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Research Note

Gene action and combining ability analysis for kernel yield and its attributing traits in maize [*Zea mays* (L.)]

M. Patel

Maize Research Station, S.D. Agricultural University, Bhiloda-383245,Gujarat India
E-Mail: rmpate106@gmail.com

Abstract

Combining ability estimates were studied for kernel yield, its components and morphological traits in nine maize parents and 36 F_1 hybrids generated from cross in half diallel mating design. Analysis of variance for combining ability revealed that mean sum of squares due to general combining ability were found significant for all the traits except cob length and cob girth, whereas, the specific combining ability effects were found highly significant for all the characters except cob length, cob girth and anthesis - silking interval. Based on estimates of general combining ability, two parents *viz*., WNC 40228 (6.17) and WNC 31702 (5.47) were found as good general combiners because they registered significant and positive *gca* effects. The estimates of *sca* effects revealed that 13 hybrids were exhibited significant positive *sca* effects. The top most three hybrids for kernel yield per plant on the basis of specific combining ability effects were Z 485-50 x Z 485-11 (22.77), WNC 40228 x BLD - 105 (20.13) and WNC 40228 x Z 485-11 (17.47). The low ratio (<1.0) of GCA to SCA variance for fourteen traits indicated that non-additive type of gene action was predominant in the expression of yield and component traits.

Keywords: Maize, geneal combining ability, specific combining ability, hybrid, kernel yield

Maize (*Zea mays* L.,2n=20) is the world's most widely grown cereal and is the primary staple food in many developing countries (Morris *et al*., 1999). It is a versatile crop with wider genetic variability and able to grow successfully throughout the world covering tropical, subtropical and temperate agro-climatic conditions. India ranks 4th in area and 7th in production of maize globally. Maize grain is gaining popularity due to diversified uses as food for human, live stocks and poultry. It is also a source of industrial raw material for the production of flour, flakes, corn starch, corn oil, corn syrup, glucose, alcohol, ethanol, gluten, dextrose, custard powder and many more product. Maize belongs to the grass family *Poaceae (Gramineae),* tribe *Maydeae* and maize is the only cultivated and economically important species of genus *Zea*. The word "*Zea*" (zela) was derived from an old Greek name for a food grass. The other *Zea* species referred to as teosinte [*Zea mexicana* (schrad.) Kuntze], is wild species.

The success of breeding procedure is determinedby the useful gene combinations, organized in the form of good combining lines and isolation of valuable germplasm. Some lines produce outstanding progenies on crossing with others, while, others may be equally desirable but may not produce good progenies on crossing. The lines, which perform well in combination, are eventually of great importance to the plant breeders. Hence, investigation of general and specific combining ability would yield very useful information. Accordingly, a good knowledge of gene action involved in the inheritance of quantitative characters of economic importance is required in order to form an efficient breeding plan leading to rapid improvement.

The material used for this experiment consisted of nine parents (BLD 98, WNC 52348, WNC 40228, BLD 105, WNC 32913, WNC 31702, BLD 109, Z 489-50 and Z 485-11), their 36 half-diallel crosses and a check GDYMH-101. The seeds of 36 hybrids were produced during *kharif* 2020 at Maize Research Station, S.D. Agricultural University, Bhiloda. The seed of inbred lines were maintained by sibbing. A set of 46 genotypes comprising of nine parents and their 36 F_1 hybrids with a check (GDYMH-101) were sown in Randomized Block Design (RBD) with three replications, during *rabi* 2020-21. Each entry was sown in 4m length row and 60 cm distance between row and maintained 20 cm distance between plants within row. The recommended agronomical practices and plant protection measures were adopted for raising a good crop. The observations were recorded both as visual assessment (days to tasseling, days to silking, anthesis-silking interval (ASI) and days to dry husk) on plot basis and measurement on randomly selected five individual plants (plant height, ear height, cob length, cob girth, number of kernel rows per cob, number of kernels per row, cob weight, kernel yield per plant, 100-kernel weight and shelling percentage). The ear height of the each tagged five plants per plot was measured in centimeter from the base of the plant to the base of the uppermost ear on the main stalk at a time of maturity. Whereas, cob length was measured in centimeter from the end of the cob to the tip of the cob. The replication wise mean valuesof each entry for the fourteen traits were analysed using Randomized Block Design (RBD) as suggested by Sukhatme and Amble (1985).The analysis of variance for combining ability was performed as per method suggested by Griffing (1956) Model-I and method-2.

