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COMBINING ABILITY AND HETEROSIS ANALYSIS OF MORPHO- PHYSIOLOGICAL CHARACTERS IN WHEAT

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ABSTRACT

Combining ability analysis was done in Line X Tester mating design by using 6 lines, 3 testers and 30 F_1 s in a randomized block design with two replications. Data revealed that variances due Lines and Testers and Line X Tester were significant for grain yield and almost all attributes, thereby, showing these were under the control of both additive and non-additive inheritance. Additive variances governed the days to heading and days to maturity. Whereas, only first inter-node length governed by non-additive inheritance. Lines 'WH-1062' was good general combiner for days to heading, days to flowering, days to maturity, plant height, length of spike, grain per spike and test weight. 'HI-8696 (d)' was good general combiner for days to heading, grain filling period, plant height, second-inter-nodes length, flag leaf area, spike length, peduncle length and test weight. Tester viz., 43rd IBWSN-1043, 43rd IBWSN-1157 and 18en HRWYT-227 identified as good general combiners for grain yield and most of the attributes including harvest index. The cross, VL-920 X 18en HRWYT-227 and VL-920 X 18SE SAWYT-303 was good specific combiner for grain yield and various yield components. These parents may be used for varietal improvement through the simple / recurrent selection in segregating generations to increase in yield potential of wheat. This may lead in the fixation of both additive and non-additive components while making improvement in grain yield and its attributes.

Key words: Bread wheat, combining ability analysis, heterosis

INTRODUCATION

Wheat (*Triticum aestivum* L.) is the second most important cereal crop after rice in the context to its antiquity and its use as source of food and energy in India. Wheat crop has occupied almost 29.9 million hectares and producing 93.9 million tonnes in India. Improvement in wheat production can be achieved by enhancing through the development of new cultivars having wider genetic base and better performance. Earlier research review revealed that both general and specific combining abilities were involved in the inheritance of grain yield and its components (Singh *et al*., 2000; Murliya and Sastry, 2001). Selection of parents together with information on nature and magnitude of gene action controlling grain yield and its attributing characters is prerequisites while improving the plant type efficiently. Hence an attempt has been made to study nature and magnitude of genetic variation for grain yield and morpho-physiological characters in wheat.

MATERIALS AND METHODS

An experiment consisting 30 F_1s and their 9 parents was conducted along with 2 checks *viz*., MP-4010 and RVW-4106 in randomized block design with 2 replications during winter season 2012. Thirty crosses were developed in Line x Tester mating design using 6 lines *viz*.,WH-1062, VL-920, DBW-54, KPL-249 HI-8696(d), MPO-1226(d) and 5 testers selected form international nurseries *viz*., 31 SE ESWYT-125, 18 SE SAWYT-303, 43rd IBWSN-1043, 43rd IBWSN-1157 and 18en HRWYT-227. Each entry was sown in 2.5 meter long single row with row to row spacing of 20 cm. Observations were recorded on five randomly selected plants in each line for grain yield and its attributes. Combining ability analysis was worked out in Line X Tester mating design (Kempthorne 1957).

RESULTS AND DISCUSSION

Combining ability variances

The mean sum of square due to lines, testers and line X tester were significant for plant height, flag leaf area, spikelet per spike, spike length, peduncle length, grain per spike and test weight. Testers and line X tester variances were significant for second-inter-node length, grain yield and harvest index, whereas, lines and line X tester variances were significant for days to flowering and grain filling period. Only line X tester variance was significant for first inter-node (Table 1, 2). These results revealed importance of additive as well as non-additive components in the inheritance of yield and yield components. Significance of general combing ability variances were also reported earlier for yield and yield components by Chowdhry *et al.* (2005) and Meena *et al.* (2003). Specific combing ability variances were also reported earlier for yield and yield components by Grakh and Singh (2005), Vanpariya *et al.* (2006), Burungale *et al.* (2011).

