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Study of Combining Ability in Diallel Crosses of Maize (*Zea Mays* L.) for Grain Yield and Quality Traits

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***Abstract* — The twenty one maize hybrids generated from 7 x 7 half-diallel cross were evaluated with their parents and two standard hybrid checks *viz.*, HQPM 1 and Ganga safed 2. The analysis of variance for combining ability revealed importance of both additive and non-additive genetic variance with prime importance of non-additive genetic variance for inheritance of all the characters except 100 kernel weight and grain yield. The estimates of *gca* effect revealed that parents PFSR R2-4, GYL 12, GYL 7 and LM 6 were observed to be good general combiners for grain yield. Moreover for protein and starch content, parents GYL 7 and GYL 12 observed to be good general combiners. Among all the crosses, GYL 12 x PFSR 15016-1, GYL 12 x PFSR S3-4 and PFSR S3-5 x GYL 7 were identified as outstanding for grain yield. The cross GYL 12 x PFSR 15016-1 considered the best cross as that recorded significant and desired *sca* effect for the traits ear length, ear girth, number of grains per row, 100 kernel weight and starch content in the seed. While, the cross PFSR 15016-1 x GYL 7 exerted highest significant *sca* in the desirable direction for protein content. Hence, this cross could be used in future breeding programme.**

***Keywords* — GCA, Grain, Protein, SCA, Significant**

I. Introduction

Maize (*Zea mays* L.) is one of the most important cereal crop, contributing to agriculture economy in various ways by finding its utility as a source of food for human being as well as a feed for animals and poultry across the world. It is a crop being commercially exploited extensively fetches the name "queen of cereals". Maize has been proved to yield well in all season; which necessitates the need to develop hybrids suitable for different agro climatic situation. Information on combining ability provides guidelines to the plant breeders in selecting the elite parents and desirable cross combinations and at the same time implies the nature of gene action involved in the inheritance of various traits and thereby helps in formulation of breeding methodology to be used.

II. Material and Methods

The experimental material comprised of seven yellow grained parental inbred lines, their 21 half-diallel crosses and two hybrid checks, HQPM 1 and Ganga safed 2. The seed of 21 hybrids were produced during 2012 by hand pollination. The inbred lines were maintained by sibbing. The experiment comprises 30 entries which comprised of 7 parents LM 6, GYL 12, PFSR 15016-1, PFSR S3-4, PFSR S3-5, GYL 7 and PFSR R2-4; 21 hybrids and two standard hybrid checks. Each plot consisted of two rows of 5 m length with inter and intra row spacing of 60 cm and 20 cm, respectively.15 characters were studied *viz.,* days to 50% tasseling, days to 50% silking, plant height, ear height, days to 75% dry husk, ear length, ear girth, number of rows per ear, number of grains per row, 100 kernel weight, grain yield, protein content and starch content. The observations were recorded on randomly selected five plants and subjected to statistical analysis. Analysis of variance technique suggested by Panse and Sukhatme (1967) was followed to test the differences among the genotypes for all the characters. Combining ability analysis was performed with the data obtained for parents and hybrids according to Model-I, Method-II proposed by Griffing (1956).