The analyses of variance for combining ability for fourteen traits are presented in **Table 1.** The results revealed that mean sum of squares due to general combining ability were found significant for all the traits except cob length and cob girth, whereas, the specific combining ability effects were found highly significant for all the characters except cob length, cob girth and anthesis-silking interval. The low ratio (<1.0) of GCA to SCA variance for fourteen traits indicated that non-additive type ofgene action was predominant in the expression of yield and component traits.

The *gca* effects of parents revealed that none of the parents consistently good general combiner for all the characters under study. The parents, WNC 40228 and WNC 31702 were general combiner for kernel yield per plant. In addition to kernel yield, WNC 40228 was also found to be good general combiner for cob weight, shelling percentage, plant height and ear height. The WNC 31702 was found to be general combiner for traits *viz.*, cob weight, days to tasseling, days to silking, days to dry husk and ear height (**Table 2**).

Table 1. Analysis of variance for combining ability for fourteen traits of maize

Source of variation	d f	Days to tasseling	Days to silking	ASI	Days to dry husk	Plant height	Ear height	Cob length
GCA	8	5.03**	2.30**	0.60*	7.46**	238.00**	156.87**	2.43
SCA	36	3.26**	1.84**	0.31	3.73**	98.14**	87.66**	2.34
Error	88	0.22	0.55	0.24	1.39	20.58	9.14	3.24
δ^2gca		0.13	0.21	0.14	0.33	1.28	0.85	0.51
δ^2sca		0.43	0.67	0.45	0.07	4.14	2.76	1.64
δ^2gca / δ^2sca		0.14	0.12	0.49	0.23	0.25	0.17	0.08

Table 1. Continued

Source of variation	d f	Cob girth	Number of kernel rows on cob	Number of kernels per row	Cob weight per plant	Kernel yield per plant	Kernel weight	Shelling percentage
GCA	8	0.41	0.65**	5.26**	276.93**	200.53**	8.72**	2.56**
SCA	36	0.35	0.44**	3.18*	223.98**	266.20**	9.40**	2.29**
Error	88	0.38	0.23	1.90	117.84	78.27	1.55	0.82
δ^2gca		0.17	0.13	0.39	3.08	2.51	0.35	0.25
δ^2sca		0.56	0.44	1.26	9.92	8.09	1.14	0.83
δ^2gca / δ^2sca		-0.10	0.17	0.23	0.13	0.12	0.09	0.11

* and ** , significant at 5 and 1 per cent level , respectively

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Table 2. General combining ability effects (*gca*) of fourteen traits of maize

Parents	Days to tasseling	Days to silking	ASI	Days to dry husk	Plant height	Ear height	Cob length
BLD 98	0.62**	0.51*	-0.07	0.24	-9.48**	-6.59**	-0.47
WNC 52348	0.84**	0.47*	-0.31*	1.66**	-1.72	-2.98**	0.65
WNC 40228	0.14	0.14	0.05	-0.43	-3.00**	-1.77*	-0.06
BLD 105	0.23	0.29	0.11	-0.79*	-0.66	-1.32	0.07
WNC 32913	-0.01	0.23	0.29*	0.84*	4.03**	4.05**	0.84
WNC 31702	-0.83**	-0.59**	0.11	-0.98**	-1.36	-1.83*	-0.40
BLD 109	-1.32**	-0.77**	0.29	-0.16	2.79**	2.87**	-0.07
Z 489-50	0.08	-0.31	-0.34*	-0.28	5.28**	3.44**	-0.50
Z 485-11	0.26	-0.02	-0.13	-0.10	4.12**	4.14**	-0.07
S. E. (g_i)	0.13	0.21	0.14	0.33	1.28	0.85	0.51

