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Heterosis Analysis in F1Hybrids of Bread Wheat

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Abstract: The present research was conducted to estimate heterotic effects of yield and its associated traits in F_1 hybrids of bread wheat genotypes in a set of line x tester crosses developed from five parents of which two were considered as lines (Anmol-91 and Kiran-95) and three testers (Imadad-05, SKD-1 and Khirman). The experiment was carried out in a randomized complete block design with three replications at Southern Wheat Research Station, A.R.I.,Tandojam during the Rabi season, 2013-14.Results revealed that genotypes (parents and F_1 hybrids) were differed significantly($P \leq 0.01$) for all studied characters, showing that used crop genetic resources may be exploited for further breeding programs. Considering the mean performance, the F_1 hybrid Anmol-91 x Imdad-05 showed exceptionally good performance for tillers plant^{-1}, spike length, spikelets spike^{-1} and grains spike^{-1}, while next rank hybrid was Kiran-95 x Imdad-05, which also produced desirable results for grain yield plant^{-1}, seed index and total biomass plant^{-1}, suggesting that these promising cross combinations may further be used in various breeding programs. With respect to heterotic effects in comparison to better parent, the F_1 hybrid Kiran-95 x Imdad-05 showed the highest positive heterosis for grain yield plant^{-1}, seed index and biological yield plant^{-1}, while next promising cross combination was Anmol-91 x Imdad-05, which also showed the highest positive heterobeltiosis for tillers plant^{-1} and spikelets spike^{-1}. These cross combinations may be used for hybrid crop development in bread wheat for potential yield.

Keywords: F_1 Hybrids, Heterosis, Heterobeltiosis, Bread Wheat

1. INTRODUCTION

Bread wheat is considered as a staple food source for a large population of the world and also provides a range of diversified baked food products. Hence, wheat and its production are the chief food sources for human diet (Kumar *et al.,* 2013).To feed flourishing population of Pakistan; the genetic improvement of wheat genotypes for high yield potential is a dire need. For this purpose, the exploitation of maximum genetic potential from available genetic resources of wheat is a pre-requisite. F_1 hybrid carrying heterotic effects, which are featured in all crop species, the yield gains are limited to the F_1 generation. The F_2 and succeeding generations obtained through selfing are discarded since reduced yields and developmental characters (Wang *et al.,* 2015). Heterosis is considered as the superiority of the hybrids in comparisons to either of its parents. It is the allelic or non-allelic interaction of genes under the influence of specific environment. Heterosis has been estimated in a range of cultivated crops and has been the purpose of considerable importance to study as mean of increasing productivity of crop plant. It is now well established that heterosis does occur with proper combination of parents. Formerly, utilization of heterotic effects for grain yield was mainly ascribed to cross-pollinated crops. However, later itwas reported in wheat as being predominantly self-pollinated for the first time by Freeman (1919), who well-versed the supremacies of F_1 crosses over their parents (Özgen, 1989). Briggle (1963) described existence of heterosisin substantial quantity for grain yield components in different F_1 wheat crosses. Keeping in view the above facts, the current research was designed to estimate heterotic effects in intraspecific crosses of wheat.

2. MATERIALS AND METHODS

The present study was conducted at Southern Wheat Research Station, Tandojam. In this study, F_1 hybrids were raised fromintra-specific crossing between two cultivated female wheat varieties viz.,Anmol-91 and Kiran-95 with three promising male lines viz., Imdad-05, SKD-1 and Khirman. These five wheat varieties were crossed in a line x tester design; consequently, six F_1 hybrids (Anmol-91 x Imdad-05, Anmol-91 x SKD-1, Anmol-91 x Khirman, Kiran-95 x Imdad-05, Kiran-95 x SKD-1 and Kiran-95 x Khirman) were obtained. The characters were analyzed including tillers plant^{-1}, spike length (cm), spikelet's spike^{-1}, grains spike^{-1}, seed index(1000-grain weight, g), grain yield plant^{-1}(g), and total biomass plant^{-1} (g) The experiment was conducted in randomized complete block design having three replicates. The analysis of variance was carried out after Gomez and Gomez (1984). Moreover, heterosis of all F_1 hybrids was computed according to Fehr (1987).

