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Phenotypic association and heritability analysis in bread wheat (*Triticum aestivum* L.) genotypes

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Abstract

Development of new cultivars with high yield potential is one of the main objectives of most of the wheat improvement programs. In the current study a set of eight bread wheat genotypes were evaluated to determine phenotypic association and heritability analysis for some quantitative traits. Eight bread wheat genotypes were evaluated in a randomized complete block design with three replications at Southern Wheat Research Station, Tandojam. The mean squares from analysis of variance revealed highly significant differences among genotypes for all the studied traits. Based on mean performance, the varieties TD-1 showed outstanding performance for most of the traits, thus can extensively be used as parental materials in upcoming breeding programs. High heritability estimates (h^2b.s.) were detected for plant height tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, seed index and grain yield plant^{-1}.The results showed significant positive correlation among various traits. Tillers plant^{-1} manifested significant positive associations with grains spike^{-1} and grain yield plant^{-1}; spike length with seed index and grain yield plant^{-1}. The trait spikelets spike^{-1} established positive and significant association with seed index; while seed index showed positive and significant correlation with grain yield plant^{-1}. High heritability in broad sense coupled with positive correlation among most the yield related traits indicated that selection in early generation could be effective and progress for desired traits from selection would be high. The identified superior line (TD-1) could be used in future improvement program to improve yield related attributes.

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Introduction

Hexaploid wheat (*Triticum aestivum*) is cultivated worldwide (Moon *et al.*, 2008) and is the principal source of human diet with prominent position among cereals. In the south Asian region, supplying 68 percent of the calories and protein in the diet (Shewry *et al.,* 2009). Wheat flour is used for leavened, flat and steamed breads as well as most of the baked products (Cauvain*et al.,* 2003). In Pakistan 60 percent of daily diet of common man is based on wheat with average per capita consumption of 125 kg (Khan and Habib, 2003).

Pakistan is among the top ten countries of the world where wheat is cultivated extensively in its all ecological conditions. (Khan *et al*., 2002). Although it is cultivated on large acreages in the country but the average yields are much lower than other major wheat growing countries including China, USA, India etc. (Arain *et al.*, 2005). Area under wheat has decreased to 9180 thousand hectares in 2014-15 from last year's area of 9199 thousand hectares which shows a decrease of 0.2 percent. The production of wheat stood at 25.478 million tons during 2014-15, showing a decrease of 1.9 percent over the last year's production of 25.979 million tons (GoP, 2015).

The yield of wheat varies under the interactive influence of various environmental factors, because the grain is contributed by numerous factors that have direct or indirect effect on grain yield. The grain yield can be improved by evolution and development of high yielding wheat lines with better adaptability across environments as well as resistance to multiple stresses. The wheat breeders are emphasizing on improving yield potential by evolving new crop varieties possessing high genetic potential to produce desired grain yields. The understanding of association among character influencing yield is of prime importance for development of a successful plant-breeding program because the information about the correlation coefficient amongst agronomic and morphological as well as quality traits with grain yield trait is useful to identify yield component (Baloch *et al.,* 1992).

Heritability studies provide valuable genetic information to the breeders to envisage the genes' interaction in segregating populations (Degewione *et al.,* 2013). It has been observed that in breeding programs, the extent of inheritance of the genetic factors and expected genetic gains are very essential to predict response to selection in different environmental conditions and offer the basis for effective selection for particular traits in segregating populations.

The present experiment was carried out with the objectives to determine the relationships between yield and yield traits in wheat genotypes and also to estimate heritability in broad sense for the different traits.

Materials and methods

The experimental material comprised of 8 wheat genotypes namely, TJ-83, Sarsabz, TD-1, Abadgar, Mehran, Anmol, Khirman and Benazir and were evaluated in a randomized complete block deign using three replications duringrabi season, 2014-15 at Southern Wheat Research Station Tandojam. Each entry was sown in 6 rows and 5 meter long with row to distance of 25 cm. Standard cultural practices were adopted throughout the crop growing season.Data were recorded on plant height (cm), number of tillers plant^{-1}, spike length (cm), spikelets spike^{-1}, grains spike^{-1} , grain yield plant^{-1} (g), seed index and 1000-grain weight (g).

