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COMBINING ABILITY ESTIMATES FROM LINE X TESTER MATING DESIGN IN MAIZE (*Zea mays* L.)

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A line x tester analysis was carried out in maize variety Sarhad white with 25 lines and two testers to study combining ability effects at the University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan, during 2009. The resultant 50 testcrosses along with 27 parents and four checks were evaluated in replicated trial for four characters viz., cob length, number of grain rows per cob, 100 grain weight and grain yield. Among the parents studied the following parental lines viz; 12-2, 46, 77-2, 91-3, 128-1, 151-1, 195, 220, 222 and 237 were having good general combining ability with testers for grain yield. Among 50 evaluated testcrosses viz., 12-2 x Jalal, 77-2 x Jalal, 96-1 x Jalal, 144-1 x Jalal, 173 x Jalal, 189 x Jalal, 192 x Jalal, 220 x Jalal, 222 x Jalal, 231 x Jalal, 237 x Jalal, 46 x Kiramat, 65 x Kiramat, 91-3 x Kiramat, 119-1 x Kiramat, 126 x Kiramat, 151-1 x Kiramat and 195 x Kiramat, were identified as good specific combiners for grain yield. These hybrids could be utilized in maize heterosis breeding to exploit hybrid vigor for grain yield.

Key words: general combining ability, specific combining ability, hybrid vigor, grain yield, maize

INTRODUCTION

Maize (*Zea mays* L.) is one of the important food and forage crops with abundant natural diversity. It is one of the most important cereal and ranks next to rice and wheat in production. It is highly cross pollinated crop as about 95% of the pistillate flowers on a cob receive pollen from near by plants and about 5% of the kernels as result of self pollination. Maize plant is protoandrous in which anthesis normally begins 1-3 days before the emergence of silks and 3-4 days after the silks emergence are ready to be pollinated (Poehlman, 1977). Line x tester analysis (Kempthome, 1957) has widely been used for evaluation of inbred lines by crossing them with testers. The value of any inbred line in hybrid breeding ultimately depends on its ability to combine very well with other lines to produce superior hybrids. Hence, combining ability is a useful biometric tool to the plant breeders for formulating efficient breeding programs. Early testing of inbred line in maize crop are very effective, the best performing inbred lines are identified, and the resulting progeny evaluated for grain yield and general performance for other morphological traits.

Combining ability of maize inbred lines to produce superior hybrids in combination with other inbred lines. General combining ability (GCA) as defined by Sprague and Tatum (1942) is the average performance of a genotype in hybrid combination while specific combining ability (SCA) as those cases in which certain combinations perform relatively better or worse than would be expected on the basis of the average performance. Line x tester programs has been applied to provide a systematic approach for the detection of suitable parents and crosses for investigated characters. In many studies, GCA effects for parents and SCA effects for crosses were estimated in maize (Araujo and Miranda 2001). Non-additive gene effects for grain yield were found to be significant in maize (Kalla et al., 2001) which suggested that several combinations among parental lines by their mean performance and genetic nature had the potential for the development of more yielding and earlier genotypes.

MATERIALS AND METHODS

The present experiment was conducted to evaluate testcross performance of maize inbred lines for grain yield and yield related traits in maize variety Sarhad white, at the University of Agriculture Peshawar, Khyber Pakhtunkhwa, Pakistan, during 2009, in spring and summer crop season. In the spring season (February – June) 25 best promising inbred lines of Sarhad white variety were crossed with two tester's viz., Kiramat (hybrid) and Jalal (OPV) at two isolations. In the summer season (July – October), performance of the resulting testcrosses were evaluated in replicated trial along with their parental lines and four commercial checks viz., Babar, 30k08, CS200 and WD3x6. The experiment comprising 81 entries was sown in partially balanced lattice square design with two replications. Each entry was raised in single row plot with a row length of 5 m, having row to row and plant to plant distance of 0.75 m and 0.20 m, respectively. Data were recorded on the following parameters viz., cob length, number of grain rows per cob, 100 grain weight and grain yield.

