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Original Research Article

Heterotic Capablity of Eight Crosses for Quantitative and Qualitative Traits in Wheat (*Triticum aestivum* L.) With Inbreeding Depression Studies

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A B S T R A C T

The present experiment based on "Heterosis and Inbreeding depression of Grain Yield and It's Components Traits In Wheat Over The Environments" was carried out during rabi season at two locations. The study was on eight crosses comprising 56 treatments of wheat using randomized block design with three replications. The eight crosses *viz.*, AKW-619 X DBW-31, AKAW-3997 X AKAW-3722, HI-1418 X LOK-54, AKAW-3997 X NIAW-34, DL-788-2 X AKAW-3722, AKAW-2978-12 X PHS-O722, GW-496 X NIAW-301 and GW-496 X AKAW-4651. Analysis of Variance revealed highly significant differences among the wheat genotypes for all the characters *viz.*, Plant height, no of tillers per plant, no of spiklets per spike, no of grains per spike, grain weight per earhead, grain yield per plant (g), Days to heading, Protein content(%), Sedimentation value (ml), Beta carotene content (ppm) and 1000 seed wt.(g). In case of plot basis observations, the characters were mostly governed by dominance gene effects. Significance of dominance effects in days to heading, sedimentation value (ml) in Akola environmental condition and for Days to heading. The extent of heterosis and inbreeding depression to determine the heritability along genetic advance and to estimate the maternal effects on yield and it's contributing characters. The highest heterosis over mid parent recorded for no of tillers per plant and over better parent recorded for days to heading while inbreeding depressions for all characters found to be negative.

Keywords

Quantitative and Qualitative Traits in Wheat (*Triticum aestivum* L.)

Introduction

Wheat is the most widely consumed cereal crop of the world in the variety of forms. Globally demand for wheat by the year 2050 is forecasted around 900 million tones and the world population is estimated around 9 billion. This target will be achieved only if global wheat production is increased by 2.5 per cent per annum. This can be achieved with the help of various plant breeding programs.

The main objective of plant breeding program is to improve yield either by evolving high yielding varieties or hybrids. The knowledge of gene action of quantitative character helps in selection of parents for use in the hybridization program and also in the choice of appropriate breeding procedure for various quantitative characters. Estimation of various genetic components of variances is used as a measure of gene action as well as it is essential to plant breeder for starting judicious breeding program. However, cross combination with high heterosis with low inbreeding depression in conjunction with

high heritability and high genetic advance could be prove useful for the development of better segergants.

Materials and Methods

The study based on eight crosses comprising 56 treatments of wheat using randomized block design with three replications. The eight crosses *viz.*, AKW-619 X DBW-31, AKAW-3997 X AKAW-3722, HI-1418 X LOK-54, AKAW-3997 X NIAW-34, DL-788-2 X AKAW-3722, AKAW-2978-12 X PHS-O722, GW-496 X NIAW-301 and GW-496 X AKAW-4651

The eight wheat crosses were planted on Rabi 2011 at Wheat Research Institute Unit, Dr. P.D.K.V, Akola (M.S). Recommended agronomical practices were followed from sowing to maturity of the crop. The data were recorded on plot basis viz. days to heading, 1000 grains weight (g), protein content (%), sedimentation value (ml) and beta carotene (ppm), while six another characters, which are recorded on plant basis viz. plant height (cm), numbers of tillers per plant, number of spikeletes per spike, grain weight per earhead (g) and grain yield per plant (g) etc. were studied. The average data of each character was analyzed as per the procedure suggested by Panse and Sukhatme (1985)

Results and Discussion

Heterosis and Inbreeding Depression

Data presented in Table 2, 3 & 4 Cross-I, AKW-619 x DBW-31 exhibited highest significant heterosis and heterobeltiosis with significant in breeding depression for protein content, number of spikeletes per spike and grain weight per earhead. However, significant heterosis, heterobeltiosis with low in breeding depression for sedimentation value, β-carotene content, number of tillers per plant, number of grains per spike and grain yield per plant.