III. Results and Discussion

The analysis of variance for combining ability revealed that mean square values due to *gca* and *sca* were significant, accordingly the estimates of both $\sigma^2 gca$ and $\sigma^2 sca$ were significant for all the characters, suggesting an importance of both additive and non-additive genetic variances for the inheritance of all the characters under investigation (Table 1). The value of $\sigma^2 sca$ was higher than $\sigma^2 gca$ for all characters except 100 kernel weight and grain yield. The less than one estimates of potence ratio and below one half estimates of predictability ratio for the characters days to 50% silking, ear height, days to 75% dry husk, number of grain rows per ear, protein content and starch content revealed preponderance of non-additive genetic variance, while for the characters ear length, number of grains per row, 100 kernel weight and grain yield above one estimate of potence ratio and above one half value of predictability ratio suggested prime importance of additive genetic variance. Whereas for the characters days to 50% tasseling, plant height, and ear girth, close to one values of potence ratio indicated equal magnitude of both additive and non-additive genetic variance, but for the said characters values of predictability ratio were less than one half which suggested predominance of non-additive genetic variance. The *gca* effect of parents revealed that for seed yield, parents LM 6, GYL 12, GYL 7 and PFSR R2-4 possessed significant *gca* effect and they were good general combiners (Table 2). The parent LM 6 was also good general combiner for days to 50% silking, ear length, ear girth, number of grains per row and 100 kernel weight in desirable directions. Parent GYL 12 was also observed to be good general combiner for days to 50% tasseling, days to 50% silking, days to 75% dry husk, ear length, ear girth, number of grains per row, 100 kernel weight, protein content and starch content in favorable direction. Parent GYL 7 was also observed to be good general combiner for days to 50% tasseling, days to 50% silking, ear length, ear girth, number of grains per row, 100 kernel weight, protein content and starch content. The GYL 12 x PFSR 15016-1 which had highest sca effect for grain yield also had desirable significant *sca* effect for plant height, ear height, ear length, ear girth, number of grains per row, 100 kernel weight and starch content in the seed. The cross GYL 12 X PFSR S3-4 also showed desirable significant sca effect for grain yield, plant height, ear length, ear girth, number of grain rows per ear, number of grains per row and starch content. Whereas, the cross PFSR S3-5 x GYL 7 had desirable significant sca effect for grain yield, days to 50% tasseling, days to 50% silking, plant height, ear height, ear length, ear girth, number of grains per row, 100 kernel weight and starch content in the seed. These findings were in agreement with those obtained by Devi and Prodhan (2004), Melani and Carena (2005), Iken and Olakojo (2006), Murayaet *al.* (2006), Scapimet *al.* (2006) for grain yield. The single cross PFSR 15016-1 x GYL 7 (0.82), LM 6 x GYL 12 (0.81), and PFSR S3-4 x PFSR R2-4 (0.52) showed positive and significant estimates of *sca* effect for protein content. The results obtained are also correspond with those of Dadheech and Joshi (2007) and Soni (2012).

IV. Conclusion

As a future breeding strategy, improvement of the traits showing preponderance of non-additive gene action could be achieved through some sort of recurrent selection, by way of intermatting the most desirable segregants followed by selection or the use of multiple crosses or biparental matting.

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Author's Profile

Gopal Kuchhadiya is pursuing Ph.D. in Genetics and plant breeding subject at Anand Agricultural University, Anand (Gujarat). For research, he had selected heat and moisture stress tolerance genotypes, make crosses and evaluating them. He had completed M.Sc. (Agri.) in Genetics and Plant Breeding in 2014 at B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). After that he worked for a year in Seed Company during 2015. He had published more than six research papers in different national and international journals on maize, chilli and tobacco for improvement of qualitative as well as quantitative traits.

Table 1: Analysis of variance for combining ability for various characters

Source	d.f.	DT	DS	PH	EH	DDH	EL	EG	GRE	NGR	KW	GY	PC	SC
GCA	6	34.11**	32.17**	1424.65**	251.55**	23.40**	24.23**	3.73**	0.28**	101.16**	51.74**	4093.58**	0.098**	0.42**
SCA	21	14.00**	15.99**	584.46**	233.33**	13.46**	3.77**	1.57**	0.20**	18.88**	4.84**	447.66**	0.22**	1.01**
Error	54	0.50	0.48	33.13	15.18	1.45	0.61	0.14	0.05	2.15	0.21	32.99	0.0019	0.0007
$\delta^2 gca$		3.73**	3.52**	154.61**	26.26**	2.43**	2.63**	0.40**	0.03**	11.00**	5.73**	451.18**	0.010**	0.05**
$\delta^2 sca$		13.50**	15.50**	551.34**	218.15**	12.00**	3.17**	1.43**	0.15**	16.78**	4.63**	414.67**	0.21**	1.01**
Potence Ratio		0.97	0.79	0.98	0.42	0.71	2.90	0.98	0.61	2.30	4.33	3.81	0.17	0.16
Predictability Ratio		0.36	0.31	0.36	0.19	0.29	0.65	0.36	0.26	0.57	0.71	0.68	0.09	0.09

