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Review Article

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CORRELATION AND REGRESSION ANALYSIS FOR YIELD & RELATED ATTRIBUTES IN F_2 POPULATION OF BREAD WHEAT (*Triticum aestivum* L.) GENOTYPES

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ABSTRACT

This research was carried out to study correlation & regression analysis in bread wheat at Southern Wheat and Barley Research Institute, Tandojam in RCBD with three replications. The results showed that most of the traits were significantly different at (P≤0.01) among the genotypes. Correlation analysis showed that spikelets per spike had a positive and highly significant association with biological yield per plan ($r = 0.82^{**}$). Among the F_2 crosses, days to 75% heading was significantly and positively associated with the grain yield ($r = 0.80^{**}$). The trait tillers per plant had a positive association of significance with grain yield per plant ($r = 0.86^{**}$) and biological yield per plant (g) ($r = 0.84^{**}$). Regression analysis showed that the contribution rate of plant height to the change of grain yield was 0.47%; although the contribution to the variation of grain yield per plant was 08.21%. Spike length and spikelets per spike contributed 51.99% and 57.02% to the variation of grain yield per spike. The same character, grain yield was also contributed by grains per spike and seed index with the change of 58.99% and 78.36%. Above mentioned studies have shown that seed index, tillers per plant and spike length can be used to increase the grain yield of wheat genotypes to develop wheat varieties.

Keywords: Correlation, Regression, Wheat, Yield performance

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a second most essential and initial adapted cereal crop after rice in the world and it is also the world's most important source of food and feed. The demand of food is increasing day by day due to growing world population and living standard of humans. Increasing wheat output is necessary to maintain food security worldwide (Maulana *et al*., 2018; Garcia *et al*., 2019). Almost 30% of cereal agricultural land is used for the widespread cultivation of wheat, which supplies 25% of the world's total energy needs (Khan *et al*., 2015). Approximately one-sixth of all cultivated land worldwide is used for wheat production. (Fang *et al*., 2017).

Pakistan's output in 2019-2021 was 24.946 million tons, increased of 2.5% by last year. The The past year's production was 24.349 million tons, whereas the yield was 8.825 hectares, showing a 1.7 percent increase over the previous year's yield. Wheat's value addition in agriculture accounts for 8.7 percent and 1.7 percent of the GDP. Due to the development of healthy grain and better crop yields, wheat production is increasing in cultivated area (GoP, 2019-20).

The correlation coefficient is a statistical method which provides information about relationship of plant characteristics, and it leads to a target yield model. This technique can provide some knowledge to the breeders in selection for greater yield. Correlation analysis also shows the relationship between specific trait with its equal parts and provides an outstanding index for predicting related changes that present in one trait due to proportional changes in

another trait (Ahmad *et al*., 2008).

Due to the complex relationship between grain yield and grain factors, direct selection of crop yield in breeding programs is misleading. (Ali *et al*., 2008). Breeders often use the value of the correlation coefficient among quantitative characters in their breeding work. In breeding, plants are taken from a hybridized population and used as an indirect test for the correlation coefficient between traits. Through detailed analysis of the internal correlation coefficient and the qualitative correlation, which are determined according to the main characteristics of economic value, breeders can evaluate closely related factors (Okon *et al*., 2015).

The relationship between two variables is called simple correlation, which can be calculated from unreplicated and replicated data. Phenotypic correlation is a significant relationship between two variables. This includes genotypic and environmental impact.

Regression analysis identifies the connection between seed yield and other agronomic attributes. This correlation and regression study provides a knowledge on the corresponding characteristics of plants with the maximum variations in seed yield. Until now, different researchers have used different multiple regression models to estimate the assessment selection criteria. Their results were different depending on the environmental conditions and the population in which the selection was made (Josm, 2015).

Therefore, this study was performed to provide a correlation and regression analysis between some yield related attributes in F_2 wheat hybrids and their associated parents.