The Cross-II, AKAW-3997 x AKAW-3722 also exhibited highest significant heterosis and heterobeltiosis with low in breeding depression for β-carotene content. However, significant heterosis, heterobeltiosis and low in breeding depression were recorded for 1000 seed weight, protein content, sedimentation value, plant height, number of tillers per plant, number of spikeletes per spike, number of grains per spike, grain weight per earhead and grain yield per plant.

In third Cross, HI-1418 x Lok-54, exhibited highest significant heterosis and heterobeltiosis with low in breeding depression for 1000 seed weight, sedimentation value, β-carotene content, plant height, number of tillers per plant, number of spikeletes per spike, number of grains per spike, grain weight per earhead and grain yield per plant. The Cross-IV, AKAW-3997 x NIAW-34 reported highest significant heterosis and heterobeltiosis with low inbreeding depression for grain yield per plant. However, significant heterosis and heterobeltiosis but non-significant inbreeding depression recorded in days to heading, 1000 seed weight, protein content, number of spikeletes per spike, number of grains per spike and grain weight per earhead.

The Cross-V, DL-788-2 x AKAW-3722, exhibited significant heterosis, heterobeltiosis and inbreeding depression for number spikeletes per spike. However, significant heterosis and heterobeltiosis with non-significant inbreeding depression recorded in 1000 seed weight, protein content, number of grains per spike grain weight per earhead and grain yield per plant.

Table.1 Average Heterosis (H1), Heterobelteosis (H2) and inbreeding depression for different characters on Plot basis character in Akola environmental conditions

Environment	Akola														
Crosses	Days to heading			1000 seed wt			Protein content			Sedimentation value			Beta carotene content		
	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID
Cross I	-2.35	-2.68	0.00	6.83	5.59	0.37	22.49*	21.13*	11.54*	14.6*	13.33*	9.80*	39.83*	33.61*	-5.39
Cross II	-3.87	-3.87	0.00	35.02*	32.25*	0.65	19.51*	17.08*	1.23	-14.58*	-16.32*	3.65	44.85*	34.56*	-8.14
Cross III	-1.34	-2.64	0.00	34.53*	25.12*	14.99*	6.30	1.86	-1.36	-7.36*	-8.33*	0.00	40.67*	25.99*	-0.57
Cross IV	-7.97*	-11.24*	0.66	19.39*	15.29*	1.01	14.69*	11.65*	4.47	3.50	0.00	0.84	29.50	10.31	-31.95*
Cross V	-0.65	-3.2	3.97	25.23*	19.08*	3.79	7.74*	7.52*	5.31	-1.92	-13.55*	0.00	15.96	1.69	-5.12
Cross VI	-4.05	-4.93*	-1.29	15.61*	15.45*	3.98	13.10*	9.57*	2.63	-0.46	-9.4*	8.49*	38.12*	33.78*	9.32
Cross VII	-4.26	-4.57	-6.16*	19.07*	18.11*	4.15	4.83	3.78	-6.90*	18.32*	14.14*	2.65	51.07*	24.61*	4.97
Cross VIII	-5.61*	-7.14**	-1.39	36.79*	33.28*	11.94*	4.33	3.92	5.29	7.29*	1.98	-3.88	20.78	19.58	-9.45

