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COMBINING ABILITY ANALYSIS FOR YIELD AND ITS COMPONENT TRAITS IN MAIZE (*Zea mays* L.)

P. B. Chavan[1], M. K. Moon[2], S. R. Patil[3], Prakash Hosur[4] and Ankush Sapkal[5]

ABSTRACT

The present study was conducted to assess the general combining ability effect of parents and specific combining ability effect of crosses for yield and yield contributing traits and analyse their use in hybrid development. Six lines *viz.*, UMI1200, CM145, CM152, CM116, CM123 and CM124 were crossed in diallel fashion to obtain 30 crosses during 2017-18. Crossed seeds of these 30 crosses along with 6 parents and two checks Maharaja and Rajarshi were raised in RBD with two replications in *kharif* 2018-19 for evaluation. The ratio of sca/gca revealed that there was preponderance of additive gene action for traits like days to 50% tasseling, days to 50% silking, days to maturity and for traits *viz.*, plant height (cm), cob length (cm), cob girth (cm), number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g) and grain yield plot^{-1} (kg) exposed the presence of non additive gene action. Parental lines *viz.*, CM145, CM123, CM152 were good general combiner for yield and yield contributing characters. Among the hybrids, UMI1200 X CM152, CM152 X UMI1200, UMI1200 X CM124 and CM152 X CM145 exhibited highest significant sca effect for yield and yield contributing traits *viz.*, days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), cob length (cm), cob girth (cm), number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g) and grain yield plot^{-1} (kg).

(Key words: Diallel, maize, gca, sca)

INTRODUCTION

Maize (*Zea mays* L.) is world's important cereal crop after rice and wheat. Maize grain is recognized worldwide as a strategic food and feed crop. It is oldest food grains in the world and first domesticated by indigenous peoples in southern Mexico about 10,000 years ago. It is diploid crop (2n=20) with a high rate of photosynthetic activity leading to high grain and biomass yield potential called C_4 grain crop. Plant breeder always has an objective to advance the yield of maize which requires continuous development and release of higher yielding and well adapted varieties having better advantage over the existing commercial varieties (Pandit *et al.,* 2019). Nature of gene action gives correct indication of breeding potential. Diallel analysis is one of the most informative systems which are widely and extensively used for estimating the types of gene action (Griffing, 1956). GCA and SCA are two main genetic parameters essential in developing breeding strategies. Combining ability is a powerful tool in identifying the best combiners for hybridization especially, when a large number of advance inbred lines are available and most promising ones are to be selected on the basis of their abilities. General and specific combining ability are due to genes which are largely additive and dominance or epistatic effects respectively (Sprague and Tatum, 1942). Therefore, the present investigation was undertaken to study the general and specific combining ability of parents and crosses respectively over the environments for grain yield and yield contributing traits.

MATERIALS AND METHODS

Six lines *viz.*, UMI1200, CM145, CM152, CM116, CM123 and CM124 were crossed in diallel fashion to obtain 30 crosses during 2017-18. Crossed seeds of these 30 crosses along with 6 parents and two checks Maharaja and Rajarshi were raised in RBD with two replications in *kharif* 2018-19 for evaluation with a spacing 60 cm x 20 cm at research farm of Agricultural Botany Section, College of Agriculture, Nagpur. Data recorded on quantitative traits *viz.*, days to 50% tasseling, days to 50% silking, days to maturity, plant height (cm), cob girth (cm), cob length (cm), number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g) and grain yield plot (kg) on randomly selected five plants. Six lines *viz.*, UMI1200, CM145, CM152, CM116, CM123 and CM124 were crossed in diallel fashion to obtain 30 crosses during 2017-18. (kg) on randomly selected five plants. Six lines

1, 4 and 5. P.G. Students, Botany section, College of Agriculture, Nagpur
2. Assoc. Professor, Botany section, College of Agriculture, Nagpur
3. Asstt. Professor, Botany section, College of Agriculture, Nagpur

viz., UMI1200, CM145, CM152, CM116, CM123 and CM124 were crossed in diallel fashion to obtain 30 crosses during 2017-18. The data were subjected to the statistical analyses suggested by Panse and Sukhatme (1954) and for analysis of variance and for combining ability (Diallel analysis Method-1 and model-I) suggested by Griffing, (1956).