MATERIALS AND METHODS

Currant study was performed to observe a correlation and regression analysis for ten yield and yield related traits in wheat genotypes such as Days to heading 75%, Days to maturity 75%, Plant height (cm), Tillers plant^{-1}, Spike length (cm), Spikelets spike^{-1}, Number of grains spike^{-1}, Seed index (g), Grain yield plant^{-1} (g), Biological yield plant^{-1} (g) and Harvest index (%). The research was conducted on five parents (TD-1, SKD-1, Benazir-2013, Imdad-2005 and V-11005) along with ten cross combinations (TD-1 x SKD-1, TD-1 x Benazir-2013, TD-1 x Imdad-2005, TD-1 x V-11005, SKD-1 x Benazir-2013, SKD-1 x Imdad-2005, SKD-1 x V-11005, Benazir-2013 x Imdad-2005, Benazir-2013 x V-11005 and Imdad-2005 x V-11005) at Barley and Wheat Research Institute, Agriculture Research Centre Tandojam in the season of Rabi during 2018-

Experimental design: Three repetitions of the experimental materials were employed in a RCBD. For each genotype, there were four rows that were two meters long in the trial. We used the dibbling method to sow the seeds. Plants were spaced 20 and 30 cm apart in rows.

Statistical analysis: Analysis of variance was applied to the data according to the method suggested by (Gomez & Gomez, 1984) and the means were compared using Duncan's multiple range test as suggested by (Duncan, 1955). Correlation and regression analysis between different characters was calculated according to (Raghavrao, 1983).

The simple correlation coefficients (r) were calculated using the following formula given by (Snedecor & Cochran, 1980).

Formula for Correlation Coefficient

$$\mathbf{r} = \frac{\text{Covariance}}{\text{Geometric mean of variance}}$$

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

Where

$$\sum xy = \sum xy - \frac{(\sum x)(\sum y)}{N}$$

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

$$\sum x^2 \quad \sum x^2$$

Where

X = Independent variable

Y = Dependent variable

N = Number of observations

$\sum x^2$= Variance or deviation of independent variable

$\sum y^2$= Variance or deviation of dependent variable

$\sum$ = Summation

Results

Analysis of variance: The analysis of variance was calculated out for some yield and its related traits. The mean squares results showed that most of the traits were significantly different at ($P \leq 0.01$) for the genotypes, but some of them expressed nonsignificant difference for spike length and harvest index. For F_2 crosses, the mean squares results exhibited that the parameters were strongly significant different at ($P \leq 0.01$) among the genotypes, but some crosses also indicated the nonsignificant differences among the genotypes.

The present results were in resemblance with such as Kumar *et al.* (2018). Significant results were also determined by Roy *et al.* (2016) and Solanki *et al.* (2017).

Table 1a. Mean squares of different traits of parents and F_2 crosses of bread wheat

Source of variances	D.F.	Days to heading 75%	Days to maturity 75%	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Spikelet's spike^{-1}
Parents							
Replications	2	6.06	0.46	3.65	0.16	2.73	0.99
Parents	4	160.83**	41.40**	545.05**	2.11*	9.81^{NS}	10.08**
Error	8	0.73	0.30	4.42	0.33	3.71	0.27
F_2 Crosses							
Replications	2	1.29	1.54	6.42	0.04	0.20	0.20
F_2 crosses	7	380.76**	83.02**	176.88**	29.91**	3.45**	19.80**
Error	14	1.81	1.39	16.92	0.12	0.39	0.48

* = significant at 0.05% probability level.
** = highly significant at 0.01% probability level.
NS = non-significant at 0.05% probability level.

Table 1b. Mean squares of different traits of parents and F_2 crosses of bread wheat

Source of variances	D.F.	Number of grains spike^{-1}	Seed index (1000 grain weight g)	Grain yield plant^{-1} (g)	Biological yield plant^{-1} (g)	Harvest index (%)
Parents						
Replications	2	2.56	0.15	1.93	54.19	36.18
Parents	4	491.07**	41.01**	27.16**	174.05**	49.68^{NS}
Error	8	13.27	3.26	1.99	19.21	41.79
F_2 Crosses						
Replications	2	390.82	1.97	0.46	0.79	13.55
F_2 crosses	7	524.43^{NS}	96.32**	66.42**	230.31**	165.44**
Error	14	460.45	4.75	1.14	1.44	8.60

* = significant at 0.05% probability level.
** = highly significant at 0.01% probability level.
NS = non-significant at 0.05% probability level.

