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Research Article

ESTIMATION OF HETEROSIS FOR YIELD TRAITS IN F1AND F2 GENERATION OF IN WINTER WHEAT X SPRING WHEAT CROSS COMBINATIONS (*TRITICUM AESTIVUM* L.) UNDER RAINFED CONDITIONS

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Abstract: The present investigation was carried out at the research farm of the Division of Plant Breeding & Genetics, SKUAST, Jammu, Chatha, from *Rabi* 2104-15 to 2016-17. The experimental material of the present study comprised 20 true breeding facultative type winter wheat lines which were evaluated under rainfed conditions in a Randomized block design. The best ten winter wheat genotypes (Arkaan, Blue boy, China 4435893, Drina, DrinaNS 720, Norderspez, WW12, WW21, WW23 and WW25) used as line and three spring wheat genotypes (PBW175, PBW 644 and WH 1080) were used as tester to develop the experimental material for line x tester mating design. In *Rabi* 2016-17, 30 F1s and advanced 30 F2 seeds along with parents were sown in a randomized block design under rainfed conditions. Observations were recorded on yield traits. Heterotic pattern estimation revealed that none of the cross combination had significant heterosis for all the traits. However, on individual trait basis, some of the crosses revealed significant heterosis. The crosses showing desirable heterosis (10 % or above that) were Nordersprez x PBW 175, WW21 x PBW 175, Drina x PBW 175, WW12 x PBW 175, WW25 x PBW 175 and Drina NS 720 x PBW 175, in F1 and F2 generation of crosses. Significant desirable heterosis for many traits revealed the possibility of yield improvement through heterosis breeding.

Keywords: *Winter Wheat, Spring Wheat, Line x Tester, Heterosis*

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Introduction

Wheat (*Triticum aestivum* L.), self-pollinated crop of the Poaceae family and of the genus Triticum, is the world's largest cereal crop. It is popularly known as 'Stuff of life or King of the cereals' because of the acreage occupied, high productivity and the prominent position it holds in the international food grain trade. Wheat is extensively grown crop in the world. Its cultivation is widespread between 30 to 60 degrees north and between 27 to 40 degrees south of latitude. It is grown below sea level near the Dead Sea and in the Imperial Valley of California and at as high as 5000m altitude of Tibet [1]. Wheat (*Triticum* spp.), is the most important cereal crop and occupies prominent position in Indian agriculture after rice [2]. India is now the second largest producer of wheat in the world with the production hovering around 106.21 million tonnes in 2020. It is consumed mostly in the form of bread, biscuits, chapatti, baati, upma, dalia *etc*. The total production of wheat in the world is around 735.9 million metric tons covering an area of about 227.61 million ha with an average productivity of 3289.3 kg ha-1 [3]. One of the ways by which this can be achieved is by the incorporation of genes from winter wheat (drought tolerant). The reports of [4] in wheat and by [5] in barley highlighted the importance of winter genotypes in the improvement of spring genotypes. Very little work has been done in this aspect. Subsequently several workers have explored the potential of winter wheat in spring wheat improvement programme [6, 7 & 8]. Thus, winter x spring wheat hybridization appears to be important for achieving quantum jump in better wheat production in rainfed areas. A great interest has been generated in the inter crossing of spring wheat with winter wheat with the hope that this will help in surpassing the existing yield plateau of spring wheat by generating additional variability. The success of winter x spring hybridization depends upon the ability of these two physiologically different ecotypes to combine well with each other. In order to formulate a sound breeding strategy, information on the relative magnitude of genetic variance, heterotic pattern studies for grain yield and its related traits is essential. Such information is useful for the selection of parental lines having superior performance and isolation of potential combination for their further use in the breeding programmes. The technique of line x tester analysis tends itself to the detailed genetic analysis and identifies superior parents and cross combinations on the basis of the combining ability. Strategy to overcome the yield plateau is the commercial production of hybrid varieties.

Materials and Methods

The breeding material, represented ten winter wheat and their derivatives that were used as females (lines) and three of spring wheat, used as males (Testers). The above selected ten winter wheat lines used as females were crossed with three spring wheat lines used as males (Testers) in Line x Tester fashion during 2015-2016 at University Research Farm of Sher-e- Kashmir University of Agricultural Sciences and Technology, Jammu (SKUAST, J) Main campus, Chatha, Jammu to generate 30 F1s. These were advanced in off-season nursery to generate 30 F2s. 30 F1 crosses, 30 F2 crosses and 13 Parents (10 lines + 3 testers) were evaluated in RBD during the Rabi 2016-17. The observation was recorded on five competent for different traits namely: tillers per plant, spike length, grains per plant, 1000 grain weight, Biological yield per plant, grain yield per plant and harvest index.

