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Diallel Analysis in Maize (*Zea Mays* L.)

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ABSTRACT
Combining ability analysis was carried out in a 5x5 maize diallel for days to mid silking, plant height, ear height, ear length, number of kernels per ear, 250-kernel weight and grain yield per plant at two locations. Mean squares due to gca, sca environment and interactions (gca x environment and sca x environment) were highly significant for all the characters. Non-additive gene action i.e. sca played a preponderant role in the genetics control of all the characters except days to mid silking for which both additive and non-additive gene action were of equal importance. None of the parents was good combiner for all the traits over both the environments. The cross J-54 x Vijay was the best cross combination.
Key words: *Maize (Zea Mays), combining ability, diallel analysis. gene action.*

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INTRODUCTION

Maize is the third most important cereal crop of the India after rice and wheat and is valued as food, feed, fodder and industrial raw material. Maize production has shown a tremendous increase in the India. The growth rate of production of maize since last five years is higher than that of maize in USA and China. The productivity of >4 t/ha in *rabi* season is catching up with global average productivity of maize. India is now major maize producer after USA, China, Brazil and Argentina [1]. Development of varieties with high yielding potential should be the first step in the direction of up-grading the Maize yield. In order to develop a sound breeding programme to identify such varieties, the knowledge of combining ability together with *per se* performance of parents and hybrids over environments is essential to selection of suitable parents and crosses. Combining ability studies in varietal crosses, thus become very essential to either develop new elite populations for use *per se* or in further breeding programme or to have new varietal hybrids.

In allogamous crops like maize combining ability analysis is of special importance as it helps in identifying potential inbred lines expected to produce good hybrids, synthetics or composites, and thus assist in isolating basic material on which the success of any breeding program depends. Estimates of genetic parameters based on test conducted in a single environment may be biased. A measure of relative stability of genetic variance under a wide range of environmental conditions is necessary in determining efficient breeding procedure. Researchers emphasized the importance of genotypes x environment in combining ability studies [2-4]. In view of this, the present study has been undertaken to analyze a 5x5 diallel cross over two environments (locations) for various characters.

MATERIAL AND METHODS

Five varieties of maize (*Zea Mays* L.), namely, Suwan (y), J-684, J-54, Vijay and Ageti-76 were crossed in all possible combinations excluding reciprocals. The 10 F_1 and 5 parents were grown in randomized block design with three replications at two separate research farms of Rajasthan Collage of Agriculture, Udaipur. At both the locations each plot consisted of single 5 meter long row but the spacing was differing. Plant to plant and row to row distances were 22 cm and 75 cm in E1 and 22 cm and 65 cm in E2, respectively. Non-experimental rows were planted around the experimental plot to eliminate border effects. Recommended cultural practices were followed for raising the crop. Ten competitive plants were selected randomly for recording observations on days to mid silking, plant height (cm), ear height (cm), number of kernels per ear, 250-kernel weight (g) and grain yield per plant (g). The progeny means were used for statistical analyses. The combining ability analysis was done according to Method 2, model 1 of Griffing [5].

RESULT AND DISCUSSION

The analysis of variance for combining ability for the data pooled over locations showed that mean squares due to gca and sca were highly significant (P<0.01) for all the characters studied (Table 1). This suggested the existence of both additive and non-additive gene effects for all traits under study, indicating that these lines could be useful in the production of hybrids as well as synthetics, and that the traits could be improved through recurrent selection methods[6]

The relative importance of gca and sca is usually judged form the ratio 2 σ^2g/2 σ^2g+ σ^2 s[7]. If the ratio is closed to 1, additive gene action is of greater importance. In the present study non-additive gene action, i.e. sca played a preponderant role in the genetics control of most of the characters viz; grain yield per plant, ear length, 250 kernel weight, number of kernels per ear, ear height and plant height[8-12]. Additive and non-additive gene effects seemed to be equally important for days to mid silking.

Both, gca and sca exhibited significant interaction with location (table 1), indicating the role of environment in influencing the variances. The ratio σ^2 se/ σ^2 ge was greater than unity for all the traits, suggestion that sca variance exhibited greater interaction than gca variance. The ratio σ^2 g/ σ^2 ge and σ^2 s/ σ^2 se showed that interaction variances of ear length, 250- kernel weight and grain yield per plant were higher than the respective main effects for both gca and sca.