Statistical analysis

Data collected was subjected to analysis of variance (ANOVA) according to Gomez and Gomez (1984) for various traits. Correlation coefficient between different traits were computed according to Snedecor and Cochran (1983). The heritability was estimated as suggested by Allard (1960).

Results and discussion

Analysis of variation

The mean squares corresponding to various growth and yield contributing traits of wheat are presented in Table 1. Analysis of variance showed highly significant differences (P<0.01) among the genotypes for plant height, number of tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, seed index and 1000-grain weight while, significant difference (P<0.01) was found for grain yield plant^{-1}. Its shows that the genotype varied significantly for the studied traits and genetically diverse. Significant variations (P<0.01) were observed among the genotypes for all the growth and yield traits. Similar results have been reported by Safeer-ul-Hassan *et al.* (2005) who found that the genotypes differed highly significantly for all the traits such as spikelets spike^{-1}, plant height, grains plant^{-1}, grain weight per spike, 1000-grain weight, spike length and grain yield. Moucheshi *et al.* (2013) also observed significantly difference in yield and its components.

Table 1. Mean squares for various quantitative traits of wheat genotypes.

Source of variation	Degrees of freedom	Characters						
		Plant height	Tillers plant^{-1}	Spike length	Spikeletsspike^{-1}	Grains spike^{-1}	Grain yield plant^{-1}	Seed index
Replications	2	1.500	0.45	0.88	0.50	4.54	0.12	7.54
Genotypes	7	162.64**	4.87**	4.03**	14.07**	42.47**	48.51*	61.23**
Errors	14	10.35	0.81	0.65	2.78	2.35	19.75	1.44

Mean agronomic performance of wheat genotypes

Mean performance of wheat genotypes for different agronomic traits of are given in Table. 2. Maximum plant height was recorded for Khirman (80.66 cm), followed by genotypes Sarsabz, Benazir and Mehran with mean plant height of 80.33, 80.00 and 79.67 cm, respectively. While variety TD-1 exhibited the minimum plant height of 59.66 cm. Maximum number of tillers plant^{-1} (12.70) wheat variety TD-1, followed by varieties Khirman, Mehran and Sarsabz with 11.00, 10.20 and 9.70 tillers plant^{-1}, respectively. However, the minimum number of tillers (8.83) plant^{-1} was observed by variety Abadgar.

Table 2. Mean values for agronomic performance of wheat varieties for different traits in bread wheat genotypes.

Genotypes	Characters						
	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Spikeletsspike^{-1}	Grains spike^{-1}	Grain yield plant^{-1}(g)	Seed index (g)
TJ-83	75.00 b	9.16 c	12.36 a	16.33 b	60.33 a	20.00 c	37.66 c
Sarsabz	80.33 a	9.70 b	11.66 b	17.66 b	62.33 a	20.00 c	36.33 c
TD-1	59.66 d	12.70 a	13.43 a	21.66 a	62.66 a	27.66 a	44.33 a
Abadgar	69.33 c	8.83 c	10.33 b	16.33 b	58.33 b	18.66 c	40.66 b
Mehran-89	79.67 a	10.20 b	10.93 b	16.33 b	63.33 a	17.00 d	35.00 c
Anmol	77.33 a	9.16 c	11.33 b	19.00 a	56.66 b	17.66 d	38.00 b
Khirman	80.66 a	11.00 b	9.86 c	15.66 b	52.00 c	17.66 d	29.33 d
Benazir	80.00 a	9.53 b	10.63 b	15.00	59.00 b	25.00 b	41.00 b
LSD 0.05	4.8691	1.5168	1.4343	2.7368	4.32	1.3952	2.5722

Means followed by similar alphabetic letters are not significantly different from each other according to DMR test.

