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Estimation of heterosis for grain yield and some yield components in bread wheat (*Triticum aestivum* L. Em. Thell.)

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Abstract
The experiment was conducted to assessment the nature and magnitude of heterosis for grain yield and its contributing traits using 10 x 10 half-diallel fashion under normal sown condition. The maximum heterosis range has been assessed for yield and its contributing traits. The heterosis ranged observed for grain yield per plant from -4.84 per cent to 67.82 per cent. Among the eleven crosses, two crosses DPW 621-50 x Raj 4079 and Raj 4037 x Raj 4079 exhibiting desired significant heterosis and heterobeltiosis for yield and its contributing traits. These crosses might be exploited for finding transgressive segregants for improvement of yield and yield contributing traits in bread wheat

Keywords: Heterobeltiosis, heterosis, bread wheat, varieties

Introduction
Wheat is a major staple food crop of the world, this is one of the most important and widely cultivated crops in the world, used mainly for human consumption and support nearly 35% of the world population. It is believed to be originated from near East Region of South-West Asia (Lupton, 1987) [13]. It is primarily grown in temperate region, warm, humid to dry, cold environments. Wheat (*Triticum sp*.) is self-pollinated cereal crop which belong to *Poaceae* family. Bread wheat (*Triticum aestivum* L.) is an allohexaploid (2n = 6x = 42 = AABBDD). Wheat is a unique gift of nature to the mankind as a good supplement for nutritional requirement of human body as it contains 12% protein, 1.8% lipids, 1.8% ash, 2% reducing sugar, 59.2% starch, 70% total carbohydrates and provide 314 kcal/100 g of food (Iqbal *et al.*, 2017) [7]. The present study revealed for identifying superior cross combinations that may be used for commercial hybrid seed production of wheat and in the isolation of pure lines among the progenies of heterotic crosses for further enhancement in the grain yield of wheat (Singh and Singh 1984) [18]. In fact, commercial exploitation of the heterosis in wheat has limited use because of practical complications in the hybrid seed production in appropriate quantity. Understanding of the manifestation levels of heterosis that are suitable to help of breeders for select the superior hybrid combinations that will assist the basis for in selection of superior genotypes. The Diallel cross analysis is a tool that help in the identification of hybrid combination which have the maximum development and identifying superior lines among the crosses in early segregations (Khan *et al.*, 2007). Crosses which exhibiting high heterosis might be exploited for finding transgressive segregants for improvement of yield and yield contributing traits in bread wheat. The magnitude of heterosis aids in defining genetic diversity and in the selection of desirable parents, it depends on its exploitation, utilization and feasibility of hybrid seed production. In wheat crop, heterosis may not be useful except it is acceptable to utilize it through the development of hybrid. Hence, in wheat heterosis is used to select needed crosses to acquire superior transgressive segrgants in advance generation for added enrichment of grain yield (Arunachalam *et al.*, 1984) [2].

Material and Method
The experimental material for the present study consists of ten diverse bread wheat varieties (DPW 621-50, DBW 90, PBW 502, Raj 1482, Raj 4037, UP 2425, Raj 3765, PBW 550, HI 1563 and Raj 4079) selected on the basis of broad range of genetic diversity for different yield components, from the elite germplasm maintained in All India Coordinated Wheat and Barley Improvement Project [AICW&BIP] at RARI, Durgapura, Jaipur under Sri Karan Narendra Agriculture University, Jobner, Jaipur (Rajasthan).

All the 10 varieties were sown at Agricultural Research Farm of RARI Durgapura, Jaipur and crossed in half-diallel fashion (excluding reciprocals) in *Rabi* 2018-19. In *Kharif* 2019 F_1's seed was grown at IARI regional sub-station Wellington (Tamil Nadu), to advance the generation.

