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RESEARCH ARTICLE

Analysis of combining ability in white seeded genotypes of maize (*Zea mays* L.)

■ **P.P. SHARMA, MUKESH VYAS AND S.P. SHARMA**

SUMMARY

The present investigation consisted of 45 hybrids alongwith 18 parents and four checks *viz.*, Arawali Makka-1, Mahi Kanchan, Navjot and PEHM-2 a total 67 entries was conduted during *Kharif* 2002 in Randomised Block Design having three replications. The data were recorded on fourteen traits to study general and specific combining ability effects. In general inbred lines L_1, L_3, L_{11} and L_{15} were considered good general combiner for yield and yield contributing traits as well as for quality traits. Among the testers, the tester T_2 was considered good general combiner for maturity traits, plant type traits, harvest index and starch content. Majority of the hybrids exhibited significant positive values for yield and yield contributing traits as well as quality traits. Thereby, indicating that for these traits the genes with positive effects were dominent. The variance due to lines was of greater magnitude than that of testers for most of the traits. The ratio of 6^2sca/6^2gca indicated prependerance of non-additive variance for most of the traits. Parental lines L_1, L_3, L_{11} and L_{15} were found to be good general combiners for grain yield per plant as well as for other traits. Hybrid L_{12} x T_1 exhibited maximum significant positive sca effects for grain yield per plant. While the hybrid L_2 x T_1 exhibited highest estimates of significant positive sca effects for starch content. In general, there is a close association between sca effects, relative heterosis and per se performance for grain yield per plant was observed among the best hybrid identified on the basis of sca effects.

Key Words : Maize (*Zea mays* L.), Single cross hybrid, Combining ability, Gene effects

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The breeding strategy for single cross hybrid development in maize (*Zea mays* L.) requires identification of high per se performing vigorous and productive inbred lines combined with good seed quality traits and desirable combining ability effects in cross combination to identify single crosses with high heterotic effects. The single cross hybrids are considered most desirable as the breeding and seed production is much easier than the multiparent hybrids.

Selection of parents on the basis of phenotypic performance alone is not a sound procedure since phenotypically superior lines may yield poor recombination. It is therefore, essential that parents should be chosen on the basis of their genetic value. The performance of parent may not necessarily reveal it to be a good or poor combiner. Therefore, gathering information on nature of gene effects and their expression in terms of combining ability is necessary. At the same time, it also elucidates the nature of gene action involved in the inheritance of charaters. The concept of good combining ability refers to the potential of a parental form of

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
P.P. SHARMA, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

Address of the Co-authors:
MUKESH VYAS AND S.P. SHARMA, Department of Plant Breeding and Genetics, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

producing by its crossing with another parent superior offspring for the breeding process and it is widely used in the breeding of cross pollinated plants.

Information and exact study of combining ability can be useful in regard to selection of breeding methods and selection of lines for hybrid combination. The prersent study was, therefore, under taken with a view to estimate general and specific combining ability variances and effects in maize for seed yield and quality traits in white grained maize by using line tester x mating design.

MATERIAL AND METHODS

15 inbred lines *i.e.* L_1 (E1 552), L_2 (E1-553), L_3 (E1 554), L_4 (EI-555), L_5 (EI-556), L_6 (E1557), L_7 (E1 503), L_8 (E1 501), L_9 (E1 499), L_{10} (E1 460), L_{11} (E1 461), L_{12} (E1 423), L_{13} (E1 420), L_{14} (E1 558) and L_{15} (E1 559) were crossed with three tester *viz.*, T_1 (EI 457), T_2 (EI 494) and T_3 (CM 400) in line x tester design in *Rabi* season and developed a total of 45 hybrids. 45 hybrids with 18 parents and four checks *viz.*, Arawali makka-1, Mahi Kanchan, Navjot and PEHM-2 thus, experimental material consisted of 67 entries were planted in Randomized Block Design comprising three replications with a single row plot of 5 meter length maintaining crop geometry of 60 x 25 cm. Reommended agronomical practices were followed to raise a healthy crop.

The data were recorded on fourteen traits to magnitude of general and specific combing ability effects at Instructional Farm of Rajasthan College of Agriculture, Udaipur.

RESULTS AND DISCUSSION

The combining ability analysis is a powerful tool to determine good as well as poor combiners for selecting appropriate parents to formulate an efficient breeding programme. The nature of gene action for yield and its component traits have a bearing on the development of an efficient breeding methodology. General combining ability is attributed to addituie, additive x additive, interactions and is fixable in nature while the specific combining ability is attributed to non - additive (*i.e.* dominance, dominance x dominance and additive x dominane interactions) gene action and is non fixable in nature.

