotypes based on estimation of genetic parameters viz., combining ability and heterosis.

3.1. Analysis of variance

The analysis of variance for maturity traits and grain yield revealed significant differences among the genotypes for all the traits indicating the existence of sufficient variation in the material used for the study (Table 2).

3.2. Mean performance of lines, testers and their cross combinations

The mean performance of lines, testers and their cross combinations for maturity traits and grain yield are presented in Table 3. The overall mean performance for days to 50% tasseling revealed that hybrids flowered earlier than parents. For days to 50% tasseling, the mean performance of lines is 61.5, ranging from 60 days (MGC-434, MGC-445 and MGC-461) to 63 days (MGC-440, MGC-439 and MGC-444), whereas for testers it was from 59 days (GP-170 and PFSR-56) to 63 days (BML-14 and PFSR-132) and in case of hybrids the mean value is 55 days ranging from 52 days (MGC-445×PFSR-132) to 62 days (MGC-440×GP-170). The mean value of days to 50% tasseling for the checks DHM-117 and NK-6240 was 57 days and 58 days respectively. The lines MGC-434, MGC-461 and MGC-445 (60 days); testers GP-170 and PFSR-56

Table 2: Analysis of variance for maturity traits and grain yield of selective maize genotypes evaluated during *kharif,* 2021–2022

Character	Mean sum of squares		
Source of variation	Replications	Genotypes	Error
Degrees of freedom	2	35	70
Days to 50% tasseling	0.53	31.600**	0.34
Days to 50% silking	0.40	41.160**	0.36
Days to 50% maturity	0.62	41.160**	0.33
Grain yield ha^{-1} (kg)	78323.96	8096020.00**	459315.30

Level of statistical significance **p<0.01

(59 days) were the earliest among the parents and MGC-445×PFSR-132 (52 days) was the earliest among hybrids.

The mean value for days to 50% silking for lines was 64.16 days ranging from 61 days (MGC-434) to 66 days (MGC-440, MGC-444 and MGC-439), for testers it was 63.5 days ranging from 61 days (GP-170 and PFSR-56) to 66 days (BML-14 and PFSR-132), and for hybrids, it was 57 days ranging from 52 days (MGC-445×PFSR-132) to 64 days (MGC- 440×GP-170) (Table 3). The mean value for the check DHM-117 was 59 days and for NK-6240 it was 60 days. The line MGC-434 (61 days) and testers GP-170 and PFSR-56 (61 days) were the earliest among the parents and in case of hybrids MGC-445×PFSR-132 (54 days) was the earliest among hybrids.

The data for days to 50% maturity shown that the hybrid MGC-445×PFSR-132 recorded least days to 50% maturity (83 days) (Table 3). The performance of genotypes for the trait days to 50% maturity, varied from 91 days (MGC-434) to 96 days (MGC-440, MGC-444 and MGC-439) for lines, in testers 91 days (GP-170 and PFSR-56) to 96 days (BML-14 and PFSR-132) whereas in hybrids ranged from 83 days (MGC-445×PFSR-132) to 94 days (MGC-440×GP-170). The check DHM-117 recorded 89 days while NK-6240 was recorded 86 days for 50% maturity.

The range of grain yield varied from 3161.40 kg ha^{-1} (MGC445) to 3910.26 kg ha^{-1} (MGC-434) for lines, in testers it ranged from 2751.20 kg ha^{-1} (PFSR-56) to 3529.82 kg ha^{-1} (PFSR-132) (Table 3).

3.3. Combining ability analysis for various maturity traits and grain yield of selective maize genotypes

All the genotypes exhibited highly significant differences for all the studied traits based on the analysis of variance for combining ability. Parents exhibited significant differences, indicating the presence of greater diversity as well as crosses exhibited significant differences, indicating the varying

Table 3: Mean performance of lines, testers and their cross combinations for maturity traits and grain yield evaluated during *kharif,* 2021 and 2022