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Environment	Akola																	
Crosses	Plant height			No of tillers per plant			No of spikletes per spike			No of grains per spike			Grain Wt			Grain yield per plant		
	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID	MP	BP	ID
Cross I	2.71	2.18	-6.22**	11.32**	9.66**	3.95*	64.35**	62.87**	20.09**	22.34**	12.19**	15.18**	40.26**	35.42**	1.74	13.91*	7.76*	1.11
Cross II	5.06*	-2.06	1.76	14.55**	10.18**	2.36	50.15**	48.76**	29.87**	23.93**	12.42**	1.15	18.82**	17.65**	5.95	6.96*	6.64*	3.73
Cross III	17.12**	14.62**	3.24*	27.69**	24.34**	9.33*	56.52**	52.72**	27.24**	52.13**	47.53**	5.56	27.71**	25.56**	10.86**	13.97*	13.56*	3.04
Cross IV	10.74**	7.98**	-3.82*	10.33**	-0.30	16.71*	44.60**	42.55**	7.13	16.99**	16.77**	2.70	29.27**	28.19**	1.39	14.63*	13.5*	6.33*
Cross V	0.82	-5.33**	-3.18	5.88*	4.30	1.90	37.37**	36.91**	11.92**	17.58**	16.57**	2.56	9.98*	9.40*	1.97	9.03*	6.54*	4.49
Cross VI	4.65*	-2.40	1.13	16.88**	12.5**	2.32	33.75**	26.62**	5.91	26.91**	23.63**	20.62**	13.85**	13.23**	2.31	13.8*	9.6*	5.22*
Cross VII	2.77	-1.88	5.39**	7.46**	5.73**	4.07*	51.79**	44.52**	3.16	31.55**	40.68**	17.27**	15.89**	22.45**	3.95	10.69*	7.25*	1.07
Cross VIII	6.47**	6.45**	7.4**	11.69**	9.63**	1.8	30.96**	24.32**	12.5**	19.81**	17.45**	3.22	3.23	2.48	-5.8	10.4*	7.54`1*	2.42

Table.2 Promising heterotic crosses with Inbreeding depression for different characters in Wheat

Sr. no	Characters	Range of Heterosis over		Inbreeding Depression	Desirable Cross combination		
		Mid Parent	Better Parent		Mid Parent	Better Parent	ID
1	Days to heading	-7.97 to -1.34	-11.24 to -2.68	-6.16 to 3.97	Cross- IV AKAW-3997 x NIAW-34	Cross- IV AKAW-3997 x NIAW-34	Cross- VII GW-496 x NIAW-301
2	1000 seed wt.	6.83 to 36.79	5.59 to 33.28	0.37 to 14.99	Cross -VIII (GW-496 x AKAW-4651)	Cross -VIII (GW-496 x AKAW-4651)	Cross -VIII (GW-496 x AKAW-4651)
3	Protein Content (%)	4.33 to 22.49	1.86 to 21.13	-6.9 to 11.54	Cross- I (AKW-619 x DBW-31)	Cross- I (AKW-619 x DBW-31)	Cross- I (AKW-619 x DBW-31)
4	Sedimentation Value(ml)	-14.58 to 18.32	0 to -16.32	-3.88 to 9.8	Cross- VII GW-496 x NIAW-301	Cross- VII GW-496 x NIAW-301	Cross- I (AKW-619 x DBW-31)
5	Beta Carotene content (ppm)	15.96 to 51.07	1.69 to 34.56	-31.45 to 9.32	Cross -VIII (GW-496 x AKAW-4651)	Cross -II(AKAW-3997 x AKAW-3722)	Cross -VIII (GW-496 x AKAW-4651)
6	Plant Height (cm)	0.82 to 17.12	5.3 to 14.62	6.22 to 7.4	Cross -III (HI-1418 x LOK-54)	Cross -III (HI-1418 x LOK-54)	Cross -VIII (GW-496 x AKAW-4651)
7	No.of tillers/plant	7.46 to 27.69	0.3 to 24.34	1.8 to 16.71	Cross -III (HI-1418 x LOK-54)	Cross -III (HI-1418 x LOK-54)	Cross- IV AKAW-3997 x NIAW-34
8	No.of spikelets /spike	30.96 to 64.35	24.32 to 62.87	3.16 to 29.87	Cross- I (AKW-619 x DBW-31)	Cross- I (AKW-619 x DBW-31)	Cross -II(AKAW-3997 x AKAW-3722)
9	No.of grains/spike	17.58 to 52.13	12.19 to 47.53	1.15 to 20.62	Cross -III (HI-1418 x LOK-54)	Cross -III (HI-1418 x LOK-54)	Cross -VI (AKAW-2978-12 x PHS-0722)
10	Grain wt.(gm)	3.23 to 40.26	2.4 to 35.42	-5.8 to 10.86	Cross- I (AKW-619 x DBW-31)	Cross- I (AKW-619 x DBW-31)	Cross -III (HI-1418 x LOK-54)
11	Grain Yield /Plant (gm)	6.9 to 14.63	6.96 to 13.56	1.11 to 6.33	Cross- IV AKAW-3997 x NIAW-34	Cross -III (HI-1418 x LOK-54)	Cross- IV AKAW-3997 x NIAW-34