RESULTS AND DISCUSSION

The mean sum of squares for combining ability and estimated components of genetic variance for various characters are given in table 1. The analysis of variance revealed that mean squares due to general combining ability were significant for all the characters studied indicating that substantial variability were present among the parents. The mean squares due to specific and reciprocal combining ability significant for all characters studied except days to 50 % tasseling and cob girth. The significant mean squares due to sca were also reported by Mohammad *et al.* (2017) and Shamarka *et al*. (2015). Significant mean squares due to gca and sca in maize for characters *viz.*, days to 50% tasseling, days to 50% silking, days to maturity, plant height, cob girth, cob length, number of grains cob^{-1}, 100 grain weight, grain yield plant^{-1} and grain yield plot^{-1} reported by Karad *et al.* (2017). The gca had higher magnitude than that of sca for characters *viz.*, days to 50% tasseling, days to 50% silking and days to maturity which indicated preponderance of additive gene action for these traits. This was confirmed by Hoque *et al.* (2016) and Mohammad *et al.* (2017), who also reported higher gca for days to 50% tasseling, days to 50% silking and days to maturity whereas sca appeared higher than gca for characters *viz.*, plant height, cob length, cob girth, number of grains cob^{-1},100 grain weight, grain yield plant^{-1} and grain yield plot^{-1} revealed presence of non additive gene action for these traits. Mohammad *et al.* (2017), Niyonzima *et al.* (2015) and Aslam *et al.* (2017) also reported higher sca than gca for 100 grain weight, grain yield plant^{1}, number of grains cob^{-1}, cob length, cob girth and grain yield plot^{-1}.

The gca effects are of direct utility to decide the next phase of the breeding programme and the selected parents can be exploited for the development of suitable hybrids. The general combning ability effects were estimated and results obtained are presented in table 2. The parents UMI1200 and CM116 had significant positive gca effect for days to 50% tasseling and days to 50% silking, whereas parents UMI1200, CM152 and CM123 showed positive significant gca effects for days to maturity. These parents found to be good combiner for developing early maturing hybrid. Significant positive gca effects showed by only one parent CM145 indicated that it is good general combiner for plant height. Parents UMI1200 and CM152 recorded significant and positive gca effects indicated as good combiner for cob length. The parent CM145 was found to be good general combiner for cob girth, number of grains cob^{-1}, 100 grain weight, grain yield plant^{-1} and grain yield plot^{-1} as it exhibited significant positive gca effect. Parents CM145, CM123 and CM152 were found good general combiner on the basis of overall gca effect and suggested to exploit them for further use in maize hybrid breeding programme.

Specific combining ability effects were estimated and results obtained are presented in table 2. For days to 50% tasseling positive significant sca effects is desirable. Out of fifteen crosses, none of the cross exhibited positive significant sca effect for days to 50% tasseling. The cross CM152 X UMI1200 showed positive significant rca effect for days to 50% tasseling among all reciprocal crosses. Three crosses were recorded significant positive rca effects for days to 50% silking and the crosses CM152 X UMI1200, CM123 X UMI1200 and CM116 X UMI1200 exhibited positive significant rca effect. Niyonzima *et al*. (2015), Shamarka *et al.* (2015) and Hoque *et al.* (2016) also reported positive significant rca effect.

Two crosses *viz.*, CM124 X UMI1200 (5.50) and CM123 X CM116 (6.25) showed positive significant rca effects for days to maturity. Niyonzima *et al*. (2015) also reported positive significant rca effects for days to maturity.

