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Test Cross Potential of F_4 Inbred Lines in Maize (*Zea mays* L)

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Abstract

Development of inbred lines with good nicking ability in hybrid combinations is the prerequisite for the development of maize hybrids with high yield potential. Test cross performance is widely used as the criterion for selection of inbred lines derived from breeding populations. Differences among the crosses are generally assumed to arise from genetic variability among the inbred lines crossed to a common tester. The superior inbred lines identified based on test cross performance are expected to perform better in hybrid combinations. To assess test cross potential and to identify those with good combining ability, nine F_4 inbred lines were crossed to two testers and the resulting hybrids were evaluated for commercial grain yield in two replications following RCBD design at two locations. The results suggested significant mean squares among the hybrids based on both the testers. Significant variability among the hybrids is suggestive of differences in test cross potential of test F_4 inbred lines. The estimates of standardised range (SR), PCV and GCV suggested substantial differences among the hybrids and hence among the test F_4 inbred lines. The average test cross performance of inbred lines with CML 564 was higher that of those with CML 578. The tester CML 564 with better ability to discriminate the F_4 inbred lines and high grain yield performance in test cross performance is suggested for further evaluation to confirm its ability to discriminate and produce hybrids with better performance. The F_4 inbred lines F_4-185, F_4-144, F_4-170 and F_4-160 with better test cross potential were identified as promising ones in hybrid combinations. These F_4 inbred lines need to be tested with other testers in multi-location trials to confirm their superiority.

Keywords : Test cross, Genetic variability, Inbred lines in maize

Maize is one of the most important staple cereal crops in India. India stands 4th in area and 6th in production in the world (FAOSTAT, 2022) contributing around 2 per cent to the world total maize production. In India, maize is the third most important crop after rice and wheat (Noor *et al.,* 2023). Karnataka, Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and West Bengal are the important maize producing states in India. Karnataka alone contributes 60 per cent of maize production in India. Maize is considered as staple food throughout the globe because of its high nutritional importance enriched with an abundant amount of macronutrients like starch, fiber, protein, and fat along with micronutrients like B-complex vitamins, β-carotene and essential minerals, *i.e.,* magnesium, zinc, phosphorous, copper, etc. (Gautam *et al.,* 2022). It is also a basic element of animal feed and raw material for many industrial products such as corn starch, maltodextrins, corn oil, corn syrup and products of fermentation and distillation industries. Ever increasing demand for maize coupled with decreasing land and water resources necessitates enhanced maize production per unit area and per drop of water. Hybrids have played a vital role in increasing the area and productivity of maize (Sowmya and Gangappa, 2018).

Hybrids compared to open-pollinated cultivars in crops including maize are known to be more productive and resilient to moisture stress (Khan and Mahmud, 2021). Hence, in all the countries including India where hybrid seed production system is well developed, hybrids are the major cultivar option in maize.

About 65-70 per cent of area planted to maize is occupied by hybrids maize in India at large and Karnataka in particular. In the recent years, farmers continue to replace traditional open pollinated cultivars with the hybrids (Arunkumar *et al.,* 2020). Development of inbred lines with good nicking ability in hybrid combinations is the prerequisite for development of maize hybrids with high yield potential. Test cross performance is widely used as the criterion for selection of inbred lines derived from breeding populations. Differences among the crosses (breeding populations) are generally assumed to arise from genetic variability among the inbred lines crossed to a common tester (Mihaljevic *et al.,* 2005). The superior inbred lines identified based on test cross performance are expected to perform better in hybrid combinations. With this background, the objective of the present investigation is to determine the test cross potential of F_4 inbred lines using two common testers and to identify those promising in hybrid combinations.

Material and Methods

Basic Genetic Material

The material for the study consisted of nine inbred lines selected from F_4 populations derived from the cross *i.e.,* MAI 137×97B (Table 1). These nine inbred lines were selected based on their uniformity for plant type and flowering time. The material also consisted of two other genotypes namely CML564 and CML578 which were used as testers.

Development of Experimental Material

Five of the nine F_4 inbred lines were crossed to tester CML 564 to obtain five hybrids and four of the nine F_4 inbred lines were crossed to tester CML 578 during rainy season of 2021.

Table 1

Pedigree of F_4 inbred lines and testers used in the study

Pedigree of female lines	Pedigree
F_4-47	MAI 137 × 97B
F_4-113	
F_4-133	
F_4-144	
F_4-160	
F_4-161	
F_4-170	
F_4-185	
F_4-186	
Male lines	**Pedigree**
CML 564	HY18R-Y75-3
CML 578	HY18R-Y75-5

Evaluation of Experimental Material

Nine hybrids (Table 2) were evaluated for commercial grain yield in two replications in a Randomized complete block design (RCBD) at two locations *i.e.,* College of Agriculture, University of Agricultural Sciences, GKVK, Bengaluru and F-Block, V.C. Farm, Mandya during 2022 *summer* season. Each hybrid was grown in two rows of 3m length with a spacing of 0.3m between plants within a row and 0.6m between rows. During the crop growth period, the recommended management practices were followed to raise a healthy crop.