Table.3 Mean performance of six quality characters recorded on plant basis in Akola environmental conditions

Crosses	Characters					
	Plant height (cm)	No. of tillers per plant	No. of spikletes per spike	No. of grains per spike	Grain weight (g)	Grain yield per plant (g)
Akola Cross - I (AKW-619 x DBW-31)						
P_1	83.16 ± 1.06	5.46 ± 0.32	17.4 ± 0.29	42.86 ± 2.21	1.43 ± 0.02	15.58 ± 0.15
P_2	84.03 ± 0.92	5.56 ± 0.38	17.93 ± 0.22	51.4 ± 1.07	1.54 ± 0.02	17.46** ± 0.15
F_1	85.86 ± 0.52	9.06** ± 0.17	19.66 ± 0.13	57.66 ± 0.6	2.09** ± 0.02	18.82** ± 0.43
F_2	91.21** ± 0.78	7.24** ± 0.1	18.88 ± 0.13	48.91 ± 0.77	2.05** ± 0.01	18.61** ± 0.18
BC_1	80.03 ± 1.72	5.36 ± 0.23	17.26 ± 0.22	42.16 ± 0.67	1.85** ± 0.05	17.1* ± 0.2
BC_2	82.10 ± 0.91	4.86 ± 0.16	18.66 ± 0.20	40.86 ± 0.59	1.96** ± 0.02	17.11** ± 0.37
Akola Cross -II(AKAW-3997 x AKAW-3722)						
P_1	91.86** ± 1.38	5.40 ± 0.31	18.33 ± 0.16	51.50 ± 0.58	1.77 ± 0.02	15.89 ± 0.25
P_2	79.40 ± 0.71	5.30 ± 0.19	16.93 ± 0.31	41.93 ± 0.51	1.80 ± 0.04	15.99 ± 0.31
F_1	89.96** ± 0.60	8.03** ± 0.27	20.2** ± 0.27	57.90 ± 1.11	2.12** ± 0.02	17.05 ± 0.15
F_2	88.37** ± 0.52	5.63 ± 0.16	19.72* ± 0.14	57.23 ± 0.71	2.00** ± 0.02	16.41 ± 0.24
BC_1	85.80 ± 1.03	5.63 ± 0.22	19.00 ± 0.20	52.46 ± 0.87	1.89** ± 0.02	15.66 ± 0.33
BC_2	86.30 ± 0.75	5.33 ± 0.13	18.33 ± 0.19	54.23 ± 1.67	1.78 ± 0.06	16.16 ± 0.27
Akola Cross -III (HI-1418 x LOK-54)						
P_1	78.53 ± 0.93	5.23 ± 0.29	16.86 ± 0.28	41.96 ± 1.11	1.57 ± 0.05	14.44 ± 0.37
P_2	82.03 ± 0.77	5.50 ± 0.22	17.80 ± 0.39	44.66 ± 0.88	1.62 ± 0.03	14.55 ± 0.14
F_1	94.03** ± 1.23	8.40** ± 0.16	22.13** ± 0.28	65.90** ± 1.32	2.04** ± 0.06	16.52 ± 0.32
F_2	90.97** ± 1.41	6.11 ± 0.13	20.06** ± 0.19	62.23** ± 0.87	1.81* ± 0.02	16.02 ± 0.22
BC_1	78.16 ± 1.67	5.73 ± 0.18	18.60 ± 0.17	50.43 ± 1.15	1.75 ± 0.02	15.22 ± 0.48
BC_2	77.86 ± 0.91	5.80 ± 0.22	18.86 ± 0.26	54.30 ± 1.35	2.02** ± 0.05	15.27 ± 0.30
Akola Cross -IV(AKAW-3997 x NIAW-34)						
P_1	77.36 ± 1.23	4.70 ± 0.19	17.86 ± 0.23	54.03 ± 0.91	1.41 ± 0.05	14.58 ± 0.57
P_2	81.43 ± 2.37	4.56 ± 0.25	22.13** ± 0.30	54.23 ± 1.23	1.43 ± 0.05	14.87 ± 0.46
F_1	87.93** ± 1.18	6.70** ± 0.32	22.06** ± 0.27	63.33** ± 1.75	1.84* ± 0.04	16.88 ± 0.59
F_2	91.3** ± 0.95	6.22 ± 0.11	18.37 ± 0.14	61.62** ± 0.94	1.81* ± 0.02	15.81 ± 0.28

