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Evaluation of Inbred Line Through Line X Tester Method

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Abstract

Early generation evaluation of inbred lines through line × tester method was conducted at Regional Agricultural Research Station, Rahmatpur during rabi 2013-14 in maize involving 12 S_4 lines and 2 testers (BIL 28 and BIL 29) for grain yield, yield components and other characters to estimate the general combining ability of the lines and specific combining ability effects of the crosses. Highly significant genotypic differences were observed indicated wide range of variability present among them. The crosses with high SCA effect for grain yield evolved from high × low general combiner parents were revealed additive x dominance type of gene action. The cross combinations E-7 X BIL-29, E-11 X BIL-29, E-10 X BIL-28 and E-9 X BIL-28 with high positive SCA effect having high mean values might be used for obtaining high yielding hybrids. The information on the nature of gene action with respective variety and characters might be used depending on the breeding objectives.

Key words: Combining ability, Inbred, Maize, Tester

Introduction

Maize is a highly allogamous crop and it has been successfully exploited for the production of hybrids. Parental selection is very important in hybrid development. In this context, LxT analysis (Kempthome, 1957) has widely been used for evaluation of inbred lines by crossing them with testers. Selection during inbreeding based on the performance of test cross progeny is highly effective in improving the GCA of inbred lines. The general combining ability (GCA) of inbred lines can be effectively tested at an early stage during the inbreeding program. Based on the test cross test, about 50% of the inbred lines can be eliminated. This reduces the number of inbred lines to a manageable size for the next step. Exploitation of hybrid vigor and selection of parents based on combining ability has been used as an important breeding approach in heterosis as well as specific combining ability. Combining ability is prerequisite for developing a good hybrid maize variety. The present study involving a line × tester analysis aimed to determine the general combining ability (GCA) and specific combining ability (SCA) of the crosses for different traits and to explore heterotic hybrid combinations.

Materials and Methods

Twelve S_4 generation inbred lines (as female parents) derived from Nath Samrat hybrid through recycling method and 2 testers (as male parents) of maize were selected and crossed in a line × tester fashion to generate 24 cross combinations in rabi 2012 at Regional Agricultural Research Station, Rahmatpur. In the following rabi, 2013 seeds of all the parental lines, their F_1 hybrids and two testers were sown at Regional Agricultural Research Station, Rahmatpur following Alpha Lattice Design with 3 replications. The unit plot size was 4.0 × 0.75 m. Spacing adopted was 75 × 25 cm between rows and hills, respectively. One healthy seedling per hill was kept after proper thinning. Fertilizers were applied @ 250, 120, 120, 40, 5 and 1kg/ha of N, P_2O_5. K_2O, S, Zn and B respectively. Standard agronomic practices were followed and plant protection measures were taken as required. Two border rows were used at each end of the replication to minimize the border effect. Ten randomly selected plants were used for recording observations on days to tasseling, days to silking, plant height, ear height, days to tasseling, days to silking and grain yield were recorded on whole plot basis. Combining ability analysis was done as per the method given by Kempthrone (1957).

Results and Discussion

The mean performance of all the 24 crosses along with the check varieties are presented in Table 1. The genotypes differed significantly for all the characters, indicating sufficient genetic variability present among them. Significant differences among the genotypes for yield and other traits. The analysis of variance showed significant variations among the genotypes for all the studied characters that revealed wide range of genetic variability among the genotypes. The analysis of variance for combining ability revealed significant differences in the variance due to lines, testers, hybrids and Line x Testers for all the traits (Table 2). Similar genotypic difference for ear length, grain weight, grain yield and other characters were reported by Sofi and Rathor (2006) and Narro *et al.* (2003).Highly significant differences present between parents due to all the traits. Significant differences were also observed between interactions of parent × hybrid for all traits, indicated wide range of variability present among them. Significant differences were also observed between the hybrids for all the characters except days to tasseling, silking and number of kernel per row. This indicates that the crosses were sufficiently different from each other for these traits and hence, selection is possible to identify the most desirable crosses. Significant differences were observed between the lines for one character number of kernel per row. A significant difference was also existed between testers for days to tasseling, silking, plant height and thousand grain weight. The interaction of line × tester also showed significant differences in ear height and yield.