Table 2

Hybrids based on two testers

Hybrids based on CML 564 tester	Hybrids based on CML 578 tester
F_4-185×CML564	F_4-161×CML578
F_4-144×CML564	F_4-113×CML578
F_4-47×CML564	F_4- 170×CML578
F_4-186×CML564	F_4-160×CML578
F_4-133×CML564	

Sampling and Data Collection

Cobs were harvested from five randomly selected plants (avoiding border one's) from each of nine

TABLE 3

Analysis of variance of hybrids based on the two testers for grain yield plant^{-1} in GKVK, Bengaluru and V.C. Farm, Mandya

Source of Variation	Degrees of freedom				Mean sum of squares			
	GKVK		Mandya		GKVK		Mandya	
	CML 564	CML 578	CML 564	CML 578	CML 564	CML 578	CML 564	CML 578
Replications	1	1	1	1	0.63	0.11	0.17	1.28 *
Hybrids	4	3	4	3	957.86 ***	336.08 ***	157.57 ***	17.53 ***
Error	4	3	4	3	7.06	5.27	1.01	0.04
SEm±					1.87	1.62	0.51	0.14
CD @ P=0.05					7.37	7.3	3.98	0.66
CD @ P=0.01					12.23	13.4	6.60	1.21

*** Significant @ P=0.001

hybrids. The cobs were sun-dried, hand – threshed and grains were weighed. The average grain weight from each hybrid in each replication was recorded as grain yield plant^{-1}(g).

Statistical Analysis

ANOVA

Data on average grain yield plant^{-1} of each hybrid and replication were used for statistical analysis. Location-wise analysis of variance was performed as per RCBD (Fisher, 1918) to detect significance or otherwise of differences among the hybrids. The analysis was performed using 'R Studio' and 'Variability : An R package'.

Estimation of Descriptive Statistics

The first degree statistics such as mean, absolute range, variance and their standardized values-standardized range (maximum-minimum/mean) and second degree statistics such as genotypic coefficient of variability (GCV) and phenotypic coefficient of variation (PCV) (Burton and De Vane, 1953) were estimated to quantify variability.

RESULTS AND DISCUSSION

Analysis of Variance

ANOVA is a diagnostic tool for detection of variability for the target traits like grain yield. Highly significant mean squares indicated substantial variability present among the hybrids based on both the testers for grain yield^{-1} (Table 3). Significant variability among the hybrids is suggestive of differences in test cross potential of test F_4 inbred lines. Several previous researchers such as Mushtaq *et al.* (2016), Kashiani *et al.* (2014), Azam *et al.* (2014) and Saleem *et al.*

TABLE 4

Estimates of variability parameters among the hybrids based on the two testers for grain yield plant^{-1}

Descriptive statistics	GKVK		Mandya	
	CML 564	CML 578	CML 564	CML 578
Mean	136.93	97.21	149.21	93.95
Absolute range (AR) (Highest - Lowest)	58.00	31.67	24.11	7.52
Standardised range (AR/mean)	0.42	0.21	0.24	0.08
GCV (%)	15.92	8.61	9.07	3.14
PCV (%)	16.04	8.75	9.19	3.15

TABLE 5

Mean performance of hybrids based on the two testers for grain yield plant^{-1} in GKVK, Bengaluru and V.C. Farm, Mandya

Hybrids	CML 564		Mean	Hybrids	CML 578		Mean
	GKVK	Mandya			GKVK	Mandya	
F_4-185×CML564	151.62	111.35	131.49	F_4-161×CML578	141.50	92.60	117.05
F_4-144×CML564	164.61	98.85	131.73	F_4-133×CML578	136.66	94.85	115.76
F_4-47×CML564	135.77	90.50	113.14	F_4-170×CML578	165.75	90.75	128.25
F_4-186×CML564	109.84	89.05	99.44	F_4-160×CML578	152.915	97.61	125.27
F_4-133×CML564	122.83	96.30	109.57				

(2011) have also reported significant differences for test cross potential of inbred lines in maize.