Two crosses CM152 X CM116 (19.19) and UMI1200 X CM124 (12.16) showed positive significant sca effects for plant height (cm) among 15 direct crosses. For the plant height (cm), five reciprocal crosses *viz.*, CM145 X CM1200, CM152 X CM145, CM116 X CM145, CM116 X CM152 and CM124 X CM152 showed positive significant rca effects. Niyonzima *et al*. (2015) and Hoque *et al*. (2016) reported similar result that is positive significant sca effects for plant height.

Six crosses *viz.*, UMI1200 X CM152, UMI1200 X CM124, CM145 X CM124, CM152 X CM116, CM123 X CM124 and CM152 X CM123 exhibited positive significant sca effect and identified as promising crosses for cob length (cm) among the direct crosses. Two crosses CM124 X CM152 and CM116 X CM145 exhibited positive significant rca effect for cob length (cm). This result is similar to the results of Shamarka *et al*. (2015), Niyonzima *et al*. (2015) and Hoque *et al*. (2016) where positive significant sca and rca effect reported.

Among the fifteen direct crosses, cross UMI1200 X CM152 (1.19) showed significant positive sca effect for cob girth (cm) and identified as best cross combination. None of the cross exhibited significant rca effect among all 15 crosses. Niyonzima *et al*. (2015) and Mohammad *et al*. (2017) also reported positive significant sca and rca effect.

Seven crosses showed most desirable and significant sca effects for number of grains cob^{-1} among the crosses. The cross UMI1200 X CM152 found best specific combiner for number of grains cob^{-1}. Four crosses showed positive significant rca effect. The cross CM145 X UMI1200 exhibited highest positive rca effect followed by CM116 X CM145 for number of grains cob^{-1}. These results are supported by Niyonzima *et al*. (2015) and Hoque *et al*. (2015) where positive significant rca effect reported.

The crosses UMI1200 X CM152, UMI1200 X CM124, CM116 X CM124, CM145 X CM152, CM145 X CM124, CM152 X CM116 and CM116 X CM123 showed significantly positive sca effect for 100 grain weight (g). Among the reciprocal crosses, four crosses showed positive significant rca effect for 100 grain weight (g). Niyonzima *et al.* (2015), Hoque *et al.* (2015) and Aslam *et al.* (2017) reported significantly positive sca effect for 100 grain weight (g).

Out of fifteen direct crosses significant positive sca effect observed in ten crosses for grain yield plant^{-1} (g). Among the reciprocal crosses, four crosses showed significant rca effect for grain yield plant^{-1} (g). Highest rca effect was recorded in CM152 X CM145 followed by CM116 X UMI1200 and CM152 X UMI1200 for grain yield plant^{-1}. Avinash *et al.* (2017) reported significant rca effect for grain yield plant^{-1} (g).

Among fifteen direct crosses, five crosses *viz.*, UMI1200 X CM152 (0.66), followed by UMI1200 X CM124 (0.53), CM152 X CM116 (0.27), CM152 X CM123 (0.35) and CM116 X CM124 (0.31) showed positive significant sca effects, for grain yield plot^{-1} (kg). Cross UMI 1200 X CM123 (-0.59) showed negative significant effect for this trait. Among the reciprocal crosses, nine crosses showed significant rca effect, out of which five crosses showed positive and four crosses showed negative rca effect. Niyonzima *et al*. (2015) and Talukder *et al*. (2016) have reported negative rca effect.

