Research Article

Line × tester analysis for estimating combining ability in F₁ hybrids of bread wheat

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Abstract

The present research was conducted so as to estimate the combining ability effects of wheat genotypes for some quantitative traits in a set of line x tester crosses developed from five parents of bread wheat (*Triticum aestivum* L.), of which two were considered as lines (Anmol-91 and Kiran-95) and three as testers (Imdad-05, SKD-1 and Khirman). The characters studied were tillers plant⁻¹, spike length, spikelets spike⁻¹, grains spike⁻¹, grain yield plant⁻¹ and seed index. 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 variances due to F₁ hybrids, lines, testers and line x tester were significant for grain yield and almost for all other characters. Thus, showing these attributes were controlled by both additive and non-additive inheritance. Line 'Kiran-95' proved worthy general combiner for spikelets spike⁻¹, grain yield plant⁻¹ and seed index. Tester, Imdad-05 was identified as good general combiner for tillers plant⁻¹, spike length, spikelets spike⁻¹, grains spike⁻¹, and seed index, while tester Khirman proved promising for grain yield plant⁻¹. The cross Khirman x Imdad-05 was found as potential hybrid for grain yield plant⁻¹, while other two crosses, namely, Anmol-91 x Khirman and Kiran-95 and Khirman also showed desirable specific combining ability for variety of characters. These parents and cross combinations may be used for varietal improvement through the simple selection in segregating generations to increase yield potential of bread wheat genotypes. This may lead in the fixation of both additive and non-additive components, while making improvement in grain yield and its attributes.

Key words: Grain yield; Combining ability; F₁ hybrids; Bread wheat

Introduction

Bread wheat belongs to family *Poaceae* and is regarded as major staple food with highly nutritive value, hence cultivated at large scale in many countries including Pakistan.

It is the second highest produced crop after only corn [1], offers a great segment of the total food supplements and dietary protein too, it is also grown in a range of environments [2]. This hexaploid wheat is

preferred for principal food products and is also used as feed for livestock. It adds 10.1% to the value added in agriculture and 2.2 % in GDP of Pakistan. Plant breeders are always interested in production of superior wheat varieties by using good general combining genotypes in crossing programs and selecting promising transgressive segregants from resulting hybrids for grain yield and its related traits [3]. The information in respect to combining ability is valuable to evaluate differences among the cultivars and also, explicate the nature and extent of gene actions involved. It plays a key role to pick the choice parents and crosses and it assists to take decision about breeding approaches to be followed to select promising genotypes [4]. Line $\times$ tester analysis is one of the most important tools for envisaging the general combining ability (GCA) of parental lines and choosing the appropriate parents and their subsequent F_1 hybrids with high specific combining ability (SCA). Line $\times$ tester analysis gives knowledge regarding combining ability effects of breeding materials and also, information about genetic mechanism which control yield attributes. Knowledge of GCA and SCA influencing yield and its attributes has become very imperative to plant breeders for the selection of choice plant materials for producing of hybrid cultivars, most importantly in cross pollinated crops. Nonetheless, a great number of workers have focused on the estimation of combining abilities and determination of gene actions in bread wheat hybrid populations by opting line $\times$ tester analysis for variety of characters [5- 8]. Therefore, this research was planned to determine combining ability in F_1 hybrids of bread wheat for yield and its associated traits.

Materials and methods

The present study was conducted on wheat at Southern Wheat Research Station, Tandojam. In this study, F_1 population raised from intra-specific crossing between two cultivated wheat varieties viz., Anmol-91 and Kiran-95 with three promising

breeding varieties viz., Imdad-05, SKD-1 and Khirman. These five wheat varieties were crossed in a line $\times$ tester design; consequently, six F_1 hybrids were obtained. The current experiment was laid out in randomized complete block design with three replications. The characters were analyzed including tillers plant⁻¹, spike length (cm), spikelets spike⁻¹, grains spike⁻¹, grain yield plant⁻¹(g) and seed index (1000 grain-weight, g). The analysis of variance was carried out after Gomez and Gomez [9]. Line $\times$ tester analysis was carried out for determining the effect due to general and specific combining ability as described by Kempthorne [10] and adapted by Singh and Chaudhary [11].

