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Research Article

Combining ability analysis for yield and its component traits in maize (*Zea mays L.*)

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Abstract

Combining ability analysis for yield and its component traits was performed with twenty four lines, three testers and the resulting 72 hybrids using Line x Tester analysis. The interaction of Line x Tester was highly significant for all the characters studied except number of leaves per plant. Variance due to sca was greater than gca variance for the traits *viz.,* grain yield per plant, cob diameter, cob length, plant height, ear height, leaf length, 100 grain weight, grain rows per cob, days to 50 per cent tasseling and days to 50 per cent silking. The variance due to SCA was higher than due to GCA indicating the predominance of non-additive type of gene action in the governance of above mentioned traits. Among the lines, the line UMI 1093 was found as the best general combiner with better mean performance for most of the yield contributing traits followed by UMI 1044-7, UMI 1053-6, UMI 1029-5 and UMI 2244-1. Considering the testers, UMI 61 was found as the best general combiner with better mean performance for most of the yield contributing traits followed by UMI 1119. Among the crosses, UMI 1044-7 x UMI 61 was found to be the superior with positive significant SCA effects and better mean performance for grain yield, cob length and grains per row. Similar superior positive significant SCA effects with better mean performance were also observed in UMI 1093 x UMI 61 (grain yield per plant) and UMI 2244-1 x UMI 1119 (grain yield per plant and grain rows per cob).

Key Words: Combining ability, Line x Tester, *gca, sca*, maize, quantitative traits, nature of gene action.

Introduction

Maize (*Zea mays*) is an important cereal crop of India. It is a member of grass family *poaceae* and is highly cross pollinated crop. . It has assumed greater significance due to its demand for food, feed and industrial utilization. Hybrid cultivars have played a vital role in increasing acreage and productivity of maize. Combining ability is the relative ability of a genotype to transmit its desirable performance to its crosses. Combining ability analysis is not only the quickest method of understanding the genetic nature of quantitatively inherited traits, but also gives essential information about the selection of parents which in turn throws better segregants. The variance due to general combining ability (*gca*) is usually considered to be an indicator of the extent of additive type of gene action, whereas specific combining ability (*sca*) is taken as the measure of non- additive type of gene actions in heterosis breeding. The present study was undertaken to estimate the combining ability of parents and hybrids, nature and Magnitude of gene action for yield and yield components in maize by adopting Line x Tester analysis (Kempthorne, 1957).

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Material and Methods

The material for the study consisted of twenty four lines and three testers. The parents were crossed in Line x Tester mating design to generate 72 F_1 hybrids at Millets Breeding Station, Department of Millets, Tamil Nadu Agricultural University, Coimbatore during *Rabi* 2009. Each genotype was sown in two rows of four meters length adopting Completely Randomized Block Design and replicated twice. The trial was conducted in black loamy soil. The recommended fertilizer dose of 135: 62.5: 50 kg NPK/ha was applied. The row-to-row and plant-to-plant distance was 60 and 25 cm respectively. All other agronomic and plant protection practices applicable for maize crop were adopted. Observations were recorded on eleven quantitative characters. Data related to days to 50% tasseling and days to 50% silking were recorded on plot basis while data related to other characters were recorded on five randomly selected plants leaving border plants of each row. The mean values were subjected to line x tester analysis.

Results and Discussion

The analysis of variance revealed significant differences among the parents and hybrids for all the traits studied. Variance due to lines was highly significant for all the characters and Variance due to testers was highly significant for all the characters except for the grain yield per plant. Variance due to interaction effects of lines and testers were highly significant for all the characters (Table 1). Obviously due to the diverse nature of the line and testers the crosses between them were also found to be significant for all the characters. The significant variance of line x tester interaction indicated the importance of specific combining ability. The mean squares due to testers were of a larger magnitude than those of lines and line x tester for all characters except number of grains per row and grain yield per plant indicating greater diversity among the testers than the lines.

The magnitude of specific combining ability variances was much greater than those of general combining ability variances for all the characters, which indicated the preponderance of non additive gene action for all the characters. The role of non additive gene action for grain yield and other some traits have been reported earlier by Singh and Singh (1998), Prasad and Pramod Kumar (2003), Subramaniyan and Subbraman (2006), Jayakumar and Sundram (2007), Vijayabharathi *et al.,* (2009).

