INTERRELATIONSHIP BETWEEN VARIOUS MORPHOYIELD TRAITS OF SOME EXOTIC STRAINS OF WHEAT, *TRITICUM AESTIVUM* L.

ABSTRACT

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Some exotic bread wheat lines were evaluated for genotypic variation and correlation coefficient among morphoyield characters in comparison with local check (Imdad-2005). The study was carried out at Dr. Muhammad Hafeez Halipoto Farm near Umerkot during the year 2012-2013. The exotic lines were assumed as No. 1, 2, 3, 4, 5, 6, 7, 8 and 9, where No. 10 was kept the local check (Imdad-2005). The correlation coefficient (r) between yield and yield contributing traits such as days to heading, days to maturity, plant height, tillers plant^{-1}, spike length, spikelets spike^{-1}, grains spike^{-1}, grain yield plant^{-1} and seed index. The results show that the growth and yield components including days to heading, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1} number of grains spike^{-1}, grain yield plant^{-1} and seed index differed significantly ($P<0.01$) among exotic wheat lines. The number of days to maturity and spike length did not differ significantly ($P>0.05$) among exotic wheat lines. The agronomic performance indicated that exotic lines Nos. 5, 6, 9 and 8 for days to heading were at par with check variety where exotic line 9 was at par with check for days to maturity. For plant height, tillers plant^{-1}and spike length none of the exotic lines either surpassed or were at par with the check variety. For spikelets spike^{-1}, exotic lines Nos.8, 6, 9, 3 and 7 surpassed check variety; for grains spike^{-1} exotic line Nos. 1, 9, 2 and 6 surpassed the check variety; while exotic line No.7 was at par with the check. In grain yield spike^{-1} exotic line No. 6 surpassed the check variety, and Nos. 8 and 2 were at par; while for grain yield plant^{-1}, none of the exotic lines either could surpass or at par with check variety; but in seed index, exotic line Nos. 6, 2, 4, 8 and 1 surpassed the check variety. The correlation coefficient for morphoyield characters of exotic wheat lines showed a positive and significant (r=0.5460**) correlation of plant height and spike length; plant height and grains spike^{-1} (r= 0.3524*); days to heading and tillers plant^{-1} (r= 0.5257**), tillers plant^{-1} and spikelets spike^{-1} (r= 0.3711*), tillers plant^{-1} and yield plant^{-1} (r=0.4137*), spike length and days to maturity (r=0.3648*), yield spike^{-1} with seed index (r=0.6778**) and between yield plant^{-1} and seed index (r=0.3448*).

Keywords: Interrelationship, morphoyield traits, exotic wheat strains

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INTRODUCTION

Among wheat bread species, *Triticum aestivum* L., is cultivated most widely as food crop world over ranks 1st in area and production in the *Gramineae* family. Wheat yields in Pakistan are 2787 kg ha^{-1} (2012-2013) as against 4762 kg ha^{-1} in China; world average is 3086 kg ha^{-1}, 3018 kg ha^{-1} in the USA and 2801 kg ha^{-1} in India (GoP, 2013). In Pakistan, the contribution of wheat to value addition in agriculture is 10.1, while it contributes to GDP is 2.2 percent. The area under wheat cultivation increased to 8693 thousand hectares in 2012-13 from 8650 thousand hectares showing an increase of 0.5 percent over preceding year area under wheat. The production of wheat stood at 24.2 million tons during 2012-13 against the target of 25.5 million tons showing 5.1 percent decrease while an increase of 3.2 percent over the last year production of 23.5 million tons. The yield per hectare in 2012-13 remained 2787 kg showing a positive growth of 2.7 percent as compared to negative 4.2 percent growth last year (GoP, 2013).

Wheat yields in Pakistan are not sustainable and increase in wheat production is mostly proportionate to increase in area under wheat. Wheat yield varies mostly due to change in its contributing characters because yield per unit area is the product of several contributing factors including traits related to growth attributes and number and weight of grains. However, wheat yield can be increased through development of productive genotypes which better adapt 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). Significant and positive phenotypic correlation of plant height with spike length and negative correlation of plant height with grain yield has been reported by Akhtar and Chowdhary (2006); while at both phenotypic and genotypic levels, number of spikelets spike^{-1} had significant positive correlation with grain yield (Aycecik and Yildirim, 2006). The correlation studies suggested that number of grains spike^{-1} is the major trait that has significant contribution to yield (Lad *et al.,* 2003).