Results and discussion

The present research was carried-out to determine general combining ability (GCA) and specific combining ability (SCA) effects of different economic traits in a set of line $\times$ tester crosses along with five parental lines in which two parents used as lines (female parents) as three parents as testers (male parents) of bread wheat (*Triticum aestivum* L). The obtained results for each character is discussed as under:

Regarding tillers plant⁻¹, the mean squares from analysis of variance showed highly significant differences among F_1 hybrids and male inbreds (Table 1). Since male inbreds designate GCA and crosses designate SCA variances, implied the importance of additive as well as dominant gene controlling the trait tillers plant⁻¹. Nevertheless, GCA of males was greater than SCA, suggesting prevalence of additive genes over dominant genes. Among the female parents (Table 2), Anmol-91 expressed maximum positive GCA effects (6.26), while among the male parents, maximum GCA was shown by Imdad-05 (2.74). These results refer that parents with high positive GCA effects harbor more additive genes so can be utilized for the development wheat varieties in respect to maximum tillers plant⁻¹. The SCA effects (Table 3) revealed that hybrid

Anmol-91 x Imdad-05 exhibited maximum positive SCA effects (0.36), whereas next maximum positive SCA effects (2.66) was displayed by the hybrid Kiran-95 x Khirman, indicating that these genotypes

may be used in heterosis breeding in wheat crop. These results are in agreement with those of Akbar *et al.* [12] and Attia *et al.* [13].

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

Source of variation	D.F.	Tillers plant ⁻¹	Spike length	Spikelets spike ⁻¹	Grains spike ⁻¹	Grain yield plant ⁻¹	Seed index
Replications	2	1.4594	0.3464	11.009	0.025	0.839	42.182
Genotypes	10	18.800**	10.535**	147.578**	116.176**	132.85**	723.978**
Parents	4	7.529**	2.177**	9.189 ^{ns}	153.513**	16.205**	9.161 ^{ns}
Crosses	5	3.1982**	0.708**	49.015**	46.64**	117.112**	140.545**
Lines	1	1.075*	0.268 ^{ns}	0.5 ^{ns}	143.369**	201.938**	1.626 ^{ns}
Testers	2	6.722**	1.34**	91.279**	7.547**	53.055**	120.082**
Line x Tester	2	0.735 ^{ns}	0.295 ^{ns}	31.009**	37.369**	138.757**	230.466**
Pooled error	20	0.238	0.146	4.435	0.371	0.173	15.358

Considering the spike length, the mean squares from analysis of variance showed highly significant differences among F₁ hybrids (Table 1). Since crosses designate SCA variance, implying the importance of dominant gene controlling the character spike length. Among the female parents (Table 2), Anmol-91 manifested maximum positive GCA effects (0.12), while among the male parents, maximum GCA was shown by Imdad-05 (0.53), these results refer that parents with high positive GCA effects contain more additive genes, thus can be utilized for the development wheat varieties in respect to longer spike length. The SCA effects (Table 3) displayed that hybrid Kiran-95 x Khirman exhibited maximum positive SCA effects (0.26), whereas next maximum positive SCA effects (0.14) was displayed by the hybrid Anmol-91 x SKD-1, signifying that these genotypes may be preferred in heterosis breeding program for wheat crop. The obtained facts are in consonance with those of Kamaluddin *et al.* [14] and Kumar *et al.* [15].

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 mean squares from analysis of variance for spikelets spike⁻¹ indicated significant differences among crosses and line x tester interaction, while non-significant for lines and testers (Table 1). The significance of mean squares due to crosses and line x tester interaction signify SCA variances, suggesting the importance of non-additive genes controlling spikelets spike⁻¹. Among the female parents (Table 2), Kiran-95 expressed maximum positive GCA effects (0.17), while among the male parents, maximum GCA was demonstrated by Imdad-05 (4.18), the results refer that parents with high positive GCA effects possess more additive genes; consequently can be utilized for the improvement of spikelets spikes⁻¹ in wheat varieties. The SCA effects (Table 3) exhibited that hybrid Kiran-95 x Khirman showed maximum positive SCA (2.50), whereas next maximum positive SCA effects (1.94) were displayed by the hybrid Anmol-91 x SKD-1, registering that these genotypes may be proved a choice breeding stock for the hybrid program in wheat crop. These

results are in line with those of Saeed *et al.* [16] and Golparvar *et al.* [17].

Table 2. General combining ability estimates of female and male inbreds for various characters in intra-specific crosses of bread wheat

Source of variation	D.F.	Tillers plant ⁻¹	Spike length	Spikelets spike ⁻¹	Grains spike ⁻¹	Grain yield plant ⁻¹	Seed index
Replications	2	1.4594	0.3464	11.009	0.025	0.839	42.182
Genotypes	10	18.800**	10.535**	147.578**	116.176**	132.85**	723.978**
Parents	4	7.529**	2.177**	9.189 ^{ns}	153.513**	16.205**	9.161 ^{ns}
Crosses	5	3.1982**	0.708**	49.015**	46.64**	117.112**	140.545**
Lines	1	1.075*	0.268 ^{ns}	0.5 ^{ns}	143.369**	201.938**	1.626 ^{ns}
Testers	2	6.722**	1.34**	91.279**	7.547**	53.055**	120.082**
Line x Tester	2	0.735 ^{ns}	0.295 ^{ns}	31.009**	37.369**	138.757**	230.466**
Pooled error	20	0.238	0.146	4.435	0.371	0.173	15.358

