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Research Article

COMBINING ABILITY ANALYSIS OF F_1 AND F_2 GENERATION OF TEN PARENT HALF DIALLEL IN BREAD WHEAT (*Triticum aestivum* L. em. Thell)

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Abstract- To increase the production and productivity in wheat cultivation, new set of varieties having good combining ability are required. Because, the choice of the most suitable breeding method depends mainly on the combining ability behaviour *vis-a-vis* nature of gene action involved in the control of the trait of interest to the breeder. Therefore, the present research investigation was carried out with 10 parent half diallel set consisting of parents, F_1's and F_2's to estimate the general and specific combining ability variances and effect. An overall appraisal revealed that parent Raj 3777, Raj 4037, Raj 4120 and Raj 4083 were most desirable parents while among the crosses, the cross WH 1021 x Raj 3777 emerged as good specific cross combinations for grain yield and its contributing attributes as they showed significant and high gca and sca effects for most of the characters under study.

Keywords- Wheat, Combining Ability, Half Diallel, GCA, SCA.

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Introduction

Wheat (*Triticum* spp.) is a cereal grain, originally from the Levant region of the Near East and Ethiopian High lands, but now cultivated worldwide. The north-western end of Indian subcontinent, the fold between Hindukush and Himalaya is regarded as the secondary centre of origin of hexaploid wheat [1]. Among the three main species of the genus Triticum i.e. bread wheat (*Triticum aestivum*), macaroni wheat (*Triticum turgidum* var. durum) and *Triticum dicoccum*, bread wheat is being cultivated on maximum area of about 95 per cent. Among cereals it is the most important food grain crop and stands next to rice in India. Increased yield of crops had been a prime concern in breeding programmes. Wheat breeding programmmes mostly involve hybridization, evaluation and selection of desirable genotypes. The assessment of combining ability and determining gene action are elementary tools for selection of ideal genotypes. Advancement in the yield of this important crop species requires adequate information regarding the nature of combining ability of the parents available in a wide array of genetic material to be used in the hybridization programme and also the nature of gene actions involved in the expression of quantitative and qualitative traits of economic importance. Diallel mating design has been extensively used to analyze the combining ability effects of wheat genotypes and also to provide information regarding genetic mechanism controlling grain yield and other traits [2].Therefore, the present research investigation was carried out to understand the effect of yield contributing attributes under high temperature conditions and identification of tolerant genotypes suitable for such environments.

Material and Method

Material for the present investigation comprised ten genetically diverse bread wheat (*Triticum aestivum* L. em. Thell.) varieties, namely: Raj 3765, WH 1021, Raj 3777, Raj 4037, Raj 4120, PBW 343, Raj 4083, Raj 4238, DBW 17 and PBW 550. These varieties were crossed in all possible combinations excluding reciprocals (*Rabi* 2013-14). After advancing the generation (*Rabi* 2014-15), ten genotypes along with their 45 F_1's and 45 F_2's progenies were evaluated in timely sown condition, with 3 replications at Agricultural Research Farm of RARI Durgapura. Row length was 3 meter. Row to row and plant to plant distance was kept 30 cm and 10 cm, respectively. Observations were recorded for days to heading (75%), days to maturity (75%), grain filling period (days), plant height (cm), flag leaf area (cm^2), peduncle area (cm^2), and grain yield per plant (g) on 10 randomly selected plants in each of the F_1's progenies along with each parent while 30 plants were selected in F_2's population from each replication. Mean values over selected plants was used for analysis of combining ability following Griffing's Method II Model I.[3]

Flag Leaf area (cm^2) = Length x breadth (maximum) x 0.79

Peduncle area (cm^2) = Peduncle length x Peduncle diameter x 3.1416

Result and Discussion

Estimation of combining ability of the parents is requisite to recognize superior parental combinations that can yield useful segregants. It has been established from the prior studies that different parental combinations perform non-identically i.e. superiority of different parental combinations vary cross to cross. Some combinations possess superior progeny while others produce inferior. Therefore, combining ability analysis is a convenient approach to fulfill this objective.

