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ASSESSMENT OF COMBINING ABILITY IN BREAD WHEAT BY USING LINE X TESTER ANALYSIS UNDER MOISTURE STRESS CONDITIONS

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Eight genotypes of wheat with Chakwal-50 (control) were crossed by using Line X Tester analysis to study the spike traits under moisture stress conditions. The results revealed significant differences among lines and testers for most of the traits under stress. The parental lines i.e. Chakwal-50, GD-159 and GD-171 and crosses, i.e. GD-170 x GD-159 and GD-153 x GD-171 were found to be the most resistant to moisture stress. The parent GD-153 remained best for spikelets per spike, grain yield per plant, spike density and GD-171 for spike length, while GD-102 for maximum awn length and grains per spike. Whereas, the cross GD-170 x GD-159 was found to be the best for increased spike length and the crosses GD-170 x GD-159, GD-170 x GD-189, GD-153 x GD-171 for yield and yield components. These superior genotypes and crosses can be used to develop new varieties for irrigated as well as barani areas.
Keywords: Moisture stress, genotypes, Line x Tester analysis, wheat

INTRODUCTION

Moisture stress is the most momentous factor that restricts plant growth and shortage of irrigated water in spring during the late phases of wheat development and particularly, since the beginning of heading and after anthesis, should be careful as a major factor restrictive yield (Dias and Lidon, 2010). Wheat is used as staple food for the humanity and grown all over the world. This is the cheapest source of energy and supplies 72 percent of calories and protein in the average diet (Heyne, 1987). Canal irrigation is deficit for wheat crop in most of the areas at the time of critical growth stages. Shortage of water in irrigated areas is one of the major problems in Pakistan. However, geometrical increase in the population of Pakistan has been a big challenge for plant breeders because of increasing gap between demand and supply of basic staple food.

Moisture stress (drought) is a major abiotic stress in agriculture throughout the world. In developing countries, 37% of the area is semi-arid in which available moisture is the primary constraint to wheat production. About one third of total wheat acreage falls in rainfed regions where rainfall is the scarce (Dhanda and Sethi, 2002).

So, the best option is to make genetic improvement for yield by using new techniques. Saeed *et al.* (2001) examined the highest positive GCA estimates for number of grains per spike and grain yield per plant were obtained in Chakwal-86, while Barani-83 showed highest positive GCA effects for flag leaf area. Chowdhry *et al.* (2007) reported that GCA variance was highly significant for all the traits studied except for number of spikelets per spike and grain yield per plant. Akbar *et al.* (2009) conducted Line × Tester analysis in spring wheat (*Triticum aestivum* L.) to estimate the gene action for some polygenic traits. The objective of this study was to use line × tester analysis approach that investigates the gene action which would help to further breeding strategies and help in development of high yielding, drought tolerant wheat genotypes.

MATERIAL AND METHODS

Four lines of wheat, GD-102, GD-153, GD-170, 7-1 (female parents), four testers GD-159, GD-171, GD-185, GD-189 (male parents) were crossed. Necessary precautions were taken to avoid the contamination of genetic material at the time of crossing. Emasculation of spikes was done and sufficient hybrid seeds for each cross were produced by hand pollination.

The F_1 seeds of the sixteen crosses (4x4) along with their parents were planted in randomized complete block design with three replications. The genotypes were assigned at random to experimental unit in each block and each row contained 20 plants. Each replication consisted of eight varieties and sixteen F_1 crosses with 3 meter long single row for each treatment. Inter-plant and inter-row distances were as 15cm and 30 cm, respectively. Two seeds per hole were sown with the help of a dibble and later thinned to one seedling per site after germination. Only single irrigation (75mm) was applied at tillering stage, after that no irrigation was applied to keep the experiment under moisture stress. Ten tagged plants from each plot were selected randomly and data were recorded on some spike traits like, spike length, spike density, awns length (cm), number of spikelets per spike, number of grains per spike and grain yield per plant (g). The data recorded were subjected to analysis of variance according to Steel *et al.* (1997). Combining ability studies were made by using line x tester analysis as described by Kempthorne (1957).