Data recorded were analyzed to know the significance of differences among genotypes including crosses. The superiority of a hybrid as compared to mid parental or better parental performance was calculated in two ways. The significance was tested at 5% and 1% probability level respectively, at the degrees of freedom for error. The heterosis was expressed as percentage increase over mid and better parent.

Table-1 *ANOVA for yield traits on the basis of F_1 generation of crosses in Winter x Spring wheat derivatives*

Sources of variation	D.F.	No of Tillers/ Plant	Spike Length (cm)	No. of Grains/ Plant	Grain Yield (g)	1000 Grain Weight (g)	Biological Yield / Plant (g)	Harvest Index (%)
Replicates	2	2.39	0.05	8.43	10.53	0.57	46.08	6.53**
Treatments	42	82.97 **	5.43 **	77.96 **	325.84 **	219.55 **	574.63 **	142.47 *
Parents	12	38.94 **	1.38 **	27.99**	141.65 **	49.29 **	274.64**	23.91 **
Parents (Line)	9	28.45 **	1.05 **	25.39 **	138.93 **	48.14 **	197.37 **	25.51
Parents (Testers)	2	67.44 **	3.09 **	2.21	195.46 **	1.53	726.88 **	9.75
Parents (L vs T)	1	76.41 **	0.94	102.91 **	58.49 *	155.18 **	65.56	37.83 *
Parents vs Crosses		265.24 **	20.05 **	210.83 **	30.6	4620.17*	184.66 *	1523.67
Crosses	29	94.91 **	6.59 **	94.06 **	412.23 **	138.25 **	712.22***	143.89*
Error	84	4.92	0.3	7.47	14.32	2.04	32.22	5.41

**, ** significant at 5% and 1% level, respectively.*

Table-2 *ANOVA for yield traits on the basis of F2 generation of crosses in Winter x Spring wheat derivatives*

Sources of variation	D.F.	No of Tillers/ Plant	Spike Length (cm)	No. of Grains/ Plant	Grain Yield (g)	1000 Grain Weight (g)	Biological Yield /Plant (g)	Harvest Index (%)
Replicates	2	2.39	0.05	8.43	10.53	0.57	46.08	6.53**
Treatments	42	82.97 **	5.43 **	77.96 **	325.84 **	219.55 **	574.63 **	142.47 *
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**, ** significant at 5% and 1% level, respectively*

Table-3 *Estimates of Heterosis over Better parent and per se performance on the basis of F1 and F2 generation of crosses*