Genotype selection in wheat for grain yield can only be effective if desired variability is present in the genetic stock. Many earlier researchers studied phenotypic correlation coefficients of various grain yield components with grain yield for its genotypic improvement (Shahid *et al*. 2002 and Aycecik and Yildirim, 2006). Akram *et al*. (2008) reported that grain yield was positively correlated with 1000-grain weight, Kashif and Khaliq (2004) also found that yield components like tillers plant^{-1} had significantly contributed towards grain yield development. They also notated that number of heads m^{-2}, grains spike^{-1} and 1000-grain weight was main contributors to grain yield in wheat. Aycecik and Yildirim (2006) also reported that grain yield plant^{-1} showed significantly positive association with number of productive tillers plant^{-1}, plant height, 1000-grain weight and spike length at genotypic and phenotypic levels. Negative correlations of plant height with grain yield and number of spikelets spike^{-1} with 1000-grain weight were also reported by Shahid *et al*. (2002). The number of spikelets spike^{-1} was negatively associated with 1000-grain weight. Lad *et al*. (2003) observed that grain yield exhibited highly significant and positive correlations with tillers plant^{-1} and spikelets spike^{-1} both at genotypic and phenotypic levels. Some other breeders such as Kashif and Khaliq (2004) reported that plant height, spike length, spikelets spike^{-1} and 1000-grain weight were positively and significantly correlated with grain yield at genotypic level.

The evaluation of exotic material (wheat lines) in comparison with the commercial check varieties is of great significance for further improvement in wheat yields. The performance of a genotype under the influence of yield components on yield is more important for wheat cultivation and improvement (Vaughan and Judd, 2003). Although there are positive correlation between grain yield and some of its components, but the existence of negative correlations has caused different efficiency of selection for some components that are not in the same direction of increasing the wheat yield. Increase in one component usually causes the decreasing of other components. Furthermore, although a number of morpho-physiological traits have proved associated with yield of wheat; their contribution to selection can be adversely affected by the fact that this association may be environment-specific (Moghadam *et al*. 1998). Khan (2009) found that grain yield was significantly and positively associated with number of spikelets plant^{-1}, followed by number of tillers and 100-seed weight at both phenotypic and genotypic levels. Generally correlation coefficients show relationships among independent variables and the degree of linear relations among the variables, they could not sufficiently describe the relationship when a clear cause-result relationship was found between the variables (Dokuyucu *et al*. 2002). Therefore, the correlations between yield and yield components should be known in breeding programs (Turk and Celik, 2006). For this aim, the correlation coefficient is used to determine the extent of relationship between morphoyield traits with the grain yield ha^{-1} (Kara and Akman, 2007). The research was therefore, conducted to examine interrelationship amongst morphoyield traits of exotic wheat strains.

MATERIALS AND METHODS

The ANOVA was used to determine the significance of difference in morphoyield traits of the following exotic wheat strains as suggested by Gomez and Gomez (1984) and correlation was calculated according to Dewey and Lu (1959).

1. CM85836-4Y-0M-8M-0Y-01ND
2. PRL/2*PSTOR(CGSS97Y000034M-099T0PB-027Y-099M-099M-27T-0B)
3. R0ELPS F2007(CGSS—B169T-099TOPY-099M-099Y-099M-9CEL-0B)
4. MUNAL#1(CGSS01B00S4T-099Y-099M-099M-099Y-099M-13Y-0B)
5. WHEAR//2*PRL/2*PAST0R(CGSS01B0090T-099Y-099Y-099M-6WGY-0B-3B)
6. WHEAR//2*PRL/2*PAST0R(CGSS03B0090T-099Y-099M-099Y-099M-6WGY-0B-6B)
7. MARCHOCH*4/KUKUNA//FRET2(CGSS01B00206T-099M-099M-099Y-099M-099Y 00ZTM-7WGY-0B)
8. WAXWING/6/PVN//CAR422/ANA/5/BOW/CROW/BWC/PVN//3/YR/4/TRAP#1 CGSSOSY0036S-0B-099Y-099M-099NJ-6WGY-0B
9. INQLAB91*2/TUKURU/WHEAT CGSSOSY00SY00463B-0B-099Y-099M- 099NJ-099NJ-3WGY-0B
10. CHECK VARIETY: Imdad-2005

