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Combining Ability for Yield and Yield Related Traits in Yellow Seeded Maize (*Zea mays* L.)

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ABSTRACT

The present study was conducted to assess the general combining ability effects of parents and specific combining ability effects of hybrids for yield and yield related traits and explore their use in hybrid development. 45 F1s generated by 10 × 10 half diallel were evaluated. The ratio of sca / gca variance revealed that there was preponderance of additive gene action in the expression of yield and yield contributing characters viz,. ear length, number of grain rows per ear, 100-grain weight, grain yield per plant, harvest index under study. Parent P1 (Number of grain rows per ear), P6 and P7 were good general combiners for another yield and yield attributing characters. Hybrid P1 x P5 showed highest positive significant sca effects (48.60) along good per se performance (151.67 g/plant) and positive significant economic heterosis (26.39 %) for grain yield per plant. This hybrid also exhibited positive significant sca effects for 100-grain weight and harvest index. Another hybrid P6 x P7 showed good sca effect (35.07) along with highest economic heterosis (41.67 %) and maximum per se performance (170.00 g/ plant) for grain yield per plant.

Key words: *Maize, half Diallel, Yield and yield contributing characters, general combining ability and specific combining ability*

INTRODUCTION

Maize (*Zea mays* L.) 2n=20 is one of the most important cereal crops of the world and contributes to food security in most of the developing countries. Maize is third most important crop after rice and wheat in the world. It is used world-wide for feed, food and also serves as source of basic raw material for a number of industries *viz.*, oil, starch, protein, food, alcoholic beverages, sweeteners, cosmetics and bio-fuels etc. There is no other cereal crop which has immense potential as maize and therefore, maize occupies the unique place as "Queen of cereals" or "Miracle Crop". By origin, maize is native to South America. It is a seasonal crop and annually it can be harvested thrice, i.e. in *kharif*, *rabi* and *summer* seasons.

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The success of any breeding programme depends on the selection of parents together with information regarding nature of gene action controlling the various characters. Application of biometrical techniques like diallel analysis has appeared to be the immensely useful breeding tool, which gives generalized picture of genetics of the characters under study. Studies on combining ability help to identify the best parents and provide genetic information on the inheritance pattern of characters. The superiority of parents may not depend so much on their superior *per se* performance but in their ability to transmit desirable genes to their progenies. Therefore, combining ability analysis was a powerful tool to discriminate the good and poor combiners. This analysis also furnishes useful information on nature of gene action involved for the expression of various quantitative characters, which can be utilized for planning an effective breeding programme. The main objective of this part of study was to identify the parents with better potential to transmit the desirable characteristics to the progenies and to sort out the best specific hybrids for yield and its component characters.

MATERIALS AND METHODS

The experimental material comprising ten S_6 inbred lines were crossed using diallel design during *Rabi* 2013-2014 and developed 45 half-diallel crosses (reciprocals excluded). These 45 hybrids with 10 parental inbred lines and three economic checks *viz.,* Prakash, PMH-5, HM-8 were evaluated in randomized block design with three replications during *Kharif* 2014 at the Instructional farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur. Each treatment was grown in single row plot of 4.0 m row length with row to row and plant to plant spacing of 60 cm. and 25 cm. respectively. Recommended package of practices of zone IV (a) of Rajasthan were used to raise a healthy crop. The data were recorded on yield and yield contributing characters *viz,.* ear length, number of grain rows per ear, 100-grain weight, grain yield per plant, harvest index on ten randomly selected competitive plants. Harvest index was calculated using the formula of Donald and Hamblin[8].

$$Harvest\ index\ = \frac{Economic\ (grain) yield\ per\ plant}{Biological\ yield\ per\ plant} \text{ x } 100$$

The combining ability analysis for diallel mating design was performed according to Model-I (fixed effect) Method-II (parents and one set of F1's without reciprocals) proposed by Griffing[11]. This includes partitioning of variation among sources attributable to general combining ability (gca) and specific combining ability (sca) components by Model-I, Method- II of Griffing[11]. The mean squares for GCA and SCA were tested against desired error variance.