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

Sources	DF	Days to heading	Days to flowering	Days to maturity	Grain filling period (days)	Plant height (cm)	Tiller / plant	Flag leaf area(cm^2)	First- inter-nodes length (cm)	Second - inter-nodes length (cm)
Lines	5	82.7767**	103.2800**	24.1867**	66.5367**	871.0715**	2.3502	248.5092*	0.4174	8.0129
Tester	4	3.5250	3.5167	0.6000	2.9333	59.8046**	3.4345*	122.2758**	0.0761	3.3132**
L X T	20	3.7850	5.4967*	3.5700	9.1033*	26.7236**	2.8632**	79.6174**	0.4437**	3.4396**
Error	42	3.6811	2.9147	3.1921	4.6606	2.7131	1.3208	17.0597	0.1860	0.7275

Continued

Sources	DF	Spikelet / spike	Spike length (cm)	Peduncle length (cm)	Grain / spike	Test weight.(g)	Grain yield / plant (g)	Biological yield / plant (g)	Harvest index (%)
Lines	5	14.5127**	17.1399**	172.0949**	391.4488**	123.9670**	2.7790	40.4532	9.7983
Tester	4	2.9898**	3.2182**	29.3875**	71.6453**	24.7310**	5.9155*	40.3951	28.7155**
L X T	20	1.9594**	2.5735**	16.6350**	164.0070**	21.7290**	3.5263*	23.9779	14.7046**
Error	42	0.5285	0.1532	4.42z97	14.4349	2.7922	1.7647	19.7250	4.5840

and significant at 5 and 1 % levels, respectively,*

General combining ability (GCA) or specific combining ability (SCA) variances were substantial for most of the characters, thereby, indicating impotence of both additive as well as non-additive components of genetic variance in the control of these traits. Similar results were also reported earlier for yield and yield components in wheat (Dagusta *et al.*, 2008; Khan and Ali, 2005; Chowdhry *et al.*2005; Grakh and Singh, 2005; Dagusta *et al.* (2008) reported significant GCA and SCA variances for plant height, spike length; Khan and Ali (2005) for flag leaf area, tillers per plant, spike length, spikelet per spike, grain per spike, test weight, grain yield per plant; Chowdhry *et al.*(2005) for tillers per plant; Grakh and Singh (2005) for harvest index; Meena *et al.*(2003) for spike length, peduncle length, tillers per plant.

The magnitudes of genetic components

Table 2: Genetic components Estimates for 17 characters in wheat crosses in Line X tester mating design

Covariance	Days to heading	Days to flowering	Days to maturity	Grain filling period (days)	Plant height (cm)	Tiller /plant	Flag leaf area (cm^2)	First inter nodes length (cm)	Second – inter nodes length (cm)
Cov HS (Line)	4.94	6.11	1.29	3.59	52.77	-0.03	10.56	0.00	0.29
Cov HS (Tester)	-0.03	-0.20	-0.30	-0.62	3.31	0.06	4.27	-0.04	-0.01
Cov HS (Average)	0.26	0.32	0.06	0.17	2.92	0.00	0.58	0.00	0.01
Cov FS	78.35	100.65	18.33	60.50	922.64	3.41	345.74	0.17	10.30
Genetic components									
σ2gca (Lines)	0.26	0.32	0.06	0.17	2.92	0.00	0.58	0.00	0.01
σ2gca(Testers)	1.05	1.28	0.23	0.66	11.67	-0.02	2.32	-0.01	0.04
σ2gca (Parents)	77.30	84.91	1.31	17.33	1059.37	3.20	446.17	-2.42	3.75
σ2sca	0.21	5.16	0.76	8.89	48.02	3.08	125.12	0.52	5.42
σ2gca / σ2sca	368.09	16.44	1.72	1.94	22.06	1.04	3.57	-4.65	0.69
σ2 A	154.60	169.83	2.62	34.66	2118.75	6.40	892.34	-4.83	7.50
σ2 D	0.05	1.29	0.19	2.22	12.01	0.77	31.28	0.13	1.36