The combining ability analysis revealed significant mean squares due to GCA and SCA for all the characters in F_1 and F_2 generations except spike area in F_2 generation [Table-1]. The significant differences of GCA and SCA indicated that both additive and non-additive gene effects played an important role in the genetic control of the traits under study. [4-14]

The GCA / SCA variance ratio was less than unity indicated the importance of non-additive gene action for all the characters under investigation except for F_1 generation of days to maturity, where predictability ratio was more than unity, which showed preponderance of additive gene action [Table-1][15,16]. The role of additive gene effect in controlling days to maturity [6] has also been established. The preponderance of non-additive genetic variance for most of the characters indicated that the best cross combinations might be selected on the basis of SCA for further tangible advancement in wheat. Joshi and Dhawan [17] and Dhaliwal and Singh [18] discussed the importance of combining ability analysis in selection of parental lines in self-pollinated crops where GCA effects are more pronounced. An appreciable progress could be achieved through conventional breeding methods such as pedigree and bulk method when GCA effects or additive gene action is preponderant. But for the traits where non-additive gene effects are more pronounced, some kind of recurrent selection e.g. diallel selective mating [19] or bi-parental mating in early generations might prove to be effective breeding approach.

The gca estimates of the parents indicated that, WH 1021 was good general combiner for days to maturity and grain yield per plant; Raj 3777 for days to maturity, grain filling period, flag leaf area and peduncle area; Raj 4037 for days to maturity, grain filling period and plant height; Raj 4120 for days to maturity, grain filling period and flag leaf area and Raj 4083 for days to heading, days to maturity and grain filling period [Table-2]. Therefore, these parents have good potential and may be used in synthesizing a dynamic population with most of the favorable genes accumulated. Since GCA effects are attributed to additive and additive × additive gene effects, the above mentioned parents have good potential for perspective characters and may be used in a multiple crossing programme to synthesize a dynamic population with most of the favorable genes accumulated [3]. However, there is still further scope for improving the combining ability for component traits, as none of the high combiners for grain yield was a high combiner or at least an average combiner for all the desirable traits. In bread wheat, parents having good general combining ability have been reported earlier by several workers [20-22].

Table-1 *Analysis of variance for general and specific combining ability for yield and its contributing attributes*

Character	Source of variation							
	GCA (df = 9)		SCA (df = 45)		Error (df =110)		GCA/SCA	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
Days to heading	25.13**	20.19**	8.61**	6.25**	1.58	1.25	0.28	0.32
Days to maturity	119.4**	121.16**	9.88**	13.91**	1.7	1.14	1.2	0.78
Grain filling period	105.65**	89.68**	18.86**	18.87**	3.81	3.03	0.56	0.46
Plant height	70.95**	40.23**	8.94**	8.8**	0.97	1.84	0.73	0.46
Flag leaf area	18.54**	26.06**	8.1**	5.37**	2.52	2	0.24	0.6
Peduncle area	13.86**	10.61**	9.08**	9.48**	4.08	4.95	0.16	0.1
Grain yield per plant	16.07**	12.41**	9.34**	12.03**	2.86	1.87	0.17	0.09

Table-2 *Estimates of general combining ability effects for yield and its contributing attributes*