BC_1	81.73 ± 1.1	6.10 ± 0.27	18.86 ± 0.18	57.63 ± 1.72	1.76 ± 0.04	15.32 ± 0.16
BC_2	86.10 ± 0.98	5.53 ± 0.14	20.13** ± 0.30	56.30 ± 1.66	1.75 ± 0.02	15.42 ± 0.39
Akola Cross -V (DL-788-2 x AKAW-3722)						
P_1	73.50 ± 1.42	4.93 ± 0.17	20.13** ± 0.38	53.36 ± 2.25	1.57 ± 0.02	14.80 ± 0.25
P_2	83.73 ± 0.88	4.96 ± 0.18	19.53 ± 0.24	54.30 ± 0.99	1.55 ± 0.02	15.51 ± 0.22
F_1	79.26 ± 1.47	6.80** ± 0.18	21.00** ± 0.38	63.30** ± 1.42	1.71 ± 0.07	16.53 ± 0.51
F_2	81.78 ± 0.85	5.98 ± 0.12	20.60** ± 0.22	61.67** ± 1.10	1.68 ± 0.03	15.78 ± 0.28
BC_1	74.80 ± 0.45	5.23 ± 0.17	19.53 ± 0.26	57.43 ± 1.12	1.69 ± 0.04	15.54 ± 0.58
BC_2	77.60 ± 0.79	5.66 ± 0.24	19.06 ± 0.20	56.30 ± 1.04	1.50 ± 0.05	15.54 ± 0.31