The experimental material comprised of 9 exotic wheat genotypes/lines and a commercial variety (check). The trial consisted of four rows of 320 cm length and 210 cm width for each genotype per replication. The sowing was done by drilling, keeping 20 centimeters space between plants and 30 cm between rows. Ten plants were randomly selected and tagged from each replication. After collecting necessary data under field conditions, further observations were recorded at the laboratory. After four weeks of sowing thinning was done to maintain plant to plant space. Ten plants of each genotype from each replication selected at random were tagged to record the data in the field and laboratory. Statistical analysis will include analysis of variance and correlation for assessing morphoyield characters in exotic genotypes.

Data Analysis

The collected data were analyzed through New Student Statistics Software SXW Package. Simple correlation coefficients (r) were calculated after Snedecor and Cochran (1989) by using the following formula.

$$\text{Correlation Coefficient (r)} = \frac{\text{Covariance}}{\text{Geometric mean of covariance}}$$

$$= \frac{\sum xy}{\sqrt{\sum x)^2 (\sum y)^2}}$$

$$\sum xy = \frac{\sum XY - (\sum X)(\sum Y)}{N}$$

$$\sum x^2 = \sum X^2 - \frac{(\sum X)^2}{N}$$

$$\sum y^2 = \sum Y^2 - \frac{(\sum Y)^2}{N}$$

Where:

X = Independent variable
Y = Dependent variable
N = Number of observations recorded

RESULTS AND DISCUSSION

The results in relation to mean squares suggested that among genotypes, the growth and yield components including days to heading, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1} number of grains spike^{-1}, grain yield plant^{-1} and seed index were influenced significantly (P<0.01); while the number of days to maturity and spike length were not significantly (P>0.05) influenced. The non-significant (P>0.05) variation in days to maturity might be associated with environmental change which is specifically observed in the area of study at maturity stage of wheat.

Table 1. Mean squares from analysis of variances for days to heading, plant height, number of tillers plant^{-1}, spike length and spikelets spike^{-1}

Source of Variation	df	Days to Heading	Days to maturity	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)
Replications	2	7.2333	10.1333	5.2661	0.2963	0.0280
Genotypes	9	29.4407**	3.4407^{NS}	43.2342**	3.6625**	0.3955^{NS}
Error	18	1.1963	1.9852	2.4213	0.4452	0.3094

Table-2 Mean squares from analysis of variances for number of grains spike^{-1}, grain yield spike^{-1}, grain yield plant^{-1}, seed index and days to maturity

Source of Variation	df	Spikelets spike^{-1}	Grains spike^{-1}	Grain yield spike^{-1}	Grain yield Plant^{-1}	Seed index (g)
Replications	2	0.4710	2.522	0.0135	0.4683	3.8253
Genotypes	9	2.2603**	248.303**	0.1098**	3.7788**	25.0519**
Error	18	0.6476	14.498	0.0149	0.5665	1.8065

Agronomic performance of exotic wheat lines

The agronomic performance of exotic wheat lines as compared to local check (Imdad-2005) indicated that exotic lines Nos. 5, 6, 9 and 8 were at par with the check variety for days to heading, while in days to maturity exotic line 9 was at par with local commercial check. For plant height, tillers plant^{-1}, spike length none of the exotic wheat lines either surpassed or were at par with the local check Imdad-2005. For spikelets spike^{-1}, exotic lines Nos. 8, 6, 9, 3 and 7 surpassed the commercial variety Imdad-2005 (check) and for grains spike^{-1} exotic line Nos. 1, 9, 2 and 6 surpassed the check variety while exotic line No.7 was at par with the local check. Similarly, in grain yield spike^{-1} exotic line No. 6 surpassed the local check, while exotic line Nos. 8 and 2 were at par with check variety Imdad-2005. For grain yield plant^{-1}, none of the exotic lines either could surpass or at par with check variety Imdad-2005, while in seed index, exotic line Nos. 6, 2, 4, 8 and 1 surpassed the check variety.

