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Heterosis and combining ability for grain yield and its contributing traits in bread wheat (*Triticum aestivum* L.)

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ABSTRACT

Six lines were crossed with four testers in line x tester fashion to determine the general and specific combining ability for yield and yield contributing traits in wheat. The mean square due to gca and sca were significant for most of the traits which indicates the presence of both additive and non additive gene effects for controlling the expression of yield and yield contributing characters. The σ^2 gca / σ^2 sca ratio suggested that the presence of non additive gene action was predominant for most of the characters including grain yield. Varieties viz., HD-2687 and WH- 542 among lines and K-65 and Raj.-3077 among testers were adjudged the best general combiner as it depicted high gca effect in desirable direction for grain yield and yield contributing traits. Among the selected hybrids WH-542 x Raj-3077 and WH 542 x K-65 were exhibited highest magnitude of positive significant sca effects with highest magnitude of heterobeltiosis and per se performance for grain yield. In general, close association between sca effects and heterobeltiosic was observed among the best hybrids identified on the basis of sca effects for grain yield.

INTRODUCTION

Triticum aestivum L. is an important cereal of the world and a staple food in India. It plays a remarkable role in meeting the food requirements of the country. A feasible strategy to achieve quantum jump in the yield of wheat (*Triticum aestivum* L.) is the commercial production of hybrid varieties. The exploitation of heterosis in wheat can be accomplished through the vigorous parental line and their subsequent evaluation for combining ability in cross combination to identify hybrid with high heterotic effect. For this purpose, basic knowledge of genetic architecture of yield and yield components and nature of gene action is required. Among various genetic techniques, combining ability analysis developed by Kempthorne [1] provides important information for selection of parents in terms of the performance of their hybrids. Further it elucidates the nature and magnitude of various types of gene actions involved in the expression of quantitative characters. Combining ability has been defined and categorized originally by Spargue and Tatum who described that high general combining ability (GCA) effects were due to additive type of gene action, whereas high specific combining ability (SCA) indicated non-additive gene effects. Therefore the present studies conducted to assess the relative magnitude of GCA and SCA for yield and yield contributing traits and to select the best combiner for successful wheat hybridization.

MATERIALS AND METHODS

Six lines namely HD-2687, Raj-1114, PBW-343, RS-392, UP-2338 and WH-542 were crossed with four testers namely Job-666, Job-673, K-65 and Raj-3077 in line x tester fashion at Agronomy Farm, SKN College of Agriculture, Jobner to generate a total of 24 hybrids. All the genotypes (10 parents and 24 F_1's) were evaluated in Randomized Block Design with three replications during *Rabi*

1999-2000. Each genotype was grown in 2 rows of 2m length with inter row and intra row spacing of 30cm and10cm respectively. To raise a good crop stand all the recommended cultural practices were followed. The data were recorded on plant height (cm), number of productive tillers per plant, grain yield per spike (g), 1000-seed weight (g), grain yield per plant (g) and biological yield per plant (g) on a sample of 10 plants/replication in each genotypes whereas for days to ear emergence, days to 50% flowering (and and harvest index (%) data were taken on whole plot basis. Combining ability effect and their variances were estimated as per Kempthorne [1].

RESULT AND DISCUSSION

Analysis of variance for combining ability revealed that the mean square due to lines, testers and line x testers were significant suggesting that the experimental materials possessed considerable variability that both general and specific combining ability were involved in the genetic expression of these characters (table 1). The non significance of variance for grain yield in testers and high mean values for the traits suggest that the testers chosen had high and comparable yield potentials (Table 3).

The relative estimation of variance due to general combining ability indicated that the specific combining ability variances were predominant for all traits studied. The ratio of variance due to general and specific combining ability ranged from -0.10 for number of grains per ear to 1.28 for peduncle length (Table 2).Various workers reported predominance of non-additive gene action for seed yield and yield contributing traits [2, 3, 4, 5] stated that the per se performance of the parents with the nature of general combining ability provide the criteria for the choice of parents for hybridization. The parents which performed well for both per se performance and gca effect can be considered as good parents. Raj-1114 among lines and K-65 among testers recorded low mean value and negative gca effects for days to 50% flowering which might be useful in breeding program for earliness. The lines *viz*., HD-2687 and WH-542 and tester's *viz*., K-65 and Raj-3077 were found to be good general combiner with good per se performance for yield and most of the yield contributing traits.