The data on 45 crosses were analysed and the total variance was partitioned into coponent *viz.*, variance due to line, testers and line x testers. The data on crosses were further analysed to determine the line x tester (gca) and line x tester (sca) variance components for all traits.

The mean squares due to crosses, line x testers and line x testers were significant for all the traits except due to tester for anther silking interval, ear length, 100 grain weight and grain yield per plant.

The significant mean square for lines x testers indicated significant contribution of lines x testers towards general combinign ability variance components for these traits. The significant mean square for line x testers indicated significant contribution of hybrids for specific combining ability variance components.

The analysis of variance for combining ability indicated that the mean sqares due to lines and testers were significant for all the traits except due to tester for anthesis-silking interval, ear length, 100- grain weight and grain yield per plant, thereby, indicating significant contribution of lines and testers towards gca variance. The mean squares due to line x tester interaction were significant for all the traits indicating significant cotnribution of line x tester towards sca variance.

Variance due to lines were of higher magnitude than that of testers for days to 50 per cent tasseling, days to 50 per cent silking, anthesis silking interval, plant height, ear length, ear girth, 100 grain weight, grain yield per plant, biological yield per plant, harvest index, starch content and protien content. This indicating that the contribution fo lines for these traits was greater towards 6^2gca.

Variance due to testers was of higher magnitude than that of lines for days to 50 per cent brown busk and ear height. This indicated that the contribution of tester for these traits was greater towards 6^2gca.

The ratio of 6^2sca/6^2gca (the sca, gca variance ratio) was greater than one for all the traits. This indicated that non-additive component played greater role in the inheritance of these traits (Table 1). These results are in accordance with the findings of EI-Hosary (1990), Hang *et al*. (1991), Jha and Khera (1992), Joshi *et al*. (1998), Joshi *et at.* (2001). However, additive variance for grain yield in maize was also reported by Beck *et al.* (1990), Cosmin *et al.* (1991) and Gama *et al.* (1995). On the other hand, Kumar and Gangashetti (1998), Singh *et al.* (1998), Zelleke *et al.* (2000) and Sinha (2002) reported that both gca and sca variance were important for grain yield in maize.

The estimates of gca effects revealed that good general combiner inbred lines for majority of yield and yield contributing traits were L_1, L_3, L_{11} and L_{15}, for protein content inbred lines L_7, L_{10}, L_{11} and L_{12}, for start content inbred lines L_1, L_5, L_7, L_{10}, L_{11}, L_{14} and L_{15}, for maturity related traits L_2, L_{11}, L_{13} and L_{14} and for plant type traits L_1, L_5, L_{11} and L_{12}. In general the inbred lines L_1, L_3, L_{11} and L_{15} have been found good general combiners for yield and yield contributing traits as well as for quality traits (Table 2).

Among the testers, the tester T_2 (HP (B)-33-3) was considered good general combiner for maturity traits, plant type traits, harvest index and starch content and tester T_3 (CM-400) was considered good general combiner for ear girth, biological yield per plant and protein content. The tester T_1 (SLT-32-3) was considered good general combiners for bilogical yield per plant and starch content. High general combining ability (gca) observed were due to additive and additive x additive gene effects (Griffing, 1956 and Sprague, 1966).

A perusal of sca effects revealed that significant positive sca effects for harvest index were recorded in hybrids L_2xT_1,

Table 1 : GCA and SCA variances for fourteen traits in maize

Source of variantion	Days to 50% tasseling	Days to 50% silking	ASi	Days to 50% brown husk	Plant height	Ear height	Ear length	Ear girth	100 grian weight	Grain yield per plant	Biological yield per plant	Harvest index (HI)	Protein content	Starch content.
6^2L	0.6836	0.57531	0.028924	0.91411	77.594	26.888	0.28303	0.080177	0.025564	18.379	286.42	1.1113	0-11753	0.74812
6^2t	0.37919	0.28466	-0.003527	1.4697	62.735	7.4287	-0.01944	0.020905	-0.13208	-2.7354	4.546	0.54002	0.018036	0.47814
6^2Gca	0.13919	0.11355	0.0038507	0.2864	17.851	4.695	0.039251	0.01387	-0.010031	2.3953	42.243	0.21831	0.019019	0.15891
6^2sca	0.81173	0.75521	0.048148	6.3383	125.36	29.072	0.45991	0.13484	1.8908	32.165	522.84	4.3488	0.90312	5.7705
6^2SCA/GCA	5.8318	6.650903	12.5037	22.13094	7.022576	6.19212	11.717154	9.721702	-188.4957	13.428381	12.37696	19.920297	47.48515	36.31301

Table 2 : Parents and hybrids possessing good general combining ability and specific combining ability effects for fourteen traits