Continued

Covariance’s	Spikelet / spike	Spike length (cm)	Peduncle length (cm)	Grain / spike	Test weight (g)	Grain yield / plant (g)	Biological yield/plant (g)	Harvest index (%)
Cov HS (Line)	0.78	0.91	9.72	14.22	6.39	-0.05	1.03	-0.31
Cov HS (Tester)	0.10	0.06	1.28	-9.24	0.30	0.24	1.64	1.40
Cov HS (Average)	0.04	0.05	0.54	0.30	0.33	0.00	0.07	0.00
Cov FS	16.58	20.34	193.40	458.46	145.51	5.46	41.95	31.03
Genetic components								
σ2gca (Lines)	0.04	0.05	0.54	0.30	0.33	0.00	0.07	0.00
σ2gca(Testers)	0.17	0.19	2.16	1.19	1.30	0.00	0.27	0.01
σ2gca (Parents)	19.25	18.76	238.35	-372.91	121.75	14.78	123.19	86.16
σ2sca	2.86	4.84	24.41	299.14	37.87	3.52	8.51	20.24
σ2gca / σ2sca	6.73	3.88	9.76	-1.25	3.21	4.20	14.48	4.26
σ2 A	38.50	37.51	476.70	-745.82	243.50	29.57	246.37	172.33
σ2 D	0.72	1.21	6.10	74.79	9.47	0.88	2.13	5.06

revealed that the additive variances were higher compared to dominance variances for all characters studied except grain per spike and first inter-node length, where it was in negative direction. The ratio of genetic components "σ^2gca / σ^2sca" also showed more than one thereby indicating predominance of additive variances for almost all characters except second inter-node length. The similar reports were also published by Vanpariya et *al.* (2006), Meena *et al*. (2003).

General combining ability effects

The significant negative estimates of GCA effects revealed that 'WH-1062' was good general combiner toward earliness for days to heading, days to flowering, days to maturity and positive GCA effects reflected good general combiner for plant height, spike length, grain per spike and test weight (Table 3). 'HI-8696(d)' showed good general combiner due to significant negative GCA effects for days to heading, grain filling period, plant height, second-inter-nodes length and grain per spike. Further it was also good general combiner for flag leaf area, spike length, peduncle length and test weight as reflected by significant positive values of GCA effects. '43[Rd] IBWSN-1043' was good general combiner for days to heading, days to flowering, plant height, first & second inter-nodes length, peduncle length, grain per spike, grain yield per plant, tillers per plant, flag leaf area, spikelet per spike, spike length, and test weight. Whereas'43[Rd] IBWSN-1157' was good general combiner for grain filling period, first-inter-nodes length and grain yield/plant, days to heading, days to flowering, days to maturity, plant height, tillers / plant, second inter-nodes length, spikelet/spike, spike length, peduncle length, test weight and harvest index in positive direction.'18 En HRWYT-227' was good general combiner for days to maturity, plant height, second inter-nodes length, spike length, peduncle length, harvest index in negative direction and grain yield per plant, grain filling period, tillers per plant, first-inter-nodes length, spikelet per spike and test weight in positive

Table 3: Estimates of general combining ability of lines and tester parents in wheat

Parents Lines	Days to heading	Days to flowering	Days to maturity	Grainfilling period (days)	Plant height (cm)	Tiller / plant	Flag leaf area (cm^2)	First-inter-nodes length (cm)	Second - inter-nodes length (cm)
WH-1062	-3.1833**	-3.7000**	-2.2667**	1.1833	4.8750**	-0.6658	-1.3903	-0.2028	0.3582
VL-920	3.1167**	3.1000**	0.1333	-1.3167	3.9430**	-0.0558	-5.6533**	0.1762	1.4332**
DBW-54	-1.1833	1.2000**	-0.1667	0.8833	1.3930**	-0.3958	0.5537	-0.3128**	-0.2158
KPL-249	4.0167**	4.7000**	0.6333	-4.4167**	-17.3530**	0.5942	2.1787	0.1092	-1.1888**
HI-8696d	-1.6833**	-0.9000	2.4333**	3.0833**	-2.2450**	0.4642	8.3207**	0.1052	-0.5738**
MPO-1226(d)	-1.0833	-2.0000**	-0.7667	0.5833	9.3870**	0.0592	-4.0093**	0.1252	0.1872
SE (Female)	0.6067	0.5399	0.5650	0.6827	0.5209	0.3634	1.3061	0.1364	0.2697
Tester									
31SE ESWYT-125	0.3667**	-0.6500**	0.1833**	0.4833**	2.5917**	0.1142**	-0.9700	0.1285**	0.7088**
18SE SAWYT-303	0.2000**	0.3500**	-0.3167**	-0.3500**	-0.3400**	-0.8900**	-3.6992	-0.0148**	-0.1095**
43[rd] IBWSN-1043	-0.8833**	-0.4000**	0.1000	0.2333	-1.6983**	0.1975**	3.9992**	-0.0290**	-0.5120**
43[rd] IBWSN-1157	0.4500**	0.6833**	0.1833**	-0.6833**	1.9667**	0.5475**	2.5617	-0.0882**	0.3588**
18[en] HRWYT-227	-0.1333	0.0167	-0.1500**	0.3167**	-2.5200**	0.0308**	-1.8917	0.0035**	-0.4462**
SE (Male)	0.0941	0.0590	0.0708	0.1508	0.0511	0.0121	2.0211	0.0002	0.0037

