



Research Article

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Combining Ability and Heterosis for Morpho-Physiological Characters on Bread Wheat (*Triticum aestivum* L.)



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Abstract

The present investigation entitled "Combining ability and Heterosis for morpho-physiological characters in bread wheat (*Triticum aestivum* L.)" was undertaken to study the combining ability and heterosis for grain yield and its components in F1 generation of wheat through Line X Tester analysis. Experiment was conducted with 2 replications and 54 genotypes consisting 10 lines viz., 33rd ESWYT150, 20th HRWYT213, 20th HRWYT235, 45th IBWSN1021, 14th FHBSN6418, 36th SAWSN3065, PBW658, KB2013-03, KB2013, VW921 and 4 testers viz., GW273, GW366, RVW 4106, SUJATA and their 40 crosses made in L X T mating fashion in randomized block design at experimental Research Farm, College of Agriculture, Gwalior, (M.P.) during 2014-2015. Genetic analysis revealed that GCA and SCA variances were significant for all characters, thereby, indicating all traits under the control of both additive and non-additive components inheritance.

The predictability ratios were more than unity, inferring the predominance of additive gene action governing the traits. Good general combiners on the basis of GCA effects were 33rdESWYT150, PBW658, KB2013-03, KB2013 and VW921, GW273 and SUJATA. These parents involved in F2 generations may yield superior trans aggressive recombinant and may exploit either through pedigree selection or progeny selection or mass selection. Segregating generations of good specific combination, 'KB2013-03 × SUJATA', 'PBW658 × SUJATA', 'KB2013 × GW273' and 'VW921 × SUJATA' consisting good general combining parent would be highly desirable for effective selection. The cross 33rd ESWYT150 × RVW4106 followed by KB2013-03 × SUJATA and KB2013-03 × RVW4106 was recognized as best heterotic cross as well as high per se performance for grain yield and it exhibited highly significant positive heterosis over both the better and mid parent.

Keywords: Combining ability; GCA; SCA; Relative heterosis; Heterobeltiosis

Introduction

Wheat is the principal food crop in most areas of the world and also occupies prominent position in Indian agriculture after rice. It is nutritionally important cereal essential for the food security, poverty alleviation and for livelihoods. It is widely cultivated as staple food crop among the cereals and is contributing about 30% to the food basket of the country. India is the second largest producer of wheat in the world with the production around 75 million tonnes during the last decade and it is a major contributor to the food security system in India, occupying nearly 30.37 million hectares, producing 90.78 million tonnes and productivity 29.89q/ha and in Madhya Pradesh, grown in 5.56 million hectares with production of 13.37 million tonnes and productivity of 24.05q/ha (Anonymous 2014-2015). The substantial improvement in production is utmost necessary not only to meet ever increasing food requirement for domestic consumption, but also for export to earn foreign exchange. To feed the growing population, the country's wheat requirement

by 2030 has been estimated at 100 million metric tonnes and to achieve this target, wheat production has to be increased at the rate of <1per annum and this can be achieved through horizontal approach i.e. by increasing area under cultivation or through vertical approach i.e. varietal/hybrid improvement, which is one of the strongest tool to take a quantum jump in production and productivity under various agro- climatic conditions.

Triticum aestivum (bread wheat) ($2n=6x=42$) is an allohexaploid produced from two separate naturally occurring hybridization events. The initial hybridization, that occurred between the two grass species *Triticum urartu* ($2n=2x=14$) (the A genome donor), and *Triticum speltoides* ($2n=2x=14$) (B genome donor). This new species would have been tetraploid wheat ($2n=4x=28$) viz., *Triticum turgidum* var. durum (Durum wheat). Hexaploid wheat arose as a result of a second hybridization between the new tetraploid and a third diploid species ($2n=2x=14$) viz., *Triticum tauschii* (D genome donor).

Again, doubling chromosome must have occurred in order to produce a fertile individual. This new species would then have 42 chromosomes; i.e. six complete genomes each of 7 chromosomes.

