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Study of Combining Ability and Stability in Maize (*Zea mays* L.)

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

An investigation was carried out in diallel fashion with the main objectives to evaluate the general combining ability of parents, specific combining ability of crosses and breeding values of genotypes for population improvement. Forty-five F1's along with ten parents and two checks were evaluated in a randomized complete block design with three replications. Genotypes indicated the presence of considerable variability for both additive and non-additive gene effects. The magnitude of the component of variances indicated the importance of non-additive genetic variation and its interaction with the environments for eleven traits whereas, it indicated the importance of additive genetic variance for the traits 500 kernel weight. The parent CM 601was identified as the best general combiner for grain yield and its component traits. Although, it was average combiner for early maturity and the best combiner for ear length, girth and number of kernel rows. Similarly, the parents CML-3, POP 49 and CML-107 were also identified as a good general combiner for grain yield and yield attributing traits. The cross combination {(M9 x CM601) X CML 3}was found to be a best specific combination for grain yield and yield attributing traits followed by (CML-83 x CML-14), (Pop 34 x CML-14) and (CM601 x Pop 34) and these crosses were found to be promising for desirable traits. These parents may be exploited in the development of hybrid maize for higher and stable yield.

Keywords: Diallel; combining ability; crosses; hybrid; Zea mays.

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1. INTRODUCTION

Maize breeders are interested in identifying parental lines possessing high and stable specific combining ability in their hybrid combination that can produce useful hybrids. The knowledge of combining ability of the parental lines and their crosses is an initial step towards achieving the GCA of hybrid development. The economical and combination of vigorous hybrids largely depends on the high yielding suitable combination of vigorous inbred lines. Since combining ability helps to study nature and magnitude of genotypic variability and to facilitate the correct choice of parents in the hybrid programme. The present investigation has been, therefore undertaken to obtain information on the consistent combining ability of parents and crosses over the environment.

2. MATERIALS AND METHODS

Ten inbred lines of maize of diverse origin were sown in the breeding nursery during Rabi 1998-99, and they were crossed in a diallel fashion excluding reciprocals. Parents were also sibbed for their maintenance. In the following season (Kharif 1999) forty-five F_1's, ten parental inbred lines and two checks were evaluated in the three environments (three different dates of sowing)in a randomised complete block design with three replication at Dholi Farm of Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar. Each entry was accommodated in two rows of 5-meter length, spacing at 75cm from row to row and 25cm from plant to plant within the rows. The recommended agronomical and plant protection practices were followed all along the crop growth period. Observations were recorded on five randomly taken plants in each plot of every replication for the characters namely, plant height, ear height, ear girth,500-kernel weight, number of kernel rows per ear, grain yield per plant and grain moisture at harvest. However, days to 50 per cent silking, days to maturity, vegetative growth period and grain filling period were recorded on plot average basis in each replication. The diallel analysis based on Model - 1, Method-II of Griffing [1] and combining ability over several environments [2] were followed in the present investigation.

3. RESULTS AND DISCUSSION

The pooled value of variance for combining ability showed significant difference due to GCA and SCA for all the characters under study (Table 1). The indicated the presence of considerable variability for both additive and non-additive gene effects. Similar to results were also reported by other workers [3,4,5,6]. The interaction of GCA of the present with environments and SCA of crosses with environments were found significant for all the characters studied. This indicated that the environments influenced both GCA and SCA variances. Similar results have been reported by Pal and Prodhan [7] and Zelleke [4] However variance due to SCA x environments were greater in magnitude than the variance due to GCA x environments for all characters namely days to 50 per cent silking, days to maturity, plant height, ear length, number of kernel rows per ear grain yield per plant, grain filling period and grain moisture at harvest . This suggested SCA variance was more influenced by environments than GCA. Several workers had also similar observation viz. Debnath and Sarkar [8], Pal and Prodhan [9]. The GCA x environment was significantly greater than SCA x environments were higher in magnitude then GCA and GCA x environments for all the characters under study except for 500 - kernel weight for which GCA variance was light. This higher value of SCA and SCA x environments indicated the importance of non-additive genetic variance and its pronounced interaction with the environments for these characters. Many workers [10] and [11] have reported greater importance of SCA variance than GCA for above mentioned one or more characters. A higher magnitude of GCA was found greater than the magnitude of SCA variance for 500 - indicated greater importance of additive grolic variance for the trait [7,12]. This indicated the importance of additive genetic variation for this trait. Several workers [12,7] have reported greater importance GCA variance SCA for this trait. The pooled general combing ability (GCA) effects of parents for twelve quantitative characters over environments have been presented in Table 3. Amongst the parents P1 (CM 601-S4-2-3) WAS found to be best general combiner for grain yield per plant followed by p7(CML3), P6(Pop 49(C4)-P5-80), P45 (POP 30-C5-83(CML-107) (Table 3). Parent P1 was also observed to be the best ear length, ear girth band number of kernel rows and a good combiner for 500—kernel weight, whereas it was average combiner days to 50 per cent silking, days to maturity, ear height and vegetative growth period and poor combiner for rest of the characters studied. The parent p ranked second for grain yield and also found to vbe good general combines for ear length,

