Indian J. Genet., **67**(1): 79-80 (2007)

Short Communication

Combining ability for grain yield and drought related morpho-physiological traits in maize (*Zea mays* L.) under late sown conditions

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(Received: January 2006; Revised: September 2006; Accepted: November 2006)

In India, more than 80 per cent area under maize (*Zea mays* L.) grown depends on the rain, hence vulnerable to vagaries of monsoon. The present investigation was undertaken to assess the combining ability among different genotypes for drought stress tolerance under varied environments so as to assess the possibility of using these lines to develop tolerant material.

Twenty diverse early maturing white seeded inbred lines of maize derived from different population of maize germplasm obtained from AICMIP, MPUA&T, Udaipur. These 20 inbred lines were crossed with 3 inbred testers in Line × tester (20 × 3) mating design [1] during *rabi* 2002-2003 to generate a total of 60 hybrids. These 60 hybrids, along with 23 parents and 4 standard checks were planted in RBD with 3 replications in a single row plot of 5 m length having 60 × 25 cm crop geometry under four different environmental conditions during *kharif* 2003: E_1 (Early sowing and irrigated), E_2 (Normal sowing and rainfed), E_3 (Late sowing and irrigated), E_4 (Late sowing and terminal moisture stress at flowering). The data were recorded on yield and its related different morpho-physiological traits. The combining ability analysis was carried out according to the procedure of Kempthrone [1].

An examination of magnitude of mean squares for general and specific combining ability for morpho-physiological characters under terminal moisture stress condition (E_4) indicated that mean squares due to lines, tester, lines × tester were significant for most of the traits. These results revealed significant contribution of lines and testers towards *gca* variance and of lines x testers towards *sca* variance. The $\Sigma^2 sca$ effects were greater than $\Sigma^2 gca$ effects due to lines as well as testers in E_4 environment indicating the preponderance of non-additive gene effects in the expression of all the characters in moisture stress environment (Table 1). The preponderance of non-additive gene effects for grain yield in maize was also reported by earlier [2-3].

A perusal of *gca* effects revealed that line L_{11} showed maximum *gca* effects followed by L_{16} and L_3 in moisture stress condition. Line L_2 was identified as good general combiner for 100-seed weight and harvest index along with significant negative *gca* effects for chlorophyll stability index. Line L_{12} showed significant negative *gca* effect for both chlorophyll stability index and desiccation injury. Similarly, L_{16} in addition to significant positive *gca* effects for grain yield per plant, ears per plant harvest index also showed significant *gca* effects for desiccation injury. Thus, inbred lines L_1, L_3, L_4, L_{11}, L_{16} and L_{20} were identified as good general combines for yield and its contributing traits. (Table 2) Among testers T_2 was the good general combiner for yield and other physiological traits. Earlier workers also have reported some of the parents to be good general combines for yield under drought condition [3].

Among hybrids, $L_4 \times T_3$ exhibited maximum SCA effects for grain yield per plant followed by $L_{11} \times T_3$ and $L_{11} \times T_1$ in terminal moisture stress environment. $L_{11} \times T_3$ and $L_{11} \times T_1$ also showed significant negative *sca* effects for desiccation injury while $L_3 \times T_1$ showed significant negative *sca* effects both chlorophyll stability index and desiccation injury under stress condition (Table 3). Earlier workers also reported significant negative *sca* effects for chlorophyll stability index and desiccation injury as measured by percent injury in maize and wheat [4]. A comparison of the combining ability effects of the parents and their corresponding crosses indicated that the *gca* effects of the parents were reflected in the crosses for most of the characters studied [3]. The above findings suggested that inbreds, L_1, L_3, L_4, L_{11} and L_{20} were good general combines for grain yield and its related traits and L_{12} and L_{16} were identified as good general combines for drought adaptive physiological traits like chlorophyll stability index and desiccation injury. Thus these lines could be used in breeding elite genotypes for drought tolerance.

References

1. **Kempthorne O.** 1957. An Introduction to Genetic Statistics. John Wiley and Sons. Inc. New York. p. 545.
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Table 1. Analysis of variance for different characters in maize in terminal moisture stress environment (E_4) environment