Materials and Methods

The experimental material consisted 54 genotypes consisting 10 lines viz., 33rd ESWYT150, 20th HRWYT213, 20th HRWYT235, 45th IBWSN1021, 14th FHBSN6418, 36th SAWSN3065, PBW658, KB2013-03, KB2013, VW921 and 4 testers viz., GW273, GW366, RVW 4106, SUJATA and their 40 crosses made in L X T mating fashion in randomized block design at experimental Research Farm, College of Agriculture, Gwalior, (M.P.) during 2014-2015. Observations were recorded on randomly selected 5 tagged plants for grain yield per plant and different yield contributing traits viz., days to heading, days to maturity, plant height, tillers per plant, spike length, 1st internodes length, weight of spikes per plant, weight of grains per spike, grains per spike, test weight, canopy temperature index, biological yield and harvest index. The analysis was carried out by adopting Kempthorne O [1] for estimation of variances components and combining ability effects. Heterosis over mid parents and better parents

were determined as per standard procedure. Significance of heterosis value was tested using 't' test.

Results and Discussion

Line × tester analysis techniques has been extensively used in almost all the major field crops to estimates GCA and SCA variances and effect and to understand In the present research work, variances due to both lines and testers were significant for days to heading, plant height, tillers per plant, spike length, weight of spikes per plant, grains per spike, test weight, grain yield per plant, canopy temperature index, biological yield and harvest index. However, lines were significant for days to maturity, 1st inter-node length, weight of grains per spike. Variances due to Line × tester were significant for all the 14 characters [2,3] also reported similar results). In the present study both GCA and SCA variances were significant for most of the characters, thereby, indicating importance of both additive as well as non additive components of genetic variance in the control of these traits (Table 1). Singh et al. [2] & Kumar et al. [4] also reported similar results.

Table 1: Analysis of variance for combining ability for Grains yield and yield contributing characters in wheat.

Sources	DF	Days to Heading	Days to Maturity	Tillers/Plant	1 st Inter-Node Length	Spike Length	Wt. of Spike/Plant
Lines	9	2.48**	4.47**	0.91**	0.09**	0.76**	6.10**
Tester	3	3.90**	0.55	0.27	0.01	0.90**	0.54*
L X T	27	2.14**	5.49**	0.38**	0.08**	2.41**	3.58**
Error	53	0.4	0.49	0.08	0.01	0.01	0.17

Sources	DF	Grains Weight/ Spike	Grains/Spike	Test Weight	Grains Yield/Plant	Canopy Temperature Index	Biological Yield	Harvest Index
Lines	9	0.08**	16.35**	48.25**	7.40**	0.0011**	8.66**	64.79**
Tester	3	0.01	26.96**	2.42**	0.42**	0.0004*	2.32**	3.69**
L X T	27	0.03**	79.12**	14.63**	2.29**	0.0010**	3.45**	15.93**
Error	53	0.01	1.06	0.18	0.02	0.0001	0.32	1.57

Genetic components

Genetic component of variances is assessed through the estimates of GCA and SCA variances. The additive genetic variance is equal to GCA variance and dominance variance is equal to SCA variance. In the present research, the genetic component's magnitudes showed that the additive components of variances

were higher compared to dominance components of variances for all characters. The ratio of genetic components " $\sigma^2_{gca}/\sigma^2_{sca}$ " also showed more than one, indicating predominance of additive variances for almost all characters (Table 2). Present finding are in confirmation with Kandil et al. [5], Khiabani et al. [6] & Samier & Ismail (2015) were recorded predominance of additive variances for all the traits.

Table 2: Genetic components for Grains yield and its attributes in wheat.