Table 2: General combining ability (*gca*) effect of parents for various characters

Parents	DT	DS	PH	EH	DDH	EL	EG	GRE	NGR	KW	GY	PC	SC
LM 6	-0.37	-0.71**	7.03**	5.53**	-0.07	1.52**	0.29*	0.04	2.96**	0.97**	12.62**	-0.03	-0.05**
GYL 12	-3.37**	-3.41**	10.20**	5.01**	-3.15**	1.31**	0.64**	-0.21**	3.02**	1.19**	13.66**	0.06**	0.32**
PFSR 15016-1	2.11**	1.92**	-9.34**	-3.21**	0.88*	-1.42**	-0.80**	-0.14	-2.89**	-1.20**	-15.73**	0.03*	-0.25**
PFSR S3-4	1.56**	1.48**	-19.92**	-9.22**	1.81**	-1.82**	-0.61**	-0.08	-4.37**	-2.86**	-27.55**	-0.01	-0.23**
PFSR S3-5	1.37**	1.25**	-9.13**	-2.24	-0.12	-1.98**	-0.61**	-0.01	-3.60**	-2.85**	-22.44**	-0.21**	-0.05**
GYL 7	-1.56**	-1.19**	12.16**	0.83	-0.60	1.30**	0.56**	0.06	2.68**	0.91**	12.77**	0.13**	0.24**
PFSR R2-4	0.26	0.66**	9.01**	3.30	1.11**	1.09**	0.54**	0.34**	2.21**	3.84**	26.66**	0.02	0.02*
Range	-3.37 to 2.11	-3.41 to 1.92	-19.92 to 12.16	-9.22 to 5.53	-3.15 to 1.81	-1.98 to 1.52	-0.80 to 0.64	-0.21 to 0.34	-4.37 to 3.02	-2.86 to 3.84	-27.55 to 26.66	-0.21 to 0.13	-0.25 to 0.32
S. E. (gi) +	0.22	0.21	1.78	1.20	0.37	0.24	0.12	0.07	0.45	0.14	1.77	0.013	0.008
CD 5 % (gi)	0.68	0.65	5.48	3.70	1.14	0.74	0.37	0.22	1.39	0.43	5.45	0.04	0.02

*, ** Significant at 5% and 1% levels, respectively. > When both *GCA* and *SCA* were significant then predictability ratio calculated

d.f. = degree of freedom DT = Days to 50% tasselingDS = Days to 50% silking PH = Plant height EH = Ear height DDH = Days to 75% dry husk EL = Ear length EG = Ear girth GRE = Number of grain rows per ear NGR = Number of grains per row KW = 100 kernel weight GY = Grain yield PC = Protein content SC = Starch content

Table 3: Specific combining ability (*sca*) effect of hybrids for various characters