Line/tester/cross combination	Days to 50% tasseling	Days to 50% silking	Days to maturity	Grain yield (kg ha^{-1})
Lines				
MGC-434	60.00	61.00	91.00	3910.26
MGC-461	60.00	63.00	93.00	3531.55
MGC-445	60.00	63.00	93.00	3161.40
MGC-440	63.00	66.00	96.00	3479.89
MGC-444	63.00	66.00	96.00	3647.07
MGC-439	63.00	66.00	96.00	3787.40
Mean of lines	61.50	64.16	94.16	3586.30
Range highest	63.00	66.00	96.00	3910.26
Range lowest	60.00	61.00	91.00	3161.40
Testers				
BML-14	63.00	66.00	96.00	2983.30
GP-170	59.00	61.00	91.00	2859.32
PFSR-132	63.00	66.00	96.00	3529.82
PFSR-56	59.00	61.00	91.00	2751.20
Mean of testers	61.00	63.50	93.50	3030.90
Range highest	63.00	61.00	96.00	3529.82
Range lowest	59.00	61.00	91.00	2751.20
Cross combinations				
MGC-434×BML-14	54.00	56.00	86.00	13564.80
MGC-434×GP-170	53.00	55.00	85.00	10537.50
MGC-434×PFSR-132	57.00	59.00	89.00	7520.80
MGC-434×PFSR-56	54.00	56.00	86.00	6935.13
MGC-461×BML-14	57.00	59.00	89.00	6963.06
MGC-461×GP-170	53.00	55.00	85.00	6218.22
MGC-461×PFSR-132	53.00	55.00	85.00	8581.58
MGC-461×PFSR-56	55.00	57.00	87.00	7763.74
MGC-445×BML-14	56.00	58.00	88.00	6497.10
MGC-445×GP-170	57.00	58.00	88.00	6424.90

Table 3: Continue...

Line/tester/cross combination	Days to 50% tasseling	Days to 50% silking	Days to maturity	Grain yield (kg ha^{-1})
MGC-445×PFSR-132	52.00	53.00	83.00	7282.73
MGC-445×PFSR-56	55.00	56.00	86.00	7616.37
MGC-440×BML-14	57.00	59.00	89.00	7934.31
MGC-440×GP-170	62.00	64.00	94.00	7052.19
MGC-440×PFSR-132	56.00	57.00	87.00	7365.43
MGC-440×PFSR-56	57.00	59.00	89.00	6827.02
MGC-444×BML-14	53.00	55.00	85.00	6721.54
MGC-444×GP-170	58.00	60.00	90.00	8682.66
MGC-444×PFSR-132	56.00	57.00	87.00	6388.06
MGC-444×PFSR-56	57.00	59.00	89.00	5919.39
Range highest	62.00	64.00	94.00	13564.8
Range lowest	52.00	53.00	83.00	5919.39
SEm±	-	-	-	-
CD (p=0.05)	1.08	0.95	0.94	1103.65
CV	9.70	8.76	9.36	10.31

performance of cross combinations (Table 4).

The GCA effects for days to 50% tasseling among lines ranged from -2.67 (MGC-440) to 4.3 (MGC-461) and among testers it ranged from -0.19 (GP-170) to 0.19 (BML-14) (Table 5). Among the lines, MGC-445 (-0.50), MGC-440 (-2.67), MGC-444 (-2.58) and MGC-439 (-1.33) has exhibited significant negative GCA, indicating that these lines are good general combiners for earliness. While MGC-434 (2.8), and MGC-461 (4.3) exhibited significant positive effects and were considered to be poor combiners for this trait. None of the testers have reported either significant negative or positive GCA effects for days to 50% tasseling. These results are comparable with findings of Lahane et al. (2015), Murtadha et al. (2018) and Andorf et al. (2019) showing the importance of additive gene action for days to 50% tasseling. Therefore, the identified lines are effective for developing early maturing maize hybrids.

Among 24 hybrids, 20 hybrids showed significant SCA effects (Table 6). Among these, nine hybrids have shown negative significant SCA effects MGC-439×BML-14 (-4.61), MGC-445×PFSR-56 (-4.22), MGC-445×PFSR-132 (-3.28), MGC-461×PFSR-56 (-2.97), MGC-444×BML-14 (-2.36), MGC-440×PFSR-56 (-2.06), MGC-440×GP-170 (-1.22), MGC-439×GP-170 (-1.56) and MGC-434×BML-14 (-1.11), which is desirable for earliness. Murtadha et al. (2018) also explained the importance of non-additive gene action for days to 50% tasseling.

For days to 50% silking, GCA effects among lines ranged from -3.13 (MGC- 444) to 4.88 (MGC-461), and among testers it ranged from 0.15 (GP-170) to 0.18 (PFSR-132) (Table 5). Among lines, four lines recorded negative significant GCA effects, among which the highest negative significant GCA effect was recorded by MGC-444 (-3.13) followed by MGC-440 (-2.71) MGC-439 (-1.96) and MGC-445 (-0.46), implying that these lines are good general combiners for earliness and two other lines, MGC-434 (2.83) and MGC-461(4.88) documented positive significant GCA effects. None of the testers has reported either significant negative or positive GCA effects for days to 50% silking.