Continued

Lines	spikelet/ spike	Spike length(cm)	Peduncle length(cm)	Grains / spike	Test weight (g)	Grain yield/ plant (g)	Biological yield/plant (g)	Harvest index (%)
WH-1062	-0.1350	0.8440**	0.5888	3.7122**	1.4030**	-0.6645	-1.7385	1.1852
VL-920	2.2450**	1.2340**	-3.9922**	0.8722	-4.7460**	0.3635	2.0105	-1.4558**
DBW-54	-1.2550**	0.8630**	-2.2862**	-2.7178**	1.0810*	-0.5215	-2.9265**	0.8992
KPL-249	-0.6550**	-1.4260**	-3.4192**	-1.6678	-3.9980**	0.4575	1.5115	-0.3548
HI-8696d	0.1950	0.3400**	2.1708**	-9.3458**	3.7400**	0.5485	1.4825	0.3122
MPO-1226d	-0.3950	-1.8550**	6.9378**	9.1472**	2.5200**	-0.1835	-0.3395	-0.5858
SE (Female)	0.2299	0.1238	0.6656	1.2015	0.5284	0.4201	1.4045	0.6771
Tester								
31 SE ESWYT-125	-0.2600**	-0.0497**	2.0528**	-1.0112	-0.2208**	-1.1117**	0.3402	-1.9702**
18 SE SAWYT-303	-0.7267**	-0.7813**	-1.1580**	2.6988	-2.2100**	-0.2600**	-2.7690	1.2815**
43 Rd IBWSN-1043	0.4983**	0.4878**	-0.6413**	-2.8778*	0.3417**	0.5083**	1.8043	0.0448
43 Rd IBWSN-1157	0.1150**	0.4570**	1.2512**	-1.2195	0.3333**	0.5683**	-0.7440	1.7073**
18 En HRWYT-227	0.3733**	-0.1138**	-1.5047**	2.4097	1.7558**	0.2950**	1.3685	-1.0635**
SE (Male)	0.0019	0.0002	0.1363	1.4470	0.0541	0.0216	2.7019	0.1459

**, ** significant at 5 and 1 percent levels, respectively,* direction. Rests of the parents were poor combiner for grain yield per plant having negative or non-significant positive values of general combining ability effects. Present results are in agreement with those of Vanpariya *et al.* (2006) for days to heading, plant height, spike length, spikelet per spike; Ajmal *et al.* (2011) for peduncle length, Chowdhry and Mahmood (2000) for flag leaf area; Yadav and Behl (2002) for days to flowering, plant height, tillers per plant, grain per spike, flag leaf area, test weight and grain yield per plant.

Specific combining ability effects

Significant SCA effects revealed that cross ‘VL-920 X 18 En HRWYT-227’ having higher grain yield and also was good specific combiner for grain yield per plant, plant height, spikelet per spike and harvest index as reflected by significant and positive SCA values. Whereas cross ‘KPL-249 X 18 SE SAWYT-303’ showed high mean grain yield but was average specific combiner for grain yield but it showed good specific combiner for plant height, first-inter-nodes length, second-inter-nodes length and test weight, might be contributing in higher grain yield in the cross. It was noticed that the crosses with high SCA effects had either one or both parents with average or good GCA effects. The superiority of average X average or average X low GCA parent combinations may be due to the presence of genetic diversity among the parents and there could be some complementation indicating importance of non-additive effects. Similar results were also reported earlier by Burungale *et al.* (2011) for plant height, Shrivastava *et al.* (2012) for spike length, Chowdhry *et al.* (2005) for flag leaf area, spike length.