Table 1. Performance of different characters of test cross hybrids under evaluation at RARS, Rahmatpur, Barisal during 2013-14

Entry/ Crosses	Days to tassel	Days to silk	Plant height (cm)	Ear height (cm)	Ear length (cm)	Ear diameter (cm)	Number of row	Number of seed/row	Thousand seed weight (g)	Yield (t/ha)	Root lodging (%)
E1 X BIL28 (E$_{1}$)	86	89	191.4	84.2	16.10	4.6	14.7	38.80	355.3	8.97	-
E1 X BIL29 (E$_{2}$)	83	87	212.7	103.3	14.40	4.2	13.7	35.00	337.1	9.47	-
E2 X BIL28 (E$_{3}$)	85	89	190.0	95.5	16.80	4.4	16.1	39.90	319.0	9.02	5
E2 X BIL29 (E$_{4}$)	85	89	224.1	109.0	19.33	4.6	14.1	41.53	349.2	9.03	-
E3 X BIL28 (E$_{5}$)	83	87	230.6	115.0	17.40	4.6	15.9	43.40	367.4	9.62	5
E3 X BIL29 (E$_{6}$)	82	85	217.9	121.6	18.10	4.3	13.9	40.20	331.1	9.19	5
E4 X BIL28 (E$_{7}$)	83	86	195.0	83.3	15.90	4.8	14.9	37.50	421.9	9.41	-
E4 X BIL29 (E$_{8}$)	82	85	216.7	112.1	17.16	4.4	13.6	39.60	365.9	10.44	-
E5 X BIL28 (E$_{9}$)	86	89	192.1	99.8	15.40	4.9	15.5	34.90	411.3	8.55	5
E5 X BIL29 E$_{10}$)	82	85	215.6	106.5	15.47	4.9	14.6	36.00	390.1	10.41	-
E6 X BIL28 E$_{11}$)	83	87	226.0	114.6	17.13	4.8	15.8	44.13	384.1	8.67	-
E6 X BIL29 E$_{12}$)	81	85	242.8	138.3	18.50	4.4	12.8	44.63	346.2	10.45	-
E7 X BIL28 E$_{13}$)	85	89	193.0	104.1	16.87	4.6	14.2	42.43	390.1	9.61	-
E7 X BIL29 E$_{14}$)	84	88	246.5	124.3	16.83	4.6	13.5	41.00	367.8	11.70	-
E8 X BIL28 E$_{15}$)	85	89	180.5	92.5	14.80	4.9	16.0	35.77	376.5	9.64	-
E8 X BIL29 E$_{16}$)	84	87	213.3	107.3	17.43	4.6	13.8	40.20	332.6	10.50	-
E9 X BIL28 E$_{17}$)	86	90	199.0	104.7	17.00	5.0	14.2	40.20	382.5	10.61	15
E9 X BIL29 E$_{18}$)	80	84	199.5	79.9	15.83	4.4	13.6	39.10	329.6	6.71	15
E10 X BIL28 (E$_{19}$)	85	88	201.5	123.6	15.00	4.7	15.2	39.20	397.6	10.70	10
E10 X BIL29 E$_{20}$)	84	88	218.4	118.7	15.80	4.3	12.8	40.80	294.8	8.66	-
E11 X BIL28 E$_{21}$)	84	88	205.5	108.0	16.80	4.6	14.6	37.96	391.6	7.40	-
E11X BIL29 (E$_{22}$)	86	89	228.7	106.0	15.67	4.7	13.6	36.76	353.8	10.80	-
E12 X BIL28 E$_{23}$)	85	89	205.7	113.6	15.16	4.4	13.9	40.30	355.3	8.61	-
E12X BIL29 (E$_{24}$)	85	89	196.4	96.0	16.10	4.4	14.0	40.73	329.7	7.18	-
BHM 9 (E$_{25}$)	85	89	208.5	95.5	17.30	4.7	13.7	39.80	400.7	10.77	-
BHM 7(E$_{26}$)	86	90	207.0	102.3	15.03	5.5	16.6	33.30	429.4	11.02	-
Mean	84.05	88.15	209.89	105.87	16.44	4.63	16.11	39.35	360.74	9.54	
F-test	ns	ns	**	*	**	**	**	**	ns	**	
CV (%)	3.4	3.6	8.3	14.1	5.9	4.5	5.9	7.7	7.67	10.10	
LSD $_{(0.05)}$	4.63	5.19	28.66	24.43	1.96	0.345	1.39	4.97	95.44	1.56	