A perusal of gca estimates revealed the transcendence of the parents Vijay and Suwan (y) for plant height, ear height and ear length; suwan (y) for 250-kernel weight and Vijay for grain yield per plant as good general combiners in E1 while in E2 the parents J-684 for days to mid silking; Suwan (y) and Vijay for plant height and ear height; Ageti-76 and J-54 for number of kernels per ear and J-54 for ear length, 250-kernel weight and grain yield per plant were found good general combiners (table 2). An overall appraisal of gca effects showed that none of the parents was good combiner for all the traits over both the environments. In general, per se performance of parents were related to their gca effects.

Specific combining estimates revealed that three and two crosses for plant height; three and four crosses for ear length; three crosses each for number of kernels per ear; five and one crosses for 250-kernels weight and three and two crosses for grain yield per plant exhibited significant positive effects in E1 and E2 respectively (table 3). For days to mid silking, the desirable negative significant sca effects were observed for two crosses in E1 while it could not be observed in any cross of E2 no cross combination was good for all the characters over both the environments under study, however, the cross combination (J-54 x Vijay) showed significant. The significant sca effects of J-54 x Vijay in E1 for grain yield per plant was contributed by significant sca effects in its components viz; 250-kernel weight and number of kernel per ear. The crosses J-684 x Ageti-76, Suwan (y) x J-684 exhibited positive significant sca effects for grain yield in individual environments and also sca effects were significant for different yield contributing characters in individual environments. Cross J-684 x Ageti-76 also exhibited specific combining ability for early silking in E1.

Table 1: Analysis of variance for combining ability over (two) enviroments for different characters studied in maize (*Zea Mays* L.)

Source of variation	d.f.	Days to midsilking	Plant height	Ear height	Ear length	Number of kernels per ear	250 kernel weight	grain yield per plant
GCA	4	28.410**	365.260**	347.562**	0.589**	2460.298**	15.735**	90.271**
SCA	10	3.969**	108.905**	112.440**	0.720**	2233.606**	15.323**	186.097**
Environment	1	75.744**	9169.660**	5093.430**	89.821**	33400.013**	3422.943**	19.217.886**
GCA x Environment	4	3.841**	127.889**	33.702**	1.370**	1189.553*	14.144**	146.796**
SCA x Environment	10	1.795	52.083**	32.141**	1.335**	3896.637**	9.550**	135.340**
Error	56	0.996	9.654	9.057	0.101	484.681	1.406	24.952
σ^2g		7.841	101.601	96.715	0.139	564.462	4.094	18.662
σ^2S		15.015	496.225	516.915	3.095	8744.625	69.585	805.725
σ^2ge		1.642	67.652	14.082	0.725	402.784	7.261	69.625
σ^2Se		8.29	424.29	230.84	12.34	34119.56	81.44	1103.88
2 σ^2g / σ^2g + σ^2S		0.511	0.291	0.272	0.082	0.114	0.105	0.044

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

Table 2: Estimation of general combining ability effects for different characters studied in maize (*Zea Mays* L.)