These results are comparable with the findings of Talukder et al. (2016), Andorf et al. (2019) and Bisen et al. (2023) who reported additive gene action for days to 50% silking. The range of SCA effects for days to 50% silking of hybrids is -4.99 (MGC-439×BML-14) to 6.51 (MGC-445×BML-14) and eight hybrids exhibited significant negative SCA effects (Table 6). Hybrid MGC-439×BML-14 (-4.99) listed highest negative significant SCA effect followed by MGC-445×PFSR-56 (-4.65), MGC-461×PFSR-56 (-3.65), MGC-445×PFSR-132 (-3.60), MGC-434×BML-14 (-2.32), MGC-444×BML-14 (-2.15), MGC-439×GP-170 (-2.10), MGC-440×PFSR-56 (-2.07) and MGC-440×GP-170 (-1.01).

Among these desirable crosses, two crosses had neither of the parents are good general combiners, revealing the predominance of non-additive (dominance×dominance) gene action and seven crosses had one parent as good general combiner, also indicating the predominance of non-additive (additive×dominance) gene action in the inheritance of this trait and heterosis breeding can be followed for improvement of the trait.

These results are in agreement with findings of Schrag et al. (2018) Andorf et al. (2019) and Vedanchiya et al. (2023) who reported non-additive gene action for days to 50% silking.

The GCA effects for days to 50% maturity among the

Table 4: Analysis of variance for combining ability for yield performance, maturity traits and disease reaction of selective maize genotypes

Source of variation	Degrees of freedom	Days to 50% tasseling	Days to 50% Silking	Days to 50% maturity	Grain yield ha^{-1} (kg)
Replicates	2	33.46**	43.62**	48.22**	17370156.93**
Treatments	33	10.03**	11.07**	13.34**	2619571.29**
Parents	9	8.62**	9.69**	10.96**	2767802.88**
Parents (Line)	5	14.75**	16.08**	18.01**	2006129.99**
Parents (Testers)	3	2.94*	2.94**	3.82**	3718737.30**
Parents (L vs T)	1	40.52**	71.83**	83.55**	33048462.10**
Parents vs Crosses	1	42.33**	55.13**	59.72**	22460459.78**
Crosses	23	100.57*	135.13*	139.88*	49445826.34*
Line Effect	5	0.46	0.42**	0.55*	6950975.44
Tester Effect		31.29**	39.40**	46.52**	16567234.47**
Line * Tester Eff.		0.45	0.34	0.58	476045.40
Error	2	11.24	14.48	18.62	5987520.17
Total	33				

level of statistical significance $^{**}p<0.01$

lines ranged from -3.28 (MGC-444) to 4.88 (MGC-461) (Table 5). Four lines were recorded significant negative GCA effects *viz.,* MGC-444 (-3.28), MGC-440 (-2.92), MGC-439 (-2.08) and MGC-445 (-0.51) whereas, two lines were recorded as significant positive GCA effects.

The SCA effects ranged from -5.16 (MGC-439×BML-14) to 6.32 (MGC-439×PFSR-56). Hybrid, *viz.,* MGC-439×BML-14 (-5.16) was recorded the highest negative SCA effect followed by MGC-445×PFSR-56 and MGC-461×PFSR-56 (-3.98), MGC-445×PFSR- 132 (-3.86), MGC-434×BML-14 (-2.88), MGC-439×GP-170 (-2.62), MGC-440×PFSR-56 (-2.58), MGC-440×GP-170 (-1.42), were good combiners for early maturity (Table 6). Among 24 hybrids, nine and 12 hybrids were recorded negative and positive significant SCA effects respectively.

Similar kind of results were earlier reported by Motamedi et al. (2014), Murtadha et al. (2018) and Khan et al. (2023). The GCA effects for grain yield (kg ha^{-1}) among the lines ranged from -2702.96 (MGC-434) to 1573.60 (MGC-445) (Table 5). Among the testers, GCA effects ranged from -624.67 (GP-170) to 828.43 (PFSR-132). Four lines recorded positive significant GCA effects, of which *viz.,* MGC-445 (1573.60) was highest followed by MGC-439, MGC-444, and MGC-440 with 1449.16, 1294.59, and 887.07 respectively. One tester PFSR-132 (828.43) recorded positive significant GCA effect and as good combiner for grain yield whereas, two lines and tester recorded significant negative GCA effects.