	Days to Heading	Days to Maturity	Plant Height	Tillers/Plant	1 st Inter-Node Length	Spike Length	Wt. Of Spike/Plant
Covariances							
Cov HS (Line)	0.04	-0.05	-2.77	0.03	0	-0.08	0.13
Cov HS (Tester)	0.09	-0.62	-9.06	-0.01	-0.01	-0.19	-0.38
Cov HS (Average)	0.01	-0.02	-0.45	0	0	-0.01	0.01

Cov FS	5.85	4.9	45.96	1.06	0.1	2.07	6.85
Genetic Components							
σ^2 GCA (Lines)	0.01	-0.02	-0.45	0	0	-0.01	0.01
σ^2 GCA(Testers)	0.02	-0.06	-1.81	0.01	0	-0.05	0.03
σ^2 GCA (Parents)	11.77	-33.1	-526.51	-0.16	-0.5	-11.43	-17.24
σ^2 SCA	0.87	2.5	39.93	0.15	0.04	1.2	1.7
σ^2 GCA / σ^2 SCA	13.52	-13.26	-13.19	-1.06	-12.87	-9.54	-10.11
σ^2 A	23.54	-66.19	-1053.02	-0.31	-1	-22.87	-34.48
σ^2 D	0.87	2.5	39.93	0.15	0.04	1.2	1.7

	Grains Weight/Spike	Grains/Spike	Test Weight	Grains Yield/Plant	Canopy Temperature Index	Biological Yield	Harvest Index
Covariances							
Cov HS (Line)	0	-3.14	1.68	0.26	0	0.65	6.11
Cov HS (Tester)	0	-6.52	-1.53	-0.23	-0.0001	-0.06	-0.61
Cov HS (Average)	0	-0.46	0.17	0.03	0	0.03	0.25
Cov FS	0.08	55.12	52.38	8.1	0.0014	10.79	67.04
Genetic Components							
σ^2 GCA (Lines)	0	-0.46	0.17	0.03	0	0.03	0.25
σ^2 GCA(Testers)	0	-1.82	0.67	0.1	0	0.11	1.02
σ^2 GCA (Parents)	-0.09	-401.83	-45.77	-7.03	0	-2.09	-30.72
σ^2 SCA	0.01	39.03	7.23	1.13	0	1.56	7.18
σ^2 GCA / σ^2 SCA	-6.58	-10.29	-6.33	-6.2	-7.8	-1.34	-4.28
σ^2 A	-0.18	-803.67	-91.54	-14.05	-0.01	-4.19	-61.45
σ^2 D	0.01	39.03	7.23	1.13	0	1.56	7.18

Combining ability

Combining ability plays major role in the evaluation of inbred in terms of their breeding values; and this will help to decide efficient breeding method to be applied in segregating generation.

General combining ability effects

It is primarily a function of additive genetic variance; it helps in the selection of suitable good general combining parents for hybridization. Data presented in Table 3 revealed that 5 lines

viz., 33rd ESWYT150, PBW 658, KB 2013-03, KB 2013 and VW921 reported significant and positive GCA effect for grain yield, test weight, weight of spike/plant, biological yield and harvest index, thereby, suggesting good general combiner for these traits. Tester 'GW273' was good general combiner for grain yield, test weight and biological yield, whereas, tester SUJATA registered significant and positive GCA effect for grain yield, days to heading, spike length and harvest index, thereby, suggested good general combiner for these traits.

Table 3: Parents showing significant GCA effects for grain yield along with GCA effects for other attributes.

Parents	Lines/Tester	Grain Yield/Plant(G)		Days to Heading		Days to Maturity		Plant Height(Cm)		Tillers/Plant (Cm)	
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
GW 273	T	17.91	0.17*	85.5	0.1	135	0.22	104.8	-0.05	8.3	0.08
SUJATA	T	17.33	0.07*	85.5	0.55**	137	-0.09	104.6	-0.09	8.3	-0.12
VW 921	L	16.56	0.75**	87.5	0.45**	135	-0.60**	103.9	2.83**	7.1	-0.01
PBW 658	L	16.46	0.47**	86.5	-1.05**	138.5	-0.47	104.7	-1.95**	7	-0.21**
33 rd ESWYT 150	L	16.23	1.51**	87	-0.05	139	-0.35	100.2	-1.85**	7.2	0.77**