Mean performance

Mean performance of crosses and their parents are shown in Table-2a-b. Results of parents revealed that maximum 75% days to heading were taken by the genotype V-11005 (77.66) and the minimum 75% days to heading were counted by the genotype SKD-1 (58.00). According to F_2 hybrids, maximum 75% heading was recorded in the cross SKD-1 × Benazir (98.66) and minimum 75% days to heading was shown by the cross TD-1 x SKD-1 (72.33). The maximum 75% days to maturity was taken by the parent Imdad-2005 (118.67) and the parent TD-1 (108.33) took the minimum 75% days to maturity. In the F_2 hybrid, the SKD-1 x V-11005 (134.67) achieved 75% of the maximum days to maturity, and the TD-1 x SKD-1 (117.67) cross achieved the 75% of the minimum maturity. The maximum and the minimum plant height was obtained by the parents Imdad-2005 (97.93) and TD-1 (61.53). According to F2 hybrids, cross SKD-1 x 11005 obtained maximum plant height (93.93 cm), while the minimum plant height was recorded by the cross TD-1 x V-11005. The most tillers per plant were recorded by the parent SKD-1 (9.26), where the least tillers per plant were counted by the parent TD-1 (7.20). According to F_2 hybrids, the maximum tillers per plant were obtained by the cross SKD-1 x Benazir-2013 (16.33) and the minimum tillers per plant were recorded by the cross Imdad x V-11005 (5.86). In case of spike length, the maximum length of spikes was observed in the parent V-11005 (13.46), while the minimum length of spike was obtained by the parent TD-1 (9.00 cm). Among the F_2 crosses, maximum length of spike was recorded by the cross of Imdad-2005 x V-11005 (12.20 cm) and the minimum length of spike were recorded by the cross SKD-1 x V-11005 (8.70). According to spikelets per spike, the maximum spikelets per spike were obtained by the parent V-11005 (19.13), while the minimum spikelets per spike were obtained by the parent TD-1 (14.20). Among the F_2 crosses, maximum spikelets per spike were recorded by the crosses of Imdad-2005 x V-11005 (20.33) and the minimum spikelets per spike were recorded by the crosses of SKD-1 x V-11005 (11.93). The most grain per spike were gotten by the parent V-11005 (67.20), while the least grain per spike were gotten by the parent TD-1

(35.00). Among the F_2 crosses, most grain per spike were recorded by the crosses of TD-1 x V-11005 (88.60) and the least grain per spike were recorded by the crosses of TD-1 x SKD-1 (50.73). The maximum thousand-grain weight was gained by the parent Benazir (50.82 g), while the least seed index was gotten by the parent V-11005 (41.54). Among the F_2 crosses, maximum thousand-grain weight (seed index) was noted in the cross of TD-1 x Benazir-2013 (45.21) and the minimum thousand-grain weight (seed index) was documented by the cross of TD-1 x SKD-1 (32.60). According to the parameter grain yield per plant, the maximum value of this trait was noticed in the parent SKD-1 (15.86) and the minimum value of this trait was recorded in the parent TD-1 (8.27). Among the crosses, maximum value of grain yield per plant, was achieved by SKD-1 x Benazir-2013 (23.30) and the minimum value of this trait exhibited by the cross of TD-1 x Benazir-2013 (8.89). The maximum biological yield per plant was noted in the parent Imdad-2005 (38.49 kg), whereas the least biological yield per plant was noted in the parent TD-1 (20.05 kg). Among the F_2 crosses, maximum biological yield per plant was documented by the cross of SKD-1 x Benazir-2013 (54.13) and the minimum biological yield per plant was recorded by the cross of TD-1 x Benazir-2013 (25.94). Parent SKD-1 obtained the maximum harvest index (49.02 %) while the least value of this trait obtained by the parent Imdad-2005 (39.24 %). Such results were also contributed by Singh and Supriya *et al*. (2019). Tiwari *et al*. (2017) also supported our final findings

Table 2a. Mean performance of parents and F_2 crosses of bread wheat for various traits

Traits	Days to heading 75%	Days to maturity 75%	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}
Parents						
TD-1	63.66 b	108.33 d	61.53 d	7.20 b	9.00 b	14.20 d
SKD-1	58.00 c	113.33 c	84.80 c	9.26 a	9.13 b	16.60 c
Benazir-2013	64.00 b	114.6s7 b	89.13 b	7.40 b	10.46 ab	17.13 bc
Imdad-2005	63.33 b	118.67 a	97.93 a	7.46 b	10.06 ab	17.93 b
V-11005	77.66 a	114.67 b	85.13 c	8.06 b	13.46 a	19.13 a
F_2 crosses						
TD-1 x SKD-1	72.33 d	117.67 d	73.13 c	8.06 c	9.23 cd	18.73 b
TD-1 x Benazir	78.66 bc	128.33 c	82.20 b	7.26 d	10.30 bc	18.33 b
TD-1 x Imdad	79.66 b	128.00 c	72.60 c	7.06 d	10.96 b	18.33 b
TD-1 x V-11005	79.00 bc	128.00 c	71.00 c	8.13 c	10.86 b	18.06 b
SKD-1 x Benazir	98.66 a	132.00 b	76.60 bc	16.13 a	10.40 b	19.26 ab
SKD-1 x Imdad	98.66 a	133.67 ab	74.93 c	9.33 b	10.63 b	19.26 ab
SKD-1 x V-11005	98.66 a	134.67 a	93.93 a	9.80 b	8.70 d	11.93 c
Imdad x V-11005	77.00 c	129.00 c	83.46 b	5.86 e	12.20 a	20.33 a