Table 2. Analysis of variance for grain yield, yield components and other characters in line x tester analysis maize

Source	df	DT	DS	PH (cm)	EH (cm)	EL(cm)	K/ROW	TGW	Yld
Genotypes	37	18.5**	20.5**	1770**	964.**	11.67**	46.92**	15168**	23.4**
Parents (P)	13	35.9**	38.7**	1558**	899**	15.51**	68.12**	19474**	11.2**
P vs C	1	40.8*	53.1**	24719**	11169**	129.4**	355.32**	195705**	635**
Crosses (C)	23	7.7	8.8	891**	558**	4.38**	21.53	4885*	3.7**
Lines (L)	11	6.8	8.7	792	683	5.82	36.84**	3568	4.6
Testers (T)	1	42.0*	51.7**	6108**	728	4.90	0.094	38702**	1.1
L x T	11	5.4	5.0	516	417*	2.88	8.18	3127.89	3.1*
Error	37	7.1	9.1	316	183.	1.56	14.01	3097.16	1.38

*P=0.05, **P=0.01

DT =Days to tasseling DS =Days to silking Yld= Grain yield (t/ha) K/row= Kernel per row

PH =Plant height (cm) EH =Ear height (cm) TGW=1000-kernel weight (g) EL=Ear length

The contribution of lines, testers and interactions to total variance are presented in Table 3. The proportional contribution of lines and interactions to the total variances was much higher than testers in all the traits. The contribution of lines for all characters were much higher than that of interactions of line x tester, indicating higher estimates of variances due to general combining ability and female parent contributed maximum to total variance in maize, which was followed by interaction. Testers contributed lowest to total variance, which is in conformity with Parvin (2009).

Table 3. Proportional contribution of lines, testers and their interactions to total variance in maize

Source	DT	DS	PH (cm)	EH (cm)	EL(cm)	K/ROW	TGW	Yld
Due to line	42.24	47.45	42.52	58.53	63.60	81.81	34.93	59.11
Due to tester	23.82	25.48	29.78	5.67	4.87	0.02	34.44	1.28
Due to line × tester	33.92	27.12	27.68	35.79	31.52	18.16	30.62	39.6

DT =Days to tasseling DS =Days to silking Yld= Grain yield (t/ha) K/row= Kernel per row
PH =Plant height (cm) EH =Ear height (cm) TGW=1000-kernel weight (gm) EL=Ear length

General combining ability effects

Selection of parents with good general combining ability is a prime requisite for any successful breeding program especially for heterosis breeding. The general combining ability effects and *per se* performance of parents (line and tester) are presented in Table 4. The GCA effects of parents indicated that line E-3 and E-6 exhibited highly negative GCA effects for both days to tasseling and silking could be utilized for evolving early variety. Roy *et al*. (1998) and Hussain *et al*. (2003) also observed similar phenomenon in their study. The GCA effects of parents indicated that the lines E-8 contributed highly significant negative effects for evolving shorter plant height while E-6 showed significant positive effects. The general combining ability (GCA) effects of parents indicated that E-1and E-9 contributed highly significant negative effects for evolving less ear height could be utilized for evolving lower ear height. The lines E-2, E-3, and E-6 exhibited positive gca effect for ear length. E-6 expressed highly significant positive GCA effects for karnel per ear and yield indicated that this parents was good general combiner and could be used for exploiting more positive alleles for yield

Table 4. General combining ability (gca) effects and mean of parents for grain yield and yield components and other characters in maize.

