CORRELATIONS AND HERITABILITY ESTIMATES OF YIELD AND YIELD ATTRIBUTING TRAITS IN WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

The research was carried out to examine the correlations of yield components with grain yield and to determine the extent of transmission of traits from parents to their offspring by heritability estimates. The experimental material consisted of eight wheat genotypes viz. Moomal, Kiran-95, Sarsabz, TD-1, Imdad, Sahar, Sasuee and Sundar. The mean squares from analysis of variance revealed significant differences among the genotypes for all the traits studied. The variety TD-1 produced maximum tillers plant^{-1}, more spikelets spike^{-1}, gave higher grain yield plant^{-1} (g), more seed index (g) and harvest index (%). Sarsabz produced longer spike length, more spikelets and grains spike^{-1}, however Sundar recorded taller plants. The correlation coefficient (r) indicated that tillers plant^{-1}, spike length, spikelets spike^{-1}, number of grains spike^{-1}, seed index and harvest index were significantly and positively correlated with grain yield plant^{-1}. The higher correlations coefficients of yield components with grain yield also suggested that yield components can reliably be used as indirect selection criteria to improve grain yield in wheat. The regression coefficient (b) indicated that a unit increase in tillers plant^{-1}, spike length, grains spike^{-1}, spikelets spike^{-1}, seed index and harvest index caused a substantial increase in grain yield plant^{-1}. The coefficient of determination (r^2) further suggested that major portion of total variability in grain yield plant^{-1} was attributable to traits such as tillers plant^{-1}, spike length and harvest index. The heritability estimates in broad sense were higher for plant height, tillers plant^{-1}, spike length, spikeletes spike^{-1}, grains spike^{-1}, grain yield plant^{-1}, seed index and harvest index which suggested that these traits had more genetic variance and less influenced by the environmental factors, hence could be improved through selection from segregating populations.

Keywords: Correlations, heritability estimates, wheat, yield traits.

INTRODUCTION

Major cultivated species of wheat is *Triticum aestivum*, which is a hexaploid (2n=6x=42). Pakistan ranks among the top ten leading wheat producing countries

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of the world (Agriculture Corner, 2010), but the average yield of the wheat is much lower than its potential yield (Arain *et al*., 2005). The low yield is attributable to many factors viz. sowing patterns, seed rate, irrigation regimes, varietal potential, etc. However, the wheat yield is governed mainly by variety and genetic variability (Alam and Shereen, 2003).

Production of wheat yield fluctuates widely as a result of its interaction with environment because grain yield is a complicated quantitative parameter and is the product of several contributing factors affecting grain yield directly or indirectly. Wheat production can be increased through development of productive varieties which better adapt to various agro-climatic conditions and also resist all types of stresses. Selection for grain yield improvement can only be effective if sufficient genetic variability is present in the breeding material (Ali *et al*., 2008). Genotypic and phenotypic correlations are important breeding parameters used for determining the degree of association of various yield contributing parameters with grain yield (Ali *et al*., 2009). Many earlier researchers studied phenotypic correlations of various grain yield components with wheat grain yield for its genotypic improvement (Shahid *et al*., 2002; Aycicek and Yildirim, 2006). Akram *et al*. (2008) reported positive correlation between grain yield and 1000-grain weight, while Kashif and Khaliq (2004) also found that yield components like tillers plant^{-1} had significantly contributed towards grain yield development. They also noted that number of heads m^{-2}, grains spike^{-1} and 1000 grain weight were main contributors to grain yield in wheat. It was also reported that the grain yield plant^{-1} showed significantly positive association with productive tillers plant^{-1}, plant height, 1000-grain weight and spike length at both genotypic and phenotypic levels (Aycicek and Yildirim, 2006). While negative correlations of plant height with grain yield and number of spikelets spike^{-1} with 1000 grain weight were reported by Shahid *et al*. (2002). The value of the genetic components with negative sign has been accepted as zero in order to prevent the unnecessary reduction in the value of phenotypic variance (Goksoy *et al*., 2003). Since the predictions of the heritability with phenotypic variance definition are exhaustive, hence they are more realistic than the other one. Therefore, the priority may be given to this type of heritability. Considerable research has been conducted around the world on the aspects related to the present studies. In some studies, a low value for the heritability was obtained with regard to the plant height ($h^2 = 0.0402$), moderate and mostly high values had been obtained for the plant height (Fida *et al*., 2001). The present studies were therefore, carried out to obtain more comprehensive information on the correlation of yield components with grain yield and also to determine the extent of transmission of traits from parents to their offspring through heritability estimates.