RESULTS AND DISCUSSION

A perusal of results Table 1 shows that male (tester) and female parents (lines) revealed highly significant differences for all traits except spike density which is non-significant. Interaction of line x tester was highly significant for all the traits except spike density and awn length for which, it was non-significant. Male and female parents used in the present study provided broad range of expression for various characters (Table 2). Spike density was highest in Chakwal-50 (control) and minimum in parent, GD-189, i.e. 2.31, 1.42, respectively. Maximum length of spike was found in GD-189 and minimum in Chakwal-50. Awn length was maximum in GD-102 and minimum in GD-185. GD-170 produced maximum number of spikelets per spike, while minimum was recorded in GD-159. In case of number of grains per spike and grain yield per plant GD-185 showed the minimum while GD-171 and GD-159 exhibited the maximum number of grains per spike and grain yield per plant, respectively.

Mean performance of sixteen crosses is presented in Table 2 which revealed a considerable degree of hybrid vigour existing in most of the crosses. In case of spike density maximum value (1.81) and minimum value (1.48) was found in crosses 7-1 x GD185 and GD153 x GD185, respectively. Hybrids GD102 x GD159 showed the maximum value (14.18), minimum value was found in 7-1 x GD185 (8.61) for spike length trait. Maximum value (9.21) was observed in GD102 x GD189 for awn length and minimum awn length was observed in GD170 x GD189 (6.61). Number of spikelets per spike ranged from 24.32 (GD170 x GD185) to 15.43 (7-1 xGD185). Maximum number of grains per spike (79.81) was observed in the cross GD170 x GD159 whereas, 7-1 x GD189 showed the minimum value for the same trait. In case of grain yield per plant minimum (8.17 g) and maximum (17.58 g) value were recorded in the crosses GD153 x GD159 and GD170 x GD159, respectively.

***General combining ability studies (GCA)*:** Estimates of variation due to GCA were partitioned for both male and female parents for various spike traits to search out the potential parents for further breeding and results are given in Table 3. In case of spike density, female parents GD153 (-0.06) and 7-1(-0.01) and male parent GD171 (-0.04) showed negative GCA, respectively. These results are in accordance with the results of Gorjanovic *et al.* (2007). Spikelets per spike contribute positively towards grain yield. More the number of spikelets per spike, greater will be the grain yield. Among the male parents only GD-159 showed the highest positive GCA value, i.e. 1.58, while two female parents viz., GD-102 (2.22) and GD-170 (1.35) were found to reveal positive general combining ability effects. These results are in agreement with those of Tosun *et al.* (1995), Saeed *et al.* (2005), Malik *et al.* (2005) and Chowdhry *et al.* (2007) who concluded higher GCA for crosses. However, these results are contrary to those of Mahantashivayogayya *et al.* (2004). Number of grains per spike is also an important factor for enhanced grain yield. Therefore, positive GCA effects are more important due to positive contribution of grain yield. Among male parents, GD-159 and GD-171 showed positive and higher values (9.69 and 1.36 respectively) of GCA effects for number of grains per spike. Among female parents, only GD-102 showed positive and higher values i.e. 4.89. It should be noted that values of female parents were higher than male parents. These results match with the findings of Saeed *et al.* (2001), Singh *et al.* (2002), Ahmadi *et al.* (2003), Saeed *et al.* (2005), Hassan *et al.* (2007) and Khan *et al.* (2007). The results of Nazir *et al.* (2005) differ from these findings. Awns contribute an important role in conferring drought tolerance in plants by reflecting light and reducing transpiration losses. For awn length, positive value of GCA is required because maximum awn length contributes towards maximum light reflectance. Two female parents GD-102 and 7-1 showed positive values viz., 0.68 and 0.06, respectively and two testers GD-159 and GD-171 showed positive GCA values of 0.39 and 0.36, respectively. These results are in accordance with Ahmadi *et al.* (2003), Nazir *et al.* (2005), Hassan *et al.* (2007) and Hasnain *et al.* (2006). Positive value of spike density is essential for enhanced yield as it is related with more spike length and more number of spikelets per spike. Among parent two lines viz., GD-170 and GD-102 showed positive values i.e. 0.03 and 0.04, respectively. Three testers namely GD-185, GD-159 and GD-189 exhibited high GCA for spike density i.e. 0.01, 0.02 and 0.01, respectively. These results were quite close to the findings of Awan *et al.* (2005), Sharma and Garg (2005) and Hassan *et al.* (2007).