The *gca* effects of parents is presented in Table 2. The estimates of *gca* showed that among the lines, UMI 1044-7, UMI 1093, UMI 1029-5 and UMI 2244-1 have exhibited positive and significant *gca* effects for grain yield per plant. UMI 2128-1 and UMI 2244-1 have positive and significant *gca* effects for earliness and UMI 1266-7, UMI 1265-6 and UMI 1093 have positive and significant *gca* effects for plant height. The lines UMI 1051-5, UMI 1265-6, UMI 1044-7 and UMI 6143-16 have positive and significant *gca* effects for leaf length, cob length, number of grains per row and 100 grain weight respectively and hence these lines were good combiners for above respective traits. UMI 1093 was observed to be good combiner for cob diameter and number of grain rows per cob. Among the testers, UMI 61 and UMI 1119 were observed best combiners for grain yield per plant and cob diameter. With respect to earliness and reduced plant height and ear height UMI 1119 was found to be the best combiner. Similarly, UMI 285 and UMI 61 were the best combiners for cob length. The testers UMI 285, UMI 61 and UMI 1119 have registered positive and significant *gca* effects for 100 grain weight, number of grains per row and number of grain rows per cob respectively and hence they were promising for the traits concerned. None of the single parent evidenced as positive and significant *gca* effects for all traits. However, the lines UMI 1044-7, UMI 1093, UMI 1029-5, UMI 2244-1 and testers UMI 61 and UMI 1119 were found to be the best combiners for grain yield and various yield characters.

Three best crosses with significant *sca* effects for various traits along with per se performance and *gca* effects of parents involved in the crosses are listed in Table 3. Most of the crosses selected on the basis of significant *sca* effects also had high per se performance. Among of 72 crosses, many of the crosses were ranked as top crosses for one or more characters. None of the crosses was found desirable simultaneously for all the characters i.e., different crosses expressed significant *sca* effects for different characters. However, out of 72 crosses, 4 crosses had shown highly significant positive *sca* effects for grain yield. Among them UMI 1044-7 x UMI 61 (17.65), UMI 1093 x UMI 61 (15.66) and UMI 2244-1 x UMI 1119 (14.27) expressed maximum *sca* effects along with high per se performance for grain yield per plant. The crosses which exhibited significant desirable *sca* effects were UMI 1024-5 x UMI 61 for days to 50 per cent tasseling, UMI 1137-6 x UMI 61 for days to 50 per cent silking, CML 460 x UMI 61 for plant height and UMI 1024-5 x UMI 61 for ear height. Similarly while considering cob and grain characters, the crosses viz., CML 118 x UMI 61 (cob length), CML 460 x UMI 1119 (cob diameter), CML 357 x UMI 285 (grain rows per cob), UMI 1044-7 x UMI 61 (grains per row) and UMI 1023-6 x UMI 61 (100 grain weight). The results, thus obtained in the present study are mostly in conformity with the earlier findings of Pal and Prodhan (1994), Rao *et al.,* (1996), Mahto and Gunguli (2003) and Malik *et al.,* (2004) for grain yield and other component characters. It is evident that the best three crosses exhibiting desirable *sca* effects for grain yield were showed the involvement of parents with high x high *gca* effects.

Thus three crosses namely, UMI 1044-7 x UMI 61, UMI 1093 x UMI 61 and UMI 2244-1 x UMI 1119 which have shown high *sca* effects for grain yield involving parents of positive and significant *gca* effects can be exploited for the development of single cross hybrids since non additive gene action for most of the traits was observed. Further they can also be used for population improvement programme through reciprocal recurrent selection.

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Table 1. Analysis of variance for combining ability analysis under Line x Tester

Sources	df	Mean squares										
		50 per cent tasseling	**50 per cent silking**	**Plant height**	**Ear height**	**Leaf length**	**Cob length**	**Cob diameter**	**Grain rows per cob**	**Grains per row**	**100 grain weight**	**Grain yield per plant**
Cross	71	11.45**	11.83**	558.56**	288.64**	86.03**	2.60**	1.15**	3.55**	17.36**	16.17**	435.23**
Line	23	24.34**	24.87**	1063.35**	362.55**	164.59**	3.35**	1.51**	4.31**	32.96**	28.63**	863.05**
Tester	2	96.30**	102.27**	5041.89**	4519.54**	704.48**	5.99**	7.44**	56.10**	13.37**	181.55**	492.67
Line x tester	46	1.31**	1.38*	111.23**	67.73**	19.86**	2.08**	0.69**	0.89**	9.74**	2.75**	218.82**
Error		0.7	0.76	42.38	27.78	9.22	0.43	0.16	0.13	2.42	1.07	115.83
GCA		0.123	0.1268	5.429	2.6811	0.8031	0.0063	0.0055	0.0323	0.0925	0.1629	0.1054
SCA		0.3046	0.3112	34.4268	19.9759	5.3148	0.8269	0.2672	0.3772	3.6582	0.838	1.2189
GCA/SCA ratio		0.404	0.407	0.158	0.134	0.151	0.008	0.021	0.086	0.025	0.194	0.086