3. RESULTS AND DISCUSSION

For the improvement of any plant character, plant breeders heavily rely on the availability of genetic variability generated from different matting designs. It

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is also well know phenomena that in a hybridization program, certain crosses pass on more favorable genes than the others. Thus, some cross combinations may be superior as compared to their parents for improving any economic trait in wheat breeding. The mean squares (**Table-1**) from analysis of variance revealed highly significant differences ($P \leq 0.01$) among tested genotypes including parents and F_1 hybrids, exhibiting that used plant genetic resources have worth to be evaluated for upcoming breeding programs.

The mean performance of hybrids are given in **(Table-2)**, as regard to number of tillers plant^{-1}, the maximum tillers (13.80) were produced by the cross combination Anmol-91 x Imdad-05, while Kiran-95 x SKD-1 produced minimum tillers plant^{-1} (11.13).As far as the character spike length is concerned, the hybrid Anmol-91 x Imdad-05 measured the longest spike (15.40 cm), whereas Kiran-95 x SKD-1 measured the shortest spike with the length of 14.00 cm.With respect to spikelets spike^{-1}, among the F_1 hybrids, the cross Anmol-91x Imdad-05 produced maximum number of spikelets spike^{-1}(35.77). However, the hybrid combination Anmol-91 x Khirman produced minimum number of spikelets spike^{-1} (24.99). Regarding to grains spike^{-1}, the maximum grains spike^{-1} (70.33) were produced by the cross combination Anmol-91 x Imdad-05, while Kiran-95 x Imdad-05 produced minimum grains spike^{-1} (59.00).For the character grain yield plant^{-1}, the hybrid Kiran-95 x Imdad-05 produced the highest grain yield plant^{-1}(29.27g), whereas Anmol-91 x Imdad-05 produced the lowest grain yield plant^{-1} (21.48g).As for as seed index is concerned, the highest seed index (80.33g) were demonstrated by hybrid Kiran-95 x Imdad-05, whereas Anmol-91 x SKD-1 gave the lowest seed index of 63.81g. Taking thetotal biomass plant^{-1}, the cross Kiran-95 x Imdad-05 produced maximum total biomass plant^{-1} (68.23g); however, Kiran-95 x Khirman produced minimum total biomass plant^{-1} (32.32g). All in all, the cross combinations *i.e.*Anmol-91 x Imdad-05 and Kiran-95 x Imdad-05 showed promising results for a range of traits, hence these crosses may be preferred for further breeding programs to improve bread wheat.

With respect to heterotic effects for tillers plant^{-1} **(Table-3)**, the hybrid Anmol-91 x Imdad-05 recorded maximum relative heterosis (106.35), followed by Anmol-91 x SKD-1 (72.36), while the maximum heterobeltiosis was shown by hybrid Anmol-91 x Imdad-05 (59.35), followed by Kiran-95 x Imdad-05 (45.49). It is well noted from above mentioned results that cross Anmol-91 x Imdad-05 not only displayed outstanding performance in terms of maximum tillers plant but also expressed maximum better parent heterosis, hence this cross combination may be preferred for upcoming breeding programs. Similar results were also obtained by Chowdhry, *et al.* (2005), Frooque, *et al.* (2005), Jan *et al.* (2005) and Beche, *et al.* (2013).