Source	df	Ears/ plant	100-seed weight (g)	Grain yield/ plant (g)	Harvest index (%)	Chlorophyll stability index	Desiccation injury (%)
1. Replications	2	0.012	1.22	57.36	1.96	0.0005	83.59
2. Genotype	86	0.023**	16.66**	410.64**	71.79**	0.0063**	340.07**
Checks	3	0.00	3.61	48.63	48.54**	0.0051**	347.60**
Check v/s parent	1	0.03**	66.17**	4468.42**	246.70**	0.0019*	1.45
Parent	22	0.01**	17.53**	227.43**	71.23**	0.0064**	270.28**
Tester	2	0.00	0.69	79.0	83.42**	0.0038**	199.25*
Line	19	0.01**	20.17**	202.89**	64.22**	0.0066**	283.44**
T v/s L	1	0.02*	1.11	990.48**	180.10**	0.0091**	162.15
P v/s hybrid	1	0.20**	388.02**	17025.86**	1403.75**	0.012**	586.16**
Hybrid	59	0.02**	10.94**	211.64**	51.59**	0.0063**	365.73**
Tester	2	0.02**	38.26**	474.67**	11.62	0.0098**	5.40
Lines	19	0.03**	14.86**	230.08**	71.71**	0.0051**	395.91**
L × T	38	0.02**	7.54**	188.58**	43.64**	0.0067**	369.60**
3. Error	172	0.00	1.87	32.84	6.07	0.0004	43.98
Summation of combining ability effects							
Σ^2 *gca* T		0.00	1.21	14.72	0.18	0.0003	–1.28
Σ^2 *gca* L		0.31	27.42	416.41	138.57	0.0099	742.96
Σ^2 *sca*		1.00	71.74	1972.70	475.81	0.0798	4124.50

*,**significant at 5 and 1 % level respectively

Table 2. General combining ability for different traits in lines and testers of maize under terminal moisture stress environment

S.No.	Code	Symbol	Grain yield/plant (g)	Ears/ plant	100-seed weight (g)	Harvest index (%)	Chlorophyll stability index	Desiccation injury (%)
1.	EI-460	T_1	–3.08**	–0.00	–0.68**	0.13	0.01**	0.07
2.	EI-499	T_2	2.44**	0.02*	–0.20	0.36	–0.01**	–0.33
3.	EI-412	T_3	0.64	–0.02	0.88**	–0.49	0.00	0.26
4.	EI-506	L_1	5.31**	0.09**	–1.06*	3.12**	0.05**	–4.06
5.	EI-507	L_2	1.81	0.01	2.11**	2.76**	–0.03**	0.77
6.	EI-508	L_3	6.25**	0.08**	1.01*	1.07	0.01	5.85*
7.	EI-509	L_4	5.47**	0.12**	–0.03	4.54**	0.01	1.16
8.	EI-510	L_5	–7.14**	–0.10**	–1.72**	–2.68**	0.04**	2.33
9.	EI-511	L_6	–6.80**	–0.07**	0.13	–3.43**	–0.02*	1.56
10.	EI-512	L_7	1.42	0.06*	–1.30**	–1.53	–0.00	–5.67*
11.	EI-514	L_8	–3.08	–0.06**	0.66	–3.20**	0.02**	–8.30**
12.	EI-515	L_9	–3.53	–0.03	–0.19	–0.12	0.04**	–7.72**
13.	EI-516	L_{10}	3.70	0.01	0.14	0.10	0.00	7.47**
14.	EI-517	L_{11}	7.59**	0.04	3.26**	4.12**	–0.01	1.33
15.	EI-518	L_{12}	–2.19	–0.03	0.82	–1.55	–0.02*	–11.02**
16.	EI-519	L_{13}	–5.53**	–0.04	0.21	–3.27**	–0.02**	11.74**
17.	EI-520	L_{14}	1.14	0.00	–2.28**	0.47	–0.04**	–1.03
18.	EI-521	L_{15}	–5.99**	–0.02	–0.37	–3.81**	–0.01	12.61**
19.	EI-522	L_{16}	6.97**	0.07**	–0.65	3.62**	0.02**	–5.09*
20.	EI-532	L_{17}	–2.70	–0.10**	–1.21*	–2.71**	0.00	–0.26
21.	EI-533	L_{18}	–4.25*	–0.07**	–0.62	–1.92*	–0.03**	–8.07**
22.	EI-525	L_{19}	–3.97*	–0.02	0.36	1.21	–0.03**	6.81**
23.	EI-527	L_{20}	5.53**	0.05*	0.73	3.22**	0.00	–0.41

*,**significant at 5 and 1 % level respectively

Table 3. Promising maize hybrids identified on the basis *per se* performance and *sca* effects for yield and its contributing traits in terminal moisture stress environment

	Per se performance						*sca* effects					
Hybrids	Grain yield/ plant (g)	Ears/ plant	100-seed weight (g)	Harvest index (%)	Chloro-phyll stability index	Desi-ccation injury (%)	Grain yield/ plant (g)	Ears/ plant	100-seed weight (g)	Harvest index (%)	Chloro-phyll stability index	Desi-ccation injury (%)
1. $L_{11} \times T_3$	70.83	1.20	21.77	43.29	0.08	19.64	9.59*	0.15**	–0.48	5.23**	–0.00	–10.48*
2. $L_4 \times T_3$	70.00	1.17	21.57	42.88	0.06	22.65	10.86**	0.04	2.60**	4.40**	–0.04	–7.31
3. $L_{11} \times T_1$	66.00	1.13	20.55	41.80	0.09	17.61	8.46*	0.07	–0.14	3.12	–0.00	–12.33**

*,**Significant at 5 and 1 % level respectively

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