Table 3. Mean values for agronomic performance of wheat genotypes for days to heading, plant height, number of tillers plant^{-1}, spike length and spikelets spike^{-1}

Line	Days to Heading	Days to maturity	Plant height (cm)	No. of Tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}	Grains spike^{-1}	Grain yield spike^{-1}	Grain yield Plant^{-1}	Seed index (g)
1	80.67 b	130.67	99.40 b	6.30 c	10.50	17.30 b	55.57 a	2.16 d	9.72 c	39.87 b
2	81.00 b	129.67	98.83 b	7.07 c	10.10	18.53 b	54.10 a	2.28 b	11.21 b	41.77 b
3	78.67 c	132.00	100.05 b	6.93 c	10.07	19.30 a	50.93 c	2.14 e	9.74 c	36.47 c
4	82.00 b	131.33	97.83 b	7.27 c	10.03	17.40 b	49.67 c	2.14 e	11.48 b	41.10 b
5	87.00 a	130.67	93.07 d	7.33 c	10.07	18.73 a	45.17 d	2.18 c	10.13 c	39.33 b
6	87.00 a	131.67	93.30 d	8.23 b	10.13	19.50 a	53.50 b	2.71 a	11.45 b	47.53 a
7	81.67 b	132.00	94.87 d	8.50 b	10.00 b	19.13 a	52.00 b	2.10 f	10.15 c	39.50 b
8	85.67 a	132.33	96.80 c	7.47 c	10.40	19.87 a	49.63 c	2.28 b	11.26 b	40.53 b
9	86.33 a	133.00	98.83 b	8.30 b	10.70	19.47 a	54.23 a	2.01 g	9.25 c	38.50 c
10	86.33 a	133.00	106.03 a	10.23 a	11.10	19.07 a	52.50 b	2.28 b	12.94 a	39.63 b
S.E.±	0.8930	1.1504	1.2705	0.5448	0.4542	0.6571	0.7328	0.0999	0.6146	1.0974
LSD 0.05	1.8762	-	2.6692	1.1446	-	1.3805	1.5395	0.2098	1.2911	2.3056

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

Correlation coefficient

The studies in regards to correlation coefficient among morphoyield traits of exotic wheat lines indicate a negative and non-significant (r= -0.2035^{NS}) correlation between plant height and days to heading, positive (r= 0.5257**) and significant (P<0.01) for days to heading and tillers plant^{-1}, positive (r=0.2778^{NS}) and non-significant (P>0.05) between days to heading and spike length, positive but non-significant (P>0.05) relationship (r= 0.3026^{NS}) between heading and spikelets spike^{-1} was observed. negative and non-significant correlation (r= -0.2419^{NS}) between days to heading and grains spike^{-1} was observed; positive and non-significant (r=0.2792^{NS}) for days to heading and yield spike^{-1}; positive but non-significant (P>0.05) relationship (r= 0.2355^{NS}) between days to heading and yield plant^{-1}, positive but non-significant (P>0.05) (r=0.3121^{NS}) between days to heading and seed index, positive but non significant (r=0.1605^{NS}) for days to heading and days to maturity.

Similarly, Positive (r=0.3111^{NS}), non-significant (P>0.05) between plant height and tillers plant^{-1}, positive and highly significant (r=0.5460**) for plant height and spike length, negative but non-significant (r= -0.0178^{NS}) between plant height and spikelets spike^{-1}, while plant height and grains spike^{-1} correlation was positive and significant (r= 0.3524*). Negative and non-significant (P>0.05) association (r= -0.1280^{NS}) between plant height and grain yield spike^{-1} was observed; positive and non-significant (r= 0.3320^{NS}) between plant height and spike length, negative and non-significant (r= -0.3245^{NS}) for plant height and seed index, positive and non-significant (r= 0.2507^{NS}) between plant height and days to maturity was observed.

The correlation study further indicated positive (r=0.3444^{NS}) but non-significant (P>0.05) for tillers plant^{-1} with spike length, positive and significant (P<0.05) between tillers plant^{-1} and spikelets spike^{-1} (r= 0.3711*), positive and non-significant association (r=0.0277^{NS}) between tillers plant^{-1} and grains spike^{-1}; positive but non-significant (r=0.0702^{NS}) between tillers plant^{-1} with yield spike^{-1}; positive (r=0.4137*) and significant (P<0.05) between tillers plant^{-1} and yield plant^{-1}, positive (r=0.1772^{NS}) but non-significant (P>0.05) between the tillers plant^{-1} and seed index; positive and non-significant (r= 0.3176^{NS}) between tillers plant^{-1} and days to maturity;

Results also indicates that positive but non-significant ($r= 0.1334^{NS}$) between spike length and number of spikelets spike^{-1}, positive but non-significant correlation ($r= 0.2901^{NS}$) between spike length and grains spike^{-1}; negative and non-significant ($P>0.05$) association ($r= -0.0065^{NS}$) between spike length and yield spike^{-1}; positive and non-significant ($r= 0.1916^{NS}$) between spike length with yield plant^{-1}; negative and non-significant ($r= -0.0854^{NS}$) between spike length and seed index and significant ($P<0.05$) and positive ($r=0.3648^{*}$) association between spike length and days to maturity was observed.