MATERIALS AND METHODS

A field experiment was conducted to evaluate the performance of some commercial wheat varieties; to estimate correlations between yield and its components; and also determine heritability estimates of various yield traits. The seed of eight wheat genotypes viz. Moomal, Kiran-95, Sarsabz, TD-1, Imdad, Sahar, Sasuee and Sundar were grown in a randomized complete block design

with four replications at the experimental field of Department of Plant Breeding and Genetics, Sindh Agriculture University Tandojam, during the year 2010. The row to row and plant to plant spaces were kept as 30 cm and 15 cm, respectively. Drilling method was adopted for sowing and after four weeks of sowing thinning was done to maintain 15 cm plant to plant space. For proper growth and development, one bag of diammonium phosphate (DAP) fertilizer was applied at the time of sowing, while two bags of urea, one with 1st irrigation and another at the time of grain formation were applied. Ten plants from each genotype and each replication were randomly selected and tagged to record the data in the field and laboratory. Correlation coefficients (r) were determined according to statistical methods suggested by Raghavrao (1983) whereas, heritability estimates in broad sense were estimated as suggested by Gardener (1961). The data was taken on plant height (cm), tillers plant^{-1}, spike length (cm), spikelets spike^{-1}, seeds spike^{-1}, grain yield plant^{-1} (g), seed index (1000-grain weight in g) and harvest index (%). The heritability was calculated from variance components, followed by Gardener (1961) as under:

$$H^2 = \frac{a^2 g}{a^2 g + \dfrac{a^2 e}{r}} \quad OR \quad \frac{a^2 g}{a^2 p}$$

$$\text{Coefficient of } h^2 = \frac{a^2 g}{a^2 p} \times 100$$

RESULTS AND DISCUSSION

The genetic parameters such as correlations; heritability estimates in broad sense (h^2%), phenotypic variance ($\delta^2 p$) and genotypic variance ($\delta^2 g$) were determined. The mean squares for plant height, tillers plant^{-1}, spike length and spikelets spike^{-1}, grains spike^{-1}, grain yield plant^{-1}, seed index and harvest index were significantly different among genotypes (Table-1). The data in relation to mean values corresponding to all the traits studied are given in Table-2. The results for correlation coefficients among yield traits of economic importance are shown in Table-3; while the results for heritability estimates are depicted in Table-4.

Mean performance of genotypes

The data regarding mean performance of different yield traits of wheat varieties presented in Table-2 revealed that wheat genotype Sundar gave significantly maximum plant height (84.00 cm), followed by Sasuee, Sarsabz and Moomal, while minimum plant height was recorded by TD-1. Significantly higher number of tillers plant^{-1} was produced by TD-1, followed by Kiran-95, Moomal and Imdad; while minimum but similar number of tillers plant^{-1} was produced by Sahar and Sundar varieties. The longer spikes were measured by Sarsabz, followed by Moomal and Kiran-95, whereas smaller spikes were given by Imdad. Likewise, significantly higher spikelets spike^{-1} were produced by Sarsabz and TD-1

followed by Kiran-95, yet minimum spikelets spike^{-1} were formed by Imdad and Sahar (Table-2). The mean performance of genotypes further indicated that maximum grains spike^{-1} produced by Sarsabz, followed by Kiran-95 and Sasuee with 53.0 and 52.5 grains spike^{-1}, respectively.

Table 1. Mean squares from analysis for various yield traits of wheat cultivars.

Source of variation	Degrees of Freedom	Character			
		Plant height	Tillers plant^{-1}	Spike length	Spikelets spike^{-1}
Replication	3	0.208	0.781	0.120	4.166
Cultivar	7	268.125**	4.174**	1.98*	17.071**
Error	21	1.265	0.305	0.341	1.500
Source of variation	Degrees of Freedom	Character			
		Grains spike^{-1}	Grain yield plant^{-1}	Seed index	Harvest index
Replication	3	2.614	2.023	0.708	2.970
Cultivar	7	51.817**	33.065**	27.196**	43.362**
Error	21	1.352	0.926	0.589	0.870

**,* = Significant at 1 and 5% probability levels respectively

Table 2. Mean performance of wheat cultivars for various yield traits.