Sr. No.	Traits	Parentasl lines	Testers	Hybrids
1.	Days to 50% tasseling	L_2,L_{11},L_{13} and L_{14}	T_2	(L_{14} x T_1), (L_{15} x T_1) and (L_2 x T_3)
2.	Days to 50% silking	L_2,L_{11},L_{13} and L_{14}	T_2	(L_{10} x T_1), (L_{14} x T_1), (L_{15} x T_1) and (L_2 x T_3)
3.	Anthesis silking interval	L_{10}	-	-
4.	Days to 50% brown husk	L_1,L_2,L_4,L_{11} and L_{15}	T_2	(L_6 x T_1), (L_8 x T_1), (L_{14} x T_1), (L_5 x T_2), (L_2 x T_3), (L_7 x T_3), (L_9 x T_3) and (L_{13} x T_3)
5.	Plant height	L_1,L_5,L_6,L_{11} and L_{12}	T_2	(L_2 x T_1), (L_9 x T_1), (L_9 x T_2), (L_5 x T_3), (L_{10} x T_3) and (L_{14} x T_3)
6.	Ear height	L_1,L_5,L_8, ,L_{11},L_{12} and L_{13}	T_2	(L_2 x T_1), (L_8 x T_1), (L_9 x T_1), (L_{11} x T_1), (L_1 x T_2), (L_4 x T_2), (L_{11} x T_2), (L_{12} x T_2), (L_5xT_3), (L_6 x T_3), (L_{10} x T_3) and (L_{14} x T_3)
7.	Ear length	L_1 and L_{12}	-	(L_6 x T_1) and (L_{13} x T_3)
8.	Ear girth	L_3,L_{11},L_{13} and L_{15}	T_3	(L_3 x T_1) and (L_2 x T_3)
9.	100-grain weight	L_2,L_4 and L_5	-	(L_5 x T_1), (L_8 x T_2), (L_{12} x T_2) and (L_{10} x T_3)
10.	Grain yield per plant	L_3,L_{14} and L_{15}	-	(L_{12} x T_1), (L_4 x T_2), (L_2 x T_3) and (L_{10} x T_3)
11.	Biological yield per plant	L_1,L_3,L_7,L_{10},L_{11},L_{14} and L_{15}	T_1, T_3	(L_{11} x T_1), (L_{12} x T_1), (L_{15} x T_1), (L_2 x T_2), (L_4 x T_2), (L_8x T_2), (L_{13} x T_2), (L_2 x T_3) and (L_7 x T_3)
12.	Harvest index	L_3,L_4 and L_6	T_2,	(L_1 x T_1), (L_2 x T_1), (L_{13} x T_1) and (L_{12} x T_3)
13.	Protein content	L_7,L_{10},L_{11} and L_{12}	T_3,	(L_3 x T_1), (L_5 x T_1), (L_9 x T_1), (L_1 x T_2), (L_{12} x T_2), (L_{14} x T_2), (L_{15} x T_2), (L_6 x T_3) and (L_{13} x T_3)
14.	Starch content	L_1,L_5,L_7,L_{10},L_{11},L_{14} and L_{15}	T_1, T_2	(L_2 x T_1), (L_8 x T_1), (L_{12} x T_1), (L_{13} x T_1), (L_1 x T_2), (L_4 x T_2), (L_6 x T_2), (L_{11} x T_2) , (L_{14} x T_2), (L_3 x T_3) , (L_{10} x T_3), (L_{11} x T_3), (L_{12} x T_3) and (L_{15} x T_3)

Table 3 : First four best hybrids identified on the basis of sca effets for harvest index

Sr. No.	Hybrid/pedigree	SCA/GCA effects	Economic heterosis (%) over the best check 'mahi Kanchan'	Harvest index (%)
1.	L_2 x T_1 (pop 49-117-2#1-1-2 x SLT 32-3)	4.85	8.50	41.05
2.	L_{12} x T_3 (HP(A)-42-1-1 x CM400)	3.60	-	39.42
3.	L_{13} x T_1 (HP(A)-67-2-1-1 x SLT 32-3)	2.92	-	39.49
4.	L_1 x T_1 (Shweta 74-1-2#1-2-1 x SLT 32-3)	2.60	-	37.69
5.	L_1(Shweta 74-1-2#1-2-1)	-1.43	-	30.94
6.	L_2(pop 49-117-2#1-1-2)	-0.32	-	29.04
7.	L_{12}(HP(A)-42-1-1)	-0.74	-	29.31
8.	L_{13}(HP(A)-67-2-1-1)	0.06	-	35.70
9.	T_1 (SLT32-3)	-0.57	-	32.03
10.	T_3(CM 400)	1.09	-	31.34
11.	Mahi Kanchan	-	-	37.83