Parents	Days to heading		Days to maturity		Grain filling Period		Plant Height		Flag Leaf Area		Peduncle Area		Grain yield per plant	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2		
GCA effects														
P1	-1.9**	-2.12**	-0.55	-0.59*	1.35*	1.53**	-0.17	-0.36	-0.29	-0.32	0.03	0.01	0.23	0.17
P2	-1.21**	-1.29**	1.31**	0.93**	2.52**	2.22**	4.33**	2.74**	-0.95*	-0.09	1.21*	0.93	1.36**	0.76*
P3	0.85*	0.1	-2.11**	-1.84**	-2.96**	-1.94**	3.28**	3.18**	2.72**	2.87**	1.99**	1.78**	0.17	0.64
P4	-0.23	0.35	-3.49**	-3.82**	-3.26**	-4.17**	-0.88**	-1.15**	-1.48**	-0.88*	-0.91	-0.6	0.47	0.27
P5	0.27	-0.54	-3.19**	-2.62**	-3.46**	-2.08**	0.54*	0.89*	1.39**	1.48**	0.65	0.55	-0.67	-0.95*
P6	3.43**	2.57**	3.84**	4.29**	0.41	1.72**	0.83**	0.31	-0.22	0.66	0.12	0.29	0.63	0.79*
P7	-0.96**	-0.9**	-3.38**	-3.82**	-2.43**	-2.92**	0.06	-0.52	0.3	0.36	-1.3*	-1.47*	0.86	-0.11
P8	-0.46	0.52	0.06	0.38	0.52	-0.14	-2.02**	-1.21**	-0.1	-0.23	-1.38*	-0.91	-0.7	-0.55
P9	0.16	0.63*	1.98**	1.74**	1.82**	1.11*	-3.02**	-2.63**	-0.3	-1.59**	-0.33	-0.29	-2.76**	-2.23**
P10	0.04	0.68*	5.53**	5.35**	5.49**	4.67**	-2.96**	-1.25**	-1.08*	-2.26**	-0.09	-0.3	0.43	1.19**
SE (gi)±	0.34	0.31	0.36	0.29	0.53	0.48	0.27	0.37	0.44	0.39	0.55	0.61	0.46	0.37
SE (gi-gj)±	0.51	0.46	0.53	0.44	0.8	0.71	0.4	0.55	0.65	0.58	0.82	0.91	0.69	0.56
Parents	Days to heading		Days to maturity		Grain filling Period		Plant Height		Flag Leaf Area		Peduncle Area		Grain yield per plant	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2		

P1=Raj 3765; P2=WH 1021; P3=Raj 3777; P4=Raj 4037; P5Raj 4120; P6=PBW 343; P7=Raj4083; P8=Raj4238; P9=DBW 17; P10=PBW 550

Cross 2x4 and 3x6 are desirable for days to heading, 9x10, 6x8 and 1x7 for days to maturity, 6x10 for grain filling period, 2x4 for plant height, 1x2 for flag leaf area, 1x6 and 4x5 for peduncle area, 7x10 for grain yield per plant, as these crosses attained high significant sca effect in both the generations and were included in top three parents for respective characters [Table-4]. Cross combinations with significant and high sca effects in both the generations for more than one character were 1x6 for peduncle area and grain yield, 1x7, 4x5, 6x10 and 9x10 for days to maturity and grain filling period, 1x10 and 2x6 for days to heading and grain yield, 6x8 for days to heading, days to maturity and grain filling period 2x3 for days to heading, plant height, flag leaf area, peduncle area and grain yield per plant [Table-3]. An overall appraisal revealed that the cross WH 1021 x Raj 3777 emerged as good specific cross combinations for grain yield and its contributing attributes as it showed significant and high sca effects in both the generations for most of the characters under study.

Conclusion

It may be concluded that for improving wheat, both additive and dominant gene action have to be exploited by adopting adequate breeding strategies *viz.,* biparental mating, diallel selective mating and reciprocal recurrent selection.

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Conflict of Interest: None declared

Table-3 *Estimates of specific combining ability effects for yield and its contributing attributes*