The longer spike length (13.43 cm) was noted in case of variety TD-1, followed by varieties TJ-83, Sarsabz and Anmol with 12.36, 11.36 and 11.33 cm spike length, respectively, and shorter spike length (9.86 cm) was noted in variety Khirman. Similarly, highest number of spikelets spike^{-1} (21.66) were recorded in varietys TD-1, followed by varieties Anmol (19.00) and Sarsabz (17.66), while varieties Mehran, TJ-83 and Abadgar equally produced 16.33 spikelets spike^{-1}, respectively. For the trait grains spike^{-1}, the maximum value (63.33) was observed for variety Mehran, followed by TD-1, Sarsabz and TJ-83 with 62.66, 62.33 and 60.33 grains spike^{-1}, respectively. The data in relation to mean agronomic performance of grain yield plant^{-1}, TD-1 displayed maximum grain yield (27.66 g) plant^{-1}, followed by Benazir, Sarsabz and TJ-83 with 25.00, 20.00 and 20.00 g mean grain yield plant^{-1}, respectively; while the minimum grain yield plant^{-1} (17.00 g) was noted in variety Mehran. The seed index (1000-grains weight) was highest (44.33 g) in variety TD-1, followed by mean seed index value of 41.00 g, 40.66 g and 38.00 g observed in varieties Benazir, Abadgar and Anmol, respectively. Safeer-ul-Hassan *et al.* (2005) who found that the genotypes differed highly significantly for all the traits such as spikelets spike^{-1}, plant height, grains plant^{-1}, grain weight per spike, 1000-grain weight, spike length.

Table 3. Correlation coefficients (r) between various traits in wheat genotypes.

Character	Plant height	Tillers plant^{-1}	Spike length	Spikelets spike^{-1}	Grains spike^{-1}	Seed index
Tillers plant^{-1}	-0.3951**					
Spike length	-0.0491^{NS}	0.1585^{NS}				
Spikelets spike^{-1}	-0.0652^{NS}	0.0704^{NS}	0.2577^{NS}			
Grains spike^{-1}	-0.0216^{NS}	0.3241*	0.2327^{NS}	0.3642**		
Seed index	-0.6428**	-0.3265*	0.3692**	0.1936^{NS}	-0.0471^{NS}	
Grain yield plant^{-1}	-0.2099^{NS}	0.6223**	0.3291*	0.2396^{NS}	0.1634^{NS}	0.4276**

* = Significant at 0.05 probability level

** = Significant at 0.01 probability levelNS = Non-Significant.

Correlation studies

The study further showed significant and positive (P<0.05) correlation for tillers plant^{-1}*vs* grains spike^{-1}(r=0.3241*), tillers plant^{-1}*vs* grain yield plant^{-1}(r= 0.6223**), spike length *vs* seed index (r= 0.3692**), spike length *vs* grain yield palnt^{-1} (r=0.3291*) and spikelets spike^{-1}*vs* grains spike^{-1} (r= 0.3642**)and seed index vs grain yield plant^{-1} (r= 0.4276**). However, there was negative and significant (P<0.05) association was recorded for plant height *vs* spike length (r= -0.3951**), plant height *vs* seed index(r= -0.6428**). These results are in accordance with those of Gupta *et al.* (2002) concluded that the length of main ear per plant, number of tillers per plant and number of spikes per plant exhibited positive and were highly and significantly correlated with grain yield. Kashif *et al.* (2004) reported that phenotypically and genotypically plant height, spike length, spikelets spike^{-1}, grains spike^{-1} and 1000-grain weights were positively and significantly correlated with grain yield; while fertile tillers per plant, spikelets per spike and 1000-grain weight exhibited negative direct effects on grain yield. Mehmet and Yildirim (2006) reported positive and significant correlation between yield and plant height, grain number per spike, grain weight per spike and 1000 kernels weight. Kashif*et al.* (2007) reported that plant height, spike length, spikelets per spike, grains per spike and 1000-grain weight were positively and significantly correlated genotypically with grain yield while highly significantly associated phenotypically. Flag leaf area was positively but non significantly associated with grain yield; whereas, fertile tillers per plant was negatively and non-significantly correlated with grain yield. Akram *et al.* (2008) revealed positive correlations for number of spikelets per spike, number of grains per spike and 1000 grain weight with grain yield at both genotypic and phenotypic levels. Anwar *et al.* (2009) observed that grain yield plant^{-1}was positively and significantly correlated with number of tillers plant^{-1}and days to maturity at genotypic level but non-significantly correlated at phenotypic level. Mollasadeghi *et al.* (2011) showed that the grain yield has a positive correlation (0.527**) with seed index, while Rashidi (2011) revealed a significant and positive relationship of grain yield with traits such as number of fertile tiller, grains/spike, biomass and harvest index. Khan *et al.*