Table 1. Pooled analysis of variances for combining ability for twelve quantitative characters in maize

Source	d.f.	Mean squares											
		Days to 50% silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500-kernel weight	No. of kernel Rows/ear	Grain yield/plant	Vegetable growth period	Grain filling period	Grain moisture at harvest
GCA(G)	9	3.11**	5.70**	629.02*	228.66**	1.14**	1.25**	7668.75**	1.55**	1275.25**	2.96**	1.65**	3.65**
SCA(S)	45	1.60**	1.99**	841.35**	120.04**	21.11**	2.08**	2.11**	1.47**	1419.24**	0.85**	2.53**	4.41**
Env.(S)	2	34.62**	25.33**	118.76	1477.16**	46.34**	18.17**	45.35**	47.88**	15059.13**	197.32**	2.18**	61.40**
G x E	18	0.80**	1.35**	153.44**	101.30**	0.84**	0.37**	3047.29**	0.72**	51.60**	6.31**	0.85**	0.43**
S x E	90	1.05**	1.71**	169.20**	63.93**	1.01**	0.31**	609.88**	0.74**	64.93**	0.73**	1.10**	0.94**
Pooled error	324	0.41	0.33	62.11	41.15	0.16	0.02	0.02	0.26**	6.39	0.48	0.10	0.22

*,** : significant at 5 and 1 per cent level of significance, respectively

Table 2. Components of general and specific combining ability variances for twelve quantitative character in maize

Components	Days to 50% silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500-kernel weight	No. of kernel rows/ear	Grain yield/plant	Vegetable growth period	Grain filling period	Grain moisture at harvest
K^2 g1	068	1.34	141.73	46.88	0.25	0.26	1917.18	0.32	317.22	0.62	0.40	0.84
K^2 Sij	17.85	24.90	11688.60	1183.35	29.25	27.90	515.85	18.15	21192.75	5.55	36.45	62.85
K^2 gc	0.30	0.77	68.50	45.11	0.51	0.11	2285.45	0.35	33.91	4.37	0.56	0.16
K^2 gc	28.80	62.10	4819.05	1025.10	38.25	4.05	27443.70	21.60	2634.30	11.25	45.00	32.40

Table 3. Pooled estimates of general combining ability (GCA) effects of maize inbred lines for twelve quantitative characters

Inbreds	Days to 50% Sliking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500-kernel weight	No. of kernel rows/ear	Grain yield/ plant	Vegetative growth period	Grain filling period	Grain moisture at harvest
P1	+0.01	+0.11	+4.82**	-0.50	+0.43**	+0.30**	+2.50**	+2.28**	+12.96**	+0.03	+0.10*	+0.70**
P2	-0.65**	-0.86**	-4.68**	-2.85**	-0.10	-0.11	-6.31**	-0.22**	-4.56**	-0.62**	+0.80**	-0.40**
P3	+0.16	+0.44**	-6.81**	-4.20**	-0.08	-0.26**	+6.70**	-0.10	-3.65**	+0.08	-0.34**	+0.08
P4	-0.13	-0.15	+3.62**	+2.00*	-0.03	+0.04	-4.65**	+0.24**	+2.58**	10.02	-0.24**	+0.20*
P5	+0.52**	+0.40**	+1.50	+3.20**	-0.40**	-0.23**	-0.14**	+0.01	-4.05**	10.55**	+0.23**	+0.05
P6	+0.08	+0.01	+4.31**	+4.74**	+0.13	+0.22**	+9.60**	+0.25**	+3.05**	+0.09	+0.21**	-0.13
P7	+0.01	+0.12	+0.60	+0.70	+0.20**	+0.05	-1.50**	+0.12	+4.05**	-0.08	+0.13	+0.02
P8	+0.16	+0.11	+2.57*	+0.50	+0.11	+0.15*	-12.58**	-0.11	+1.02*	+0.07	-0.02	-0.30*
P9	-0.03	-0.01	-4.90**	-0.43	-0.06	+0.01	+7.41**	-0.20*	-5.94**	+0.12	+0.24**	-0.16*
P10	-0.15	-0.06	-1.02	-3.70**	-0.20**	-0.15*	+4.21**	-0.27**	-5.46**	-0.14	-0.30**	-0.03
SE(Gi)	0.10	0.09	1.25	1.01	0.06	0.07	0.02	0.08	0.40	0.11	0.05	0.07
SE(gi-gi)	0.15	0.14	1.86	1.51	0.09	0.11	0.03	0.12	0.59	0.16	0.07	0.11
CD at 5%	0.30	0.27	3.64	2.96	0.18	0.22	0.06	0.24	1.17	0.32	0.15	0.22
CD at 5%	0.39	0.35	4.79	3.90	0.24	0.29	0.09	0.31	1.54	0.42	0.19	0.29