Table 2. General combining ability effects of the parents

Parents/ characters	50 per cent tasseling	50 per cent silking	Plant height	Ear height	Leaf length	Cob length	Cob diameter	Grain rows per cob	Grains per row	100 grain weight	Grain yield per plant
Lines											
UMI 1023-6	-2.44**	-2.50**	-13.99**	-4.67*	-8.61**	0.24	0.23	0.74**	-0.27	-1.70**	-1.14
UMI 1044-7	-1.11**	-1.17**	3.79	4.23	7.19**	0.85**	0.01	-0.14	4.23**	0.42	20.84**
UMI 1051-5	1.89**	1.83**	12.73**	7.66**	10.36**	0.51	0.29	0.84**	3.13**	-2.74**	7.14
UMI 1053-6	2.22**	1.67**	16.18**	10.43**	0.79	0.84**	0.66**	-0.32*	-2.50**	4.17**	7.57
UMI 1054-6	4.06**	4.50**	2.16	7.30**	5.66**	0.25	0.14	0.44**	-0.68	-0.33	0.98
UMI 1690-6	-0.28	-0.50	-19.71**	-14.54**	-6.04**	-1.64**	-0.12	0.08	-5.82**	-0.66	-24.47**
UMI 6143-16	-0.94**	-1.00**	-4.87	-0.14	-7.64**	-0.96**	-0.39*	-1.49**	-3.55**	4.22**	-9.88*
CML 115	1.06**	0.33	-22.27**	-7.50**	-0.49	0.20	-1.06**	-0.11	-0.57	-3.45**	-21.44**
CML 357	1.06**	0.50	4.53	-1.67	3.59**	0.06	0.19	-1.34**	2.60**	1.26**	2.60
CML 460	0.22	0.83*	-9.74**	-0.34	1.01	-1.28**	0.04	0.06	-0.80	0.17	-8.66*
UMI 1093	2.56**	2.00**	16.83**	4.03	2.39	0.84**	1.11**	2.21**	2.50**	-1.53**	19.55**
UMI 1114-10	0.72*	0.83*	5.79*	6.76**	0.03	-0.16	-0.01	0.56**	0.03	-2.08**	-4.30
UMI 1266-7	0.89*	0.67	22.39**	11.30**	-2.61*	0.56*	0.19	-1.11**	-0.41	4.01**	6.74
CML 118	0.22	-0.17	-24.81**	-10.34**	-3.84**	-0.55*	-0.71**	-1.19**	-0.87	0.59	-11.95**
UMI 1025-10	-2.44**	-2.17**	-6.47*	-9.67**	-2.11	-0.34	-0.30	-0.24	1.12	-0.78	-0.08
UMI 1029-5	-0.28	0.33	8.83**	1.60	3.01*	0.44	0.74**	0.01	2.00**	0.09	10.09*
UMI 1055-8	-0.11	0.17	-13.64**	-1.70	-4.01**	0.64*	-0.27	0.18	1.77**	-0.66	6.29
UMI 1131-5	-0.11	0.17	-3.81	2.46	-7.81**	-1.52**	-0.15	0.64**	-0.46	-2.78**	-8.57*
UMI 1265-6	0.06	0.17	19.36**	8.30**	-0.07	0.89**	-0.29	-1.12**	-1.87**	3.80**	-0.91
UMI 1024-5	0.06	0.17	12.79**	9.70**	0.99	-0.32	0.24	0.29*	-0.97	0.92*	4.40
UMI 2244-1	-2.78**	-2.50**	-6.81*	-8.60**	0.28	0.63*	0.69**	0.56**	2.68**	-0.20	17.46**
UMI 2128-1	-5.44**	-6.00**	-6.01*	-14.77**	-5.94**	0.02	-0.28	0.82**	-0.36	-1.20**	1.64
UMI 1137-6	2.22**	2.50**	6.26*	-0.97	8.66**	-0.21	-0.79**	-0.49**	-2.68**	-0.58	-17.55**
UMI 1269-7	-1.28**	-0.67	0.46	1.16	5.19**	0.03	-0.16	0.09	1.72**	-0.95*	3.63
Testers											
UMI 285	-0.28*	-0.35**	3.27**	3.68**	0.32	0.20*	-0.45**	-1.08**	-0.58*	2.07**	-3.15*
UMI 61	1.53**	1.60**	8.22**	7.33**	3.66**	0.20*	0.22**	0.00	0.46*	-0.28	1.58
UMI 1119	-1.26**	-1.25**	-11.48**	-11.00**	-3.98**	-0.41**	0.24**	1.08**	0.12	-1.79**	1.57