There was a negative and non-significant correlation ($r= -0.0905^{NS}$) between spikelets spike^{-1} and grains spike^{-1}; positive but non-significant ($P>0.05$) correlation ($r=0.2513^{NS}$) between spikelets spike^{-1} and yield spike^{-1}; positive but non-significant ($r=0.0189^{NS}$) between spikelets spike^{-1} and yield plant^{-1}; positive ($r=0.0675^{NS}$) and non-significant ($P>0.05$) between spikelets spike^{-1} seed index; positive and non-significant ($r=0.2901^{NS}$) between spikelets spike^{-1} and days to maturity;

The results further showed positive and non-significant ($r= 0.1224^{NS}$) correlation between grains spike^{-1} and yield spike^{-1}; negative and non-significant ($P>0.05$) correlation ($r= -0.0484^{NS}$) between grains spike^{-1} and yield plant^{-1}; positive but non-significant ($r=0.1818^{NS}$) between grains spike^{-1} and seed index; positive and non-significant ($r=0.0726^{NS}$) between grains spike^{-1} and days to maturity.

There was also positive ($r=0.4638^{**}$) but highly significant ($P<0.01$) association of yield spike^{-1} with yield plant^{-1}, positive and highly significant ($P<0.01$) correlation of yield spike^{-1} with seed index ($r=0.6778^{**}$); positive and non-significant correlation ($r=0.0521^{NS}$) between yield spike^{-1} and days to maturity was observed; while positive and highly significant ($r=0.3448^{**}$) between yield plant^{-1} with seed index; positive ($r=0.0036^{NS}$) and non-significant between yield plant^{-1} and days to maturity, negative ($r= -0.0542^{NS}$) and non-significant ($P>0.05$) between days to maturity and seed index was observed.

Table-4 Correlation (r) coefficients among various traits in wheat cultivars

Character	Days to heading	Plant height	Tillers plant^{-1}	Spike length	Spikelets spike^{-1}	Grains spike^{-1}	Yield spike^{-1}	Yield plant^{-1}	Seed Index	Days to maturity
Plant height	-0.2035^{NS}									
Tillers plant^{-1}	0.5257**	0.3111^{NS}								
Spike length	0.2778^{NS}	0.5460**	0.3444^{NS}							
Spikelets spike^{-1}	0.3026^{NS}	0.0178^{NS}	0.3711*	0.1334^{NS}						
Grains spike^{-1}	-0.2419^{NS}	0.3524*	0.0277^{NS}	0.2901^{NS}	-0.0905^{NS}					
Yield spike^{-1}	0.2792^{NS}	-0.1280^{NS}	0.0702^{NS}	-0.0065^{NS}	0.2513^{NS}	0.1224^{NS}				
Yield plant^{-1}	0.2355^{NS}	0.3320^{NS}	0.4137*	0.1916^{NS}	0.0189^{NS}	-0.0484^{NS}	0.4638**			
Seed Index	0.3121^{NS}	-0.3245^{NS}	0.1772^{NS}	-0.0854^{NS}	0.0675^{NS}	0.1818^{NS}	0.6778**	0.3448*		
Days to maturity	0.1605^{NS}	0.2507^{NS}	0.3176^{NS}	0.3648*	0.2901^{NS}	0.0726^{NS}	0.0521^{NS}	0.0036^{NS}	-0.0542^{NS}	-