Normally, the sca effects do not contribute tangibly in the improvement of self pollinated crops, except where commercial exploitation of heterosis is feasible. Breeder's interest therefore rests in obtaining transgressive segrigants through crosses by producing more potent homozygous lines. Jink and Jones [6] emphasized that the superiority of the hybrids might not indicate their ability to yield transgressive sagrigaints, but sca would provide satisfactory criteria to exploit the heterosis.

A perusal of best hybrids on the basis of sca effects for grain yield per plant in relation to heterobeltiosis and per se performance for grain yield per plant revealed that WH-542 x Raj-3077 exhibited highest magnitude of positive significant sca effects for grain yield per plant along with positive significant sca effects for other directly yield contributing traits. This cross also exhibit high magnitude of significant positive heterosis for grain yield per plant over better parent with good per se performance for grain yield and yield contributing traits, The hybrid WH-542 x K-65 ranked next in terms of magnitude of positive significant sca effects for grain yield per plant along with highest positive significant heterobeltiosis for grain yield per plants. This cross also recorded positive significant sca effects with good per se performance for grain yield per plant, number of grains per ear, 1000- seed weight and harvest index. The other hybrids like HD-2687 x Job-673, PBW-343 x Job-673 , HD-2687 x Job-666 , HD-2687 x Raj-3077, PBW-343 x K-65 ,Raj-1114 x K-65,WH-542 x Job-673 and RS-392 x Job-666 were low in terms of significant positive sca effects and magnitude of positive significant heterosis over better parent for grain yield and other yield contributing traits. Significant positive sca effect, heterosis and high per se performance for grain yield was also reported by earlier workers[7,8,9].

The hybrid WH-542 x Raj-3077, HD-2687 x Raj-3077 and RS-392 x Job-666 were found to involve of low x high parental combinations in terms of gca indicating the role of the dominance gene action. The other hybrids viz., WH-542 x K-65, HD-2687 x Job-673, PBW-343 x Job-673, HD-2687 x Job-666, PBW-343 x K-65, Raj-1114 x K-65 and WH-542 x Job-673 were the derivatives of low x low parental combinations in terms of gca and might be suitable for selection in later generations.

Thus, in the present investigation wide variation was revealed among the parents and the resultant hybrids for almost all the traits studied indicating that direct selection in the segrigants to isolate superior segrigants is feasible. Most of the characters were controlled by non-additive components. In such cases, hybrids would be ideal, however, in wheat the exploitation of heterosis is still in its infancy. Ideally in such situations, recurrent selection as proposed by Joshi, diallel selective mating as proposed by Jensen [10,11] or the use of multiple crosses and biparental mating might be effective alternate approaches.

Table 1. Analysis of variance for various morphological traits in line x tester analysis in wheat

Characters	d.f.	Days to ear emergence	Days to flowering	Plant height (cm)	Number of productive tillers/plant	Peduncle length (cm)	Grain weight/ear (g)	Grain yield/plant (g)	Number of grains/ear	Biological yield /plant (g)	1000 grain weight (g)	Harvest index (%)
Replications	2	11.674*	15.751**	7.086	0.825	2.772	0.001	9.519	0.632	81.288	12.753	12.819
Entries	33	7.846**	8.188**	219.45**	13.419**	25.294**	0.534**	63.552**	208.270**	133.289**	84.101**	122.392**
Parents	9	7.125**	10.315**	328.118**	2.412**	61.274**	0.186**	6.262	30.660	63.722*	15.839	50.184
Lines	5	11.166**	16.355**	155.261**	2.787**	37.303**	0.987**	3.889*	24.132*	77.112*	16.553	16.264
Testers	3	2.750	2.527	180.774**	3.273**	33.881**	0.061**	10.516	2.091	68.597**	7.105	144.806**
Line vs Testers	1	0.046	3.477	1634.432**	3.951*	264.506**	0.007**	5.371	149.002*	126.147**	38.467	235.921*
Hybrids	23	7.371**	7.641	185.358**	4.813**	11.714**	0.691**	64.894**	276.567*	128.836**	95.020**	129.75
Lines in hybrids	5	8.591*	11.316**	278.939**	4.603**	19.784**	1.087**	111.412**	299.554**	231.571**	35.754	189.338**
Testers in hybrids	3	20.848**	9.805*	311.862**	6.980**	32.285**	0.859**	6.791	40.833	56.571**	36.817	61.056
Line x testers in hybrids	15	4.273	5.983*	128.863**	4.449**	4.909**	0.525**	61.009**	316.052**	109.012**	126.417**	123.628**
Parents vs Hybrids	1	25.265**	1.640	25.593**	310.419**	13.832**	0.055**	548.994**	235.921	861.816**	447.348**	602.996**
Error	67	2.576	2.534	2.499	0.785	1.687	0.001	7.621	71.637	28.132	22.542	29.313