Thus, it is observed from this study that the parent CM145 was best general combiner in the estimation of gca effect as it recorded positive significant gca effect for plant height, cob girth, number of grains cob^{-1}, grain yield plant^{-1}, grain yield plot^{-1}. Parent CM152 also recorded as good general combiner for days to maturity, cob length, number of grains cob^{-1} and grain yield plant^{-1}. The parent CM123 exhibited positive significant gca effect for days to maturity, number of grains cob^{-1}, grain yield plot^{-1}. Among the direct crosses UMI1200 X CM152 exhibited significant positive sca effect for cob length (cm), cob girth (cm), number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g) and grain yield plot^{-1} (kg). In the crosses UMI1200 X CM124 and CM116 X CM124 recorded positive significant sca effect for number of grains cob^{-1}, 100 grain weight (g), grain yield plant^{-1} (g), grain yield plot^{-1} (kg) and plant height (cm). Out of fifteen reciprocal crosses, CM152 X UMI1200, CM116 X UMI1200, CM152 X CM145 and CM123 X CM145 showed positive significant rca effect for grain yield plot^{-1} (kg), grain yield plant^{-1} (g), 100 grain weight (g), number of grains cob^{-1} and plant height (cm) therefore, these hybrids can be further used for commercial exploitation.

Table 1. Analysis of variance for combining ability

Source of variation	Mean square										
	Degrees of freedom	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-2}	100 grains weight (g)	Grain yield plant^{-1} (g)	Grain yield plot^{-1} (kg)
GCA	**5**	31.025**	23.33**	41.2**	186.95**	1.23**	1.24**	6405.04**	1.87**	331.10**	0.31**
SCA	**15**	8.85**	12.42**	15.93**	410.04**	6.35**	1.39**	9615.51**	22.07**	681.99**	0.5135**
RCA	**15**	1.30	1.66**	15.28**	138.27**	0.49**	0.21	2101.55**	1.74**	125.78**	0.07**
Error	**35**	**2.57**	**0.96**	**10.1**	**74.37**	**0.45**	**0.66**	**8.21**	**0.19**	**4.07**	**0.019**

Table 2. Gca effect of parents, sca effect of crosses and rca effect of reciprocals