Parents	Days to tasseling		Days to silking		Plant height (cm)		Ear height (cm)	
	gca	mean	gca	mean	gca	mean	gca	mean
Testers:								
BIL-28	0.76	81	0.84	85	-9.21	192.3	-3.20	97.7
BIL-29	-0.76	84	-0.84	88	9.21	197.1	3.20	87.5
SE (g_i)	0.44		0.49	0.50	2.96		2.26	
SE (g_i-g_j)	0.62		0.69	0.71	4.19		3.19	
Line Parents:								
E-1	0.43	79	0.48	83	-8.04	196.1	-12.63*	95.4
E-2	1.26	79	1.82*	83	-3.01	214.5	-4.17	115.1
E-3	-1.56*	75	-1.68*	80	14.19*	191.2	8.02	101.3
E-4	-1.23	74	-1.68*	77	-4.24	174.5	-8.67	67.8
E-5	-0.23	79	-0.18	81	-6.27	178.4	-3.20	77.3
E-6	-1.56*	86	-1.68*	90	24.33**	129.2	20.4**	64.9
E-7	0.93	84	0.82	88	9.69	193.3	7.76	109.3
E-8	0.43	76	0.15	81	-13.67*	158.2	-6.57	64.9
E-9	-0.90	81	-0.68	86	-10.84	198	-14.14*	98.4
E-10	0.43	80	0.49	83	-0.14	154.8	14.72*	76.5
E-11	0.93	79	0.65	83	7.03	178.7	0.56	83.1
E-12	1.90	83	1.48	87	9.04	157.4	-1.63	63.7
SE (g_i)	0.67		1.23		6.26		5.53	-
SE (g_i-g_j)	1.15		1.74		9.26		7.82	-

*P=0.05 and **P=0.01

Table 4 (cont'd)

Parents	Ear length(cm)		No.of kernel/ear		Thousand grain wt. (g)		Yield (t/ha)	
	gca	mean	gca	mean	gca	mean	gca	mean
Testers								
BIL-28	-0.26	18.4	-0.036	36.4	23.18	364.4	0.12	6.0
BIL-29	0.26	21.9	0.036	39.6	-23.18	372.0	-0.12	5.8
SE (gi)	0.209		0.623		9.27		0.19	
S.E. (gi - gj)	0.295		0.881		13.12		0.27	
Line parents								
E-1	-1.21*	17.9	-2.69	37.7	-9.95	285.8	0.48	5.3
E-2	1.59**	20.8	1.11	39	-22.05	278.2	-0.50	5.5
E-3	1.30*	21	2.23	37.6	-6.93	303.9	0.42	6.7
E-4	0.05	19.0	-1.04	40.7	37.88	166.3	0.37	4.3
E-5	-1.01	18.3	-4.12	35.0	44.48	271.9	1.05	6.6
E-6	1.35*	19.7	4.80*	23.3	8.95	289.4	1.12*	5.2
E-7	0.39	18.9	2.13	35.7	-43.22	238.8	0.78	5.4
E-8	-0.35	17.2	-1.60	27.6	-1.64	170.9	-0.50	3.9
E-9	0.01	18.3	0.06	38.4	-0.13	328.1	-1.05	4.4
E-10	-1.06	15.8	0.39	38.1	-9.95	288.8	0.02	3.9
E-11	-0.214	17.9	-2.22	38.0	16.51	344.7	-0.40	5.5
E-12	-0.831	17.6	0.93	36	-13.73	281.2	-1.78	4.2
SE (gi)	0.51		1.53		22.72		0.48	
S.E. (gi - gj)	0.72		2.15		32.13		0.67	