RESULTS AND DISCUSSION

The mean square due to genotypes, parents, crosses and parents v/s crosses were significant for all the traits, except due to parents v/s crosses for ear length, number of grain rows per ear and grain yield per plant. This indicated the existence of appreciable amount of genetic variability in the experimental material of the present investigation **(Table 1.)**. The analysis of variance for combining ability revealed significant mean sum of squares due to gca and sca for all the traits **(Table 2.).** The ratio of σ^2 sca / σ^2 gca was greater than one for all the traits, thereby indicating the preponderance of non-additive gene effects in the expression of these traits. These results are in accordance with the findings of Joshi *et al*[13], Dubey[9], Dadheech and Joshi[7], Kumar[16], Abdel-Moniam *et al*[1], Seshu *et al*[25], Kose and Turgut[15], Afshar and Bahram[2], Amiruzzaman *et al*[3], Puttarmanaik *et al*[21], Kambe *et al*[14], Chandel *et al*[5], Tongbram and Baskheti (2014) and tamirat *et al*[27]. The positive significant gca effects exhibited by two inbred lines *viz*., P6 (0.57) and P2 (0.38) for ear length; only one inbred line *viz*., P1 (0.49) for number of grain rows per ear ; three inbred lines viz., P6 (1.95), P7 (0.92) and P3 (0.56) for 100-grain weight; three inbred lines viz., P6 (1.04), P7 (0.98) and P5 (0.48) for harvest index; two inbred lines 15.24 (P7) and 11.77 (P6) for grain yield per plant, out of ten inbred lines **(Table 4).** In general inbred line P6 was found good general combiner for majority of traits *viz*., ear length, 100-grain weight, grain yield per plant and harvest index and followed by inbred line P7 for 100-grain weight, grain yield per plant, harvest index. (**Table 3**).The gca effects of parents were in accordance to their mean values, therefore, *per se* performance of the parents could serve as useful index for combining ability. Thus inbred lines P6 and P7 with highest magnitude of gca effects and maximum *per se* performance for grain yield per plant could be used for the development of composite variety. Among the hybrids, six hybrids exhibited significant sca effects in positive direction with the magnitude ranged from 1.28 (P4 x P10) to 2.33 (P3 x P8) for ear length whereas only three hybrids viz., P2 x P7 (1.99), P9 x P10 (1.32) and P6 x P8 (1.10) showed the positive significant sca effects for number of grain rows per ear (**Table 4).** A perusal of sca effects revealed that positive significant sca effects for grain yield per plant was recorded in fourteen hybrids *viz*., P1 x P2, P1 x P5, P1 x P8, P2 x P3, P2 x P7, P2 x P10, P3 x P7, P3 x P8, P4 x P6, P4 x P10, P5 x P8, P6 x P7, P6 x P8 and P8 x P9 (**Table 3**). Among them, five best hybrids which exhibited highest significant positive sca effects for grain yield per plant are *viz*., P1 x P5, P1 x P2, P6 x P7, P3 x P8 and P5 x P8 (**Table 5**). Hybrid P1 x P5 showed highest positive significant sca effects (48.60) along good *per se* performance (151.67 g/plant) and positive significant economic heterosis (26.39 %) for grain yield per plant. This hybrid also exhibited positive significant sca effects for 100-grain weight and harvest index. This was a cross between poor x average gca effect parents for grain yield per plant. Another hybrid P6 x P7 showed good sca effect along with highest economic heterosis (41.67 %) and maximum *per se* performance (170.00 g/ plant) for grain yield per plant. This was a cross between good x good gca effect parents for grain yield per plant. This hybrid also exhibited positive significant sca effects for ear length, 100-grain weight and harvest index similarly the hybrid P4 x P10 exhibited highest positive significant sca effects for 100-grain weight. Similar finding for identification of superior inbred lines and hybrids based on gca and sca effects for grain yield and its components in maize were also reported by Bello and Olaoye[4], Cruz-Lazaro *et al*[6], Jampatong *et al*[12], Silva *et al*[26], Gichuru *et al*[10], Moterle *et al*[18], Kose and Turgut[15], Vieira *et al*[29], Afshar and Bahram[2], Petrovska[20], Amiruzzaman *et al*[3], kambe *et al*[14], Rashmi *et al*[22], Tongbram and Baskheti[28], Sarac and nedelea[24], Moradi *et al*[17], Ofori *et al*[19] and Ruswandi *et al*[23]. The study under discussion finally revealed that some of the inbred lines used in the present investigation can be selected for the successful development of single cross hybrids since they possessed high per se performance for grain yield with good seed size in addition to having good general combining ability for grain yield per plant and other yield contributing traits.