Sr. No.	Parents	Days to 50% tasseling	Days to 50% silking	Days to maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	Number of grains cob^{-1}	100 grains weight (g)	Grain yield plant^{-1} (g)	Grain yield plot^{-1} (kg)
1	UMI1200	2.29**	2.18**	1.63**	0.61	0.33*	-0.49**	-39.60**	-0.32**	-7.97	-0.24**
2	CM145	-2.33**	-1.74**	-3.04**	7.64**	0.10	0.50**	28.98**	0.63**	7.98**	0.26**
3	CM152	-0.58	-0.69**	1.54*	-1.16	0.31*	-0.10	11.95**	-0.31	1.93**	-0.03
4	CM116	1.29**	1.06**	-0.13	-1.51	-0.41**	0.11	-6.12	-0.19	-2.58	-0.02
5	CM123	-0.33	-0.53**	1.21*	-2.71	-0.36**	-0.08	8.49*	-0.16	-0.03	0.08*
6	CM124	-0.33	-0.28	-1.21*	-2.87	0.02	0.06	-3.69	0.35**	0.68	-0.05
	S.E.(gi)	**0.29**	**0.18**	**0.59**	**1.60**	**0.12**	**0.15**	**3.67**	**0.11**	**0.53**	**0.03**
	Direct crosses										
7	UMI1200 X CM145	-2.12*	-2.51**	2.25	0.39	-0.55	-0.38	13.31	-0.49**	5.64**	0.16
8	UMI1200 X CM152	-1.37	-1.56*	-2.08	0.75	2.74**	1.19*	108.44**	5.03**	28.68**	0.66**
9	UMI1200 X CM116	-0.25	-0.31	-1.17	8.33	0.41	0.05	37.38**	-1.72**	-4.39*	0.07
10	UMI1200 X CM123	0.38	0.03	-3.00	-15.25**	-2.54**	-0.77	-70.56**	-2.21**	-18.04**	-0.59**
11	UMI1200 X CM124	-1.87	-2.22**	0.17	12.16*	1.60**	0.49	37.84**	4.00**	16.19**	0.53**
12	CM145 X CM152	1.75	0.11	1.83	5.92	0.73	-0.53	-40.84**	0.84*	-5.34**	-0.22
13	CM145 X CM116	-1.62	-1.89**	-1.00	6.77	-0.94*	0.55	6.63	0.41	4.27*	0.13
14	CM145 X CM123	0.00	-0.56	0.42	7.82	0.39	-0.47	3.52	-0.20	-3.75*	-0.18
15	CM145 X CM124	-1.00	-1.56*	-2.67	9.23	1.22**	0.74	29.50*	1.93**	12.48**	0.14
16	CM152 X CM116	-0.87	-0.68	-2.08	19.19**	1.88**	0.31	-2.61	2.90**	10.62**	0.27*
17	CM152 X CM123	-2.50*	-1.85**	-3.17	6.91	0.86*	0.62	58.00**	0.45	9.78**	0.35**
18	CM152 X CM124	-1.00	-0.35	-1.50	4.87	-2.00**	0.05	55.28**	-0.35	3.87*	0.19
19	CM116 X CM123	-0.87	-0.85	2.25	6.22	-0.86	0.15	12.62	1.44**	4.25*	0.02
20	CM116 X CM124	-0.12	-0.10	2.67	-9.87	0.89	0.73	35.30**	2.16**	11.46**	0.31**
21	CM123 XCM124	1.00	0.74	-2.17	0.83	1.31**	0.21	8.45	-0.07	2.58	0.10
	S.E.(sij)	**0.94**	**0.57**	**1.87**	**5.08**	**0.39**	**0.48**	**11.63**	**0.36**	**1.68**	**0.11**
	Reciprocal crosses										
22	CM145 X UMI1200	0.50	0.00	2.25	15.8**	-1.15**	0.54	87.5**	-0.61*	-1.05	0.038
23	CM152 X UMI1200	2.00*	1.50**	3.00	-9.55*	-0.005	0.19	16.1	0.79*	8.86**	0.28**
24	CM116 X UMI1200	0.50	1.00*	-0.75	-2.97	0.097	-0.24	16.9	2.17**	12.08**	0.32**
25	CM123 X UMI1200	1.00	1.25*	-0.25	-7.40	-0.64	-0.005	-6.58	-1.34	-2.17	-0.03
26	CM124 X UMI1200	0.25	-0.25	5.50**	3.15	-0.28	-0.46	-38.2**	-2.54	-35.54**	-0.28**
27	CM152 X CM145	-1.00	-1.25*	1.25	10.6*	-0.55	0.53	25.1*	3.85**	29.64**	0.61**
28	CM116 X CM145	-0.50	-1.50**	2.75	10.0*	0.68*	0.49	50.2**	-2.74**	2.45	0.28**
29	CM123 X CM145	-0.50	-0.25	2.00	-4.70	0.31	-0.38	5.65	1.64**	4.64**	0.26**
30	CM124 X CM145	-1.00	-1.50**	3.00	0.25	-0.43	-0.01	4.95	-0.75*	2.43	0.16
31	CM116 X CM 152	0.00	0.25	2.25	9.47*	-0.06	0.12	10.3	-0.28	-1.32	-0.05
32	CM123 X CM152	-0.25	-0.50	-0.50	2.50	0.36	0.35	-8.80	-0.44	-4.25**	-0.22**
33	CM124 X CM152	0.75	0.75	-0.25	13.4**	0.90*	-0.39	-43.4**	-5.60	-29.16**	-0.82**
34	CM123 X CM116	0.75	0.25	6.25**	-7.55	-0.86	-0.15	-12.9	0.18	-2.44**	-0.02
25	CM124 X CM116	0.50	0.75	-1.25	-0.60	0.02	0.20	22.1*	-2.04	-12.72**	-0.29**
36	CM124 X CM123	-0.50	0.00	1.25	-7.10	0.76	-0.09	-10.7	-0.68	0.04	0.14
	S.E.(rij)	**0.80**	0.49	1.58	4.31	0.33	0.40	9.87	**0.30**	**1.45**	**0.09**

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