*P=0.05, **P=0.01

Table 5. Specific combining ability (sca) and mean of crosses for grain yield, its components and other characters in maize

Crosses	Days to tassel		Days to silk		Plant height (cm)		Ear height (cm)	
	sca	mean	sca	mean	sca	mean	sca	mean
E-1 X BIL-28	0.56	86	0.15	89	-1.42	191.4	-6.35	84.2
E-1 X BIL-29	-0.56	83	-0.15	87	1.42	212.7	6.35	103.3
E-2 X BIL-28	-0.59	85	-0.85	89	-7.86	190.0	-3.55	95.5
E-2 X BIL-29	0.59	85	0.85	89	7.86	224.1	3.55	109.0
E-3 X BIL-28	0.24	83	0.32	87	15.61	230.6	3.71	115.0
E-3 X BIL-29	-0.24	82	-0.32	85	-15.61	217.9	-3.71	121.6
E-4 X BIL-28	-0.10	83	-0.35	86	-1.62	195.0	-11.11	83.3
E-4 X BIL-29	0.10	82	0.35	85	1.62	216.7	11.12	112.1
E-5 X BIL-28	1.24	86	1.15	89	-2.52	192.1	-0.16	99.8
E-5 X BIL-29	-1.24	82	-1.15	85	2.52	215.6	0.16	106.5
E-6 X BIL-28	0.24	83	0.32	87	0.81	226.0	-8.66	114.6
E-6 X BIL-29	-0.24	81	-0.32	85	-0.81	242.8	8.66	138.3
E-7 X BIL-28	-0.26	85	-0.18	89	-17.49*	193.0	-6.95	104.1
E-7 X BIL-29	0.26	84	0.18	88	17.49*	246.5	6.95	124.3
E-8 X BIL-28	-0.10	85	0.15	89	-6.72	180.5	-4.21	92.5
E-8 X BIL-29	0.10	84	-0.15	87	6.72	213.3	4.21	107.3
E-9 X BIL-28	1.91*	86	1.99*	90	8.97	199.0	15.55*	104.7
E-9 X BIL-29	-1.91*	80	-1.99*	84	-8.97	199.5	-15.55*	79.9
E-10 X BIL-28	-0.43	85	-0.52	88	0.74	201.5	5.61	123.6
E-10X BIL-29	0.43	84	0.52	88	-0.74	218.4	-5.61	118.7
E-11 X BIL-28	-1.60	84	-1.35	88	-2.35	205.5	4.18	108.0
E-11 X BIL-29	1.60	86	1.35	89	2.35	228.7	-4.18	106.0
E-12 X BIL-28	-1.10	85	-0.85	89	13.84	205.7	11.98	113.6
E-12 X BIL-29	1.10	85	0.85	89	-13.84	196.4	-11.98	96.0
SE	1.33		1.71		10.26		7.82	
S.E. (sij - skl)	2.16		2.46		14.51		11.06	

*P=0.05, **P=0.01

Table 5 (cont'd)