*- Significant at 5% level **- Significant at 1% level

Table 3. Crosses with desirable *sca, gca* and *per se* effects of the parents

characters	Significant crosses	*sca* effects	*gca* effects		*Per se* performance		
			Line	Tester	F_1	Line	Tester
1	2	3	4	5	6	7	8
Grain yield per plant	UMI 1044-7 x UMI 61	17.65**	20.84**	1.58	182.63	63.50	59.57
	UMI 1093 x UMI 61	15.66**	17.46**	1.57	182.35	87.06	59.57
	UMI 2244-1 x UMI 1119	14.27**	19.55**	1.58	177.87	75.28	87.66
Days to 50 per cent Tasseling	UMI 1024-5 x UMI 61	-1.37*	0.06	1.53**	56.00	62.50	64.50
	CML 460 x UMI 1119	-1.24*	0.22	-1.26**	55.00	58.50	60.50
	CML 118 x UMI 285	-1.22*	0.22	-0.28*	54.50	57.00	61.50
Days to 50 per cent Silking	UMI 1137-6 x UMI 61	-1.77**	2.50**	1.60**	60.50	67.00	68.00
	UMI 1024-5 x UMI 61	-1.44**	0.17	1.60**	58.50	65.00	68.00
	CML 118 x UMI 285	-0.65**	-0.17	-0.35**	57.00	59.00	64.00
Plant height	CML 460 x UMI 61	16.48**	-9.74**	8.22**	193.70	112.20	127.80
	UMI 1044-7 x UMI 61	11.75*	3.79	8.22**	202.50	119.80	127.80
	UMI 1055-8 x UMI 61	10.68*	-13.64*	8.22**	184.00	108.00	127.80
Ear height	UMI 1024-5 x UMI 61	12.14**	9.70**	7.33**	121.00	53.60	81.90
	UMI 1044-7 x UMI 61	11.60**	4.23	7.33**	109.00	51.00	81.90
	UMI 1114-10 x UMI 1119	10.60**	6.76**	-11.00**	98.20	75.00	62.80
Leaf length	CML 115 x UMI 285	5.91**	-0.49	0.32	91.95	66.70	71.20
	UMI 1093 x UMI 285	5.68**	2.39	0.32	94.60	73.00	71.20
	UMI 1265-6 x UMI 1119	4.65**	-0.07	-3.98**	86.80	74.80	65.10
Cob length	CML 118 x UMI 61	1.77**	-0.55**	0.20*	17.71	10.90	13.09
	UMI 1114-10 x UMI 285	1.76**	-0.16	0.20*	18.10	12.60	13.50
	UMI 1044-7 x UMI 61	1.58**	0.85**	0.20*	18.93	12.10	13.09
Cob diameter	CML 460 x UMI 1119	1.29**	0.04	0.24**	16.00	10.73	11.10
	UMI 1029-5 x UMI 285	1.07**	0.74**	-0.45**	15.80	12.50	11.68
	UMI 1269-7 x UMI 285	0.98**	-0.16	-0.45**	14.80	10.18	11.68
Grain rows per cob	CML 357 x UMI 285	1.00**	-1.34**	-1.08**	12.60	10.10	11.40
	UMI 2244-1 x UMI 1119	0.99**	0.56**	1.08**	12.65	12.55	13.51
	CML 115 x UMI 285	0.87**	-0.11	-1.08**	13.70	11.88	11.40
Grains per row	UMI 1044-7 x UMI 61	4.86**	4.23**	0.46*	46.20	22.50	23.06
	UMI 1137-6 x UMI 1119	4.31**	-2.68**	0.12	38.40	24.60	23.20
	UMI 1114-10 x UMI 285	3.44**	0.03	-0.58*	39.55	25.15	28.35
Hundred grain weight	UMI 1023-6 x UMI 61	2.45**	-1.70**	-0.28	29.38	21.50	19.63
	UMI 1024-5 x UMI 285	2.35**	0.92*	2.07**	34.38	25.75	25.38
	UMI 1053-6 x UMI 61	1.57*	4.17**	-0.28	34.50	31.38	19.63