Cross combination	No. of tillers per plant				Spike length			
	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)
Arkaan*PBW 175	28.3	28.0	1.19	10.00	10.4	11.0	-5.22	-11.25
Arkaan*PBW 644	19.0	27.0	-29.63	-22.50	8.37	9.8	-15.22	-1.72
Arkaan*WH1080	19.3	26.6	-27.50	-31.25	10.3	9.8	4.93	8.60
Blue boy*PBW 175	31.3	28.0	11.90	30.26	11.5	11.0	4.62	4.62
Blue boy*PBW 644	21.6	27.0	-19.75	-3.95	9.0	10.1	-10.69	-1.84
Blue boy*WH1080	18.6	25.3	-26.32	-22.37	8.9	10.1	-11.61	-13.74
China4435893*PBW 175	31.6	30.6	3.26	-3.26	10.6	11.0	-3.89	-6.27
China4435893 *PBW 644	17.6	30.6	-42.39	-45.65	7.9	10.6	-25.53	-22.40
China4435893 *WH1080	20.6	30.6	-32.61	-31.52	8.2	10.6	-22.37	-16.11
WW 23*PBW 175	26.0	30.6	-15.22	-11.96	11.0	11.0	0.06	10.02
WW 23*PBW 644	20.0	30.6	-34.78	-34.78	8.4	9.9	-15.35	-4.65
WW 23*WH1080	18.0	30.6	-41.30	-40.22	7.5	9.9	-24.08	-20.70
DrinaNS 720*PBW 175	34.3	28.0	22.62	6.25	10.6	11.0	-4.01	-4.95
DrinaNS 720*PBW 644	21.6	27.0	-19.75	-27.50	8.1	10.0	-18.52	-15.86
DrinaNS 720*WH1080	24.0	26.6	-10.00	-2.50	8.0	10.0	-19.59	-14.26
WW21*PBW 175	32.3	28.0	15.48	17.72	12.2	11.0	11.25	13.82
WW21*PBW 644	28.6	27.0	6.17	-11.39	8.6	9.8	-12.27	-11.73
WW21*WH1080	24.6	26.3	-6.33	-21.52	9.3	9.8	-4.80	-2.20
WW25*PBW 175	30.0	28.0	7.14	16.67	11.5	11.0	4.10	3.80
WW25*PBW 644	19.6	27.0	-27.16	-18.06	7.3	9.2	-20.66	-13.83
WW25*WH1080	24.3	24.0	1.39	1.39	8.2	9.3	-11.50	-7.92
WW12*PBW 175	30.6	30.0	2.22	0.00	10.7	11.0	-3.02	4.37
WW12*PBW 644	20.0	30.0	-33.33	-31.11	8.4	11.0	-23.59	-21.65
WW12*WH1080	17.6	30.0	-41.11	-40.00	7.8	11.0	-29.15	-23.20
Nordresprez*PBW 175	32.3	28.0	15.48	23.75	11.3	11.0	2.35	2.84
Nordresprez*PBW 644	19.3	27.0	-28.40	-32.50	8.8	10.4	-14.64	-16.41
Nordresprez*WH1080	18.6	26.6	-30.00	-23.75	8.4	10.4	-18.65	-20.25
Drina*PBW 175	34.0	34.0	0.00	-4.90	11.3	11.2	0.86	5.26
Drina*PBW 644	21.3	34.0	-37.25	-34.31	7.8	11.2	-30.18	-24.24
Drina*WH1080	20.3	34.0	-40.20	-43.14	7.3	11.2	-34.51	-27.35

Results

Analysis of variance - Parents and F1 Generation crosses

Yield and yield contributing traits: Analysis of variance [Table-1] revealed highly significant variability all treatments in all traits except harvest Index which was significant at 5% only. The variability among the parents (lines + tester) was also highly significant for all traits. Among lines significant variability was observed for all the traits except harvest index. Among testers significant variability was observed for traits except Grains per plant, 1000 Grain weight and harvest index. The crosses arising from winter x spring wheat derivatives releaved highly significant variability for all traits except harvest index which was significant at 5% only. Significant difference in variability was observed for all the traits except Grain yield and harvest index when parents were compared with the crosses (P vs C). Similarly, Comparison of lines with testers revealed significant variability for all traits except Spike length and harvest index.

Table-4 *Estimates of Heterosis over Better parent and per se performance on the basis of F1 and F2 generation of crosses*