KB 2013-03	L	16.11	0.72**	89.5	-0.05	136.5	-0.47	109.6	1.75**	6.9	0.04
KB 2013	L	14.98	0.68**	88	0.08	137	-0.60**	109.6	0.45	6.9	-0.51**

Parents	Lines/Tester	1stinter-Node Length(Cm)		Spike Length(Cm)		Spike Weight/Plant(G)		Grain Weight/Spike(G)		Grains /Spike	
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA	mean	GCA
GW 273	T	3.11	0.17*	10.75	-0.17**	24.46	0.16	2.26	0	68.1	-1.09
SUJATA	T	2.68	0.07*	11.32	0.28**	23.78	0.12	2.11	0.02	70.8	1.52
VW 921	L	2.77	0.75**	11.11	0.05	23.08	0.66**	2.04	0.06	66.5	-0.76
PBW 658	L	2.9	0.47**	10.29	-0.15**	23.41	0.32**	2.12	0.04	60.8	0.54
33 rd ESWYT 150	L	3.02	1.51**	10.43	-0.61**	21.22	1.36**	2	0.13**	61.9	-2.11**
KB 2013-03	L	3.02	0.72**	8.94	-0.23**	21.01	0.68**	2.07	0.07**	54.2	0.94**
KB 2013	L	2.91	0.68**	11.03	0.22**	20.09	0.58**	2.02	0.07**	67.3	-0.36

Parents	Lines/Tester	Test Weight(G)		Canopy Temperature Index		Biological Yield(G)		Harvest Index (%)	
		Mean	GCA	Mean	GCA	Mean	GCA	Mean	GCA
GW 273	T	44.78	0.42**	0.41	-0.01**	32.7	0.43**	54.75	0.11
SUJATA	T	43.33	0.13	0.36	0	33.48	-0.15	51.75	0.56*
VW 921	L	41.54	1.99**	0.36	0.02**	35.04	-0.73**	47.27	2.79**
PBW 658	L	41.82	1.11**	0.35	-0.01**	35.76	0.96**	46.59	2.36**
33 rd ESWYT 150	L	40.79	3.73**	0.36	-0.01	39.4	2.18**	41.22	1.57**
KB 2013-03	L	40.49	2.02**	0.36	0.01	35.29	1.05**	45.65	3.28**
KB 2013	L	38.69	1.64**	0.37	0.01**	37.96	-0.92**	43.09	3.00**

Lines 33rd ESWYT150 was also reported significant and positive GCA effect for tillers/plant and weight of grains/plant. Line KB2013-03 also exhibited significant positive GCA effect for plant height, weight of grain/spike and grains/spike. Significant positive GCA effect was reported in KB2013 and VW921 for canopy temperature index. These genotypes can be used in the development of high yielding varieties through the pedigree selection and progeny selection or mass selection in later generations in promising segregating generations in wheat. Present finding are in confirmation with Kandil et al. [5], Samier and Ismail (2015), Kalhor et al. [7], Aslam et al. [8], Singh et al. [2], Raj & Kandalkar [9], Kumar et al. [4] & Kapoor et al. [3].

Specific combining ability Effects

It is mainly a function of dominance variances; it helps in the identification of superior cross combination for commercial exploitation of heterosis. In self-pollinated crops like wheat, SCA effects are not much important as they are mostly related to non-additive gene effects excluding those of arising from complementary gene action or linkage effects they cannot be fixed in pure lines. Further superiority of the hybrids might not indicate their ability to yield transgressive segregates; rather SCA would provide satisfactory criteria. However, if a cross combination exhibiting high SCA as well as high per se performance having at