***Specific combining ability studies (SCA)*:** In case of spike length, positive SCA effects are desired. Best crosses are those having positive and higher values of SCA effects. Specific combining ability was positive in 50% of crosses (Table 4). The cross, GD153 x GD185 (1.14) showed the highest value followed by the crosses 7-1 x GD159 (0.84), GD170 x GD185 (0.62), GD102 x GD159 (0.59) and 7-1 x GD171 (0.55). Similar studies have also been reported by Hasnain *et al.* (2006). However, these results differ from the findings of Ahmadi *et al.* (2003) and Chowdhry *et al.* (2005) who confirmed highly significant combining ability for all traits in testing different crosses of wheat. For number of spikelets per spike, positive SCA effects were displayed in 8 crosses out of 16 crosses but 7-1 x GD-171 (1.29), GD153 x GD171 (1.07), GD170 x GD159 (0.93) and GD170 x

Table 1. Mean square values for some spike traits of wheat genotypes derived from line x tester analysis (four lines and four testers)

Source	df	Spike density unit	Spike length (cm)	Awn length (cm)	Spikelets per spike	Grains per spike	Grain yield per plant (g)
Reps	2	0.03 NS	2.42*	3.51*	1.66 NS	5.91**	1.68NS
Treat	23	0.06**	5.50**	1.94**	12.03**	586.88**	32.45**
Parents	7	0.10**	3.23**	0.43 NS	2.81**	352.49**	26.43**
Parents Crosses	1	0.31**	36.75**	16.68**	22.87**	15.13**	109.88**
Crosses	15	0.02NS	4.47**	1.67*	15.60**	734.38**	30.10**
Lines	3	0.32 NS	12.21**	3.62**	56.57**	1273.41**	55.51**
Testers	3	0.01 NS	3.24**	2.37*	13.74**	522.15**	21.35**
L x T	9	0.03NS	2.31**	0.78 NS	2.57**	625.45**	24.54**
Error	46	0.025	0.57	0.81	0.71	1.15	0.61

*** Highly Significant, * Significant, NS: Non Significant*

Table 2. Mean values for some spike traits of eight parents and sixteen crosses of wheat used in line x testers analysis

Parents	Spike density unit	Spike length (cm)	Awn length (cm)	Spikelets per spike	Grains per spike	Grain yield per plant (g)
GD-170	1.98	9.97	7.31	19.78	54.00	15.60
GD-102	1.97	9.43	7.47	18.63	53.25	9.36
GD-153	1.85	10.66	6.81	19.75	51.65	11.42
7-1	1.78	9.91	6.71	17.63	48.71	10.51
Testers						
GD-185	1.97	9.80	6.34	19.23	34.81	6.40
GD-159	1.84	9.45	6.56	17.27	57.76	17.70
GD-171	1.74	10.96	6.72	19.04	60.77	16.25
GD-189	1.42	12.53	6.64	17.85	45.76	13.21
Crosses						
GD170 x GD185	1.69	12.59	7.55	24.32	27.13	10.70
GD170 x GD159	1.78	12.29	8.31	21.85	79.81	17.58
GD170 x GD171	1.71	12.13	8.49	20.81	32.41	12.62
GD170 x GD189	1.65	12.56	6.61	20.79	56.60	14.56
GD102 x GD185	1.78	12.10	7.65	21.46	52.97	9.40
GD102 x GD159	1.72	14.18	8.76	21.35	48.23	12.82
GD102 x GD171	1.65	12.81	8.50	21.09	27.41	11.58
GD102xGD189	1.76	12.23	9.21	21.42	50.60	12.62
GD153 x GD185	1.48	12.39	6.85	18.30	53.97	11.68
GD153 x GD159	1.72	11.84	7.68	20.25	61.45	8.17
GD153 x GD171	1.53	11.20	7.59	17.07	68.46	14.82
GD153 x GD189	1.70	11.29	6.67	19.23	45.67	12.87
7-1 x GD185	1.81	8.61	7.57	15.43	42.02	8.62
7-1 x GD159	1.59	12.11	8.21	19.29	41.53	11.90
7-1 x GD171	1.64	11.003	8.26	18.09	58.51	10.83
7-1 x GD189	1.62	10.36	7.56	16.72	22.89	10.92
Control						
Chakwal-50	2.31	8.46	6.61	19.52	43.92	9.41

Table 3. Estimates of general combining ability for some spike traits in four lines and four testers of wheat