Parents		Suwan (y)	(P1)	J-684	(P2)	J-54	(p3)	Vijay	(P4)	Ageti-76	(P5)	S.E. ±(gi)	
Parameter		Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca	Mean	gca
Days to mid silking	E1	63.33	0.828**	59	-0.074	63.00	1.41**	64.66	0.969**	60	-0.313	0.87	0.188
	E2	67	0.725	59.66	-3.087**	66.66	0.438	66.66	2.104**	63.66	-0.181	1.76	0.43
Plant height	E1	182.03	4.446**	159.73	-11.949**	182.73	-3.549**	196.90	8.431**	188.66	2.621*	5.00	0.957
	E2	151.00	2.957*	144.93	-4.277**	147.53	-4.082**	153.86	2.876*	155.16	2.526*	4.63	1.135
Ear height	E1	84.76	4.652**	62.10	-9.127**	77.46	-2.587	92.66	6.075**	85.76	0.985	4.83	1.072
	E2	62.76	5.322**	43.03	-5.697**	53.62	-1.314	60.86	3.242**	62.26	-1.554	3.92	0.958
ear length	E1	13.57	0.394**	12.46	-0.651**	13.40	0.151*	15.50	0.363**	14.43	0.043	0.30	0.072
	E2	10.53	-0.132	9.73	0.010	12.16	0.552**	10.06	-0.246	10.80	-0.184	0.53	0.133
No. of kernel per ear	E1	399.00	-9.180	382.33	-22.798*	408.33	13.810	459.33	4.057	452.66	14.102	35.20	8.557
	E2	300.00	-17.265**	293.33	5.780	401.33	13.685*	306.66	-17.744**	413.00	15.531*	26.81	6.127
250 kernel weight	E1	57.23	1.461	54.38	-0.270	59.90	0.394	59.68	0.290	55.40	-1.875**	1.50	0.325
	E2	38.54	0.150	34.65	-0.780	45.16	2.492**	36.50	-2.055**	42.85	0.192	1.83	0.464
grain yield per plant	E1	93.53	-4.167*	86.13	-3.749	97.43	0.832	122.93	4.289*	103.60	2.795	7.70	1.917
	E2	45.13	-4.457	52.00**	-2.875	66.14	3.025	52.03*	2.692	66.77	0.619	5.64	1.422

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

Table 3: Estimation of specific combining ability effects for different characters studied in maize (*Zea Mays* L.)

Crosses	Days to mid silking		Plant height		Ear height		ear length		No. of kernal per ear		250 kernel weight		grain yield per plant	
P1 x P2	0.823	-1.236	21.874**	6.822*	14.327**	4.188	0.015	0.630	-37.618	63.282**	5.408**	4.043**	-3.387	13.341**
P1 x P3	-0.843	-0.761	4.139	1.674	-2.643	8.944**	1.114**	1.050**	74.093**	-51.623**	3.857**	1.719*	23.361**	-5.191
P1 x P4	-0.557	0.902	8.917**	5.727	9.664	9.587**	0.900**	-0.142	-18.144	-23.853	1.088	-1.121	-1.665	-1.837
P1 x P5	2.065**	1.188	-4.102	2.800	2.754	-4.055	0.120	-0.264	-13.860	48.857**	3.243**	-5.490	0.568	-5.335
P2 x P3	-0.274	-1.618	-11.005**	-2.161	-1.333	-0.275	0.390*	1.256**	-16.617	60.670**	1.685	-1.590	-0.727	5.818
P2 x P4	1.681**	3.045*	-4.086	8.261**	0.174	12.167**	-1.654**	0.535	-62.856**	39.760**	-1.950	-1.051	-16.044	-7.767*
P2 x P5	-1.036*	-0.668	3.063	-4.695	-13.151**	-2.035	1.436**	-1.076**	100.428**	-21.527	3.375**	1.809*	31.509**	0.444
P3 x P4	-2.314**	0.859	2.613	4.414	7.164*	-2.075	0.106	-1.026**	67.186**	19.855	3.015**	-1.324*	10.774*	8.380*
P3 x P5	1.968**	1.145	1.723	0.087	6.554*	7.781**	1.334**	-0.528	-46.859*	-71.093**	-4.569**	-3.523**	-14.331**	-11.818**
P4 x P5	0.564	1.479	9.611**	-7.419*	-3.008	-9.535**	-1.218**	0.290	-49.427*	-14.333	-1.994*	-2.094*	-7.158	-4.984
S.E. ± (sij)	0.485	1.111	2.472	2.932	2.769	2.475	0.187	0.345	22.095	15.822	0.839	1.198	4.952	3.673

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

CONCLUSION

This study suggested the existence of both additive and non-additive gene effects for all traits under study, indicating that these lines could be useful in the production of hybrids as well as synthetics, and that the traits could be improved through recurrent selection methods. The best cross combination which can be further utilized in making high yielding population is J-54 x Vijay, as it showed significant sca effects for grain yield per plant over both the environments and significant gca effects at individual location.

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