cross	Days to heading		Days to maturity		Grain filling Period		Plant Height		Flag Leaf Area		Peduncle Area		Grain yield per plant	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F1	F2
P1xP2	-0.12	1.07	-0.94	-2.81**	-0.82	-3.87*	-2.02*	-3.55**	6.13**	3.21*	3.11	3.76	-5.82**	-7.71**
P1xP3	-1.17	0.01	-2.52	-1.69	-1.35	-1.71	-1.01	-3.82**	-0.09	-0.24	-2.29	-1.56	2.05	0.4
P1xP4	-3.42**	-2.24*	-2.13	-2.39*	1.29	-0.15	-1.49	1.56	-1.58	-0.98	1.72	0.67	-0.7	-1.73
P1xP5	0.41	-0.68	-1.44	-2.92**	-1.85	-2.23	0.59	0.72	-3.83*	-2.84*	-3.62	-3.93	-1.43	-0.29
P1xP6	3.91**	-1.13	5.2**	7.17**	1.29	8.3**	-2.02*	2.89*	-1.62	-1.19	7.08**	5.61**	4.36**	5.53**
P1xP7	-0.7	-1.99	-4.91**	-7.06**	-4.21*	-5.07**	1.54	2.08	-0.84	1.61	0.08	2.38	-1.05	-0.74
P1xP8	-2.87*	-1.41	4.65**	7.42**	7.52**	8.82**	0.06	0.27	3.37*	1.35	-1.19	-3.43	0.21	-1.22
P1xP9	-1.48	-0.52	-1.94	-2.94**	-0.46	-2.43	3.75**	-3.16*	0.33	-2.03	-1.62	-0.27	-0.16	2.11
P1xP10	-5.04**	-2.24*	4.84**	6.44**	9.88**	8.68**	0.37	-1.21	-2.19	1.51	-0.54	-2.01	3.96*	3.96**
P2xP3	-3.87**	-2.49*	-0.05	-0.89	3.82*	1.6	-9.09**	-5.32**	-3.74*	-1.79	5.8**	5.43**	5.14**	3.51**
P2xP4	-6.45**	-6.07**	-0.33	1.75	6.13**	7.82**	6.17**	1.21	-1.93	-0.62	-3.01	-3.9	2.06	3.27*
P2xP5	-1.29	-2.18*	-0.96	-2.11*	0.32	0.07	-2.62**	-2.31	0.42	1.42	0.2	0.42	3.94*	4.09**
P2xP6	-4.79**	-2.3*	2.01	2.31*	6.79**	4.6**	1.17	-4.64**	-0.96	-1.59	2.22	0.6	3.8*	3.06*
P2xP7	-1.06	-0.49	-4.1**	-0.58	-3.04	-0.09	1.15	1.67	0.32	0.95	-1.49	-2.75	0.61	0.8
P2xP8	2.1	0.76	0.12	-1.44	-1.98	-2.21	2.59**	3.67**	2.64	4.4**	-1.7	-0.98	1.81	1
P2xP9	1.49	1.65	2.54*	5.19**	1.04	3.55*	3.1**	2.39	-0.12	2.26	-4.03*	-5.31*	0.08	-1.85
P2xP10	3.6**	1.59	3.31**	-0.75	-0.29	-2.34	3.95**	1.68	-0.96	-2.16	-4.18*	-2.87	0.96	3.12*
P3xP4	4.16**	2.54*	-1.91	-1.14	-6.07**	-3.68*	3.03**	-1.88	-4.12**	-4.24**	2.51	1.83	-0.95	-1.72
P3xP5	2.99*	0.09	-2.88*	-1.33	-5.87**	-1.43	1.66	1.14	2.55	-1.36	0.36	-0.57	1.22	2.29
P3xP6	-5.84**	-3.35**	1.76	0.08	7.6**	3.43*	2.32*	-1.61	0.81	2.11	-5.96**	-3.77	-3.57*	-3.81**
P3xP7	1.55	-0.88	0.65	-1.14	-0.9	-0.26	2.89**	1.68	-3.29*	-0.95	-0.29	-1.12	-1.78	-2
P3xP8	-1.95	-0.96	1.87	1.67	3.82*	2.63	0.82	4.01**	-0.26	0.79	-0.11	-0.59	1.2	4.23**
P3xP9	-1.56	-2.41*	-3.05*	-1.69	-1.48	0.71	4.74**	2.55*	2.98*	2.42	2.43	1.88	-1.79	-1.78