Cross combination	No. of grains per spike				Grain yield			
	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)
Arkaan*PBW 175	47.3	42.3	11.81	9.45	67.6	65.6	3.05	4.06
Arkaan*PBW 644	41.0	40.6	0.90	3.36	44.5	54.1	-17.68	-11.52
Arkaan*WH1080	36.1	41.2	-12.52	-7.43	48.0	54.1	-11.21	-22.92
Blue boy*PBW 175	47.1	48.6	-3.22	-3.01	71.1	65.6	8.27	10.30
Blue boy*PBW 644	34.6	48.6	-28.77	-26.03	55.3	52.0	6.41	3.21
Blue boy*WH1080	38.0	48.6	-21.92	-16.51	47.0	52.6	-10.70	-20.20
China4435893*PBW 175	50.4	49.3	2.16	2.16	73.0	65.6	11.17	13.71
China4435893 *PBW 644	38.5	49.3	-21.96	-14.53	53.0	50.9	4.19	10.74
China4435893 *WH1080	38.0	49.3	-22.97	-25.74	44.8	52.6	-14.81	-12.28
WW 23*PBW 175	48.6	46.6	4.29	6.00	65.0	65.6	-1.02	1.52
WW 23*PBW 644	38.3	46.6	-17.86	-20.00	39.8	58.5	-31.99	-23.45
WW 23*WH1080	43.0	46.6	-7.86	-14.29	35.4	58.6	-39.44	-30.90
DrinaNS 720*PBW 175	52.0	43.0	20.93	20.16	75.0	65.6	14.21	17.26
DrinaNS 720*PBW 644	44.0	43.0	2.33	11.78	48.3	50.9	-5.63	-9.56
DrinaNS 720*WH1080	39.6	43.0	-7.75	-4.65	52.0	52.6	-1.20	-3.10
WW21*PBW 175	41.3	46.0	-10.14	-8.04	72.3	65.6	10.15	12.18
WW21*PBW 644	33.5	46.0	-27.03	-19.78	45.7	51.0	-10.39	-6.47
WW21*WH1080	34.7	46.0	-24.49	-11.59	54.8	52.6	4.24	-1.14
WW25*PBW 175	50.0	44.0	13.64	14.39	66.2	65.6	0.86	-10.51
WW25*PBW 644	41.1	44.0	-6.52	-9.85	42.4	50.9	-16.63	-13.36
WW25*WH1080	39.2	44.0	-10.83	-16.82	53.7	52.6	2.09	-1.08
WW12*PBW 175	40.6	42.3	-4.09	-8.03	72.1	65.6	9.80	11.57
WW12*PBW 644	34.2	42.3	-19.06	-13.54	57.5	63.2	-9.02	-13.24
WW12*WH1080	42.6	42.3	0.79	2.83	45.7	63.2	-27.64	-31.86
Nordresprez*PBW 175	51.0	46.6	9.29	10.71	68.3	65.6	4.06	7.36
Nordresprez*PBW 644	40.6	46.6	-12.86	-12.86	45.3	60.3	-24.92	-33.20
Nordresprez*WH1080	42.3	46.6	-9.29	-19.29	44.3	60.3	-26.52	-21.55
Drina*PBW 175	47.6	46.0	3.62	8.70	69.6	65.6	6.09	10.15
Drina*PBW 644	31.5	46.0	-31.52	-26.45	52.5	59.7	-12.00	-6.42
Drina*WH1080	40.3	46.0	-12.32	-13.04	46.0	59.7	-22.94	-15.68

Table-5 *Estimates of Heterosis over Better parent and per se performance on the basis of F1 and F2 generation of crosses*

Cross combination	1000 grain weight				Biological yield per plant			
	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	F_2 Heterosis (%)
Arkaan*PBW 175	45.9	60.4	-24.04 **	-27.89	135.3	129.3	4.61	-6.61
Arkaan*PBW 644	39.4	60.4	-34.84 **	-34.45	123.3	113.1	9.05	11.19
Arkaan*WH1080	36.6	60.4	-39.42 **	-33.08	97.1	138.4	-29.83	-18.18
Blue boy*PBW 175	40.4	55.5	-27.21 **	-21.62	140.6	129.3	8.73	7.78
Blue boy*PBW 644	30.8	55.5	-44.50 **	-27.09	108.5	108.1	0.34	0.85
Blue boy*WH1080	29.5	55.5	-46.79 **	-25.23	102.3	138.4	-26.10	-26.47
China4435893*PBW 175	37.4	52.6	-28.86 **	-28.86	133.6	129.3	3.32	-19.94
China4435893 *PBW 644	30.5	52.6	-42.09 **	-28.29	110.0	123.6	-11.05	-10.22
China4435893 *WH1080	31.8	52.6	-39.56 **	-18.23	121.3	138.4	-12.37	
WW 23*PBW 175	49.4	51.0	-3.07	-9.35	141.3	129.3	9.25	-0.59
WW 23*PBW 644	38.2	51.0	-25.03 **	-12.88	106.3	127.8	-16.81	-15.97
WW 23*WH1080	39.0	51.0	-23.40 **	-16.86	121.6	138.4	-12.13	-5.18
DrinaNS 72o*PBW 175	35.9	50.1	-28.32 **	-28.32	136.0	129.3	5.13	0.28
DrinaNS 720*PBW 644	30.5	50.1	-39.16 **	-25.86	118.1	124.3	-4.99	-4.75
DrinaNS 720*WH1080	36.1	50.1	-27.86 **	-21.21	118.6	138.4	-14.30	-12.30
WW21*PBW 175	47.7	50.0	-4.60	-5.93	122.6	129.3	-5.18	-3.50
WW21*PBW 644	30.1	50.0	-39.67 **	-33.00	88.0	125.3	-29.73	-29.73
WW21*WH1080	33.7	50.0	-32.60 **	-28.27	108.8	138.4	-21.40	-23.71
WW25*PBW 175	49.1	49.0	0.20	0.20	141.6	129.3	9.51	10.05
WW25*PBW 644	32.0	49.0	-34.69 **	-27.21	120.3	127.4	-5.60	-4.94
WW25*WH1080	31.3	49.0	-36.12 **	-25.24	117.0	138.4	-15.50	-16.20
WW12*PBW 175	49.0	48.6	0.75	-1.99	160.3	129.3	23.94	25.49
WW12*PBW 644	36.5	48.6	-24.88 **	-27.90	126.0	129.2	-2.48	-2.50
WW12*WH1080	34.6	48.6	-28.72 **	-20.77	109.6	138.4	-20.85	-21.86
Nordresprez*PBW 175	46.3	48.0	-3.47	2.08	115.0	129.3	-11.11	-7.51
Nordresprez*PBW 644	32.0	48.0	-33.33 **	-29.86	111.0	123.6	-10.19	-10.68
Nordresprez*WH1080	30.0	48.0	-37.50 **	-36.67	108.3	138.4	-21.76	-11.84
Drina*PBW 175	48.0	47.5	1.05	1.19	138.2	129.3	6.88	8.40
Drina*PBW 644	31.0	47.5	-34.74 **	-22.95	117.2	125.0	-6.24	-4.91
Drina*WH1080	31.6	47.5	-33.33 **	-36.07	111.6	138.4	-19.35	-21.33