The SCA effects for grain yield ranged from -3789.15 (MGC-445×BML-14) to 5140.55 (MGC-445×PFSR-132) (Table 6). Among the hybrids, six hybrids recorded significant positive SCA effects, of which *viz.,* MGC-445×PFSR-132 (5140.55) shown highest SCA followed by (MGC- 445×PFSR-56 (2868.57), MGC-444×BML-14 (1541.61), MGC-461×GP-170 (1092.80), MGC-444×GP-170 (1071.58) and MGC-440×BML-14 (888.35) identified as superior specific crosses for grain yield.

3.4. Promising general and specific combiners for grain yield and other traits

The top five crosses with high SCA effects, *per se* performance, GCA effects of parents for yield and yield attributing traits in maize hybrids are presented in Table 7.

Based on significant GCA effects, on the whole, lines MGC-439, MGC-444, MGC-440, MGC-445 and among testers PFSR-132 were identified as good general combiners for grain yield and maturity traits days to 50% tasseling, days to 50% silking, days to 50% maturity.

Based on SCA effects, on the whole, hybrids *viz.,* MGC-445×PFSR-132 (5140.55) were the highest followed by, MGC-445×PFSR-56 (2868.57), MGC-444×BML-14 (1541.61), MGC-461×GP-170 (1092.80), MGC-444×GP-170 (1071.58) and MGC-440×BML-14 (888.35) identified as good specific combiners for grain yield and other yield attributing traits. The promising hybrids with good SCA effects for various traits are given in Table

Table 5: General combining ability (GCA) effects for maturity traits and grain yield of Lines and testers included in the study

Line/tester	Days to 50% Tasseling	Days to 50% Silking	Days to 50% maturity	Grain yield ha^{-1} (kg)
MGC-434	2.80**	2.83**	3.38**	-2501.46**
MGC-461	4.30**	4.88**	4.88**	-2702.96**
MGC-445	-0.50*	-0.46**	-0.51**	1573.60**
MGC-440	-2.67**	-2.71**	-2.92**	887.07**
MGC-444	-2.58**	-3.13**	-3.28**	1294.59**
MGC-439	-1.33**	-1.96**	-2.08**	1449.16**
Range highest	4.30	4.88	4.88	1573.60
Range lowest	-2.67	-3.13	-3.13	-2702.96
S.E. (GCA for line)	0.19	0.17	0.31	0.05
S.E. (gi-gj) line	0.27	0.24	0.38	0.07
BML-14	0.19	0.07	0.26	-276.86
GP-170	-0.19	-0.15	-0.22	-624.67**
PFSR-132	0.03	0.18	0.33	828.43**
PFSR-56	-0.03	-0.10	-0.18	73.10
Range highest	0.19	0.18	0.38	828.43
Range lowest	-0.19	-0.15	-0.22	-624.67
S.E.(GCA for tester)	0.16	0.14	0.17	0.04
S.E. (gi-gj) tester	0.22	0.19	0.26	0.06
CD (p=0.05) GCA (Line)	0.39	0.34	0.22	400.92

Level of statistical significance **p<0.01

Table 6: Specific combining ability (SCA) effects for yield and maturity traits of maize cross combinations

Characters	Days to 50% tasseling	Days to 50% silking	Days to 50% maturity	Grain yield (kg ha^{-1})
MGC-434×BML-14	-1.11**	-2.32**	-2.88**	666.34
MGC-434×GP-170	-0.39	-0.10	-0.24	635.44
MGC-434×PFSR-132	-0.61	-0.43	-0.46	-1187.80**
MGC-434×PFSR-56	2.11**	2.85**	2.39**	-113.99
MGC-461×BML-14	0.806*	1.18**	1.36**	604.66
MGC-461×GP-170	1.194**	1.40**	1.52**	1092.80**
MGC-461×PFSR-132	0.972*	1.07**	1.37**	-1164.40**
MGC-461×PFSR-56	-2.97**	-3.65**	-3.98**	-5330.05
MGC-445×BML-14	5.56**	6.51**	5.77**	-3789.15**
MGC-445×GP-170	1.94**	1.74**	1.88**	-4219.96**
MGC-445×PFSR-132	-3.28**	-3.60**	-3.86**	5140.55**
MGC-445×PFSR-56	-4.22**	-4.65**	-3.98**	2868.57**
MGC-440×BML-14	1.72**	1.76**	1.92**	888.35**
MGC-440×GP-170	-1.22**	-1.01**	-1.42**	650.50
MGC-440×PFSR-132	1.56**	1.32**	1.58**	-774.67

Table 6: Continue...