None of the cross showed significant heterosis for grain yield. However, crosses showed significant heterosis for 5 yield attributing traits viz., tillers per plant, first internode length, second internode length, spikelet per spike and spike length. The significant heterosis over either one or more bases (better parent, mid-parent, standard parent) were recorded in cross HI-8696(d) X 43Rd IBWSN-1157 for tillers per plant, first internode length and spike length. Standard heterosis plays real measurement comparing varieties with hybrids for realization of benefits of heterosis. Standard heterosis over MP-4010 was recorded in cross viz., ‘VL-920 X18 SE SAWYT-303’ (32.98%) and ‘VL-920 X 43 Rd IBWSN-1043’ (32.45%) for spikelet per spike; ‘HI-8696d X 43Rd IBWSN-1157’ (8.73%), and ‘WH-1062 X 43Rd IBWSN-1157’ (8.32%) for spike length. Significant Standard heterosis over RVW-4106 was observed in crosses ‘HI-8696d X 43Rd IBWSN-1157’ (70.89%) and ‘MPO-1226d X 31SE ESWYT-125’ (64.56%) for tillers per plant; ‘HI-8696 d X 43Rd IBWSN-1157 (7.89%) and ‘WH-1062 X 43Rd IBWSN-1157’ (7.49%) for spike length.

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

Crosses	Gran yield (g)		GCA effect		SCA Effects						
	Mean	SCA	First Parent	Second Parent	Days to heading	Days to flowering	Days to maturity	Grain filling period (days)	Plant height (cm)	Tillers / plant	Flag leaf area (cm^2)
VL-920 X 18SE SAWYT-303	16.56	1.92*	0.36	-0.26**	2.30	1.15	0.62	2.15	2.80**	0.26	-2.33
MPO-1226(d) X 43rdIBWSN-1043	16.29	1.42	-0.18	0.51**	-0.42	1.00	0.60	0.17	-7.72	1.46	2.43
KPL-249 X 18 SE SAWYT-303	16.29	1.56	0.46	-0.26**	-0.10	2.05	-0.38	-2.75	3.60**	-0.19	-8.01**

Continued

Crosses	SCA Effects								
	First- inter-nodes length (cm)	Second - inter-nodes length (cm)	Spikelet / spike	Spike length (cm)	Peduncle length (cm)	Grains / spike	Test weight (g)	Biological yield per plant (g)	Harvest index (%)
VL-920 X 18SE SAWYT-303	-0.44	-0.09	2.15**	0.23	1.31	-2.40	-0.11	1.99	3.35**
MPO-1226(d) X 43rd IBWSN-1043	-0.37	-2.20	0.56	2.34	-6.78	2.75	3.81	3.10	0.52
KPL-249 X 18 SE SAWYT-303	0.69**	2.80**	-0.45	0.49	-0.51	-2.86	3.78**	2.05	2.50

**, ** significant at 5 and 1 percent levels, respectively*

Analysis of combining ability in the present wheat material suggested an idea about breeding methodology to be applied and use of promising crosses for further improvement in wheat. 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 and expected to throw desirable transgressive segregates in later generations. Grain yield and major yield components revealed the significance of both additive and non-additive gene action for grain yield and its different components.

The presence of both significant additive and non-additive genetic variances for grain yield and major yield attributing traits suggested that high performance of yield and contributing traits can be fixed in subsequent segregating generation of VL-920 X 18 SE SAWYT-303, MPO-1226(d) X 43Rd IBWSN-1043 and KPL-249 X 18 SE SAWYT-303 (Table 4).The good general combiners may be used for varietal improvement through the recurrent selection, inter-mating and bi-parental mating in F_2 generation of promising crosses consisting parents WH-1062, HI-8696(d), 43Rd IBWSN-1043, 43Rd IBWSN-1157 and 18 En HRWYT-227 would be used for improvement for high yielding varieties through the simple / recurrent selection from segregating generations in wheat. This may lead in the fixation of both additive and non-additive components while making improvement in grain yield and its attributes.

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