Parents	Spike density units	Spike length (cm)	Awn length (cm)	Spikelets per spike	Grains per spike	Grain yield per plant (g)
GD-170	0.03	0.53	-0.10	1.35	-6.96	1.63
GD-102	0.04	0.97	0.68	2.22	4.89	1.76
GD-153	-0.06	-0.17	-0.64	-1.12	-1.10	-0.67
7-1 Testers	-0.01	-1.33	0.06	-2.45	-6.82	-2.74
GD-185	0.01	-0.43	-0.43	-0.70	-4.21	0.28
GD-159	0.02	0.74	0.39	1.58	9.69	0.07
GD-171	-0.04	-0.07	0.36	0.57	1.36	1.79
GD-189	0.01	-0.25	-0.32	-0.30	-4.11	1.42

Table 4. Estimates of specific combining ability for some spike traits in four lines and four testers of wheat

Crosses	Spike density unit	Spike length (cm)	Awn length (cm)	Spikelets per spike	Grains per spike	Grain yield per plant (g)
GD170xGD185	-0.03	0.62	0.24	0.85	-9.75	0.96
GD170 x GD159	0.04	-0.84	0.17	0.93	2.55	0.84
GD170 x GD171	0.04	-0.19	0.38	0.18	-7.31	-3.80
GD170 x GD189	-0.06	0.41	-0.80	-0.10	9.62	1.68
GD102 x GD185	0.05	-0.29	-0.44	0.09	-5.78	-0.49
GD102 x GD159	-0.03	0.59	-0.16	0.66	7.15	-1.86
GD102 x GD171	-0.03	0.05	-0.39	-0.40	6.85	0.76
GD102 x GD189	0.03	-0.35	1.01	-0.35	-8.23	1.58
GD153 x GD185	-0.14	1.14	0.09	0.29	10.55	1.25
GD153 x GD159	0.08	-0.58	0.08	-0.04	4.80	0.95
GD153 x GD171	-0.04	-0.41	0.02	1.07	8.18	0.52
GD153 x GD189	0.08	-0.14	-0.19	0.82	2.83	-1.69
7-1 x GD185	0.13	-1.47	0.11	-1.24	4.99	-1.73
7-1 x GD159	-0.09	0.84	-0.09	0.32	-9.40	1.75
7-1 x GD171	0.02	0.55	-0.01	1.29	8.64	3.55
7-1 x GD189	-0.54	0.08	-0.01	-0.35	-4.22	-3.57

GD185 (0.85) performed the best and can be recommended for the future breeding programs. Further exploration of these crosses having positive SCA effects may lead to the selection of lines having more number of spikelets per spike. These results are in the conformity with those of Singh *et al.* (2002), Siddique *et al.* (2004), Mahantashivayogayya *et al.* (2004), Saeed *et al.* (2005) and Chowdhary *et al.* (2007). Positive specific combining ability effects were shown by 50 % of the crosses for number of grain per spike. Potential crosses showing higher values of specific combining ability effects were GD153 x GD185 (10.5), GD170 x GD189 (9.62) and 7-1 x GD171 (8.64). The findings of Khan *et al.* (2007) supported our results. Specific combining ability effects were found much variable among crosses for grain yield per plant. The poorest cross with respect to specific combining ability for grain yield per plant was GD170 x GD171 (-3.80). Positive specific combining ability effects were displayed in 10 out of 16 crosses. Such positive effects were impressive in crosses viz., 7-1 x GD171 (3.55) 7-1 x GD159 (1.75) and GD170 x GD189 (1.68). Same results were also reported by Chowdhry *et al.* (1996), Saeed *et al.* (2001), Saeed *et al.* (2005), Awan *et al.* (2005), Hassan *et al.* (2007), Khan *et al.* (2007) and Akbar *et al.* (2009) who amongst various testing lines attributed positive GCA and SCA for quantitative characters similar to this research parameters presented in Table 4. For awn length, positive value of GCA is required because maximum awn length contributes towards maximum light reflectance and hence increased drought tolerance. Half of the total crosses showed higher values of SCA but three most superior crosses were GD102 x GD189 (1.01), GD170 x GD171 (0.38) and GD170 x GD185 (0.24). Positive values of spike density are desirable for improved yield. About 50 % crosses exhibited positive and higher estimates for SCA. Three top superior crosses include 7-1 x GD185 (0.13), GD153 x GD159 (0.08) and GD153 x GD189 (0.08). The findings of Awan *et al.* (2005) and Hassan *et al.* (2007) also match with these results.

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