* Significant at 5% and ** Significant at 1%

Table 2. Estimates of components of variance for morphological traits in bread wheat

S. No.	Characters	σ^2l	σ^2t	σ^2lt	σ^2GCA	σ^2SCA	σ^2GCA/ σ^2SCA
1.	Days to ear emergence	0.359	0.919*	0.565	0.639*	0.656	1.13
2.	Days to 50 % flowering	0.44	0.212	1.149**	0.398**	1.149**	0.34
3.	Plant height (cm)	12.506	10.168*	42.121**	11.33**	42.121**	0.26
4.	No. of productive tillers/plant	0.012	0.140	1.221**	0.076	1.221**	0.16
5.	Peduncle length (cm)	1.239**	1.520**	1.074**	1.374	1.074**	1.28
6.	Grain weight/ear (g)	0.046	0.018**	0.174**	0.032**	0.174**	0.18
7.	Grain yield/plant (g)	4.200	-3.012**	17.796**	0.59*	17.796**	0.03
8.	No. of grains/ear	-1.375	-15.29**	81.47**	-8.33	81.47**	-0.10
9.	Biological yield/plant (g)	10.213	-2.904	26.96	3.65	26.960**	0.13
10.	1000 grain weight (g)	-7.555	-4.977	34.625**	-6.26	34.625**	0.18
11.	Harvest index (%)	5.475**	-3.476	31.1438**	0.95*	31.438**	0.03

* Significant at 5% and ** Significant at 1%

Table 3. GCA and per se performance (in parenthesis) of lines and testers for various morphological traits in bread wheat.