The data recorded was subjected to analysis of variance (ANOVA) technique appropriate for 8×8 partially balanced lattice square design using program MS-Excel package. Analysis for general combining ability (GCA) and specific combining ability (SCA) was carried out following the method of Kempthorne (1957).

General combing ability effects were calculated using the expression:

$$gi = \frac{Xi..}{tr} - \frac{X...}{ltr}$$

l = number of lines
t = number of testers
r = number of replications

Specific combining ability effects were calculated using the expression:

$$si = \frac{Xij}{r} - \frac{Xi...}{tr} - \frac{X.j.}{lr} + \frac{X...}{ltr}$$

RESULTS AND DISCUSSION

Cob length (cm)

Highly significant ($P \leq 0.01$) mean squares were observed for testcrosses, due to line effect as well as line × tester interaction, while non significant differences were recorded for tester effect (Table 1). Results are in accordance with the findings of Carlone and Russell (1989) who obtained highly significant differences for ear length among lines of maize synthetic variety after testcross evaluation. Like other yield associated traits that affects the final grain yield, ear length also has an effect on the final grain yield. Analysis on combining ability indicated that the following parental lines viz; 119-1, 149-2 and 197-2 expressed good general combiner effects, while 46 x Jalal (0.84), 151-1 x Jalal (1.00), 159-2 x Jalal (1.42), 197-2 x Jalal (0.92) and 139 x Kiramat (1.00) expressed positive SCA effects and were found to be good specific combiners for this trait.

Number of kernel rows ear^{-1}

Highly significant variations were observed among testcrosses due to line effect as well as line x tester interaction, while non significant differences were recorded for tester effect for number of kernel rows cob^{-1} (Table 1). In Table 2, the highest GCA effect was observed for the parental line 128-1 (2.68), whereas lowest GCA effect was recorded for the parental line 144-1 (-2.82). Malik (2004) published similar results for LA, GCA using different genotypes, and obtained values between +41.32 and -20.27 in maize population. The highest values of SCA was obtained for the hybrid 12-2 x Jalal (2.88), while lowest SCA effects (-2.88) was observed for the hybrid 12-2 x Kiramat (Table 3). Cob diameter and number of kernel rows per cob could be given more importance, while doing selection for grain yield improvement in maize (Manivannan, 1998).

100 kernel weight (g)

Highly significant mean squares were detected for 100 kernel weight among testcrosses due to lines effect, tester effect and their interaction (Table 1). Thiraporn *et al*. (1983) reported strong positive relationship of grain weight with final grain yield and yield components in maize and observed maximum kernel weight in controlled environments but minimum in the stressed one. Highest

Table 1. Mean squares for various parameters.

Source of variation	D.F.	Mean Squares for yield components			
		Grain yield (Kg/ha)	Ear length	Kernel rows ear^{-1}	100 Kernel weight
Replication	1	201183.86	0.23	0.22	0.00
Genotypes	80	805631.45**	2.52**	6.95**	52.12**
Testcrosses (TC)	49	843456.35**	2.30**	7.22**	21.69**
Lines	24	974012.80**	3.00**	5.99**	24.56**
Testers	1	248776.01*	0.00^{NS}	1.44^{NS}	9.62**
Line x Tester	24	737678.25**	1.68**	8.69**	19.32**
Checks (C)	3	440374.48**	3.86**	9.33**	48.72**
Error	80	58207.57	0.65	1.18	1.37

** = Highly significant at 1% of probability, * = Significant at 5% of probability,
NS = Non significant

Table 2. Estimates of GCA effects.