It has been noted in bread wheat genotypes that grains spike⁻¹ increases, the grain yield also increases, there is also close and positive correlation between grains spike⁻¹ and grain yield plant⁻¹. The mean squares from analysis of variance indicated significant differences among crosses, lines and line x tester interaction, while non-significant for testers (Table 1). The significance of mean squares due to female inbreds, which designate GCA and line x tester interaction, which signify SCA variances, suggesting the importance of both additive and non-additive genes controlling grains spike⁻¹. Among the female parents (Table 2), Anmol-91 expressed maximum positive GCA effects (2.82), while among the male parents, maximum GCA (0.87) was recorded in Imdad-05, these results indicate that parent with positive GCA effects retain more additive genes, thus providing opportunities for potential improvement of grains spike⁻¹ in wheat varieties. The SCA effects (Table 3) depicted that hybrid Anmol-91 x Imdad-05 exhibited maximum positive SCA (2.80), whereas next maximum positive SCA effects (1.82) was displayed by the hybrid Kiran-95 x SKD-1, suggesting these genotypes could be

exploited for hybrids crop development in wheat. Similar results were also reported by Kumar *et al.* [15] and Munesh *et al.* [18]. With regards to grain yield plant⁻¹, the mean squares from analysis of variance showed highly significant differences among male inbreds, female inbreds and male female interaction (Table 1). Since, the male and female inbreds both designate GCA and variance of male x female interaction signify SCA, implying that additive as well as non-additive genes controlling grain yield plant⁻¹. Yet, GCA of female was greater than the males and SCA of line x tester interaction, indicating the preponderance of additive genes over non-additive genes. Among the female parents (Table 2), Kiran-95 expressed maximum positive GCA effects (3.35), while among the male parents, maximum positive GCA was observed in Khirman (3.11). These results suggest that parent with high positive GCA effects possess more additive genes hence can be utilized for the development for grain yield plant⁻¹ in wheat variety. The SCA effects (Table 3) exhibited that hybrid Kiran-95 x Imdad-05 manifested maximum positive SCA (5.54), whereas next maximum positive SCA effects (3.05) was displayed by the hybrid

Anmol-91 x Khirman, suggesting these genotypes may be used for the exploitation heterosis in wheat hybrid program. These

findings are in agreement with those of Yao *et al.* [19] and Lohithasawa *et al.* [20].

Table 3. Specific combining ability estimates of intra-specific bread wheat crosses

F1 crosses	Tillers plant ⁻¹	Spike length	Spikelets spike ⁻¹	Grains spike ⁻¹	Grain yield ⁻¹	Seed index
Anmol-91xImdad-05	0.36	0.11	0.56	2.84	-5.54	-1.81
Anmol-91xSKD-1	-0.01	0.14	1.94	-1.82	2.50	-5.09
Anmol-91xkhirman	-0.34	-0.26	-2.50	-1.02	3.05	6.90
Kiran-95xImdad-05	-0.36	-0.11	-0.56	-2.84	5.54	1.81
Kiran-95xSKD-1	0.01	-0.14	-1.94	1.82	-2.50	5.09
Kiran-95xkhirman	0.34	0.26	2.50	1.02	-3.05	-6.90
S.E. (si)	0.282	0.221	1.216	0.352	0.240	2.263

In respect to seed index, the mean squares from analysis of variance indicated significant differences among crosses and line x tester interactions, while non-significance for lines and testers (Table 1). The significance of mean squares due to crosses and lines x testers designate SCA variances, suggesting the importance of non-additive genes controlling seed index. Among the female parents (Table 2), Kiran-95 expressed maximum positive GCA (0.30), while among the male parents, maximum positive GCA was shown by Imdad-05 (4.84), these results suggest that these parents possess more additive genes hence can be exploited for the development of wheat varieties for seed index. The SCA effects (Table 3) disclosed that hybrid Anmol-91 x Khirman manifested maximum positive SCA (6.90), whereas next maximum positive SCA effects (5.09) was displayed by the hybrid Kiran-95 x SKD-1, suggesting these genotypes could be utilized in wheat hybrid program. These findings are in agreement with those of Hassan *et al.* [21] and Kumar *et al.* [15].

Authors' contributions

Conceived and designed the experiments: SA Abro, AW Baloch & NA Sial. Performed the experiments: NA Sial & SA Abro. Analyzed the data: TA Baloch & Q

Jogi, Contributed reagents/ materials/ analysis tools: SA Abro & AA Baloch. Wrote the paper: M Baloch, AW Baloch, SA Abro & M Ali.

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