DISCUSSION

The findings of the research show that the growth and yield components including days to heading, plant height, number of tillers plant^{-1}, number of spikelets spike^{-1} number of grains spike^{-1}, grain yield plant^{-1} and seed index differed significantly ($P<0.01$) among exotic wheat lines. The number of days to maturity and spike length did not differ significantly ($P>0.05$) among exotic wheat lines. The agronomic performance indicated that exotic lines Nos. 5, 6, 9 and 8 were at par with check variety for days to heading, exotic line 9 was at par with check for days to maturity, and for plant height, tillers plant^{-1}, spike length none of the exotic lines either surpassed or were at par with the check variety. For spikelets spike^{-1}, exotic lines Nos. 8, 6, 9, 3 and 7 surpassed check variety; for grains spike^{-1} exotic line Nos. 1, 9, 2 and 6 surpassed the check variety; while exotic line No.7 was at par with the check. In grain yield spike^{-1} exotic line No. 6 surpassed the check variety, and Nos. 8 and 2 were at par; while for grain yield plant^{-1}, none of the exotic lines either could surpass or at par with check variety; but in seed index, exotic line Nos. 6, 2, 4, 8 and 1 surpassed the check variety. The correlation coefficient for morphoyield characters of exotic wheat lines showed a positive and significant (r=0.5460**) correlation of plant height and spike length; plant height and grains spike^{-1} (r= 0.3524*); days to heading and tillers plant^{-1} (r= 0.5257**), tillers plant^{-1} and spikelets spike^{-1} (r= 0.3711*), tillers plant^{-1} and yield plant^{-1} (r=0.4137*), spike length and days to maturity (r=0.3648*), yield spike^{-1} with seed index (r=0.6778**) and between yield plant^{-1} and seed index (r=0.3448*). These results are in agreement with those of Gupta *et al*. (2002) who calculated the genotypic and phenotypic correlations in 24 bread wheat cultivars and 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) determined inter-relationship and path coefficient in wheat components and 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. The traits having positive direct effects on grain yield were suggested to be considered suitable selection criteria for evolving high yielding genotypes. Safeer-ul-Hassan *et al*. (2005) found that the genotypes were highly significant for all the traits; and correlation coefficients indicated that number of spikelets per spike and plant height were significantly positive correlated with grain yield, while a non significant correlation was observed between grain yield and number of grains per plant, grain weight per spike, 1000-grain weight and spike length. Mehmet and Yildirim (2006) reported positive and significant correlation was found between yield and plant density, plant height, grain number per spike, grain weight per spike and 1000 kernels weight. Grain yield was negatively and significantly correlated with time to heading. Positive direct effect of plant height and grain weight spike^{-1} and negative direct effect of time to heading associated with significant correlation with grain yield suggested that these yield components may be good selection criteria to improve yield of wheat genotypes. Kashif *et al.* (2007) reported that genotypically plant height, spike length, spikelets per spike, grains per spike and 1000-grain weight were positively and significantly correlated 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. Plant height, flag leaf area, spike length and grains per spike had positive direct effects on 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. However, number of tillers per m^2 and spike length contributed negatively towards grain yield at both correlation levels. Plant height was positively correlated with grain yield at genotypic level, whereas negatively correlated at phenotypic level. It was, therefore, suggested that number of spikelets per spike, number of grains per spike and 1000 grain weight should be given emphasis for future wheat yield improvement programs. 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. The comparative analysis of the results achieved in the present study and achievements to this effect reported by various breeders from different parts of the world clearly suggested a positive outcome and their results are fully in accordance with the findings of the present research. Further studies are suggested to confirm the present results.

Conclusions

- In grain yield spike^{-1} exotic line No. 6 surpassed the check variety, and Nos. 8 and 2 were at par; while for grain yield plant^{-1}, none of the exotic lines either could surpass or at par with check variety; but in seed index, exotic line Nos. 6, 2, 4, 8 and 1 surpassed the check variety.
- Positive and highly significant (r=0.5460**) correlation of plant height and spike length and positive and significant (r= 0.3524*) between plant height and grains spike^{-1} was observed.

- Positive (r= 0.5257**) and highly significant (P<0.01) association for days to heading and tillers plant^{-1}, while positive and significant (P<0.05) association between tillers plant^{-1} and spikelets spike^{-1} (r= 0.3711*) was observed.

- Positive (r=0.4137*) and significant (P<0.05) association of tillers plant^{-1} and yield plant^{-1} and also positive and significant (r=0.3648*) correlation between spike length and days to maturity was also observed.

- Positive and highly significant (P<0.01) correlation of yield spike^{-1} with seed index (r=0.6778**) and a positive and significant association between yield plant^{-1} with seed index (r=0.3448**) was observed.