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Crosses	**Characters**				
	Days to heading	**1000 Seed weight (g)**	**Protein content (%)**	**Sedimentation value (ml)**	**Beta carotene (ppm)**
Akola Cross -VI (AKAW-2978-12 x PHS-0722)					
P_1	54.00* ± 0.00	40.46 ± 1.07	13.26 ± 0.13	39.00** ± 0.57	4.19 ± 0.28
P_2	53.00 ± 1.00	40.58 ± 0.71	12.43 ± 0.10	32.00 ± 1.15	3.93 ± 0.23
F_1	51.33 ± 0.66	46.85 ± 0.78	14.53** ± 0.25	35.33 ± 0.88	5.61 ± 0.17
F_2	52.00 ± 0.57	44.98 ± 1.64	14.14** ± 0.37	32.33 ± 1.45	5.08 ± 0.39
BC_1	54.33** ± 0.88	39.88 ± 1.23	14.42** ± 0.29	38.33** ± 0.33	4.12 ± 0.26
BC_2	54.00* ± 1.00	43.28 ± 1.05	14.06** ± 0.22	37.33** ± 0.66	4.64 ± 0.06
Akola Cross -VII (GW-496 x NIAW-301)					
P_1	50.67 ± 0.33	43.13 ± 0.94	13.02 ± 0.16	33.00 ± 0.57	3.24 ± 0.36
P_2	51.00 ± 0.57	43.84 ± 0.73	12.76 ± 0.18	30.66 ± 0.66	4.99 ± 0.04
F_1	48.67 ± 0.66	51.78** ± 0.97	13.51 ± 0.16	37.66** ± 0.33	6.22** ± 0.32
F_2	51.67 ± 0.66	49.63 ± 4.81	14.45** ± 0.13	36.66** ± 0.88	5.91** ± 0.34
BC_1	53.33** ± 1.20	46.75 ± 0.85	12.43 ± 0.28	31.33 ± 0.66	3.30 ± 0.38
BC_2	51.66 ± 0.33	49.25 ± 0.47	13.15 ± 0.07	30.66 ± 0.66	4.63 ± 0.17
Akola Cross -VIII (GW-496 x AKAW-4651)					
P_1	51.33 ± 0.33	41.56 ± 1.32	12.73 ± 0.13	30.33 ± 0.33	4.10 ± 0.31
P_2	49.67 ± 0.33	43.81 ± 0.81	12.63 ± 0.08	33.66 ± 0.33	4.18 ± 0.17
F_1	47.66 ± 0.33	58.40** ± 2.05	13.23 ± 0.08	34.33 ± 2.18	5.00 ± 0.33
F_2	48.33 ± 0.88	51.42** ± 0.57	12.53 ± 0.26	35.66**± 0.66	5.48 ± 0.45
BC_1	51.33 ± 1.33	49.51 ± 0.37	11.85 ± 0.24	35.33 ± 0.33	4.47 ± 0.75
BC_2	50.00 ± 0.57	49.36 ± 0.44	12.44 ± 0.17	35.33 ± 0.33	5.23 ± 0.25
Mean	58.50	46.63	12.73	33.23	4.68
S.E.(M)±	0.93	1.22	0.28	0.76	0.33
C.D. (5%)	2.61	3.44	0.81	2.13	0.93

The significant heterobeltiosis recorded in sedimentation value and plant height. The Cross-VI, AKAW-2978-12 x PHS-0722, exhibited significant heterosis, heterobeltiosis with low inbreeding depression for number of grains per spike and grain yield per plant. However, significant heterosis and heterobeltiosis with non-inbreeding depression exhibited for 1000 seed weight, protein content, β-carotene content, number of tillers per plant, number of spikeletes per spike and grain weight per earhead. The significant heterosis exhibited for plant height, while significant heterobeltiosis and inbreeding depression recorded in sedimentation value.

In seventh cross, GW-496 x NIAW-301, exhibited highest significant heterosis and heterobeltiosis with inbreeding depression for β-carotene content, number of tilers per plant and number of grains per spike. However, significant heterosis, heterobeltiosis with low inbreeding depression recorded for 1000 seed weight, sedimentation value, number of spikeletes per spike, grain weight per earhead and grain yield per plant. The significant inbreeding depression recorded in days to heading and plant height.

The Cross-VIII, GW-496 x AKAW-4651, exhibited highest significant heterosis and heterobeltiosis with low inbreeding depression for 1000 seed weight, plant height, number of spikeletes per spike. However, significant heterosis, heterobeltiosis with low inbreeding depression recorded for days to heading, number of tillers per plant, number of grains per spike and grain yield per plant. While, significant heterosis recorded for sedimentation value.