Analysis of variance - Parents and F2 Generation crosses

Yield and Yield contributing traits: Analysis of variance [Table-2] revealed highly significant variability for all treatments for all traits. The variability among the parents (lines and tester) was also significant for all traits. Among lines significant values were observed for all the. Among testers significant values were observed for traits except Grains per plant, 1000 Grain weight and Harvest Index. The crosses arising from winter x spring wheat derivatives relieved highly significant variability for all traits. Significant difference was observed for all yield contributing traits when parents were compared with the crosses (P vs C).

Table-6 *Estimates of Heterosis over Better parent and per se performance on the basis of F1 and F2 generation of crosses*

Cross combination	Harvest Index			
	Mean of the Cross	Mean of Better Parent	F_1 Heterosis (%)	Residual heterosis in F_2
Arkaan*PBW 175	47.3	48.7	-2.81	-5.20
Arkaan*PBW 644	33.9	50.6	-33.09	-31.98
Arkaan*WH1080	40.6	47.8	-15.04	-9.33
Blue boy*PBW 175	48.3	48.7	-0.75	2.84
Blue boy*PBW 644	39.0	50.6	-23.03	-22.36
Blue boy*WH1080	36.0	47.0	-23.51	-22.92
China4435893*PBW 175	51.0	49.3	2.68	5.17
China4435893 *PBW 644	34.3	50.6	-32.24	-26.32
China4435893 *WH1080	32.6	49.3	-34.23	-33.36
WW 23*PBW 175	51.3	50.0	2.53	3.36
WW 23*PBW 644	34.6	50.0	-31.58	-27.72
WW 23*WH1080	33.0	50.0	-34.07	-34.86
DrinaNS 72o*PBW 175	47.8	48.7	-1.85	3.63
DrinaNS 720*PBW 644	37.0	50.6	-26.97	-24.90
DrinaNS 720*WH1080	31.5	47.0	-32.99	-34.30
WW21*PBW 175	51.0	48.7	4.72	7.94
WW21*PBW 644	37.3	50.6	-26.32	-28.29
WW21*WH1080	34.2	48.2	-29.14	-29.70
WW25*PBW 175	37.3	49.1	-24.01	-17.10
WW25*PBW 644	31.3	50.6	-38.16	-25.66
WW25*WH1080	35.6	49.1	-27.40	-6.37
WW12*PBW 175	50.6	48.7	4.04	9.51
WW12*PBW 644	37.6	50.6	-25.66	-13.82
WW12*WH1080	30.6	47.0	-34.84	-34.84
Nordresprez*PBW 175	44.2	48.7	-9.10	-21.36
Nordresprez*PBW 644	35.6	50.66	-29.74	-3.95
Nordresprez*WH1080	31.9	47.0	-32.03	-3.70
Drina*PBW 175	49.6	48.7	2.01	4.06
Drina*PBW 644	40.7	50.6	-19.59	-5.11
Drina*WH1080	39.17	47.0	-16.78	4.47

Estimation of Heterosis

Manifestation of hybrid vigor has been concentrated more in cross-Pollinated crops wherein higher level of heterozygosity can be maintained to exploit this vigor. In the present study heterosis in the F1 an F2 generations was estimated to examine the overall behavior of cross combination for economic traits [Table-3-6]. The heterosis was measured against the performance of better parent of a cross. Heterosis to the extent of 10.0 or more percent in F1 for all the traits (except maturity traits where 5.0 or more percent) was considered good in the present study. Retention of this heterosis in F2 or exceeding the F1 value was also considered favorable. Mention about such cross combination has been made neither to.