The estimates of absolute range provide clues about the occurrence of hybrids with extreme expression. However, absolute range *per se* does not reflect variability in the expression of all the traits as they are measured in different units. The estimates of standardised range (SR) which are unit independent suggested substantial differences among the hybrids and hence among the test F_4 inbred lines. Further, the hybrids based on CML 564 exhibited wider range than those based on CML 578. The estimates of GCV and PCV (second degree statistics) which reflect average inter-hybrid differences are more useful statistics (than AR and SR which are first degree statistics) to

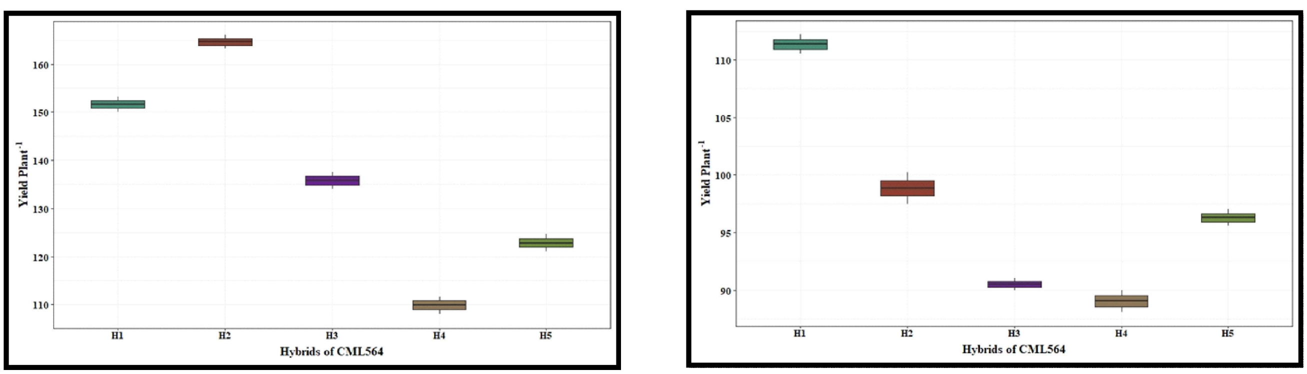

Fig. 1: Box-Whisker plots showing comparative performance of hybrids with tester CML 564 for grain yield plant $^{-1}$ in GKVK, Bengaluru and V.C. Farm, Mandya

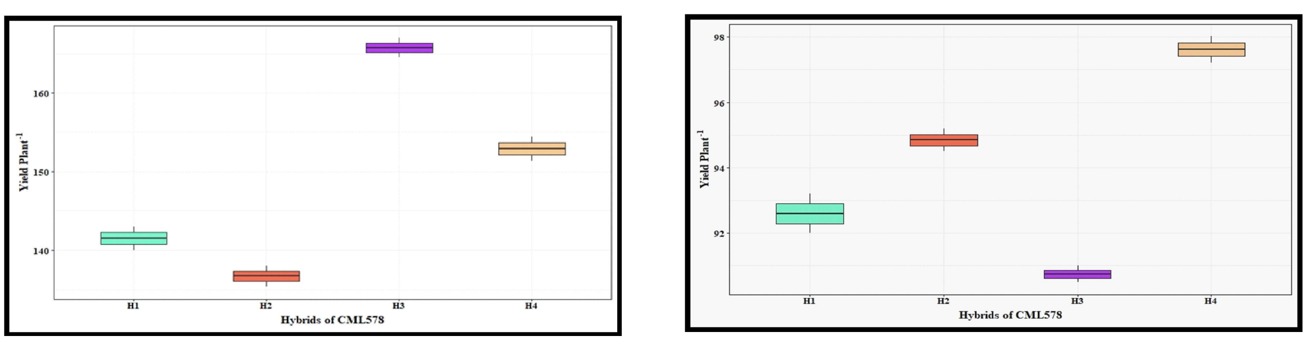

Fig. 2: Box-Whisker plots showing comparative performance of hybrids with tester CML 578 for grain yield plant^{-1} in GKVK, Bengaluru and V.C. Farm, Mandya

understand variability among the hybrids. In the present study, the hybrids based on CML 564 were more variable and those based on CML 578 at both GKVK and Mandya for grain yield plant^{-1}. The greater differences between GCV and PCV estimates (Table 4) suggested substantial influence of non-genetic sources of variation towards the expression of grain yield. The present results are similar to those of Tilahun *et al.* (2019). The average test cross performance of inbred lines with CML 564 was higher that of inbred lines with CML 578 (Table 4 & 5, Fig. 1 & 2).

Further CML 564 discriminated the F_4 inbred lines better than CML 578 as suggested from higher AR, SR, PCV and GCV. Thus present study provide adequate evidence that the F_4 inbred lines differed with respect to their test cross performance within the tester as well as between the tester. The tester CML 564 with better ability to discriminate the F_4 inbred lines and high grain yield performance in test cross performance is suggested for further evaluation to confirm its ability to discriminate and produce hybrids with better performance. The F_4 inbred lines F_4-185, F_4-144, F_4-170 and F_4-160 with better test cross potential were identified as promising ones in hybrid combinations. However, their test cross performance need to be tested with other testers in multi-location trials to confirm their superiority.

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