Variety	Plant height (cm)	No. of tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}
Moomal	80.0 b	4.5 c	11.5 b	18.0 b
Kiran-95	77.5 c	5.5 b	11.5 b	19.0 ab
Sarsabz	80.7 b	4.2 cd	12.5 a	20.0 a
TD-1	59.2 e	6.5 a	11.3 bc	20.0 a
Imdad	71.5 d	4.5 c	10.3 d	15.0 c
Sahar	71.7 d	3.5 d	10.5 d	15.0 c
Sasuee	82.7 a	4.0 cd	10.9 bcd	18.0 b
Sundar	84.0a	3.5 d	10.6 cd	16.0 c
Variety	Grains spike^{-1}	Grain yield plant^{-1} (g)	Seed index (g)	Harvest index (%)
Moomal	50.7 d	9.0 c	39.5 d	49.0 b
Kiran-95	53.0 b	11.5 b	42.5 b	48.2 bc
Sarsabz	56.2 a	9.5 c	41.2 bc	47.2 cd
TD-1	51.2 cd	14.0 a	46.2 a	51.5 a
Imdad	50.5 d	10.0 c	39.2 de	46.7 d
Sahar	43.5 e	5.7 e	38.0 ef	42.7 e
Sasuee	52.5 bc	7.2 d	37.1 f	43.2 e
Sundar	50.5 d	7.5 d	40.3 cd	42.4 e

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

The variety TD-1 recorded significantly higher grain yield plant^{-1} against rest of the genotypes. TD-1 produced bold seeds with maximum seed index, while Kiran-95 and Sundar ranked second and third. TD-1 gave significantly highest harvest index, followed by Moomal and Kiran-95.

Correlation and regression analysis

Two main reasons are believed for associations between two traits; 1) due to linkages between genes which affect both the traits simultaneously and 2) pleiotropic effect of genes which means one gene influences more than one trait (Singh, 2009). Significantly negative associations (r= -0.60**) between plant height and number of tillers plant^{-1} and between plant height and harvest index (r=-0.54**) were recorded (Table-3). The coefficient of determination (r^2) revealed that 36.0 and 29.1% of total variability in tillers plant^{-1} and harvest index, respectively was due to its association with plant height. The regression coefficient (b) indicated that a unit increase in plant height will reduce 0.08 tillers plant^{-1} and 0.25% decrease in harvest.

The correlations between plant height and spike length (r=0.11^{NS}); plant height and grain yield plant^{-1} (r=0.23^{NS}); tillers plant^{-1} and spike length (r=0.20^{NS}); tillers plant^{-1} and grains spike^{-}1 (r=0.23^{NS}) and grains spike^{-1} and seed index (r=0.45^{NS}) were non-significant (Table-3). These non-significant correlations indicated that increase in one character will not cause any significant change in another trait. Positive and significant association (r=0.73**) between tillers plant^{-1} and grain yield plant^{-1} revealed that increase in tillers plant^{-1} will increase correspondingly increase grain yield plant^{-1}. About 53.2% of total variability in grain yield plant^{-1} was due to its association with tillers plant^{-1}; while regression coefficient indicated that one tiller increase will simultaneously give increase of 0.34 g in grain yield plant^{-1}. Significant and positive association (r=0.57**) between spike length and grains spike^{-1} indicated that increase in spike length can remarkably increase grains spike^{-1}. The coefficient of determination (r^2) indicated that 32.4% of total variability in grains spike^{-1} was due to its association with spike length^{-1}; while regression coefficient suggested that one cm increase in spike length will cause an increase of 0.05 grains spike^{-1}. Highly positive association (r=0.71**) between spike length and spikelets spike^{-1} was observed which suggested that increase in spike length, will simultaneously increase spikelets spike^{-1}. The r^2 indicated that 50.41% variability in spikelets spike^{-1} was due to its relationship with spike length^{-1}. Kashif and Khaliq (2004) reported that yield components like tillers plant^{-1} had significantly contributed towards grain yield development. They also noted that grains spike^{-1} and 1000-grain weight were main contributors to grain yield in wheat. It was also reported that grain yield plant^{-1} showed significantly positive association with number of productive tillers plant, plant height, 1000-grain weight and spike length at genotypic and phenotypic levels (Aycicek and Yildirim, 2006).