least one parent as good general combiner for a specific trait, it is expected to throw desirable transgressive segregants in later generations. Data presented in Table 4 revealed that 19 crosses showed significant and positive SCA effect, thereby, indicating good specific combinations for grain yield and other attributing traits. Crosses viz., KB2013-03×SUJATA', KB2013×GW273', PBW658×SUJATA' and 'VW921×SUJATA' registered best good specific combiner for grain/yield because these crosses were the results of good x good general combiners and reported significant positive SCA effect. Crosses '33rd ESWYT150×GW366', '33rd ESWYT150 × RVW4106', '20th HRWYT213×GW273', '20th HRWYT213×SUJATA', '20th HRWYT235×SUJATA', '45th IBWSN1021×GW273', '14th FHBSN6418 × SUJATA', 'KB2013-03×GW366', 'KB2013×RVW4106' and 'VW921×GW366' were the result of good x poor general combiner and also reported significant positive SCA effect for grain yield. Rest of the crosses viz., '45th IBWSN1021 × RVW4106', '36th SAWSN3065 × RVW4106', '36th SAWSN3065 ×GW366', '14th FHBSN6418 × GW366', '45th IBWSN1021 × RVW4106', '20th HRWYT235 × GW366' were result of poor x poor general combiner but exhibited significant positive SCA effect for grain/yield, thereby, suggesting good specific combiner for these traits. Present finding are in confirmation with Kandil et al. [5], Kalhor et al. [7], Aslam et al. [8], Singh et al. [2], Raj & Kandalkar [9], Kumar et al. [4], Kapoor et al. [3].

Table 4: Crosses showing significant SCA effects for grain yield and its attributes.

SN	Crosses	Grain Yield/Plant(G)		Days to Heading	Days to Maturity	Plant Height(Cm)	Tillers/Plant	1 st Inter-Node Length(Cm)
		Mean	SCA	SCA	SCA	SCA	SCA	SCA
1	33 rd ESWYT 150 ×GW 366	17.87	0.59**	-0.5	-1.45**	2.73**	0.36	0.16**
2	33 rd ESWYT 150 ×RVW 4106	18.06	0.72**	0.15	-1.10**	5.99**	0.56**	0.14**
3	20 th HRWYT 213 ×GW 273	16.89	1.67**	-0.1	-0.1	1.85**	0.59**	-0.26**
4	20 th HRWYT 213 ×SUJATA	15.44	0.23**	-0.05	-0.85	5.59**	0.19	0.09
5	20 th HRWYT 235 ×GW 366	15.57	1.27**	-0.5	-1.70**	0.83	-0.16	-0.20**
6	20 th HRWYT 235 ×SUJATA	14.8	0.29**	-0.05	0.15	1.62**	0.17	0.13
7	45 th IBWSN 1021 ×GW 273	15.7	0.67**	2.52**	-0.1	6.75**	-0.31	0.24
8	45 th IBWSN 1021 ×RVW 4106	15.87	1.09**	-1.23**	1.35**	1.86**	-0.24	-0.31**
9	14 th FHBSN6 4188 ×GW ×366	15.79	0.54**	-0.63	0.92	2.98**	0.24	0.18**
10	14 th FHBSN6 4188 ×SUJATA	15.87	0.41**	0.8	-1.72**	-0.03	-0.23	-0.24**
11	36 th SAWSN 3065 ×GW 366	16.31	0.82**	0.63	-1.33**	0.15	0.14	0.05
12	36 th SAWSN 3065 ×RVW 4106	16.06	0.51**	-0.73	-0.47	4.41**	0.16	0
13	PBW 658 ×SUJATA	16.89	0.42**	-0.55	0.03	7.62**	0.37	0.12*
14	KB 2013-03 ×GW366	17.16	0.66**	0	-0.83	4.63**	-0.81	-0.17**
15	KB 2013-03 × SUJATA	18	1.29**	0.95	0.97*	2.32**	-0.48**	0.21**
16	KB 2013 × GW 273	17.27	0.49**	-0.73	-1.10**	5.47**	-0.63**	0.17**
17	KB 2013 × RVW 4106	17.42	0.90**	-0.48	-0.85	0.79	-0.27	-0.18**
18	VW 921 × RVW 4106	17.43	0.91**	0	1.30**	3.75**	0.04	0.13
19	VW 921 × SUJATA	17.01	0.27**	0.45	-0.85	-2.46**	-0.03	-0.20**