Regarding heterotic effects for spike length, all the hybrids recorded a fair amount of heterosis for spike length. The maximum relative heterosis was recorded in hybrids Anmol-91 x SKD-1 (36.04), followed by Kiran-95 x Imdad-05 (35.31); however, the cross Kiran-95 x Imdad-05 showed the lowest relative heterosis (24.10). The maximum heterobeltiosis was recorded in hybrid Anmol-91 x Khirman (31.95), these hybrids may prove useful for heterosis breeding in wheat, especially for longer spikes. Similar findings were also achieved by Akbar, *et al.* (2007), Ilker, *et al.* (2010) and Mahpara *et al.* (2015). In the wheat plant as the spikelets spike^{-1} increases, the yield also increases, there is close and positive association between spikelets spike^{-1} and grain yield plant^{-1}. The heterotic effects (**Table-3**) for spikelet spike^{-1} presented that all F_1 hybrids displayed positive heterosis for above said trait. The cross Anmol-91 x Imdad-05 showed maximum mid parent heterosis (79.47), followed by Kiran-95 x Imdad-05 (73.56), whereas the cross Anmol-91 x Imdad-05 gave maximum heterobeltiosis (67.14), followed by Kiran-95 x Imdad-05 (63.50) for spikelets spike^{-1}, these F_1 hybrids possess favorable gene recombination for the trait spikelets spike^{-1}, thus can better be utilized in wheat hybrid development. Similarly, Baric *et al.* (2004), Ilker, *et al.* (2010) and Ismail (2015) also reported positive heterosis for spikelets spike^{-1}. Considering the heterotic effects of grains spike^{-1}, the maximum grains spike^{-1} (70.33) were produced by the cross combination Anmol-91 x Imdad-05, while F_1 hybrid Kiran-95 x Imdad-05 produced minimum grains spike^{-1} (59.00).All the F_1 hybrids displayed positive heterosis effects for grains spike^{-1} **(Table-4)**. However, cross Kiran-95 x SKD-1 gave maximum (24.50) mid-parent heterosis, followed by Anmol-91 x SKD-1 (23.81). Whereas, the cross Kiran-95 x SKD-1 revealed maximum heterobeltiosis (21.23) for grains spike^{-1}, followed by Anmol-91 x SKD-1 (16.42). These above mentioned crosses providing opportunities for future hybrid development in wheat crop. Our findings are in accordance with Ilker, *et al.* (2010), Bache, *et al.* (2013) and Mahpara, *et al.* (2015), who also reported significant positive heterosis for grains spike^{-1}.

For heteroticeffectsof grainyieldplant^{-1} (**Table-4**), all hybrids gave a high amount of heterotic effects for grain yield plant^{-1}. However, hybrid Anmol-91 x Khirman gave the highest relative heterosis (94.02), followed by Kiran-95 x Imdad-05 (92.31), the hybrid Kiran-95 x Imdad-05 gave maximum heterobeltiosis (89.94), followed by Anmol-91 x SKD-1 (66.86) and Kiran-95 x Khirman (62.85) for grain yield plant^{-1},suggesting that these F_1 hybrids may be proved better for yield in wheat breeding. Our results are in consonance with Akbar *et al*. (2007) and Hasan *et al*. (2007).In wheat plant as the seed index gets heavier, the yield also increases at a significant level, hence there is positive association between seed index and grain yield plant^{-1}. The heterosis for seed index (Table-4) revealed that all the F_1 hybrids recorded positive relative heterosis and heterobeltiosis. Hybrid Kiran-95 x Imdad-05 showed maximum relative heterosis (76.73), followed by Anmol-91 x Khirman (72.50) and Kiran-95 x SKD-1 (72.26), whereas the cross Kiran-95 x Imadad-05 showed maximum heterobeltiosis (70.99), followed by Kiran-95 (70.81) for seed index. These crosses showed their potentiality in heterosis for seed index yet can further be exploited in wheat breeding. Other researchers like Ilker, *et al.* (2010), Bache *et al.* (2013), Ismail (2015) and Mahpara, *et al.* (2015) also reported a fair amount of mid parent as well as better parent heterosis for seed index. The heterosis for total biomass plant^{-1} (Table-4) revealed that all the F_1 hybrids recorded positive relative heterosis and heterobeltiosis.Hybrid Anmol-91 x Imdad-05 showed maximum relative heterosis (169.41), followed by Kiran-95 x Imdad-05 (151.86) and Kiran-95 x SKD-1 (129.98) for total biomass, whereas the cross Kiran-95 x Imdad-05 showed maximum heterobeltiosis (139.73), followed by Kiran-95 x SKD-1 (129.27). These crosses showed their superiority in heterosis for total biomass. Thus can be further exploited in wheat breeding other researchers like Chowdhry, *et al.* (2005) also reported significant and a fair amount of mid parent as well as better parent heterosis for total biomass.

Table-1. Mean squares from Line x Tester analysis for various characters in intra-specific bread wheat crosses.