The correlation between spike length and grain yield plant^{-1} (r) showed significantly positive association (r=0.44**) which indicated that increase in spike length will markedly increase grain yield plant^{-1}. The coefficient of determination

(r^2) revealed that 19.3% of total variability in grain yield plant^{-1} was due to its association with spike length^{-1}; while regression coefficient showed that a unit increase in spike length will result in an increase of 2.47 g in grain yield plant^{-1}. Significantly positive association (r=0.51**) between spikelets spike^{-1} and grain yield plant^{-1} showed that increase in spikelets spike^{-1} will considerably increase grain yield plant^{-1}. The coefficient of determination indicated that 26.0% of total variability in grain yield plant^{-1} was attributable to its association with spikelets spike^{-1}; while regression coefficient suggested that increase of one spikelets spike^{-1} will result in an increase of 0.57 g in grain yield plant^{-1}. The correlation coefficient suggested significantly positive association (r=0.45**) between grains spike^{-1} and grain yield plant^{-1} which suggested that increase in grains spike^{-1} will also significantly increase grain yield plant^{-1}. About 20.25% variability in grain yield plant^{-1} was due to its association with grains spike^{-1}; while regression coefficient indicated that a unit increase in grains spike^{-1} will cause an increase of 0.32 g in grain yield plant^{-1}.

Table 3. Correlation (r) and regression coefficients (b) of various traits in wheat cultivars.

Character association	Correlation coefficient (r)	Regression coefficient (b)	Coefficient of determination (r^2)
Plant height *vs* tillers plant $^{-1}$	-0.60**	-0.08	0.36
Plant height *vs* spike length	0.11 ns	0.02	0.0121
Plant height *vs* grains spike^{-1}	0.28 ns	0.13	0.0784
Plant height *vs* grain yield plant^{-1}	0.23 ns	0.19	0.0529
Plant height *vs* harvest index	-0.54**	-0.25	0.2916
Tillers plant $^{-1}$ *vs* spike length	0.20 ns	0.01	0.04
Tillers plant^{-1} *vs* grains spike^{-1}	0.23 ns	0.74	0.0529
Tillers plant^{-1} *vs* grain yield plant^{-1}	0.73**	0.34	0.5329
Spike length *vs* grains spike^{-1}	0.57**	0.05	0.3249
Spike length *vs* spikelets spike^{-1}	0.71**	0.21	0.5041
Spike length *vs* grain yield plant^{-1}	0.44**	2.47	0.1936
Spikelets spike^{-1} *vs* grain yield plant^{-1}	0.51**	0.57	0.2601
Grains spike^{-1} *vs* grain yield plant^{-1}	0.45**	0.32	0.2025
Grains spike^{-1} *vs* seed index	0.30 ns	0.24	0.09
Harvest index *vs* grain yield plant^{-1}	0.72**	0.66	0.5184
Harvest index *vs* seed index	0.83**	0.64	0.6889
Seed index *vs* grain yield plant^{-1}	0.97**	0.74	0.94

Significantly positive association (r=0.72**) between harvest index and grain yield plant^{-1} indicates that increase in harvest index will substantially increase grain yield plant^{-1}. The coefficient of determination (r^2) indicated that 51.84 percent of total variability in grain yield plant^{-1} was due to its association with harvest index; while regression coefficient (b) indicates that a unit increase in harvest index will result in an increase of 0.66 g in grain yield plant^{-1}. Similar to present findings Majumder *et al.* (2008) and Anwar *et al.* (2009) reported that spikes plant^{-1}, grains spike^{-1}, spike length, 100 grain weight and harvest index were the most