The ten parents along with their 45 F_1's and 45 F_2's, evaluated in a randomized block design with three replications date of sowing *i.e.* normal sown (10th November) in *Rabi* 2019-20. The row length was kept 3 meters with row to row spacing of 30 cm and plant to plant spacing of 10 cm kept in all plots. Observations were recorded for tillers per plant, spike length, grains per ear, 1000-grain weight, biomass per plant, grain yield per plant and harvest index on 10 randomly selected plants in each of F_1's progenies with each parent whereas, 20 plants were selected in F_2's population from each plot of each replication. Diallel cross analysis was carried out by the method as described by Jinks and Hayman (1953) [8]; Jinks (1954) and Hayman (1956) [6]. Heterosis, heterobeltiosis (Fonseca and Petterson, 1968) [4] and inbreeding depression were computed by these procedures.

Result and Discussion

Analysis of variance showed significant mean squares due to genotypes, parents and generations for all the studied characters. The F_1 and F_2 generations showed significant differences for all the characters. Similarly, F_1 vs F_2 were also found significant for all the characters, parents vs generations showed significant difference for all the characters under investigation (Table1). Singh *et al.* (2004) [17], Kumar *et al.* (2017) [11] and Sharma *et al.* (2019) [16] also reported similar conclusions for above studied characters.

The measurement of heterosis over the mid parent value is relatively limited importance but heterosis over better parent *i.e.* heterobeltiosis should be more practical as provide information about over dominance gene effects. Fonesca and Patterson (1968) [4] coined term 'heterobeltiosis' represents increase or decrease in the mean value of F_1 hybrid over the better parent. In the present study, the maximum heterosis range has been assessed for all the characters.

The magnitude of the heterosis that provide information on the extent of genetic diversity of the parents which involved in a cross and helps in choose the parents for developing superior F_1·s. The commercial utilization of heterosis in the plant breeding is regarded as superb implementation of genetics. In self-pollinated crop like wheat, commercial hybrid seed production is not practicable due to lack of the appropriate mechanism to produce hybrid seed. However, knowledge of magnitude and degree of heterosis is imperious for deciding the direction of future breeding programme and in the selection of promising crosses to acquire better segregates in the advance generations for further enhancement of grain yield in the wheat.

In the present study, the maximum heterosis range has been assessed for all the characters. An overall appraisal revealed heterosis ranged from -20.22 per cent to 36.7 per cent for tillers per plant; -11.04 per cent to 33.88 per cent for spike length; -9.34 per cent to 40.82 per cent for grains per ear; -15.94 per cent to 22.29 for 1000-grain weight; -4.04 to 40.94 for biomass per plant; -4.84 per cent to 67.82 per cent for grain yield per plant; -18.74 per cent to 39.77 per cent for harvest index. The result of experiment for different characters are conformity with the finding of several researchers such as Rasul *et al.* (2002) [15], Akinci (2009) [1], Kumar and Maloo (2011) [12], Gaur *et al.* (2014) [5], Dedaniya *et al.* (2018) [3], Nagar *et al.* (2019) [14] and Upadhyay *et al.* (2020) [19].

A good number of crosses had significant desired heterosis and heterobeltiosis for grain yield and its contributing traits. The estimates of heterosis and heterobeltiosis for grain yield and six other contributing traits with their number of crosses in Table 2&3.

Grain yield per plant: For grain yield per plant eleven crosses *viz.* DPW 6210-50 x UP 2425, DPW 621-50 x Raj 3765, DPW 621-50 x PBW 550, DPW 621-50 x HI 1563, DPW 621-50 x Raj 4079, DBW 90 x Raj 3765, PBW 502 x Raj 4037, Raj 1482 x PBW 550, Raj 1482 x Raj 4079, Raj 4037 x Raj 4079 and UP 2425 x PBW 550 revealed positive significant heterosis and heterobeltiosis. Hence, these crosses were regarded most desirable for grain yield per plant.