S. No.	Entries	Days to ear emergence	Days to 50% flowering	Plant height (cm)	No. of productive tillers/plant	Peduncle length (cm)	Grain weight Per ear (g)	Grain yield per plant (g)	No. of grains/ear	Biological yield/plant (g)	1000-grain weight (g)	Harvest index (%)
1.	Job-666	-0.542	-0.333	5.774**	-0.836	1.273**	0.115**	0.695**	0.826**	-0.976	0.191*	2.694*
		(83.00)	(90.330)	(79.70)	(5.68)	(28.76)	(2.60)	(14.28)	(53.23)	(43.13)	(45.02)	(35.68)
2.	Job-673	1.569**	1.000**	-1.821**	-0.144	-1.774**	0.049*	0.308**	1.658**	2.303*	0.044	-1.085
		(85.00)	(88.66)	(94.10)	(5.50)	(32.30)	(2.86)	(15.43)	(56.43)	(46.38)	(47.67)	(26.26)
3.	K-65	-0.819*	-0.722*	-0.038	0.469**	0.745**	-0.321**	2.683**	3.863**	0.414	1.860*	-1.277
		(83.00)	(89.33)	(94.83)	(6.91)	(36.73)	(2.72)	(16.54)	(52.77)	(43.38)	(43.88)	(31.60)
4.	Raj-3077	-0.208	0.056	-3.915**	0.481**	-0.244	0.157*	2.296**	-1.621	-1.740	1.624	0.332
		(84.00)	(89.33)	(82.70)	(5.66)	(34.06)	(2.53)	(15.58)	(58.53)	(43.43)	(44.36)	(31.57)
5.	HD-2687	0.125	-0.278	-5.488**	0.792**	-2.147**	0.104**	5.027**	3.139**	-5.678**	0.674	-5.691**
		(81.00)	(86.33)	(72.00)	(6.10)	(27.23)	(2.56)	(18.67)	(63.80)	(49.27)	(43.68)	(34.35)
6.	Raj-1114	-0.042	0.222	-3.038**	0.542*	0.320	-0.578**	0.343**	3.163**	1.397	-0.452	-0.219
		(83.33)	(89.66)	(83.86)	(6.13)	(30.86)	(3.17)	(15.85)	(56.00)	(42.91)	(42.99)	(36.81)
7.	PBW-343	-1.042*	-1.028*	-1.438**	-0.150	-0.508	0.265**	0.420**	-5.727**	5.101**	0.838	-3.657*
		(87.00)	(93.00)	(84.13)	(4.10)	(20.50)	(2.73)	(13.86)	(53.36)	(47.71)	(33.54)	(40.79)
8.	RS-392	0.292	-0.278	5.929**	-0.408	1.712**	0.039**	3.264**	4.386**	3.624**	0.077	4.108**
		(84.33)	(90.33)	(68.53)	(5.40)	(28.93)	(2.57)	(16.40)	(63.96)	(45.03)	(42.46)	(36.12)
9.	UP-2338	-0.708	-0.444	5.987**	0.117	0.037	0.072**	3.136**	4.189	0.353	1.968	3.536*
		(83.66)	(91.33)	(68.60)	(3.93)	(26.16)	(2.99)	(16.44)	(59.03)	(48.02)	(34.67)	(38.54)
10.	WH-542	1.375**	1.806**	-1.954**	-0.892**	0.587	0.176**	3.610*	5.947**	-4.798**	-3.107*	1.922
		(83.66)	(92.00)	(78.46)	(5.53)	(27.73)	(2.23)	(17.21)	(57.43)	(45.42)	(45.59)	(35.39)
	S.E.(lines)	0.327	0.324	0.322	0.180	0.265	0.009	0.083	2.010	1.082	0.969	1.105
	S.E. testers)	0.423	0.419	0.416	0.233	0.382	0.011	0.108	2.461	1.397	1.251	1.426

* Significant at 5% and ** Significant at 1%

Table 4. Sca estimate for yield and yield contributing traits showing highest sca effects with heterobeltiosis and per se performance in bread wheat

S. No.	Hybrids	Sca effects					Heterobeltiosis	Per se performance				
		Grain yield (g/p)	No. of grains /ear	Grain weight /ear (g)	1000-seed weight (g)	Harvest index (%)	for grain yield/plant (%)	Grain yield (g/p)	No. of grains /ear	Grain weight /ear (g)	1000-seed weight (g)	Harvest index (%)
1.	WH 542 x Raj 3077	7.621**	9.538**	0.287**	11.13**	6.01*	34.46**	27.13	89.80	3.28	59.72	47.65
2.	WH 542 x K-65	5.883**	3.983**	-0.306**	2.864	9.348**	38.27**	28.53	51.13	2.47	54.95	51.89
3.	HD 2687 x Raj 3077	3.444**	-6.16**	0.705**	2.255	1.173	0.64	25.72	68.27	3.11	52.43	43.48
4.	HD 2687 x Job 673	2.690**	-4.342**	-0.096**	1.515	9.971**	1.53	21.48	67.23	1.66	49.27	48.53
5.	WH 542 x Job 673	2.467**	-1.121**	0.156**	1.361	9.205**	33.83	22.16	78.97	3.24	53.89	45.27
6.	RS 392 x Job 666	2.114**	0.345	0.029	-3.054	3.029	12.92*	17.20	42.22	2.95	49.31	37.06
7.	PBW 343 x Job 673	1.189**	0.232	0.293**	3.45**	0.443	10.17*	21.28	73.77	3.33	54.55	39.53
8.	PBW 343 x K 65	1.819**	-2.620**	0.109**	1.900	1.351	16.20*	24.22	70.50	2.41	50.19	44.23
9.	Raj 1114 x K 65	1.318**	9.008**	-0.183**	-5.146**	0.846	4.17**	24.09	48.47	2.48	45.04	43.92
10.	HD 2687 x Job 666	1.176**	-6.333**	0.196**	5.999**	0.417	8.87*	16.66	49.20	3.07	56.93	37.47
	SE	0.18	0.45	0.02	0.16	2.47	2.27					

* Significant at 5% and ** Significant at 1%

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