Table 2. Continued

Parents	Cob girth	Number of kernel rows on cob	Number of kernels per row	Cob weight per plant	Kernel yield per plant	100 Kernel weight	Shelling percentage
BLD 98	-0.01	0.30*	0.55	0.03	-0.47	1.54**	-0.26
WNC 52348	-0.19	-0.34*	-1.16**	0.97	0.84	0.57	0.10
WNC 40228	0.30	0.16	0.93*	6.60*	6.17*	0.44	0.56*
BLD 105	-0.10	-0.04	0.63	-4.97	-4.98*	-0.10	-0.91**
WNC 32913	-0.07	-0.05	-0.64	-3.91	-3.07	-0.43	0.20
WNC 31702	-0.06	-0.34*	0.41	7.33*	5.47*	0.57	-0.31
BLD 109	0.22	-0.14	-0.03	3.39	3.17	-0.25	0.29
Z 489-50	-0.27	0.18	-0.57	-6.61*	-5.47*	-0.86*	-0.19
Z 485-11	0.19	0.26	-0.12	-2.82	-1.65	-1.46**	0.50
S. E. (g_i)	0.17	0.13	0.39	3.08	2.51	0.35	0.25

* and ** , significant at 5 and 1 per cent level , respectively

The estimates of general combining ability compared with the *per se* performance of parents, indicated that the parents which were goodgeneral combiner for kernel yield and component and also superior in their *per se* performance. Thus, selection of parent for kernel yield and components based on *per se* performance may be effective. Hence, high yielding parents with good attributes for different kernel yield attributes may be inter crossed to combine the gene in positive direction to augment the yield potential. Similar results are obtained by Malik *et al.*(2004), Adebayo *et al.*(2014) and Gami *et al.*(2018b)

The estimates of *sca* effects for kernel yield per plant revealed that 13 among 36 hybrids exhibited significant positive *sca* effects (**Table 3**). The top most three hybrids for kernel yield per planton the basis of specific combining ability effects were Z 485-50 x Z 485-11(22.77) ,WNC 40228 x BLD 105(20.13) and WNC 40228 x WNC 31702(17.47). A perusal of data revealed that none of the crosses had high-ranking *sca* effects for all the characters. The data revealed that the top ranking *sca* for most of the characters where accompanied by top ranking *per se* performance, which showed predominant role of non-additive gene effects in expression of kernelyield and component traits in crosses. Thus, for improvement of kernel yield and component traits, heterosis breeding may be more rewarding.

The estimates of *sca* effects revealed that the cross combinations Z 485-50 x Z 485-11, WNC 40228 x BLD 105 and WNC 40228 x Z 485-11 were observed most promising hybrids for kernel yield and some of its related traits. This showed important role of intra allelic gene interaction, *i.e.,* additive x dominance of these hybrids having high *sca* effects. These hybrids with good attributes can be evaluated under multi locations and can bedeveloped as commercial hybrids.

Table 3. Specific combining ability (*sca*) effects of hybrids for fourteen traits of maize