Ranks	Parental lines	Grain yield	Yield components		
			Ear length	Kernel rows ear^{-1}	100 Kernel weight
1	12-2	416.01**	-0.04	-1.32**	-2.64**
2	46	143.06*	-1.24**	-0.82*	-0.33
3	65	13.30	-1.04**	-1.32**	2.44**
4	77-2	280.90**	0.09	0.18	0.33
5	79-2	-118.07	0.34	-0.32	-0.81*
6	91-3	201.17*	-0.66*	0.68*	-0.87*
7	96-1	-272.31**	0.48*	-0.82*	1.00**
8	119-1	-781.78**	1.17**	1.18**	-3.27**
9	122-2	-1093.24**	0.34	0.68*	1.07**
10	126	-241.08**	0.34	0.68*	-1.63**
11	128-1	684.38**	-2.16**	2.68**	-1.59**
12	139	-164.82*	-0.58*	-0.32	3.32**
13	144-1	-46.57	-0.08	-2.82**	3.70**
14	149-2	-391.14**	1.26**	0.68*	-3.75**
15	151-1	774.27**	-1.24**	-0.82*	-2.85**
16	159-2	-187.42*	-0.66*	-1.82**	-2.15**
17	173	-199.27*	0.42*	0.18	-0.34
18	189	-634.45**	-0.08	0.18	-2.41**
19	192	-122.56	-0.16	1.18**	-0.50
20	195	697.09**	0.51*	1.18**	-0.28
21	197-2	152.85*	1.67**	0.68*	2.95**
22	220	634.87**	0.84**	1.18**	5.40**
23	222	728.03**	0.01	1.18**	4.30**
24	231-1	-611.78**	-0.16	-0.82*	-0.55
25	237	138.55	0.67**	-1.32**	-0.53
26	Jalal	49.88	0.01	0.12	-0.31
27	Kiramat	-49.88	-0.01	-0.12	0.31
	CD for male at 5%	75.69	0.25	0.34	0.37
	CD for male at 1%	108.06	0.36	0.49	0.52
	CD for lines at 5%	163.50	0.55	0.74	0.79
	CD for lines at 1%	233.43	0.78	1.05	1.13

** = Highly significant at 1% of probability
* = Significant at 5% of probability

Table 3. Estimates of SCA effects.

Genotypes	Grain yield		Yield components					
			Ear length		Kernel rows ear^{-1}		100 Kernel weight	
	Jalal	Kiramat	Jalal	Kiramat	Jalal	Kiramat	Jalal	Kiramat
12-2	157.26	-157.26	-0.46	0.46	2.88**	-2.88**	1.53*	-1.53*
46	-500.21**	500.21**	0.84*	-0.83*	1.50*	-1.50*	-0.48	0.48
65	-648.60**	648.60**	-0.79*	0.79*	2.00**	-2.00**	2.23**	-2.23**
77-2	343.10**	-343.10**	-0.67	0.67	1.50*	-1.50*	-0.08	0.08
79-2	-43.91	43.91	0.42	-0.42	1.00	-1.00	0.04	-0.04
91-3	-412.72**	412.72**	-0.75*	0.75*	0.00	0.00	1.00*	-1.00*
96-1	185.36*	-185.36*	-0.61	0.61	0.50	-0.50	3.15**	-3.15**
119-1	-373.71**	373.71**	-0.25	0.25	1.50*	-1.50*	-1.98**	1.98**
122-2	86.54	-86.54	0.25	-0.25	-2.00**	2.00**	3.66**	-3.66**
126	-866.48**	866.48**	0.08	-0.08	-2.00**	2.00**	-3.22**	3.22**
128-1	-17.87	17.87	-0.08	0.08	0.00	0.00	-5.51**	5.51**
139	-82.26	82.26	-1.00*	1.00*	-1.00	1.00	-1.18*	1.18*
144-1	162.78	-162.78	0.00	0.00	1.50*	-1.50*	0.44	-0.44
149-2	-50.07	50.07	0.17	-0.16	0.00	0.00	-4.10**	4.10**
151-1	-152.78	152.78	1.00*	-1.00*	0.50	-0.50	-0.99*	0.99*
159-2	-86.40	86.40	1.42**	-1.42**	-1.50*	1.50*	0.35	-0.35
173	844.54**	-844.54**	0.33	-0.33	1.50*	-1.50*	-0.51	0.51
189	287.08*	-287.08*	-0.67	0.67	1.50*	-1.50*	1.55*	-1.55*
192	800.78**	-800.78**	0.42	-0.42	-1.50*	1.50*	-0.86	0.85
195	-339.05**	339.05**	0.75*	-0.75*	0.50	-0.50	-3.48**	3.47**
197-2	82.96	-82.96	0.92*	-0.92*	-2.00**	2.00**	1.70**	-1.70*
220	289.88*	-289.88*	-0.58	0.58	-1.50*	1.50*	-0.23	0.23
222	341.49**	-341.49**	-0.58	0.59	0.50	-0.50	-1.85**	1.85**
231-1	691.17**	-691.17**	-0.08	0.08	-0.50	0.50	0.20	-0.20
237	498.19**	-498.19**	0.08	-0.08	-2.00**	2.00**	1.17*	-1.17*
CD at 5 %	283.19		0.95		1.28		1.37	
CD at 1%	404.32		1.35		1.82		1.96	