P3xP10	-0.45	0.54	4.06**	5.69**	4.52*	5.16**	-2.4**	2.63*	-1.37	-1.85	0.38	-1.01	3.5*	4.89**
P4xP5	1.74	-0.49	-2.83*	-3.69**	-4.57*	-3.21*	1.57	7.63**	0.38	-0.69	4.25*	6.13**	-0.2	0.18
P4xP6	4.58**	3.73**	3.15*	1.39	-1.43	-2.34	3.82**	0.71	0.08	0.42	-4.63*	-4.62*	-3.62*	-2.05
P4xP7	-2.04	2.54*	0.04	1.17	2.07	-1.37	-3.96**	-3.59**	-2.85	-2.69*	-1.45	-1.21	1.83	1.7
P4xP8	0.46	2.12*	-1.41	0.64	-1.87	-1.48	-3.65**	-3.81**	-1.08	0.01	1.48	3.37	1.68	2.49
P4xP9	3.52**	2.34*	1.67	0.28	-1.85	-2.07	1.02	0.24	0.83	3.46**	-2.67	-4.05	-2.83	-5.08**
P4xP10	-1.04	1.62	2.12	-0.33	3.15	-1.96	-1.05	-0.93	3.29*	1.61	2.56	2.36	2.95	1.48
P5xP6	-2.59*	-3.71**	0.84	2.53*	3.43	6.24**	-0.91	-1.64	-4.16**	-3.94**	-1.75	-1.03	-1.02	-3.25*
P5xP7	0.8	2.76**	0.4	0.64	-0.4	-2.12	0.12	-1.4	0.51	1.13	-0.44	-1.48	-0.5	-2.02
P5xP8	-0.37	0.01	-0.38	0.11	-0.01	0.1	0.35	-1.51	0.08	-1.41	-0.59	-0.91	-1.32	-3.63**
P5xP9	-1.31	-0.77	5.7**	4.08**	7.02**	4.85**	-1.7	1.33	-0.85	-0.48	2.78	2.28	3.5*	5.69**
P5xP10	-0.2	4.18**	1.15	5.14**	1.35	0.96	3.71**	-3.02*	-1.83	2.65*	4.24*	2.7	-4.27**	-5.12**
P6xP7	-0.04	-0.68	-1.3	-1.28	-1.26	-0.59	-1.11	0.06	-4.03**	-3.74**	2.56	1.79	-1.99	-2.47
P6xP8	-2.54*	-0.1	-5.74**	-6.47**	-3.21	-6.37**	-2.77**	-3.22*	-0.96	2.15	1.35	-0.42	1.75	0.63
P6xP9	1.52	0.46	-0.33	0.83	-1.85	0.38	-0.87	0.56	2.37	1.13	-2.52	-2.29	0.08	1.04
P6xP10	3.3**	3.4**	-3.21**	-1.78	-6.51**	-5.18**	2.4**	3.63**	-2.69	-2.15	2.13	3.84	-0.91	-0.01
P7xP8	2.19	1.37	-1.85	-3.69**	-4.04*	-5.07**	3.17**	-0.75	-1.03	-0.11	3.06	3.03	3	0.74
P7xP9	-0.42	1.59	5.9**	5.28**	6.32**	3.68*	0.26	-1.55	0.75	-2.21	-0.54	-0.94	4.71**	6.95**
P7xP10	1.02	-0.46	4.01**	4.33**	2.99	4.8**	-1.42	-1.11	5.12**	1.77	2.44	2.14	5.02**	2.14
P8xP9	-1.59	2.18*	1.79	3.08**	3.38	0.91	2.18*	2.53*	-1.17	-1.56	3.37	5.53**	0.66	0
P8xP10	0.52	-1.88	-1.1	-1.53	-1.62	0.35	0.23	1.8	3.89**	0.16	1.7	2.22	-1.5	2.98*
P9xP10	-1.09	-1.32	-7.35**	-9.56**	-6.26**	-8.23**	-1.39	4.54**	1.61	-0.57	0.14	-0.77	-1.19	-2.75*
SE (Sij)±	1.16	1.03	1.2	0.98	1.8	1.6	0.91	1.25	1.46	1.3	1.86	2.05	1.56	1.26
SE (Sij-Sik)±	1.7	1.51	1.77	1.45	2.64	2.36	1.33	1.84	2.15	1.92	2.73	3.01	2.29	1.85
SE (Sij-Ski)±	2.64	2.08	2.84	1.9	6.36	5.06	1.61	3.07	4.21	3.34	6.8	8.26	4.77	3.11