	Hybrids	Days to tasseling	Days to silking	ASI	Days to dry husk	Plant height	Ear height	Cob length
1	BLD 98 x WNC 52348	2.19**	2.31**	0.07	-2.90**	8.18**	5.36**	-0.16
2	BLD 98 x WNC 40228	0.22	0.31	0.04	-0.15	-1.55	-1.19	0.28
3	BLD 98 x BLD 105	-2.53**	-1.84**	0.65**	-0.78	-7.88**	-7.98**	0.02
4	BLD 98 x WNC 32913	1.04**	0.88**	-0.20	1.58**	-1.58	-7.01**	-1.22
5	BLD 98 x WNC 31702	-1.14**	-1.63**	-0.35	-0.93	-2.85	-9.13**	0.69
6	BLD 98 x BLD 109	-0.99**	-0.45	080**	-1.42**	-6.01**	-10.16**	-0.91
7	BLD 98 x Z 489-50	-0.05	0.10	0.10	1.70**	-2.49	-1.07	0.18
8	BLD 98 x Z 485-11	1.10**	1.10**	-0.11	1.85**	10.99**	5.24**	-1.18
9	WNC 52348 x WNC 40228	0.01	0.01	-0.05	-0.57	-7.64**	-3.13**	0.76
10	WNC 52348 x BLD 105	-0.08	-0.15	-0.11	1.13*	10.36**	7.08**	-0.36
11	WNC 52348 x WNC 32913	0.16	0.25	0.04	-0.18	8.33**	4.39**	7.26**
12	WNC 52348 x WNC 31702	1.65**	1.73**	0.22	1.64**	5.05**	6.60**	-0.03
13	WNC 52348 x BLD 109	1.13**	0.92**	0.04	2.16**	5.24**	11.90**	-0.69
14	WNC 52348 x Z 489-50	-0.26	-0.54	-0.32	2.95**	-21.92**	-24.01**	-0.73
15	WNC 52348 x Z 485-11	-0.34**	-2.54**	0.80**	1.76**	0.90	0.96	-0.56
16	WNC 40228 x BLD 105	0.28	0.19	-0.14	-0.45	0.30	5.21**	-1.72*
17	WNC 40228 x WNC 32913	0.53**	0.58*	0.01	1.58**	-11.07*	-10.82**	0.50
18	WNC 40228 x WNC 31702	1.68**	1.40**	-0.14	-0.93*	-2.67	-3.61**	0.75
19	WNC 40228 x BLD 109	-1.17**	-2.08**	-0.65**	1.92**	10.18**	12.36**	0.42
20	WNC 40228 x Z 489-50	-1.56**	-1.21**	0.32	-0.63	7.02**	5.45**	0.64
21	WNC 40228 x Z 485-11	-0.75**	0.13	0.77**	0.19	11.51**	12.42**	-0.45
22	BLD 105 x WNC 32913	-0.56**	-0.90**	-0.38*	0.28	-1.07	-7.28**	-0.02
23	BLD 105 x WNC 31702	1.59**	1.58**	0.13	2.43**	-6.01**	-2.07	-0.11
24	BLD 105 x BLD 109	-0.93**	-0.24	0.95**	-0.39	12.84**	2.57*	-0.77
25	BLD 105 x Z 489-50	-0.32	-0.02	0.25	-3.60**	5.02**	3.99**	0.05
26	BLD 105 x Z 485-11	0.16	-0.02	-0.29	-0.45	9.51**	6.96**	0.75
27	WNC 32913 x WNC 31702	1.50**	0.31	-1.05**	1.79**	2.63	4.57**	-0.29
28	WNC 32913 x BLD 109	20.32**	1.16**	-0.90**	-1.69**	11.15**	9.21**	-0.95
29	WNC 32913 x Z 489-50	-2.41**	-1.63**	0.74**	-0.24	7.33*	7.96**	-1.13
30	WNC 32913 x Z 485-11	-2.59**	-2.30**	0.19	-3.08**	-1.52	0.93	-0.96
31	WNC 31702 x BLD 109	0.80**	0.64*	0.28	-1.87**	7.21**	6.42**	-0.44
32	WNC 31702 x Z 489-50	1.41**	0.85**	-0.41*	2.92**	7.05**	-4.49**	-0.22
33	WNC 31702 x Z 485-11	1.22**	0.19	-0.29	-0.27	9.21**	11.48**	0.82
34	BLD 109 x Z 489-50	2.89**	2.04**	-0.59**	1.43**	7.24**	3.48**	0.72
35	BLD 109 x Z 485-11	2.71**	1.70**	-0.81**	0.58	-13.95**	-8.55**	0.69
36	Z 489-50 x Z 485-11	1.32**	0.58*	-0.84**	2.37**	9.90**	7.54**	0.18
	S. E. (s_{ij})	0.18	0.28	0.19	0.45	1.73	1.15	0.68