In the present study for Akola environmental condition, the maximum heterosis over mid parental value of 64 per cent for number of spikeletes per spike 51.07 per cent for carotene content 52.13 per cent for number of grains per spike, 40.26 per cent for grain weight per earhead, 36.79 per cent for 1000 seed weight, 27.69 per cent for no. of tillers per plant, 18.32 per cent for sedimentation value, 22.49 for protein content, 17.12 per cent for plant height and 14.63 for grain yield per plant has been observed by Larik (1999), Rasal *et al.,* (2002), Shruti Kawar (2003), Singh and Sain (2004) for plant height number of spikeletes per spike and grain yield per plant Akhar *et al.,* (2010) for plant height, Khan and Ali (2011) for number of tillers per plant, number of spikeletes per spike and grain yield per plant.

The maximum heterobeltiosis value for 62.87 per cent for number of spikeletes per spike, 47.53 for number of grains, per spike, 35.42 per cent for grain weight per earhead, 33.61 per cent for β-carotene content, 33.28 per cent for 1000 seed weight, 24.34 per cent for number of tillers per plant, 21.13 per cent for protein content and 14.62 per cent for plant height while, 11.24 per cent for days to heading and 16.32 per cent for sedimentation value in negative direction has been observed. This results are confirmed with the following researchers Akbar *et al.,* (2010), Khan and Ali (2011), for number of tillers per plant, number of spikeletes and number of grains per spike.

The range of inbreeding depression value 3.16 to 29.87 per cent for number of spikeletes per spike, 1.15 to 20.62 per cent for number of grains per spike, 0.37 to 14.93 per cent for 1000 seed weight, -6.9 to 11.54 per cent for protein content, -5.80 to 10.86 per cent for grain weight per earhead -3.8 per cent to 9.8 per cent for sedimentation value, 1.80 to 9.33 per cent for number of tillers per plant, -31.95 to 9.32 per cent for

β-carotene content, -6.22 to 5.39 per cent for plant height and -6.16 to 3.97 per cent for days to heading. Similar results confirmed by Shruti Kawar (2003) for plant height, number of tillers per plant, days to heading and grain yield per plant, Singh and Sain (2004) for grain yield per plant Larik (1999) for grain yield per plant.

The crosses like cross VIII, IV and cross III combination with high heterosis with low inbreeding depression would be prove useful for the development of better transgressive segergants.

References

Chhagan Lal, Vishnu Kumar and Shiv Ratan Maloo, 2013. Heterosis and inbreeding depression for some quantitative and heat tolerance characters in bread wheat (*Triticum aestivum* L.). J. Wheat Res. 5(2): 5

Chowdhry, M.A., Muhammad Iqbal, Ghulam Mohboob Shubhani and Islam Khaliq, 2001. Heterosis and Inbreeding depression and line performance in crosses of *T. aestivum.* Pakistan J. Biol. Sci. 4(1): 56-58.

Emre Ilker, Fatma Aykut, Muzaffer Tosun, 2010. Heterosis for yield and it's components in Bread wheat crosses among powdery mildew resietant and susceptible genotypes. Pakistan J. Bot., 42(1): 513-522.

Fonseca, S. and F.L. Patterson, 1968. Hybrid vigour in seven parental diallel crosses in common wheat (*Triticum aestivum* L.). Crop Sci., 8: 85-88.

Hayman, B.I., 1957. Interaction, heterosis and diallel crosses, Genetics. 42: 336-355.

Kalimullah Khan and Shujaat Ali, 2011. Heterosis study of certain important yield contributing parameters in Wheat (*Triticum aestivum* L.). Agro Crop Sci., 2(2): 23-26.

Larik, A.S., A.R. Mahar, A.A. Kakar and M.A. Shafkh, 1999. Heterosis, inbreeding depression and combining ability in Triticum aestium L. Pak. J. Agri. Sci. 36(1-2).

Muhammad Akbar, Javed Anwar, Makdoom Hussain, Muhammad Muzaffar Iqbal and Waseem Sabir, 2010. Heterosis and heterobeltiosis for grain yield improvement inbred wheat. J. Agri. Res. 48(1): 15-23.