Crosses	Ear length (cm)		No.of kernel/ear		Thousand grain wt. (g)		Yield (t/ha)	
	sca	mean	sca	mean	sca	mean	sca	mean
E-1 X BIL-28	1.04	16.10	1.94	38.80	-14.11	355.3	-0.26	8.97
E-1 X BIL-29	-1.04	14.40	-1.94	35.00	14.11	337.1	0.26	9.47
E-2 X BIL-28	-1.02	16.80	-0.79	39.90	-38.30	319.0	-0.11	9.02
E-2 X BIL-29	1.02	19.33	0.79	41.53	38.30	349.2	0.11	9.03
E-3 X BIL-28	-0.07	17.40	1.65	43.40	-5.04	367.4	0.83	9.62
E-3 X BIL-29	0.07	18.10	-1.65	40.20	5.04	331.1	-0.83	9.19
E-4 X BIL-28	-0.38	15.90	-0.98	37.50	4.78	421.9	-0.51	9.41
E-4 X BIL-29	0.38	17.16	0.98	39.60	-4.78	365.9	0.51	10.44
E-5 X BIL-28	0.24	15.40	-0.46	34.90	-12.60	411.3	-0.08	8.55
E-5 X BIL-29	-0.24	15.47	0.46	36.00	12.60	390.1	0.08	10.41
E-6 X BIL-28	-0.42	17.13	-0.21	44.13	-4.28	384.1	-0.29	8.67
E-6 X BIL-29	0.42	18.50	0.21	44.63	4.28	346.2	0.29	10.45
E-7 X BIL-28	0.28	16.87	0.75	42.43	-53.93	390.1	-0.67	9.61
E-7 X BIL-29	-0.28	16.83	-0.75	41.00	53.93	367.8	0.67	11.70
E-8 X BIL-28	-1.06	14.80	-2.18	35.77	-1.26	376.5	-0.61	9.64
E-8 X BIL-29	1.06	17.43	2.18	40.20	1.26	332.6	0.61	10.50
E-9 X BIL-28	0.89	17.00	0.59	40.20	3.27	382.5	1.15*	10.61
E-9 X BIL-29	-0.89	15.83	-0.59	39.10	-3.27	329.6	-1.15*	6.71
E-10 X BIL-28	-0.14	15.00	-0.745	39.20	28.22	397.6	0.82	10.70
E-10X BIL-29	0.14	15.80	0.75	40.80	-28.22	294.8	-0.82	8.66
E-11 X BIL-28	0.84	16.80	0.634	37.96	-4.28	391.6	-1.03*	7.40
E-11 X BIL-29	-0.84	15.67	-0.64	36.76	4.28	353.8	1.03*	10.80
E-12 X BIL-28	-0.21	15.16	-0.18	40.30	-10.33	355.3	0.80	8.61
E-12 X BIL-29	0.21	16.10	0.18	40.73	10.33	329.7	-0.80	7.18
SE	0.72		2.16		32.13		0.47	
S.E. (sij - skl)	1.02		3.06		45.44		0.76	

*P=0.05, **P=0.01

Specific combining ability effects

Specific combining ability and mean of the crosses for grain yield, its components and other characters are presented in (Table 5). With respect to number of days to tasseling and silking, crosses E-9 X BIL-29 showed the best SCA effects for earliness, whereas E-9 X BIL-28 were the latest with SCA effect. For plant height, the estimates of SCA effects were found to be significant in E-7 X BIL-28 of the twenty four crosses evaluated in the current study. The shortened plant is advantageous in case of lodging resistance. With regard to ear height; significant estimates of SCA effects were observed in E-9 X BIL-29. For grain yield, both negative and positive and significant estimates of SCA effects were observed among the crosses (Table 5). Cross E-9 X BIL-28 and E-11 X BIL-29 were good specific combiners. In general, crosses involving both good general combiner as well as one good and other poor combiner showed high SCA effects which are due to additive x additive and additive x dominant gene action. These results were in agreement with the earlier findings of Das and Islam (1994). The inbred parents E-3, E-6, E-8, and E-9 have been identified as the best general combiner due to their good combining ability effects and also their ability to transmit characters to their progenies for most of the characters. The cross E-7 X BIL-29, E-11 X BIL-29, E-10 X BIL-28 and E-9 X BIL-28 were identified as the best combinations for yield due to their SCA effects along with mean performance for yield traits.

Conclusions

Generally, the results of the current study identified that inbred lines with good GCA and cross combinations with desirable SCA for the traits studied. This indicates the possibility of developing desirable cross combinations and recombination of inbred lines with desirable traits of interest. Furthermore, promising cross combinations identified in this study could be utilized for future breeding work as well as for direct release after confirming the stability of their performances observed in the current study. Hence, the information from this study may possibly be useful for researchers who would like to develop high yielding varieties of maize.

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