Characters	Days to 50% tasseling	Days to 50% silking	Days to 50% maturity	Grain yield (kg ha^{-1})
MGC-440×PFSR-56	-2.06**	-2.07**	-2.58**	-764.18
MGC-444×BML-14	-2.36**	-2.15**	-2.76**	1541.61**
MGC-444×GP-170	0.03	0.07	0.12	1071.58**
MGC-444×PFSR-132	0.81*	0.74*	0.96*	-1648.16
MGC-444×PFSR-56	1.53**	1.35**	1.92**	-965.03*
MGC-439×BML-14	-4.61**	-4.99**	-5.16**	88.19
MGC-439×GP-170	-1.56**	-2.10**	-2.62**	769.64
MGC-439×PFSR-132	0.56	0.903*	1.22*	-365.52
MGC-439×PFSR-56	5.61**	6.18**	6.32**	-492.31
Range lowest	-4.61	-4.99	-5.16	-3789.15
Range highest	5.61	6.51	6.32	5140.55
S.E. (SCA effects) Sij	0.38	0.33	0.36	398.34
SE (Sij-Skl)	0.54	0.47	0.51	563.35
SE (Sij-Sik)	0.72	0.63	0.72	745.24

Level of statistical significance **p<0.01

Table 7: Top five hybrids with high sca effects, *per se* performance and GCA effects of parents for yield and yield attributing traits in maize hybrids

Cross Combination	*Per* Se	Sca effects	GCA effects		GCA status
			Line	Tester	
Days to 50% tasseling					
MGC-439×BML-14	56	-4.61**	-1.33**	0.19	H×L
MGC-445×PFSR-56	55	-4.22**	-0.5*	-0.03	H×L
MGC-445×PFSR-132	52	-3.28**	-0.5*	0.03	H×L
MGC-461×PFSR-56	55	-2.97**	-2.58**	-0.03	H×L
MGC-444×BML-14	53	-2.36**	-2.58**	0.19	H×L
Days to 50% silking					
MGC-439×BML-14	57	-4.99**	-1.96**	0.07	H×L
MGC-445×PFSR-56	56	-4.65**	-0.46**	-0.10	H×L
MGC-461×PFSR-56	57	-3.65**	4.88**	-0.10	L×L
MGC-445×PFSR-132	53	-3.60**	-0.46**	0.18	H×L
MGC-434×BML-14	56	-2.32**	2.83**	0.07	L×L
Days to maturity					
MGC-439×BML-14	87	-4.99**	-1.96**	0.07	H×L
MGC-445×PFSR-56	86	-4.65**	-0.46**	-0.10	H×L
MGC-461×PFSR-56	87	-3.65**	4.88**	-0.10	L×L
MGC-445×PFSR-132	83	-3.60**	-0.46**	0.18	H×L
MGC-434×BML-14	86	-2.32**	3.38**	0.07	L×L
Grain yield (kg ha^{-1})					
MGC-445×PFSR-132	7282.73	5140.55**	2702.96**	828.43**	L×H

Table 7: Continue...

Cross Combination	*Per* Se	Sca effects	GCA effects		GCA status
			Line	Tester	
MGC-445×PFSR-56	7616.37	2868.57**	2702.96**	73.10	L×L
MGC-444×BML-14	6721.54	1541.61**	1294.59**	-276.86	H×L
MGC-461×GP-170	6218.22	1092.79**	2702.96**	-624.67**	L×L
MGC-444×GP-170	8682.66	1071.58**	1294.59**	-624.67	H×L

Level of statistical significance **p<0.01

4. CONCLUSION

The present study has identified four lines MGC-444, MGC-440, MGC-439 and MGC-445 as best general combiners for early maturity and eight single cross hybrids MGC-439×BML-14, MGC-445×PFSR-56, MGC-461×PFSR-56, MGC-445×PFSR-132, MGC-434×BML-14, MGC-439×GP-170, MGC-440×PFSR-56 and MGC-440×GP-170 as best cross combinations with early maturity that can be used in maize hybrid breeding for drought-prone environments.

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