Table 1: Analysis of variance for various traits in maize

Source of variance	df	Mean Squares				
		Ear length	**Number of grain rows per ear**	**100-grain weight**	**Grain yield per plant**	**Harvest index**
Replication	2	1.519	2.206	1.673	806.297*	0.915
Genotype	54	3.7189**	2.987**	31.441**	1881.3**	11.9187**
Parent	9	3.715**	3.615**	37.128**	2184.8**	14.356**
Crosses	44	3.719**	2.909**	28.5048**	1851.45**	11.221**
Parent vs. Crosses	1	3.70647	0.775758	109.486**	463.276	20.7084**
Error	108	0.998299	1.02088	1.52982	171.217	2.24231

*,** Significant at 5 % and 1 % level of significance respectively.

Table 2: Analysis of variance for combining ability for various traits in maize

SN	Characters	Source (mean square)			Var Model I (EMS)		
		GCA 9	SCA 45	Error 108	σ^2GCA	σ^2SCA	σ^2 SCA / σ^2 GCA
1.	Ear length (cm)	2.1082**	1.0659**	0.3327	1.3316	32.9917	24.7763
2.	Number of grains rows per Ear	1.0107**	0.9927**	0.3403	0.5028	29.3603	58.3929
3.	100 Grain weight (g)	12.1299**	10.1504**	0.5099	8.7149	433.819	49.7787
4.	Grain yield per Plant (g)	878.317**	576.855**	57.0722	615.934	23390.2	37.9751
5.	Harvest Index (%)	5.35844**	3.6958**	0.7474	3.4582	132.677	38.36535

*,** Significant at 5 % and 1 % level of significance respectively.

Table 3: Inbred lines and hybrids possessing good gca and sca effects for different traits in maize

S.No.	Characters	Inbred lines	Hybrids
1.	Ear length	P2 and P6	P1 X P3, P2 XP9, P3X P7, P3 X P8, P4 XP10 and P6 X P7
2.	No. of grain rows per ear	P1	P2 XP7, P6 XP8 and P9 X P10
3.	100-grain weight	P3, P6 and P7	P1 XP2, P1 XP5, P1 XP9, P2 XP4, P2 XP6, P2 XP10, P3X P7, P3 X P8, P3 X P9, P4 XP6, P4 XP7, P4 XP9, P4 XP10, P5XP6, P5XP7, P5XP8, P6 XP7, P7 X P10 and P8X P9
4.	Grain yield per plant	P6 and P7	P1 XP2, P1 XP5, P1 XP8,P2 XP3, P2 XP7, P2 XP10, P3 X P7, P3 X P8, P4 XP6, P4 XP10, P5XP8, P6 XP7 ,P6 XP8 and P8XP9
5.	Harvest index	P5, P6 and P7	P1 XP2, P1 XP5, P1 XP8, P2 XP10, P3 X P6, P3 X P8, P4 XP10, P5XP8, P6 XP7 and P6 XP8

Table 4: General and specific combining ability effects for ear length, number of grain rows per ear 100-grain weight, grain yield per plant and harvest index

SN	Genotype	Ear length	Number of grain rows per ear	100-Grain Weight	Grain yield per plant	Harvest index (%)
1	P1	-0.06	0.49**	-0.83**	-8.23**	-0.77**
2	P2	0.38*	0.16	-0.31	2.71	0.09
3	P3	-0.59**	0.16	0.56**	-5.73**	-0.18
4	P4	-0.16	0.27	0.38	0.04	-0.04
5	P5	0.30	-0.40*	0.33	3.38	0.48*
6	P6	0.57**	0.10	1.95**	11.77**	1.04**
7	P7	0.24	-0.40*	0.92**	15.24**	0.98**
8	P8	0.21	-0.12	-0.73**	-4.18*	-0.41
9	P9	-0.71**	-0.01	-1.05**	-3.09	-0.27
10	P10	-0.18	-0.23	-1.23**	-11.90**	-0.93**
11	P1 XP2	0.16	-0.23	3.96**	42.60**	2.65**
12	P1 XP3	1.54**	-0.90	-1.67*	-18.95**	-1.07
13	P1 XP4	-0.50	0.32	-3.76**	-17.07*	-0.54
14	P1 XP5	0.71	0.32	3.94**	48.60**	3.60**
15	P1 XP6	0.04	-0.18	-2.40**	-14.79*	-0.62
16	P1 XP7	-0.23	0.99	-3.80**	-31.59**	-1.23
17	P1 XP8	-0.57	-1.29*	0.58	19.49**	1.82*
18	P1 XP9	0.45	-1.40*	3.85**	13.41	1.02
19	P1 XP10	0.59	0.82	0.31	-2.12	0.68
20	P2 XP3	0.23	0.77	-3.64**	15.10*	0.07
21	P2 XP4	0.26	-1.34*	2.96**	-15.68*	-0.40
22	P2 XP5	-0.73	-0.01	-5.28**	-29.01**	-1.60*
23	P2 XP6	0.63	0.16	1.61*	0.93	-0.15