Oguz Bilgin; K.Z. Korkut, Ismet Baser, Orhan Doglioglu, Irfan Ozturk, Turhan Kaharaman and Alpay Balkan, 2010. Variation and heritability for some semolina characteristics and grain yield and their relations in Durum Wheat (*Triticum aestivum* L.) World Journal of Agricultural Sciences, 6(3): 301-308.

Ojaghi, J. and E. Akhundova, 2010. Genetic analysis for yield and its components in doubled haploids wheat. African J. Agricultural Research, 5(4): 308-311.

Osmanzai, M. and R.C. Sharma, 2008. High yielding stable wheat genotypes for the diverse environments in Afghanistan. International J. Agric. Res. 3: 340-348.

Pal Sukram, Achala Sharma, R.P. Singh and N.S. Bains, 2010. Evaluation of exotics spring wheat lines from a world wheat collection for expression of key grain quality traits. Crop Improvement. 37(2): 157-161.

Pandit, D.B., F. Ahmed, M.A.H.S. Jahan, A.B.S. Hossain and M.A. Samad, 2001. Genetics of yield and other characters of spring Bread Wheat. Bangladesh J. Agric. 28(2): 281-288.

Panse and Sukhatme, 1985. Statistical method for agricultural workers, ICAR publication, New Delhi, pp 72-96.

Pathak, H. and R. Wassmann, 2004. Quantitative evaluation of climatic

variability and risks for wheat yield in India. Climatic Change. 93(1-2): 157-175.

Patil, A.K. and S. Jain, 2002. Studies of genetic variability in wheat under rainfed condition. JNKVV, Res. J. 36(1-2): 25-28.

Paulsen, G.M. 1944. High temperature responses of crop plant. In: Physiology and determination of crop yield. Boote, K.J. (Eds). ASA, CSSA, SSSA, Madison, WI. 365-389.

Pawar, I.S., A.S. Redhu, M. Yunus and Iqbal Singh, 2000. Evaluation of selective intermated populations for yield and it's components traits in Wheat. Haryana University J. Res., 30: 137-139.

Qaisar Mahamood, W.D. Lei, A.S. Qureshi, M.R. Khan, Yousaf Hayat, Ghulam Jilani, I.H. Shamsi, M.A. Tajammal and M.D. Khan, 2006. Heterosis, correlation and path analysis of morphological and biochemical characters in Wheat (*Triticum aestivum* L. Emp. Thell.), Agri. J. 1(3): 180-185.

Rasul Ijaz, Abdus Salam Khan and Zulfiqar Ali, 2002. Estimation of heterosis for yield and some yield components in bread wheat. Int. J. Agri. Biol. 4(2).

Sharma, H., S.N. Sharma and R.S. Sain, 2004. Heterosis studies for yield and its components in Bread wheat over environments. Hereditas, 141(2): 106-114.

Shukla, R.S., Y. Mishra and C.B. Singh, 2000. Variability and association in bread wheat under rainfed condition. Crop Res. 19(30): 512-513.

Singh, G.P., Rajbir Yadav and H. B. Chaudhary, 2007. Variability studies for morpho-physiological traits in wheat (*Triticum aestivum*) to post anthesis high temperature stress. Journal of Wheat Research, 1: 44-47.

Singh, M., G.B. Swarankar, Lallu and L. Prasad, 2003. Genetic variability and path coefficient analysis in advanced generations of bread wheat under rainfed condition. Pl. Archives. 3(1): 89-92. (Absts. 2002/08 - 2003/10).

Singh, M.K., P.K. Sharma, B.S. Tyagi and G. Singh, 2014. Heterosis for Yield Component Traits and Protein Content in Bread Wheat under Normal and Heat-stress Environment. Cereal Research Communications, 42(1): 151-162.

Singh, R.K and B.D. Singh, 1985. Biometrical methods in quantitative genetics analysis, Kalyani Publishers, Ludhiana.

Singh, S.P., P.B. Shah and D.N. Singh. 2001 Genetic variability for polygenic traits in late sown wheat genotypes. Ann. Agric. Res. 22(1): 34-36.