Tillers per plant: For tillers per plant eleven crosses *viz.* DPW 6210-50 x UP 2425, DPW 621-50 x Raj 3765, DPW 621-50 x PBW 550, DPW 621-50 x HI 1563, DPW 621-50 x Raj 4079, DBW 90 x Raj 3765, PBW 502 x Raj 4037, Raj 1482 x PBW 550, Raj 1482 x Raj 4079, Raj 4037 x Raj 4079 and UP 2425 x PBW 550 revealed positive significant heterosis and heterobeltiosis. Hence, these crosses were regarded most desirable for tillers per plant.

Spike length: For spike length five crosses DPW 621-50 x Raj 3765, DPW 621-50 x PBW 550, DPW 621-50 x HI 1563, DPW 621-50 x Raj 4079, PBW 502 x Raj 4037 and Raj 4037 x Raj 4079 exposed positive significant heterosis and heterobeltiosis. So, these crosses were considered most desirable for spike length.

Grains per spike: For grains per ear ten crosses DPW 6210-50 x UP 2425, DPW 621-50 x Raj 3765, DPW 621-50 x PBW 550, DPW 621-50 x HI 1563, DPW 621-50 x Raj 4079, DBW 90 x Raj 3765, PBW 502 x Raj 4037, Raj 1482 x Raj 4079, Raj 4037 x Raj 4079 and UP 2425 x PBW 550 showed positive significant heterosis and heterobeltiosis. Therefore, these crosses were considered most desirable for grains per ear.

1000-grain weight: For 1000-grain weight five crosses DPW 621-50 x Raj 4079, DBW 90 x Raj 3765, PBW 502 x Raj 4037, Raj 4037 x Raj 4079 and UP 2425 x PBW 550 showed positive significant heterosis and heterobeltiosis. Therefore, these crosses were considered most desirable for 1000-grain weight.

Biomass per plant: For biomass per plant seven crosses DPW 6210-50 x UP 2425, DPW 621-50 x Raj 3765, DPW 621-50 x PBW 550, DPW 621-50 x HI 1563, DPW 621-50 x Raj 4079, PBW 502 x Raj 4037 and Raj 4037 x Raj 4079 exhibited positive significant heterosis and heterobeltiosis. Therefore, these crosses were considered most desirable for biomass per plant.

Harvest index: For harvest index five DPW 621-50 x Raj 4079, DBW 90 x Raj 3765, Raj 1482 x PBW 550, Raj 1482 x Raj 4079 and Raj 4037 x Raj 4079 exhibited positive significant heterosis and heterobeltiosis. Therefore, these crosses were considered most desirable for biomass per plant harvest index. An overall appraisal of Table 2&3 that the eleven crosses for grain yield per plant and tillers per plant, ten crosses for grains per ear, seven crosses for biomass per plant and each in five crosses for spike length, 1000-grain weight and harvest index revealed positive significant heterosis and heterobeltiosis.

Table 1: Analysis of variance sowing mean squares for parents F_1's and F_2's for grain yield and its contributing traits

Characters d.f.	Source of variation								
	Replication (2)	Genotypes (99)	Parents (9)	Generation (89)	F_1's (44)	F_2's (44)	F_1 *vs* F_2 (1)	Parents vs generation (1)	Error (198)
Tillers per plant	00.1	05.47**	4.91**	005.2**	04.57**	05.87**	03.51**	034.48**	0.35
Spike length	0.52	07.99**	4.99**	07.58**	07.25**	08.00**	03.87*	071.07**	0.78
Grains per ear	5.58	152.69**	36.97**	151.84**	116.3**	189.3**	67.6**	1269.79**	8.54
1000- grains weight	1.86	105.89**	24.38**	113.28**	73.06**	154.88**	52.73**	181.36**	6.33
Biomass per plant	12.83	82.29**	21.36**	070.9**	63.46**	78.19**	77.48**	1644.63**	8.53
Grain yield per plant	6.62	83.07**	43.45**	71.07**	54.55**	85.14**	178.66**	1507.06**	4.92
Harvest index	2.01	176.49**	117.75**	171.43**	152.67**	189.85**	186.79**	1155.87**	10.04