24	P2 XP7	-0.41	1.99**	0.56	19.13**	1.57
25	P2 XP8	0.36	-0.29	0.25	8.55	0.63
26	P2 XP9	1.61**	-0.40	-0.72	-14.20*	0.49
27	P2 XP10	0.58	0.49	1.70*	24.60**	1.82*
28	P3X P4	-1.77**	-0.01	-0.97	-28.90**	-0.79
29	P3 X P5	0.35	-2.01**	0.54	-0.57	0.02
30	P3 X P6	0.50	0.82	-1.19	9.38	1.79*
31	P3X P7	1.50**	-0.01	1.81**	20.91**	1.52
32	P3 X P8	2.33**	1.05	2.27**	30.32**	1.90*
33	P3 X P9	-1.25*	0.93	1.36*	-27.43**	-1.23
34	P3X P10	-0.78	-2.18**	-1.33*	-13.62	-0.23
35	P4 XP5	-0.19	0.55	-1.68*	0.32	-1.12
36	P4 XP6	-2.00**	-1.29*	1.80**	26.93**	0.65
37	P4 XP7	0.53	-0.12	1.32*	6.80	0.38
38	P4 XP8	-0.30	0.93	-2.07**	-22.12**	-1.57
39	P4 XP9	-0.52	-0.51	1.87**	-8.20	-0.04
40	P4 XP10	1.28*	0.38	8.21**	27.27**	3.29**
41	P5XP6	0.88	0.05	2.43**	6.93	0.79
42	P5XP7	0.14	0.55	2.59**	-28.20**	-1.82*
43	P5XP8	0.11	0.93	3.32**	29.55**	2.24**
44	P5XP9	-0.57	0.16	-1.30	5.13	-0.23
45	P5XP10	-0.27	1.05	-2.80**	0.60	0.77
46	P6 XP7	1.69**	-1.95**	1.66*	35.07**	3.63**
47	P6 XP8	0.30	1.10*	1.27	17.82*	2.02*
48	P6 XP9	-1.91**	-0.34	-4.10**	-26.59**	-3.12**
49	P6 XP10	-0.01	-0.12	-3.49**	-6.12	-0.79
50	P7XP8	-0.50	0.27	0.51	-15.65*	-3.93**
51	P7XP9	-0.75	0.16	-1.95**	-16.73*	-1.40
52	P7XP10	-0.91	-1.62**	4.84**	-6.26	-0.07
53	P8XP9	0.05	-0.79	6.70**	19.35**	1.32
54	P8XP10	0.11	-0.57	-2.80**	-21.51**	-2.68**
55	P9 X P10	0.40	1.32*	0.02	-27.93**	-2.48**

*,** Significant at 5 % and 1 % level of significance respectively.

Table 5: Five best hybrids identified on the basis of sca effects for grain yield per plant

S.N.	Hybrids	sca/gca effects	Economic heterosis (%) over the best check PMH-5	Grain yield per plant (g)
1.	P1 x P5	48.60**	26.39**	151.67
2.	P1 x P2	42.60**	20.83*	145.00
3.	P6 x P7	35.07**	41.67**	170.00
4.	P3 x P8	30.32**	6.94	128.33
5.	P5 x P8	29.55**	13.89	136.67
6.	P1	-8.23**	-	71.67
7.	P2	2.71	-	87.33
8.	P3	-5.23**	-	103.33
9.	P5	3.38	-	98.00
10.	P6	11.77**	-	106.67
11.	P7	15.24**	-	146.67
12.	P8	-4.18*	-	66.67
13.	PMH-5	-	-	120.00

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