Table 2b. Mean performance of parents and F_2 crosses of bread wheat for various traits

Traits	Number of grains spike^{-1}	Seed index (1000 grain weight g)	Grain yield plant^{-1} (g)	Biological yield plant^{-1} (g)	Harvest index (%)
Parents					
TD-1	35.00 d	43.75 b	8.27 c	20.05 c	41.37 a
SKD-1	45.06 c	44.93 b	15.86 a	33.23 ab	49.02 a
Benazir-2013	45.80 c	50.82 a	12.26 b	27.35 bc	45.12 a
Imdad-2005	59.66 b	48.33 a	14.43 ab	38.49 a	39.24 a
V-11005	67.20 a	41.54 b	14.78 ab	37.16 a	40.05 a
F_2 Crosses					
TD-1 x SKD-1	50.73 b	32.60 d	10.24 fg	39.35 b	27.24 e
TD-1 x Benazir	63.73 ab	45.21 a	8.89 g	25.94 d	33.98 d
TD-1 x Imdad	63.26 ab	47.25 a	11.09 ef	26.55 d	42.19 b
TD-1 x V-11005	88.60 a	36.42 c	13.98 cd	34.10 c	41.08 bc
SKD-1 x Benazir	57.00 ab	33.33 cd	23.30 a	54.13 a	42.49 b
SKD-1 x Imdad	61.60 ab	35.53 cd	15.16 c	34.40 c	40.20 bc
SKD-1 x V-11005	45.66 b	40.67 b	18.08 b	35.00 c	52.76 a
Imdad x V-11005	51.13 ab	33.47 cd	12.58 de	34.71 c	36.31 cd

Correlation coefficient

Days to 75% heading: s According to correlation study, this trait had positive and significant association with spike length ($r = 0.67^{**}$), spikelets per spike ($r = 0.54^{*}$) and grain per spike ($r = 0.67^{**}$). Whereas positive and non-significant relationship of this parameter had recorded with ($r = 0.09^{NS}$), plant height ($r = 0.02^{NS}$), grain yield per plant ($r = 0.06^{NS}$) and biological yield per plant ($r = 0.21^{NS}$). However, it had a negative and non-significant linkage with tillers per plant, seed index and harvest index with the ratio of r= ($r = -0.21^{NS}$, -0.46^{NS} and -0.27^{NS}). For F_2 hybrids, this trait was significantly and positively correlated with days to 75% maturity ($r = 0.80^{**}$), tillers per plant ($r = 0.70^{**}$), grain yield per plant ($r = 0.80^{**}$), biological yield per plant ($r = 0.43^{*}$) and harvest index ($r = 0.69^{**}$). Whereas relationship of positive and non-significant was recorded with plant height ($r = 0.32^{NS}$) and spikelets per spike ($r = 0.38^{NS}$). However negatively non-significant linkage was recorded with spike length, grain per spike and seed index with the value of r ($r = -0.27^{NS}$, -0.11^{NS} and -0.08^{NS}).

Days to 75% maturity: According to correlation study, this trait was significantly and positively correlated with plant height ($r = 0.96^{**}$), spikelets per spike ($r = 0.77^{**}$), grain per spike ($r = 0.72^{**}$), grain yield per plant ($r = 0.68^{**}$) and biological yield per plant ($r = 0.76^{**}$). Whereas positive and non-significant relationship was recorded with tillers per plant ($r = 0.08^{NS}$), spike length ($r = 0.21^{NS}$) and seed index ($r = 0.42^{NS}$). However negative and non-significant linkage was recorded with harvest index ($r = -0.14^{NS}$). In F_2 hybrids, this trait was related to plant height (r = 0.40*), grain yield per plant (g) (r = 0.58**) and harvest index (r = 0,76**) with the association of positive**.** Whereas relationship of positive and non-significant was recorded with tillers per plant ($r = 0.35^{NS}$), spike length ($r = 0.08^{NS}$), seed index ($r = 0.15^{NS}$) and biological yield per plant (g) ($r = 0.06^{NS}$). However negatively non-significant linkage was recorded with spikelets per spike and grain per spike ($r = -0.35^{NS}$ and -0.01^{NS}).