important characters which showed positive association with grain yield. The correlation coefficient (r) illustrated significantly positive association (r=0.83**) between harvest index and seed index which suggested that increase in harvest index, will also increase seed index significantly. The coefficient of determination (r^2) explains that 68.8 percent of total variability in seed index was due to its association with harvest index; while regression coefficient (b) describes that a unit increase in harvest index will result in an increase of 0.64 g in seed index value. Highly positive correlation (r =0.97**) between seed index and grain yield plant[-1] indicated that increase in independent variable will cause simultaneous increase in dependent variable. High percent (94.0%) of total variability in grain yield plant[-1] is due to its association with seed index. One percent increase in seed index caused 0.74 g increase in grain yield plant[-1]. Similar to present results Balcoh *et al.* (2012) reported positive association of grain yield plant[-1] with seeds spike[-1] and 1000-grain weight.

Table 4. Heritability estimates in broad sense (h^2%) for various yield traits of wheat cultivars.

Traits	Genetic coefficient of variance ($\sigma^2 gcv$)	Phenotypic variance ($\delta^2 p$)	Genetic variance ($\delta^2 g$)	Heritability (h^2 % b. s.)
Plant height	10.78	67.34	67.03	99.53
Number of tillers plant[-1]	21.62	1.04	0.96	92.71
Spike length	5.66	0.49	0.40	82.79
Number of spikelets spike[-1]	11.19	4.26	3.89	91.21
Number of grains spike[-1]	6.95	13.00	12.61	97.04
Grain yield plant[-1]	27.69	6.80	6.65	97.20
Seed index	6.99	8.26	8.03	97.80
Harvest index	7.02	10.84	10.62	97.99

Heritability estimates

The heritability (h^2 b.s) estimates in broad sense, genetic variance ($\sigma^2 g$) and phenotypic variance ($\sigma^2 ph$), derived from variance components for various traits are depicted in Table-4. The results revealed that high heritability (h^2 b.s) estimates in broad sense were observed for plant height (h^2=99.53%), tillers plant[-1] (h^2=92.71%), spike length (h^2=82.79%), number of spikelets spike[-1] (h^2=91.21%), number of grains spike[-1] (h^2=97.04%), grain yield plant[-1] (h^2=97.20%), seed index (h^2=97.80%), and harvest index (h^2=97.99%). The explanations of high estimates for these traits may be attributable to the fact that phenotypic variances ($\sigma^2 p$) for these traits were about equal to their genetic variances ($\sigma^2 g$). It means the traits were less influenced by the environmental factors and were also governed by the additive genes. Present findings are in accordance with the results of Udin *et al.* (1997) who obtained moderate while Awaad (1996) and Singh *et al.* (1999) observed high heritability estimates for plant height, tillers plant[-1] and seed index. Contrary to our findings, Aycicek and Yildirim (2006) recorded low heritability for seed index (0.0881) and grain weight spike[-1] (0.049). In some other studies, a low value for the heritability was

also obtained with regard to the plant height (h^2 = 0.040), whereas moderate and mostly high values were obtained for the plant height (Fida *et al*., 2001). The reason for the low heritability in the limited meaning for these traits may be the result of some variances constituting the environmental variance. Similarly, Baric *et al.* (2005) obtained high broad and narrow sense heritability estimates for 11 traits in 15 winter wheat cross combinations; while Pearson *et al.* (2007), Majumder *et al*. (2008) and Mangi *et al.* (2010) found 80 to 83.09% heritability estimates for plant height and seed index coupled with high genetic advance. The results of the correlation coefficients and heritability estimates obtained in the present study coincide with the findings reported by various previous researchers; however, the general contradiction may be associated with the environmental conditions, soil structure, irrigation water availability and more importantly the diversity of the varieties used in different studies.

CONCLUSION

The mean performance of varieties revealed that TD-1 produced maximum tillers plant^{-1}, formed more spikelets spike^{-1}, and gave higher grain yield plant^{-1}, seed index and harvest index; whereas Sarsabz measured longer spikes; gave more number of spiketets and grains spike^{-1}. All the yield traits like tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, harvest index and seed index were significantly and positively correlated with grain yield plant^{-1} which indicated that these yield components could be used as indirect selection criteria for improving grain yield plant^{-1}. The heritability estimates in broad sense were quite high for all the traits.

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