LITERATURE CITED

Akhtar, N. and M. A. Chowdhary. 2006. Estimation of genetic and phenotypic correlation coefficients among grain yield and its components in bread wheat. Int. J. Agric. & Biol., 8(4): 516–522.

Akram Z., S. Ajmal and M. Munir. 2008. Estimation of correlation coefficient among some yield parameters of wheat under rainfed conditions Pakistan J. Bot. 40 (4): 1777-1781.

Ali, M. A., N. N. Nawab, G. Rasool and M. Saleem. 2008. Estimates of variability and correlations for quantitative traits in *Cicer arietinum* L. J. Agric. Social Sci. 4(4): 177-179.

Ali, Y., B. M. Atta, J. Akhter, P. Monneveux and Z. Lateef. 2009. Genetic variability, association and diversity studies in wheat germplasm (*Triticum aestivum* L.). Pak. J. Bot., 40(5): 2087-2097.

Anwar, J., M. A. Ali, M. Hussain, W. Sabir, M. A. Khan, M. Zulkiffal and M. Abdullah. 2008. Assessment of yield criteria in bread wheat through correlation and path analysis.

Aycecik, M. and T. Yildirim. 2006. Path coefficient analysis of yield and yield components in bread wheat (*Triticum aestivum* L.) genotypes. Pak. J. Bot., 38(2): 417-424.

Dewey, D. R. and K. H. Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. 51:515-518.

Dokuyucu, T., A. Akkaya and M. Akcura. 2002. Path analysis of yield and some yield related traits of Durum wheat genotypes grown in rain fed conditions of Mediterranean Region. Turk. J. Field Crops, 7 (1) : 31-39.

GoP, 2013. Wheat: Economic Survey of Pakistan, 2012-13. Ministry of Food, Agriculture and Livestock, Agriculture & Livestock Division (Economic Wing), Government of Pakistan, Islamabad.

Gupta, R. S., P.P. Singh and D.K. Tiwari, 2004. Analysis of heritability and genetic advance in bread wheat (*Triticum aestivum* L.). Advances in Plant Sciences. 17 (1): 303-305.

Kara, B. and Z. Akman. 2007. Correlation and path coefficient analysis in the local wheat ecotypes. Süleyman Demirel Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 11 (3): 219-224.

Kashif, K., H. Ihsan and M. Khaliq. 2007. Heritability, correlation and path coefficient analysis for some metric traits in wheat. International journal of agriculture & biology, 56 (3): 138-142.

Kashif, M. and I. Khaliq. 2004. Heritability, correlation and path coefficient analysis for some metric traits in wheat. Inter. J. Agri. and Biol. 6(1): 138-142.

Khan, M. H. and A. N. Dar. 2009. Correlation and path coefficient analysis of some quantitative traits in wheat. African Crop Science Journal, 18(1): 9-14.

Lad, D. B., N. D. Bangar, T. J. Bhor, G. D. Mukherkar and A. B. Biradar. 2003. Correlation and path coefficient analysis in wheat. J. Maharashtra Agric. Univ., 28(1): 23-25.

Mehmet, A. and T. Yildirim. 2006. Path coefficient analysis of yield and yield components in bread wheat (*Triticum aestivum* L.) genotypes. Pak. J. Bot., 38(2): 417-424.

Moghaddam, M., B. Ehdaie and J.G. Waines. 1998. Genetic variation for and interrelationships among agronomic traits in landraces of bread wheat from southwestern Iran. Journal of Genetics and Breeding, 52(1): 73-81.

Safeer-ul-Hassan, M., M. Munir, M. Y. Mujahid, N. S. Kisana, Zahid Akram , and A.W. Nazeer. 2004. Genetic analysis of some biometric characters in bread wheat (*Triticum aestivum* L.). J. Biol. Sci. 4(4): 480-485.

Shahid, M., M. Fida and M. Tahir. 2002. Path coefficient analysis in wheat. Sarhad J. Agri. 18:383-388.

Snedecor, G. W. and W. G. Cochran.1989. Statistical methods. 8th Ed. Anes: Iowa state press.

Turk, M. and N. Celik. 2006. Correlation and path coefficient analyses of seed yield components in the Sainfoin (*Onobrychis sativa* L.). J. Biol. Sci. 6(4): 758-762.

Vaughan, J. G. and P. A. Judd. 2003. The Oxford Book of Health Foods. Oxford University Press. Pp. 35.