GCA effects was observed for the parental line 220 (5.40), whereas least GCA effects was recorded for the parental line 119-1 (-3.27) (Table 2). The following hybrids viz; 65 x Jalal, 91-3 x Jalal, 96-1 x Jalal, 122-2 x Jalal, 189 x Jalal, 197-2 x Jalal, 237 x Jalal, 119-1 x Kiramat, 126 x Kiramat, 128-1 x Kiramat, 139 x Kiramat, 149-2 x Kiramat, 195 x Kiramat and 222 x Kiramat expressed significant positive SCA effects and were found to be good combiners for this trait (Table 3). The SCA variance was greater than GCA variance suggesting the importance of dominance effects in the inheritance of this trait. These results are in agreement with the investigation of Pal et al. (1986) in maize.

Grain yield (kg ha^{-1})

The calculations showed that the parental line 151 was characterized by the highest GCA effects (774.27), while the lowest GCA effects were obtained for the parental line 122-2 (-1093.24). The variation range between highest and lowest GCA effects for grain yield was -318.97, and this difference was highly significant at P $\leq$ 0.01. These results are in agreement with that of Russel at al (1992) grain yield in maize breeding population showed highly significant at P<0.01 linear gains for BS21 x BS22(R) (4.9% cycle^{-1})BS21(A632HI) xA632(3.6% cycle^{-1}) and BS21(R) x A632 (4.7% cycle^{-1}). Based on the GCA effects the following parents viz; 12-2, 46, 77-2, 91-3, 128-1, 151-1, 195, 220, 222 and 237 were good general combiners for this trait. This indicated that these parents could be utilized for developing synthetic variety. Specific combining ability analysis showed that the several testcrosses viz., 12-2 x Jalal, 77-2 x Jalal, 96-1 x Jalal, 144-1 x Jalal, 173 x Jalal, 189 x Jalal, 192 x Jalal, 220 x Jalal, 222 x Jalal, 231 x Jalal, 237 x Jalal, 46 x Kiramat, 65 x Kiramat, 91-3 x Kiramat, 119-1 x Kiramat, 126 x Kiramat, 151-1 x Kiramat and 195 x Kiramat, were found to be good specific combiners (Table 3). From this study it was found that grain yield per hectare was predominantly governed by non-additive gene action as reported by Crossa et al. (1990) and Shanti et al. (2002) for grain yield in maize breeding populations.

CONCLUSIONS

From the results it was concluded that the following parental lines viz; 12-2, 46, 77-2, 91-3, 128-1, 151-1, 195, 220, 222 and 237 were having good general combining ability for grain yield, hence, these genotypes have potential to be utilized for producing synthetic maize varieties and for other breeding purposes. Among the testcrosses viz., 12-2 x Jalal, 77-2 x Jalal, 96-1 x Jalal, 144-1 x Jalal, 173 x Jalal, 189 x Jalal, 192 x Jalal, 220 x Jalal, 222 x Jalal, 231 x Jalal, 237 x Jalal, 46 x Kiramat, 65 x Kiramat, 91-3 x Kiramat, 119-1 x Kiramat, 126 x Kiramat, 151-1 x Kiramat and 195 x Kiramat, were found to be good specific combiners and these line could be used for heterosis breeding programs in maize.

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