SN	Crosses	Spike Length(Cm)	Spikes Weight/Plant(G)	Grain Weight/Spike(G)	Grains/Spike	Test Weight(G)
		SCA	SCA	SCA	SCA	SCA
1	33 rd ESWYT 150 ×GW 366	0.22**	0.84**	0.11*	-1.50**	1.56**
2	33 rd ESWYT 150 ×RVW 4106	-0.70**	1.24**	-0.01	-3.56**	1.65**
3	20 th HRWYT 213 ×GW 273	0.27**	1.96**	0.08	0.71	4.25**
4	20 th HRWYT 213 ×SUJATA	-1.53**	-0.66**	0.05	-8.40**	0.80**
5	20 th HRWYT 235 ×GW 366	0.59**	0.73**	0.17	-3.43**	3.50**
6	20 th HRWYT 235 ×SUJATA	-0.78**	1.45**	-0.03	-3.10**	0.92**
7	45 th IBWSN 1021 ×GW 273	-1.52**	1.79**	0.02	-8.78**	1.67**
8	45 th IBWSN 1021 ×RVW 4106	-0.30**	0.65**	0.08	-2.57**	2.66**
9	14 th FHBSN6 4188 ×GW ×366	-1.25**	0.74**	-0.03	-8.85**	1.33**
10	14 th FHBSN6 4188 ×SUJATA	-0.19**	-0.03	0.06	-0.32	1.08**
11	36 th SAWSN 3065 ×GW 366	-0.30**	0.75**	0.11*	0.7	2.14**
12	36 th SAWSN 3065 ×RVW 4106	-1.17**	0.79**	0.05	-5.76**	1.13**
13	PBW 658 ×SUJATA	-1.58**	-0.48	-0.06	-10.62**	1.13**
14	KB 2013-03 ×GW366	0.24**	0.91**	0.1	1.25	1.39**
15	KB 2013-03 × SUJATA	-0.06	1.81**	0.14**	1.18	2.91**
16	KB 2013 × GW 273	-1.40**	0.36	0.14**	-4.61**	1.15**
17	KB 2013 × RVW 4106	0.43	0.39	0.04	1.09	2.23**
18	VW 921 × RVW 4106	-1.44**	1.43**	0.09	-9.15**	2.10**
19	VW 921 × SUJATA	0.34**	0.27	0.08	-0.72	0.32

SN	Crosses	Canopy Temperature Index	Biological Yield	Harvest Index
		SCA	SCA	SCA
1	33 rd ESWYT 150 ×GW 366	0.02**	0.14	1.19
2	33 rd ESWYT 150 ×RVW 4106	-0.01	0.08	2.11**
3	20 th HRWYT 213 ×GW 273	0.03**	-0.4	4.58**
4	20 th HRWYT 213 ×SUJATA	0.01	0.77	-0.22
5	20 th HRWYT 235 ×GW 366	0.01	1.10**	1.95
6	20 th HRWYT 235 ×SUJATA	-0.01	1.31**	-0.66
7	45 th IBWSN 1021 ×GW 273	-0.02	1.53**	0.17
8	45 th IBWSN 1021 ×RVW 4106	0	1.49**	1.74
9	14 th FHBSN6 4188 ×GW ×366	0.03**	0.6	0.66
10	14 th FHBSN6 4188 ×SUJATA	-0.04**	1.97**	-1.06
11	36 th SAWSN 3065 ×GW 366	-0.02**	-0.01	3.25**
12	36 th SAWSN 3065 ×RVW 4106	0	0.54	-2.55**
13	PBW 658 ×SUJATA	-0.01	-0.07	0.94
14	KB 2013-03 ×GW366	0	0.80*	0.5
15	KB 2013-03 × SUJATA	0	-2.57**	6.44**
0.16	KB 2013 × GW 273	0	-0.82**	1.93
17	KB 2013 × RVW 4106	0.02**	0.76	1.78
18	VW 921 × RVW 4106	-0.03**	-0.75	3.14**
19	VW 921 × SUJATA	0	1.48**	-1.17