P1=Raj 3765; P2=WH 1021; P3=Raj 3777; P4=Raj 4037; P5Raj 4120; P6=PBW 343; P7=Raj4083; P8=Raj4238; P9=DBW 17; P10=PBW 550

Table-4 *Top three of the parents, F_1's and F_2's for their GCA and SCA estimates for yield and its contributing attributes*

Characters	GCA		SCA	
	F_1	F_2	F_1	F_2
Days to heading	RAJ 3765	RAJ 3765	WH 1021 × RAJ 4037	WH 1021 × RAJ 4037
	WH 1021	WH 1021	RAJ 3777 × PBW 343	RAJ 4120 × PBW 343
	RAJ 4083	RAJ 4083	RAJ 3765 × PBW 550	RAJ 3777 × PBW 343
Days to maturity	RAJ 4037	RAJ 4037	DBW 17 × PBW 550	DBW 17 × PBW 550
	RAJ 4083	RAJ 4083	PBW 343 × RAJ 4238	RAJ 3765 × RAJ 4083
	RAJ 4120	RAJ 4120	RAJ 3765 × RAJ 4083	PBW 343 × RAJ 4238
Grain filling period	RAJ 4120	RAJ 4037	PBW 343 × PBW 550	DBW 17 × PBW 550
	RAJ 4037	RAJ 4083	DBW 17 × PBW 550	PBW 343 × RAJ 4238
	RAJ 3777	RAJ 4120	RAJ 3777 × RAJ 4037	PBW 343 × PBW 550
Plant height	DBW 17	DBW 17	WH 1021 × RAJ 4037	WH 1021 × RAJ 4037
	PBW 550	PBW 550	RAJ 4037 × RAJ 4083	WH 1021 × PBW 343
	RAJ 4238	RAJ 4238	RAJ 4037 × RAJ 4238	RAJ 3755 × RAJ 3777
Flag leaf area	RAJ 3777	RAJ 3777	RAJ 3765 × WH 1021	WH 1021 × RAJ 4238
	RAJ 4120	RAJ 4120	RAJ 4083 × PBW 550	RAJ 4037 × DBW 17
	RAJ 4083	PBW 343	RAJ 4238 × PBW 550	RAJ 3765 × WH 1021
Peduncle area	RAJ 3777	RAJ 3777	RAJ 3765 × PBW 343	RAJ 4037 × RAJ 4120
	WH 1021	WH 1021	WH 1021 × RAJ 3777	RAJ 3765 × PBW 343
	RAJ 4120	RAJ 4120	RAJ 4037 × RAJ 4120	RAJ 4238 × DBW 17
Grain yield per plant	WH 1021	PBW 550	WH 1021 × RAJ 3777	RAJ 4083 × DBW 17
	RAJ 4083	PBW 343	RAJ 4083 × PBW 550	RAJ 4120 × DBW 17
	PBW 343	RAJ 3777	RAJ 4083 × DBW 17	RAJ 3765 × PBW 343

Abbreviations:

GCA- General Combining Ability
SCA- Specific Combining Ability
g - Gram
cm - Centimeter
% - per cent
P1 - Raj 3765
P2 - WH 1021
P3 - Raj 3777
P4 - Raj 4037
P5 - Raj 4120
P6 - PBW 343
P7 - Raj 4083
P8 - Raj 4238
P9 - DBW 17
P10 - PBW 550

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