Table 2: Heterotic crosses showing desirable significant heterosis and heterobeltiosis for grain yield and its contributing traits

S. No.	Crosses	Grain yield per plant		Tillers per plant		Spike length		Grains per spike	
		H	HB	H	HB	H	HB	H	HB
1.	DPW 621-50 x UP 2425	67.82**	43.65**	34.44**	29.22**	-8.16	-8.48	21.27**	18.88**
2.	DPW 621-50 x Raj 3765	55.96**	24.63**	34.33**	13.56**	23.47**	16.65**	40.82**	26.56**
3.	DPW 621-50 x PBW 550	39.83**	19.89**	29.41**	19.84**	30.91**	17.86**	21.21**	20.5**
4.	DPW 621-50 x HI 1563	37.02**	15.86*	29.13**	13.49*	28.38**	26.74**	26.4**	23.97**
5.	DPW 621-50 x Raj 4079	54.19**	25.11**	32.31**	13.82**	8.48	3.49	31.03**	20.69**
6.	DBW 90 x Raj 3765	42**	17.88**	17.78**	17.03**	19.27**	9.05	26.65**	20.03**
7.	PBW 502 x Raj 4037	27.25**	17.71**	14.69**	12.89*	23.26**	18.38**	21.51**	15.71**
8.	Raj 1482 x PBW 550	22.88**	18.09**	24.81**	19.08**	3.99	2.3	0.63	0.18
9.	Raj 1482 x Raj 4079	31.79**	28.17**	14.82**	10.86*	14.82*	-2.22	23.69**	15.02**
10.	Raj 4037 x Raj 4079	39**	38.98**	15.06**	11.84*	33.88**	21.67**	28.53**	25.84**
11.	UP 2425 x PBW 550	15.05*	14.83*	29.85**	15.95*	15.64*	3.78	14.1**	12.5*

Table 3: Heterotic crosses showing desirable significant heterosis and heterobeltiosis for grain yield and its contributing traits

S. No.	Crosses	1000-grain weight		Biomass per plant		Harvest index	
		H	HB	H	HB	H	HB
1.	DPW 621-50 x UP 2425	0.82	0.54	40.94**	32.3**	19.91**	8.57
2.	DPW 621-50 x Raj 3765	6.22	2.2	21.86**	17.05**	29.34**	6.64
3.	DPW 621-50 x PBW 550	4.66	1.9	14.01**	11.22**	23.24**	7.9
4.	DPW 621-50 x HI 1563	-2.73	-5.91	10.89**	8.77*	24.04**	6.5
5.	DPW 621-50 x Raj 4079	19.01**	12.92**	15.04**	10.25*	35.31**	13.59**
6.	DBW 90 x Raj 3765	16.78**	10.99*	6.45	4.5	33.99**	12.82**
7.	PBW 502 x Raj 4037	22.19**	11.81*	19.85**	16.06**	6.29	-4.51
8.	Raj 1482 x PBW 550	3.77	-1.15	10.36**	5.72	11.89*	11.51*
9.	Raj 1482 x Raj 4079	5.75	-1.78	6.66*	4.01	23.37**	17.07**
10.	Raj 4037 x Raj 4079	12.02**	10.34*	12.35**	12.1**	23.76**	23.47**
11.	UP 2425 x PBW 550	13.52**	10.83*	8.25*	4.05	6.47	2.55

Conclusion

It is concluded from the present studies that two crosses DPW 621-50 x Raj 4079 and Raj 4037 x Raj 4079 exhibited positive significant heterosis and heterobeltiosis for grain yield as well as its associated traits. These crosses could be exploited in further breeding programme to acquire superior transgressive segrgants in advance generation for added enrichment of grain yield.

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