Yield and yield component traits

Heterosis for productive tillers per plant in F1 was exhibited by 4 cross combination viz: Blue boy x PBW 175 (22.62%); WW21 x PBW 175 (10.7%) and Nordersprez x PBW 175 (17.9%). For spike length only one cross combination viz; WW21 x PBW 175 relieved significant heterosis in F1 (11.25%) and F2 (13.82).

Discussion

Treatment revealed highly significant variance for all the trait viz, tillers per plant, spike length, grains per plant, 1000 grain weight, Biological yield per plant, grain yield per plant and harvest index. Variance for parents (lines and testers) and crosses was also significant in both F1 and F2 generations. Exception among lines was observed for harvest index (F1 and F2 generation). Comparison of crosses vs parents revealed significant variances for all the traits except grain yield per plant and harvest index (F1 generation) while as comparison of lines vs Tester also revealed significant variance except spike length (both F1 and F2 generation) and harvest index. In bread wheat wide range of variability has been reported for almost all the traits in divergent breeding material [9]. Heterotic pattern estimation revealed that none of the cross combination had significant heterosis for all the traits. However, on individual trait basis, some of the crosses revealed significant heterosis. For yield and yield component traits Blue boy x PBW 175, WW21 x PBW 175 and Nordersprez x PBW 175 for productive tiller per plant in both F1 and F2 generations; WW21 x PBW 175 for spike length; Arkaan x PBW 175, Diana x PBW 175 and WW25 x PBW 175 in both the generations for grain yield per plant. None of the crosses in F1 or F2 revealed desirable heterosis for 1000 grain weight; while as for biological yield per plant the crosses showing desirable heterosis in both the generations were WW12 x PBW 175 and WW25 x PBW 175. The most important trait *i.e.*: grain yield per plant the desirable heterosis in F1 was exhibited by China 4435893 x PBW 175 (11.2%), Diana NS 720 x PBW 175 (14.2%) and WW21 x PBW175 (10.2%) while as in F2 the crosses were Blue boy x PBW 175 (10.3%), Diana NS 720 x PBW 175(17.3%); China 4435893x PBW 644 (10.7%). However, none of the cross combination exhibited desirable heterosis for harvest index in F1 or F2 with maximum of 9.5% shown by WW12 x PBW 175 in F1. Significant heterosis over standard check in 2 crosses involving winter x spring genotypes for grain yield, grain number and harvest index [10]. Significant heterosis for grains per plant and 1000 grain weight in winter x spring crosses [7]. Heterosis in several crosses of bread wheat for maturity traits, tillers per plant, flag leaf area, plant height, spike length, grains per plant, 1000 grain weight and seed protein content [11]. Heterosis for grain yield and yield components in wheat as manifestation of dominant gene action [12].

Conclusion

The material selected (winter and spring wheat) possessed good magnitude of variability for all the traits. Significant desirable heterosis for many traits was revealed. Accordingly, for population improvement of wheat for rainfed ecosystem, multiline crossing programme is needed to introgress allelic resources from elite genotypes and the progenies showing better early generation performance are further crossed through bi- parental procedure to increase chances of generation of hidden latent variability in heterozygous polygenic blocks. Use of recurrent selection procedure for the identification of superior transgressive segregants before fixation of alleles in homozygous condition.

Application of research:

1. Increase in the variability of Indian wheat through successful hybridization of Winter & Spring wheat ecotypes.
2. Recovery of Desirables Recombinants on crossing these two diverse ecotypes for further use in Transgressive and Heterosis Breeding.

Research Category: Plant Sciences, Wheat Genetics & Breeding.

Abbreviations: GCA: General Combining Ability, SCA: Specific Combining Ability, ANOVA: Analysis of Variance, BP: Better Parent, HI: Harvest Index.

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Study area / Sample Collection: Chatha Farm

Cultivar / Variety / Breed name: Wheat (*Triticum aestivum* L.)

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