*,**: *Significant at 5 and 1 per cent levels of significance, respectively.*

Table 4. Pooled estimates of specific combining ability (SCA) effects of maize for twelve quantitative characters

Crosses	Days to 50% Silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500- kernel weight	No. of kernel rows/ ear	Grain yield/ plant	Vegetative growth period	Grain filling period	Grain moisture at harvest
P1 x P2	+0.44	+0.92**	-2.93	-6.70*	-0.20	-0.44	+25.18**	-0.80**	1.97	+0.90*	-0.13	+0.94**
P1 x P3	-0.59	-0.38	-14.70**	-7.71*	+0.98**	+0.28	+4.21**	+0.10	+16.30**	-0.40	-0.50**	+1.40**
P1 x P4	+0.22	+0.54	+7.83	+0.50	+0.26	+0.54*	-25.43**	-0.14	-2.84*	-0.20	+0.41*	-054*
P1 x P5	-0.62	-1.56**	-23.23**	-7.30*	+0.50*	+0.50*	-5.83**	+0.53*	+31.91**	-0.73*	-0.61**	+0.09
P1 x P6	-0.07	+0.16	+5.40	+5.98	-0.40*	-0.30	-13.90**	-0.04	-2.65*	-0.40	-0.93**	-1.43**
P1 x P7	+0.11	+0.40	+16.11**	+9.50**	+0.20	+0.88**	-0.92**	+0.20	+5.21**	+0.13	-0.42*	-0.48
P1 x P8	-0.50	-0.82**	+15.03**	+1.63	-0.35	+0.32	+12.33**	+0.43	-0.63	+0.31	+1.31**	+0.11
P1 x P9	-0.41	-0.60	-19.06**	-1.99	-0.55**	+0.05	+13.61**	+0.20	-12.04**	-0.43	-0.63**	-0.62*
P1 x P10	+0.50	+0.80**	+13 .96**	+1.35	+0.33	-0.40	-17.34**	-0.07	+9.51**	+0.30	+0.24	+1.30**
P2 x P3	+1.72**	+1.60**	-2.66	-2.98	+0.90	-0.34	+3.00**	-0.07	+8.50**	+0.61	-0.91**	-1.54**
P2 x P4	-0.46	-0.15	-8.25	-0.16	-0.12	-0.04	-19.36**	-0.31	-0.30	-0.11	-0.23	-1.77**
P2 x P5	-0.31	-0.14	+10.31*	+5.20	-0.46*	-0.83**	14.84**	-0.63*	-6.20**	-0.10	+1.20**	+0.65**
P2 x P6	+0.35	+0.60	+20.60**	+5.20	+1.18**	-0.32	+23.52**	-0.32	-6.02**	+0.40	+1.32**	-0.44
P2 x P7	-1.24**	-0.80**	-8.26	-1.65	+1.65**	+1.42**	+7.56**	+1.70**	+45.42**	-1.01**	+0.83**	+2.25**

Table 4 continued….