(2014) showed that grain filling rate was found positively correlated (0.652**) with grain yield. Likewise, the findings of the present research are in similarity with results reported by these workers. However, some contradiction existed that might be due to the varietal and environmental influence; moreover, the genetic material used by different past workers may differ in crop performance for different traits due to genetic makeup of parental material used for different genotypes. Junejo (2014) used wheat genotypes NIA Amber, Sarsabz, Mehran-89, TJ-83, Imdad-2005, TD-1, NIA Sonahri and Kiran for correlations studies and indicated that there was a positive and significant correlation between tillers plant^{-1} and grain yield plant^{-1} (0.9744**), spike length and spikelets spike^{-1} (0.5897**), spike length and grains spike^{-1} (0.6491**), spike length and grain yield plant^{-1} (0.5535**), spikelets spike^{-1} and grains spike^{-1} (0.5509**), spikelets spike^{-1} and seed index (0.5942**), spikelets spike^{-1} and grain yield plant^{-1} (0.4834*), grains spike^{-1} and grain yield plant^{-1} (0.4506*). Hussain *et al.* (2014) reported that phonotypic and genotypic correlation coefficient of grain yield with number of spikelets spike^{-1}, days to maturity, number of tillers m^{-2} and number of grains spike^{-1} was observed positive and significant whereas plant height and spike length was found has deterrent traits for grain yield improvement because those characters showed negative association with grain yield.

Table 4. Heritability estimates in broad sense for various character in bread wheat genotypes.

Traits	Genetic variance (δ^2 g)	Phenotypicvariance (δ^2 p)	Heritability % (Broad sense)
Plant height	144.07	145.44	99.05
Tillers plant^{-1}	2.72	2.96	91.89
Spike length	0.24	0.35	68.57
Spikelets spike^{-1}	2.56	2.93	87.37
Grains spike^{-1}	29.64	31.18	95.06
Seed indexs	10.31	13.22	77.98
Grain yield plant^{-1}	3.34	4.48	74.55

Heritability estimates

The heritability estimates (h^2) in broad sense, genetic variance (δ^2g), and phenotypic variance (δ^2p) from variance components for various traits studied are depicted in Table 4.The heritability of a trait within a population is the proportion of observable differences in a trait between individuals within a population that is due to genetic differences. Factors including genetics, environment and random chance can all contribute to the variation between individuals in their observable characteristics. Heritability estimates are helpful in deciding the characters to be considered while making selection. High heritability estimates (h^2b.s.) were observed for plant height (h^2 =99.05%), tillers plant^{-1} (h^2=91.80%), spike length (h^2 =68.57%), spikelets spike^{-1}(h^2 =87.37%), grains spike^{-1}(h^2 =95.06%), seed index (h^2 =77.98%) and grain yield plant^{-1}(h^2= 74.55%). High heritability values for these traits indicated that the variation observed was mainly under genetic control and was less influenced by environment, indicating the influence of additive gene action for these traits. Hence, the improvement of these traits can be made through direct phenotypic selection. These findings are in accordance with previous reports of Khodadadi *et al.* (2011), Baloch *et al.* (2014a) and Kandhro (2015).

Conclusions

Analysis of variance results showed significant variation for the studied traits. Among the genotypes, TD-1 showed superior performance for most of the traits, and have genetic potential to be used as parent in future breeding programs. High heritability estimates (h^2b.s.) was observed for all the studied traits. Significant positive correlation was observed among the traits. High heritability coupled with positive correlation among most the yield related traits indicated that selection in early generation could be effective and progress for desired traits from selection would be high. The identified potential line could be used in future improvement program to improve yield related attributes.

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