Hybrids/crosses	DT	DS	PH	EH	DDH	EL	EG	GRE	NGR	KW	GY	PC	SC
LM 6 x GYL 12	7.41**	7.16**	24.46**	15.22**	-1.38	-0.06	-0.17	0.08	0.27	0.62	5.74	0.81**	-0.49**
LM 6 x PFSR 15016-1	-2.41**	-2.51**	27.00**	19.57**	0.92	2.01**	0.70*	0.14	4.21**	-2.52**	3.06	-0.07	1.06**
LM 6 x PFSR S3-4	-2.52**	-1.73**	13.97**	11.19**	-2.34*	1.95**	1.24**	0.28	3.32*	-1.87**	3.16	0.007	0.25**
LM 6 x PFSR S3-5	-0.67	-0.84	-15.77**	-16.03**	-0.42	-0.63	-0.52	0.42*	0.17	-1.26**	-3.22	0.25**	-1.13**
LM 6 x GYL 7	-7.74**	-8.06**	-12.77*	-10.94**	-5.60**	-1.04	-0.49	0.28	-1.57	2.21**	7.89	0.09*	-0.78**
LM 6 x PFSR R2-4	2.44**	2.42**	21.98**	17.46**	0.69	0.84	0.30	-0.46*	1.54	3.30**	19.58**	0.30**	-0.56**
GYL 12 x PFSR 15016-1	0.26	0.19	30.64**	17.69**	2.14*	1.95**	1.59**	0.19	6.79**	4.63**	46.22**	-0.37**	0.93**
GYL 12 x PFSR S3-4	0.81	0.31	15.61**	0.10	1.88	2.75**	1.53**	0.87**	7.03**	0.78	33.38**	-0.19**	1.43**
GYL 12 x PFSR S3-5	-3.33**	-3.47**	29.56**	17.85**	0.81	1.64*	1.37**	0.34	2.42	-1.68**	1.52	-0.33**	0.77**
GYL 12 x GYL 7	-0.74	-0.69	-19.93**	-17.76**	-4.38**	-2.83**	-2.17**	-0.47*	-7.06**	-2.41**	-39.94**	-0.08*	-0.62**
GYL 12 x PFSR R2-4	2.78**	2.79**	-17.19**	-12.03**	3.92**	0.11	-0.38	-0.48*	0.98	-0.29	1.82	0.38**	-0.09**
PFSR 15016-1 x PFSR S3-4	-2.67**	-2.36**	-13.72**	-6.48	-0.16	-2.35**	-0.76*	-0.21	-4.36**	1.64**	-9.81	0.005	-0.34**
PFSR 15016-1 x PFSR S3-5	1.52*	1.86**	-24.23**	-15.39**	0.77	-0.79	1.06**	-0.21	0.36	0.05	1.70	0.29**	-0.85**
PFSR 15016-1 x GYL 7	-2.22**	-3.03**	29.34**	16.33**	-0.08	4.00**	1.37**	0.12	4.22**	-1.41**	8.39	0.82**	-0.43**
PFSR 15016-1 x PFSR R2-4	-2.04**	-2.55**	-13.65**	-9.40**	-2.45*	-0.29	0.42	0.11	0.79	-1.96**	-7.51	-0.03	-0.54**
PFSR S3-4 x PFSR S3-5	1.07	0.97	-25.60**	-15.84**	-0.82	-0.55	1.15**	-0.40	-2.26	-2.13**	-12.16*	-0.44**	0.65**
PFSR S3-4 x GYL 7	-3.00**	-3.92**	6.78	5.88	-7.01**	0.50	1.38**	-0.01	1.53	-0.30	0.42	0.20**	-0.53**
PFSR S3-4 x PFSR R2-4	-2.81**	-2.77**	-10.08	-7.79*	-4.71**	0.25	-0.40	-0.01	-0.37	-3.11**	-19.14**	0.52**	-2.08**
PFSR S3-5 x GYL 7	-1.48*	-1.69**	38.20**	25.43**	0.25	1.73*	2.01**	0.39	6.98**	0.98*	30.04**	-0.62**	1.52**
PFSR S3-5 x PFSR R2-4	0.37	-0.55	8.48	6.83	-0.79	0.34	1.07**	0.92**	-0.31	-0.83*	-3.12	0.06	-0.28**
GYL 7 x PFSR R2-4	2.30**	5.90**	8.58	0.75	4.03**	1.56*	0.50	0.25	1.94	2.30**	25.25**	0.32**	0.17**
Range of SCA effect	-7.74 to 7.41	-8.06 to 7.16	-25.60 to 38.20	-17.76 to 25.43	-7.01 to 4.03	-2.83 to 4.00	-2.17 to 2.01	-0.48 to 0.92	-7.06 to 7.03	-3.11 to 4.63	-39.94 to 46.22	-0.62 to 0.82	-2.08 to 1.52
Total significant cross	15	15	17	16	09	10	13	06	08	16	08	16	21
Positive	05	05	09	08	03	08	09	03	06	06	05	10	8
Negative	10	10	08	08	06	02	04	03	02	10	03	6	13
S. E. (S_{ij}) ±	0.63	0.63	5.16	3.50	1.08	0.70	0.34	0.20	1.31	0.41	5.15	0.039	0.03
CD @ 5 % (Sij)	1.80	1.80	14.75	10.00	3.09	2.00	0.97	0.57	3.74	1.17	14.72	0.11	0.09

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