Crosses	Days to 50% Silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500- kernel weight	No. of kernel rows/ ear	Grain yield/ plant	Vegetative growth period	Grain filling period	Grain moisture at harvest
P2 x P8	+0.30	+0.50	-6.92	-4.61	+0.12	+0.08	14.67**	-0.30	-3.76**	+0.52	+0.11	+2.45**
P2 x P9	-0.76*	-0.52	-8.30*	+3.10	-0.30	+0.33	+23.74**	+0.11	+7.05**	+0.77*	+1.40**	+1.10**
P2 x P10	-0.86*	-1.36**	+23.40**	+0.04	+0.23	+0.58*	+18.50**	+1.20**	+21.55**	-0.61	-0.95**	-0.30
P3 x P4	-0.50	+0.10	+20.10**	+8.66*	-4.35**	-0.24	-14.17**	-0.08	-3.21*	-0.40	+0.30	+0.82**
P3 x P5	-1.11**	-1.22**	-1.91	+0.73	+0.90**	+0.38	+28.26**	+0.70**	-2.80*	-0.60	+0.84**	+0.12
P3 x P6	+0.80	+0.50	+3.21	+1.66	-1.05**	-0.33	+2.90**	-0.98**	-30.91**	+0.44	-0.50**	-0.87**
P3 x P7	-0.20	-0.14	+9.95*	+7.42*	+0.51*	-0.18	-8.30**	+0.15	+0.80	+0.40	-1.08**	-0.55**
P3 x P8	-0.64	-0.93**	+0.71	+5.96	-0.30	+0.80**	-43.23**	+1.50**	+21.50**	-0.86*	+0.31	-0.22
P3 x P9	+0.55	+0.92**	-1.14	-0.78	+0.21	+0.33	+29.56**	+0.55**	+44.53**	-0.03	+1.40**	+2.15**
P3 x P10	-0.44	-0.33	+9.07*	-6.92*	+0.64**	-0.18	-20.76**	+0.10	+3.90**	-0.54	+1.35**	-2.14**
P4 x P5	+0.70*	+0.40	+7.82	+4.82	-0.45*	-1.34**	32.07**	-0.53*	-10.30**	+0.30	-1.16**	+0.60**
P4 x P6	+0.81*	-0.13	-6.51	-1.91	-0.47*	+0.25	+13.50**	+0.45	+13.50**	+0.51	-0.70**	+1.52**
P4 x P7	-0.80*	-1.14**	+1.51	-6.43	+0.30	+0.73**	+18.82**	+0.70**	+23.30**	-0.65	+2.14**	+0.05

Table 4 continued….

Crosses	Days to 50% Silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500- kernel weight	No. of kernel rows/ ear	Grain yield/ plant	Vegetative growth period	Grain filling period	Grain moisture at harvest
P4 x P8	-0.30	+0.05	-7.60	-1.01	+0.20	+1.06**	+23.64**	+1.03**	+27.55**	-0.34	+1.20**	-0.53*
P4 x P9	-0.42	-1.01**	+17.77**	+9.90**	-0.18	+0.48	-69.91**	-0.23	+0.06	+0.81*	+1.48**	+1.14**
P4 x P10	+0.26	-0.04	+10.08*	-0.66	+1.56**	+1.50**	+21.12**	-0.23	+29.92**	+0.20	-0.64**	+0.01
P5 x P6	+0.30	+0.55	+17.06**	+0.98	-0.45*	+0.80**	+3.45**	+0.35	+13.23**	+0.20	+1.51**	+17.76**
P5 x P7	+0.59	+1.20**	+7.06	+0.96	-0.62*	+0.46	-11.03**	-0.08	-13.41**	+0.26	-0.54**	+0.54*
P5 x P8	-0.88**	-0.21	+22.24**	+5.30	+0.60*	+1.19**	+19.10**	+0.04	+13.98**	-0.66	-1.03**	-1.99**
P5 x P9	+0.63	+0.89**	+11.82**	-3.10	+0.80**	+1.01**	+8.65**	+1.33**	+32.52**	+0.61	+1.14**	-1.08**
P5 x P10	+1.19**	+1.16**	+17.21**	+12.86**	+0.35	+0.70**	-1.24**	-0.46	+3.46*	+0.76*	-0.10	-1.84**
P6 x P7	-0.41	-0.30	-12.71**	-2.86	+0.62*	+0.07	-31.94**	-0.32	-1.70	-0.20	-0.18	+0.73**
P6 x P8	+0.21	-0.20	-23.76**	-0.67	+0.40	-0.05	-1.90**	+0.25	+0.70	+0.13	-0.35*	+0.90**
P6 x P9	-0.71*	-1.56**	+22.66**	+1.86	+1.36**	+1.00**	-4.22**	0.20	+25.40**	-0.93*	-1.17**	-0.62*
P6 x P10	-1.40**	-1.56**	-1.87	-0.51	+0.44*	+0.96**	+19.70**	+0.63*	+13.50**	-0.13	+0.03	-0.02

Table 4 continued….