Heterosis

The aim of estimation of heterosis in the present study has to spot out the best combination of parents giving high degree of useful heterosis and characterization of parents for their genotypic worth for future use in breeding programme. All characters had shown considerable amount of heterosis over better parent (Heterobeltiosis) and mid parent (relative heterosis). Present finding are in confirmation with Devi et al. [10]. The degree of heterosis however differed for different

characters. Data presented in Table 5 revealed that 4 cross viz., 'KB2013×RVW4106', '33rd ESWYT150×RVW4106', 'KB2013-03×SUJATA' and 'KB2013-03×RVW4106' recorded significant heterobeltiosis and relative heterosis in positive direction for grain yield, while another 3 cross '33rd ESWYT150×GW366', '45th IBWSN1021×RVW4106' and 'PBW658×RVW4106' recorded significant positive relative heterosis for grain yield. Devi et al. [10] also reported similar result [11-15].

Table 5: Heterosis over better parent and mid parent for grain yield and its attributes.

Crosses	Grain Yield/Plant		Days to Maturity				Plant Height		Tillers/Plant		1st Inter-Node Length		Spike Length	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
KB2013×RVW4106	16.33**	16.88**	-2.84**	-1.44	-1.09**	-2.61**	-2.59**	-10.14**	-9.49	-6.87**	-12.78**	-9.60**	-1.09	9.43**
33 rd ESWYT150 × RVW4106	11.24**	16.05**	-1.15	-0.29	-2.52**	-1.81**	0.05	4.28**	15.28**	18.57**	0	3.25**	-22.19**	-19.35**
KB2013-03 × SUJATA	3.90**	7.67**	-2.31**	0	-1.08**	-0.91	-4.78**	-2.33**	-21.69**	-14.47**	1.38	7.37**	-9.98**	0.59
KB2013-03 × RVW4106	3.20**	7.28**	-3.91**	-1.71	1.46**	1.65**	-15.69**	-15.48**	1.45	2.19	-0.99	2.22	-25.53**	-17.16**
33 rd ESWYT150 × GW366'	0.34	4.99**	-2.30**	-1.45	-2.88**	-1.82**	-3.43**	0.19	-1.19	6.41	-2.24	-0.49	-5.37**	2.07
45 th IBWSN1021 × RVW4106	-0.53	2.90**	-6.04**	-3.12**	-0.73	-0.55	-3.53**	-3.33**	-10.39**	-4.83	-10.07**	-7.62**	-9.63**	-9.30**

PBW658 × RVW4106	-2.43**	2.47**	-1.16	-0.58	-2.53**	-2.00**	-4.36**	-2.41**	-7.14	-5.8	-1.38	-0.17	11.14**	-7.30**
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Crosses	Weight of Spike/Plant		Weight of Grain/Spike		Grain/Spike		Test Weight		Canopy Temperature Index		Biological Yield		Harvest Index	
	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP	BP	MP
KB2013 × RVW4106	4.31**	8.82**	4.21	5.65	-7.73	-6.84**	12.54**	13.52**	-21.92**	-19.72**	1.55	7.49	2.4	3.59
33 rd ESWYT150 × RVW4106	11.80**	13.55**	6.27	7.07	-17.06**	-12.08	10.44**	14.33**	-21.13**	-20	4.00**	12.00**	-0.08	3.3
KB2013-03 × SUJATA	3.36	9.76**	4.96	6.1	-5.51	7.04**	3.67**	7.18**	-16.90**	-16.08**	0.03	2.67	-1.53	4.64**
KB2013-03 × RVW4106	1.28	3.4	-0.97	1.49	-18.22	-8.63**	5.46**	8.78**	-18.06**	-16.31**	8.39**	10.78**	-4.81	-3.16
33 rd ESWYT150 × GW366'	-1.13	5.47**	-3.95	2.46	-3.23	-2.2	0.54	4.96**	-21.79**	-18.12**	5.29**	14.44**	-19.86**	-9.28**
45 th IBWSN1021 × RVW4106	-1.07	0.5	0.76	0.76	-10.13**	-3.97	-0.55	1.8	-14.29**	-13.67**	8.73**	13.95**	-11.04**	-9.82**
PBW658 × RVW4106	-4.04**	-0.85	-1.18	2.45	-3.21	2.63	-4.33	0.23	-26.09**	-26.09**	2.03	4.95**	-5.51*	-2.91