Source of variation	Degree of Freedom	Tillers plant-1	Spike length	Spikelets spike-1	Grains spike-1	Grain yield plant-1	Seed index	Total biomass plant-1
Replications	2	1.45	0.34	11.00	0.02	0.83	42.18	28.90
Genotypes	10	18.80**	10.53**	147.57**	116.17**	132.85**	723.97**	831.32**
Error	20	0.23	0.146	4.43	0.37	0.17	15.35	27.44

**** = indicates significant level at 0.01 probability level**

Table-2. F_1 hybrid performance of various characters in bread wheat.

F_1 crosses	Tillers plant^{-1}		Spike length (cm)		Spikelets spike^{-1}		Grains spike^{-1}	
	Mid parent heterosis	Better parent heterosis	Mid parent heterosis	Better parent heterosis	Mid parent heterosis	Better parent heterosis	Mid parent heterosis	Better parent heterosis
Anmol-91 x Imdad-05	106.35	59.35	34.38	22.22	79.47	67.14	17.74	10.82
Anmol-91 x SKD-1	72.36	38.09	36.04	31.73	67.86	61.01	23.81	16.42
Anmol-91 x Khirman	60.17	25.11	35.31	31.95	42.06	35.37	5.94	-2.11
Kiran-95 x Imdad-05	51.99	45.49	24.10	18.49	73.56	63.50	2.09	-7.02
Kiran-95 x SKD-1	36.39	32.50	24.55	22.16	45.59	39.66	24.50	21.23
Kiran-95 x Khirman	35.46	27.33	30.82	27.39	70.10	60.22	2.77	-8.06

Table-3.Heterotic effects of F_1 hybrids over their mid and better parent for tillers plant^{-1}, spike length, spikelets spike^{-1} and grains spike^{-1}.

Genotypes	Tillers plant^{-1}	Spike length^{-1} (cm)	Spikelets spike^{-1}	Grains spike^{-1}	Grain yield plant^{-1}(g)	Seed index (1000 grain weight, g)	Total biomass plant^{-1}(g)
Anmol-91	95.26	5.06	10.33	18.46	57.00	10.46	44.93
Kiran-95	79.46	7.93	11.46	18.93	52.13	15.04	43.82
Imdad-05	83.26	8.66	12.60	21.40	63.46	15.41	46.86
SKD-1	82.33	8.40	11.03	20.06	49.33	13.22	42.78
Khirman	99.40	9.00	10.86	16.73	66.06	16.34	46.57
Anmol-91xImdad-05	13.80	15.44	35.77	70.33	21.48	75.91	48.20
Anmol-91 x SKD-1	11.60	14.52	32.32	65.22	22.10	63.81	38.51
Anmol-91 x Khirman	11.31	14.33	24.99	64.31	26.00	78.90	60.92
Kiran-95 x Imdad-05	12.60	14.93	35.00	59.00	29.27	80.33	68.23
Kiran-95 x SKD-1	11.13	14.00	28.80	63.20	23.81	74.60	59.40
Kiran-95 x Khirman	11.55	14.60	30.31	60.70	26.61	65.72	32.32
LSD (5%)	0.702	0.575	1.640	1.212	0.720	9.191	12.72

Table4.Heterotic effects of F_1 hybrids over their mid and better parent for grain yield plant^{-1}, seed index and biological yield plant^{-1}.

F_1 crosses	Grain yield plant^{-1}		Seed index		Biological yield plant^{-1}	
	Mid parent heterosis	Better parent heterosis	Mid parent heterosis	Better parent heterosis	Mid parent heterosis	Better parent heterosis
Anmol-91 x Imdad-05	66.12	39.39	65.41	64.75	169.41	120.66
Anmol-91 x SKD-1	86.31	66.86	45.51	42.02	74.65	48.55
Anmol-91 x Khirman	94.02	59.11	72.50	69.46	127.35	71.79
Kiran-95 x Imdad-05	92.31	89.94	76.73	70.99	151.86	139.73
Kiran-95 x SKD-1	68.15	57.97	72.26	70.21	129.98	129.27
Kiran-95 x Khirman	69.59	62.85	54.44	53.74	5.65	-8.82

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