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Table 3. Continued

	Hybrids	Cob girth	Number of kernel rows on cob	Number of kernels per row	Cob weight per plant	Kernel yield per plant	100 Kernel weight	Shelling percentage
1	BLD 98 x WNC 52348	0.48*	-0.55**	1.16*	9.64*	4.28	3.12**	-2.42**
2	BLD 98 x WNC 40228	-0.54*	0.28	1.66**	14.33**	9.62**	2.91**	-1.35**
3	BLD 98 x BLD 105	-0.15	-0.85**	0.43	1.58	3.44	-0.55	1.72**
4	BLD 98 x WNC 32913	0.09	0.09	1.30*	0.18	4.53	5.45**	3.18**
5	BLD 98 x WNC 31702	0.35	0.12	-2.28**	-1.06	0.32	0.45	0.65
6	BLD 98 x BLD 109	-0.14	0.45*	-0.71	12.21**	13.62**	-4.39**	2.20**
7	BLD 98 x Z 489-50	0.09	0.79**	-1.70**	16.65**	12.92**	1.55**	-0.06
8	BLD 98 x Z 485-11	0.16	-0.35	0.98	-11.91**	-12.56**	2.48**	-1.86**
9	WNC 52348 x WNC 40228	-0.50*	0.80**	3.17**	-12.94**	10.02**	-1.12**	0.40
10	WNC 52348 x BLD 105	-0.57*	-0.61**	1.07*	10.30*	10.13**	1.42**	1.53**
11	WNC 52348 x WNC 32913	-0.3*	-0.46*	-4.79**	-1.42	0.56	2.42**	1.16**
12	WNC 52348 x WNC 31702	-0.60*	-0.57**	-0.84	-9.33*	-6.99*	3.42**	0.36
13	WNC 52348 x BLD 109	-0.69*	2.04**	0.07	-5.73	-8.35*	-0.9	-2.49**
14	WNC 52348 x Z 489-50	0.21	0.51**	-0.99	7.61	4.95	-0.82	-0.92**
15	WNC 52348 x Z 485-11	0.35	0.50**	-2.04**	1.82	0.13	-3.21**	-1.08**
16	WNC 40228 x BLD 105	1.21**	0.36	-0.49	22.00**	20.13**	1.88**	1.70**
17	WNC 40228 x WNC 32913	-0.02	0.10	-0.28	-6.73	-6.11	0.55	-0.44
18	WNC 40228 x WNC 31702	-0.56*	-01.07**	-0.93	-4.64	7.65*	-1.12*	-2.50**
19	WNC 40228 x BLD 109	-0.18	-0.07	-3.02**	11.30**	12.32**	-1.97**	1.51**
20	WNC 40228 x Z 489-50	-1.28**	-0.66**	-0.35	-3.36	-1.72	-0.03	1.02**
21	WNC 40228 x Z 485-11	0.26	-0.61**	0.86	21.85**	17.47**	3.58**	-0.58
22	BLD 105 x WNC 32913	-0.70**	0.03	0.82	17.18**	12.71**	0.76	-0.74*
23	BLD 105 x WNC 31702	-0.24	-0.08	2.30**	15.27**	12.16**	0.42	0.10
24	BLD 105 x BLD 109	-.045	0.53**	1.21*	-1.79	-0.20	-0.42	1.11**
25	BLD 105 x Z 489-50	0.18	-0.20	1.95**	-5.12	-4.23	-3.82**	0.29
26	BLD 105 x Z 485-11	-0.62*	0.52**	-2.51**	19.42**	16.62**	2.79**	0.63
27	WNC 32913 x WNC 31702	-0.73**	-0.33	-0.63	3.55	4.25	-3.24**	0.86*
28	WNC 32913 x BLD 109	0.18	0.01	0.68	4.48	1.22	0.24	-1.57**
29	WNC 32913 x Z 489-50	0.41	-0.59**	1.62**	-11.52**	-8.81*	0.18	0.68
30	WNC 32913 x Z 485-11	-0.18	0.00	0.83	-25.30**	-21.29**	-5.88**	-0.35
31	WNC 31702 x BLD 109	-0.09	0.30	2.37**	-3.09	-4.32	2.24**	-1.19**
32	WNC 31702 x Z 489-50	-0.06	0.37*	-0.96	-8.09	-7.35*	1.18**	-0.15
33	WNC 31702 x Z 485-11	-0.05	0.56**	0.32	-2.55	-1.17	-2.21**	0.59
34	BLD 109 x Z 489-50	0.66**	-1.29**	-2.58**	-10.48**	-7.72*	1.00*	0.86*
35	BLD 109 x Z 485-11	-0.27	-0.30	1.29*	-17.94**	-14.53**	-1.39**	0.40
36	Z 489-50 x Z 485-11	-0.37	0.30	-0.10	26.06**	22.77**	1.55**	0.74*
	S. E. (s_{ij})	0.23	0.18	0.52	4.14	3.37	0.47	0.34

* and ** , significant at 5 and 1 per cent level , respectively

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