Cross 'KB2013×RVW4106' was also reported significant positive heterobeltiosis and relative heterosis for weight of spike/plant and test weight. Cross '33rd ESWYT150×RVW4106' also showed significant heterobeltiosis and relative heterosis in positive direction for tillers/plant, weight of spike/plant, test weight and biological yield. Cross 'KB2013-03×RVW4106' was also reported significant positive heterobeltiosis and relative heterosis for days to maturity, test weight and biological yield [16-18]. Cross 'KB2013-03×SUJATA' showed significant positive relative heterosis for 1st inter-node length, weight of spike/plant, test weight, biological yield and harvest index, while significant positive heterobeltiosis was reported for test weight and canopy temperature index. Cross '33rd ESWYT150×GW366' was also reported significant positive relative heterosis for weight of spike/plant, test weight, and biological yield. Cross '45th IBWSN1021×RVW4106' was also reported significant positive heterobeltiosis and relative heterosis for biological yield. Cross 'PBW658×RVW4106' also showed significant positive relative heterosis for biological yield. Further it was noticed that both significant heterobeltiosis or/and relative heterosis were recorded for attributing traits without showing heterosis for grain yield [19-23].

Conclusion

Genotypes 33rd ESWYT150, PBW658, KB2013-03, KB2013 and VW921, GW273 and SUJATA were identified good general combiner for grain yield per plant and its components in wheat [24-27]. Cross 33rd ESWYT 150 X GW 366, 33rd ESWYT 150 X RVW4106, 20th HRWYT 213 X GW273, 20th HRWYT 213 X SUJATA, 20th HRWYT 235XGW366, 20th HRWYT 235 X SUJATA, 45th IBWSN1021 X GW273, 45th IBWSN1021 X RVW4106, 14th FHBSN6418XGW366, 14th FHBSN6418 X SUJATA, 36th SAWSN3065 X GW366, 36th SAWSN3065XRVW4106,

PBW658XSUJATA, KB2013-03 X GW366, KB2013-03 X SUJATA, KB2013XGW273, KB2013XRVW4106, VW921XGW366, VW921 X SUJATA were identified good specific combiner for grain yield per plant and its components in wheat so it may be suitable for exploitation in future plant breeding programme [28-30].

Additive variance played the major role in determining all of the characters. Some of the cross recorded significant heterosis for grain yield, thereby, [31,32] indicating further scope of hybrid development in near future. The crosses KB2013-03XSUJATA was desirable for selecting higher yielding and short duration plant, while cross KB2013XRVW4106 was desirable for the selection of high yielding dwarf plant over the better parent. The crosses KB2013-03XRVW4106, KB2013XSUJATA and KB2013-03XSUJATA were suitable for selection of high yielding and short duration plant over the mid parent. The cross ESWYT 150 X RVW4106 was desirable for selecting higher yielding and short duration plant over both better and mid parent [33].

Suggetions for Further Work

The following relevant suggestions could be drawn for further scope of improvement from the present study: Good general combiners like 33rd ESWYT150, PBW658, KB2013-03, KB2013 and VW921, GW273 and SUJATA could be used in the development of high yielding varieties through the simple/recurrent selection from promising segregating cross generations in wheat. New recombinant promising single plants may be selected in F2 generations of good cross 33rd ESWYT150XRVW4106, KB2013-03XSUJATA and 33rd ESWYT150XGW 366 involving one of the good specific combining parents. The cross 33rd ESWYT 150XRVW4106 was found higher yielding and short duration plant over both better and mid parent. Thus it was very desirable for further breeding programme while selecting the genotype [34,35].

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