Crosses	Days to 50% Silking	Days to maturity	Plant height	Ear height	Ear length	Ear girth	500- kernel weight	No. of kernel rows/ ear	Grain yield/ plant	Vegetative growth period	Grain filling period	Grain moisture at harvest
P7 x P8	+0.51	+0.83**	+10.70*	+5.60	-0.09	-0.37	+2.11**	-0.30	+15.50**	-0.13	+0.40*	-0.99**
P7 x P9	-0.52	+0.73*	+17.82**	+2.40	-0.98**	-1.11**	-15.90**	-0.60*	-35.10**	-0.32	-0.44**	-1.10**
P7 x P10	-0.85*	+1.35**	+18.10**	+9.99**	-0.75**	-0.08	+22.12**	+1.10**	-11.81**	-0.37	+0.42*	-0.90**
P8 x P9	-0.01	-0.04	-7.07	-4.93	+1.30**	+0.22	+4.97**	+0.12	-19.04**	-0.01	-1.72**	-1.40**
P8 x P10	+0.11	-0.43	-11.60**	-7.10*	-1.07**	-1.87**	-36.36**	-1.12**	-43.70**	+0.14	-0.20	+0.52
P9 x P10	+1.30**	+1.34**	-23.30**	-2.15	-1.36**	-1.35**	-19.80**	-0.73**	-11.40**	+0.97**	-0.56**	-0.04
SE (Sij)	0.34	0.31	4.19	3.41	0.21	0.25	0.07	0.27	1.34	0.37	0.17	0.25
SE (Sij-Sij)	0.43	0.38	5.25	4.27	0.27	0.31	0.09	0.34	1.68	0.46	0.21	0.31
CD at 5%	0.84	0.75	10.29	8.38	0.52	0.61	0.18	0.67	3.30	0.91	0.41	0.61
CD at 1%	1.10	0.99	13.55	10.03	0.69	0.81	0.24	0.88	4.35	1.19	0.54	0.81

**, ** : Significant at 5 and 1 per cent level of significance, respectively.*

whereas it was average combiner for 50 per cent silking, days to maturity, plant add ear height, ear girth, number of kernel rows per ear, vegetative growth period and grain moisture at harvest but it was poor combiner for 500 kernel weight . The P6another good general combiner for grain yield was also observed as the best combiner for 500- kernel weight and a good combiner for ear girth and number of kernel rows per ear. However, it was average combiner for days to 50 per cent silking and maturity, ear length, vegetative growth period and grain moisture at harvest. The parent P(4) was good gourd combiner for grain yield and it also recorded good combiner for a number of kernel rows per ear and grain moisture at harvest, whereas it was average combiner for days to 50 per cent silking and maturity, ear length ear girth and vegetative growth period. Similarly, p(8) a good combiner for grain yield also recorded good combiner for ear girth and moisture at harvest. However, it was poor combiner for plant height and 500-kernel weight and an average combiner for rest of the characters. Amongst the parents, the parent P1(cm601-S4-2-3) was identified as the best general combiner for grain yield and its components traits. Although, it was average combiner for early maturity and best ear length girth and number of kernel rows. Similarly, the parentsP7 (CML-3), P6(Pop49(C4)-P5-80), P4(Pop-C5-P-83) and P8(CML-107) were also identified as a good general combiner for grain yield contributing traits.

The specific combining ability effects (Table 4) showed that out of forty-five hybrids crosses P2 x p, p3x P9, P5x p9, and P1 x P5 were noted to be better specific combinations for grain yield along with most of the desirable traits. the cross P2x P7was also having early silking and maturity, dwarf plant height, longer ear length, thicker ear girth, higher 500-kernel weight, the maximum number of kernel rows, short vegetative growth and average ear height. In the same way, the cross P3 x P9 showed better specific combination for 500-kernel weight and number of kernel rows. However, it has specific combing ability effect for days to 50 per cent silking, plant and ear height, ear length, ear girth and vegetative growth period. Similarly, the cross P5 x P9 was also found to be a better specific combination for ear length, ear girth 500-kernel weight, number of kernel rows and grain moisture at harvest, whereas, it has average SCA effect for days to 50 per cent silking, ear height and vegetative growth period. The crossP1 x P5 was also found to be a better combination for days to maturity, plant and height, ear length ear girth, number of kernel rows, vegetative growth period and grain sling period. However, it was average combination for days to 50 per cent silking, 500-kernel weight and grain moisture at harvest. These results indicated that the single crossesP2 x P7, P3 x P9, P5x P9 and P1x P5 WERE quite suitable for higher grain yield and may be further tested in multi-location evaluation trials. On the basis of general combining ability and mean performance the parents P1, P7, P6, P4 and P8 were identified as good general combiners having high mean performance. These parents may be exploited in the development of hybrids. Similarly, on the basis of specific combining ability, and mean performance hybrids P2 x P7 , P3 Xp9 and P5 x P9 and P1x P9, and P1x P5 was found to be promising, which potentiality for commercial exploitation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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