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 4 : First five best hybrids identified on the basis of sca effets for starch content

Sr. No.	Hybrids / parents	SCA/GCA effects	Economic heterosis (%) over the best check 'Mahi Kanchan'	Per se performane	
				Starch content (%)	Grain yield per plant (g)
1.	L_2 x T_1 (pop 49-117-2#1-1-2 x SLT 32-3)	3.23**	-	63.33	63.33
2.	L_{12} x T_3 (HP(A)-42-1-1 x SLT 32-3)	3.23**	-	65.60	94.33
3.	L_8 x T_1 (X_2W-3179-1-2-1 x SLT 32-3)	3.01**	-	65.77	78.33
4.	L_{14} x T_2 (pop-30-29-1-3#1-2-1 x HP(B)33-3)	2.72**	2.41**	66.78	98.33
5.	L_3 x T_3 (Hyd (W)3105-2#1 x CM400)	2.50**	-	62.58	91.67
6.	L_2(pop 49-117-2#1-1-2)	-2.68**	-	61.50	82.33
7.	L_3(pop 49-117-2#1-1-2)	-1.39**	-	64.52	77.00
8.	L_8(pop 49-117-2#1-1-2)	-0.03	-	54.79	73.33
9.	L_{12}(pop 49-117-2#1-1-2)	-0.42	-	64.61	81.67
10.	L_{14}(pop 49-117-2#1-1-2)	0.77**	-	64.33	66.67
11.	T_1 (SLT32-3)	0.27**	-	60.20	37.67
12.	T_2(HP(B) 33-3)	0.77**	-	61.27	57.67
13.	T_3(CM 400)	-1.04**	-	60.40	55.00
14.	Mahi Kanchan	-	-	64.31	78.33

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 5 : First four best hybrids identified on the basis of sca effets for grain yield per plant

Sr. No.	Hybrids/pedigree	SCA/GCA effects	Grain yield per plant (g)
1.	L_{12} x T_3 (HP(A)-42-1-1 x SLT 32-3)	10.74**	94.33
2.	L_2 x T_3 (pop 49-117-2#1-1-2 x CM400)	7.27*	85.00
3.	L_4 x T_2 (pop-30-186-1-1#1-1-1 x HP(B)33-3)	7.21*	90.00
4.	L_{10} x T_3 (SLT-28-1 x CM 400)	7.16*	93.33
5.	L_2 (pop 49-117-2#1-1-2)	-7.27*	82.33
6.	L_4 (pop 30-186-1-1#1-1-1)	-2.16	69.00
7.	L_{10} (SLT-28-1)	1.17	75.33
8.	L_{12} (HP(A)-42-1-1)	-1.27	81.67
9.	T_1 (SLT32-3)	-0.07	37.67
10.	T_2 (HP(B) 33-3)	0.01	57.67
11.	T_3 (CM 400)	0.06	55.00

Best Check- PEHM-2 (85.00) * and ** indicate significance of values at P=0.05 and 0.01, respectively

L_{12} x T_3, L_{13} x T_1 and L_1 x T_1. Hybrid L_2 x T_1 (Pop 49-117-2# 1-1-2 x SLT-32-3) exhibited maximum significant positive sca effect for harvest index alongwith economic heterosis (8.50) also showed significant positive sca effects for starh content. (Table 3).

Five best hybrid exhibiting highest significant positive sca effect for starch content were L_2xT_1, $L_{12}xT_1$, L_8xT_1, $L_{14}xT_2$ and L_3xT_3 (Table 4). However, hybrid L_2xT_1 and $L_{12}xT_1$ exhibited maximum significant positive sca effect for starch content.

Out of 45 hybrids, four best hybrids exhibiting significant positive sca effect for grain yield per plant were *viz.*, $L_{12}xT_1$, L_2xT_3, L_4xT_2 and $L_{10}xT_3$ (Table 5). However, higher significant positive sca effect for grain yield per plant was exhibited by the hybrid $L_{12}xT_1$ (HP-(A) 42-1-1 x SLT 32-3_ also showed significant positive sca effect for biological yield per plant and starch cotnent. Hybrid L_2xT_3 exhibited significant positive sca effect along with siginificant positive sca effect for ear girth and biological yield per plant. Hybrid L_4xT_2 showed significant positive sca effet along with significant positive sca effect for biological yield per plant and startch content. Hybrid $L_{10}xT_3$ exhibited significant positive sca effect along with significant positive sca effect for 100 grain weight and starh content.

Similar finding for identification of superior parental lines, testers and hybrids based on gca and sca effects for grain yield and its componetn trait in maize were reported by Vasal *et al.* (1992) Wang *et al*. (1994), Gama *et al.* (1995) and Sain *et al.* (1997).

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