Plant height (cm): According to correlation study, this trait had an association of positive and significant with spikelets per spike ($r= 0.74^{**}$), grain per spike ($r= 0.63^{*}$), grain yield (g) ($r= 0.72^{**}$) and biological yield per plant (g) ($r = 0.71^{**}$). However, it was observed that the tillers ($r = 0.17^{NS}$), spike length (cm) ($r = 0.20^{NS}$) and seed index ($r = 0.42^{NS}$) were positively correlated and nonsignificant. However, the harvest index (%) has a negative correlation with this character. In F_2 hybrids, this trait has a significant positive correlation with harvest index (%) (r =0.44*). Whereas relationship of positive and non-significant was recorded with seed index ($r = 0.19^{NS}$) and grain yield per plant (g) ($r = 0.19^{NS}$). However negatively non-significant linkage was recorded with tillers plant ($r = -0.01^{NS}$), spike length (cm) ($r = -0.31^{NS}$), grains per spike ($r = -0.22^{NS}$) biological yield per plant (g) ($r = -0.07^{NS}$) and spikelets per spike ($r = -0.57^{**}$) was negatively significant.

Tillers plant^{-1}: ccording to correlation study, this character was significantly positively correlated with the grain yield per plant (r = 0.62*), while it is positively correlated and non-significant with spikelets per spike ($r = 0.20^{NS}$) grains per spike ($r = 0.05^{NS}$), biological yield (g) ($r = 0.36^{NS}$) and harvest index (%) ($r = 0.26^{NS}$). It is observed that there is a negative correlation with spike length (cm) ($r = -0.07^{NS}$) and seed index (-0.20^{NS}) and it was non-significant. In the case of F_2 hybrids, this character was under the relationship of positive and significant with the grain yield per plant (r = 0.86**) and the biological yield per plant (g) (r = 0.84 **). Whereas harvest index ($r = 0.33^{NS}$) was in relationship of positive and non-significant. However negatively non-significant linkage was recorded with the characters spike length (cm), spikelets per spike, grains per spike and seed index with the value of $r = -0.26^{NS}$, -0.08^{NS}, -0.09^{NS} and -0.32^{NS}.

Spike length (cm): s According to correlation study, this trait had an association of significant and positive with grains per spike ($r = 0.57^{*}$). Although it is positively correlated with spikelets per spike ($r = 0.38^{NS}$), grain yield per plant (g) ($r = 0.12^{NS}$), and biological yield per plant (g) ($r = 0.18^{NS}$) though the association was non-significant. However non-significant and negative association was recorded with seed index and harvest index (%) with the value of r= ($r = -0.22^{NS}$ and -0.13^{NS}). For F_2 hybrids, this attribute was considerably and completely related to with spikelets per spike (r = 0.66**). However negatively non-significant linkage was recorded with grain per spike ($r= -0.13^{NS}$), seed index ($r= -0.05^{NS}$), grain yield (g), ($= -0.16^{NS}$), biological yield ($r= -0.12^{NS}$) and harvest index (%) ($r= -0.19^{NS}$).

Spikelets spike^{-1}: According to correlation study, above-mentioned trait had a relationship of positive and significant with grains per spike ($r = 0.89^{**}$), grain yield ($r = 0.74^{**}$) and biological yield ($r = 0.82^{**}$). Whereas linkage of positive and non-significant relationship was observed with seed index ($r = 0.02^{NS}$). However, it is found that there is a negative correlation and non-significant with the harvest index (%) ($r = -0.21^{NS}$). For F_2 hybrids, the ratio of positive and non-significant of this trait is recorded by grains per spike ($r = 0.13^{NS}$) and biological yield per plant (g) ($r = 0.12^{NS}$). However negatively non-significant linkage was recorded with seed index ($r = -0.28^{NS}$), grain yield per plant (g) ($r = -0.22^{NS}$), while harvest index ($r = -0.64^{**}$) was negatively significant with this trait.

Number of grains spike^{-1}: According to correlation study, this trait was correlated with the attributes of grain yield (r = 0.62*) and biological yield per plant (r = 0.79**). Whereas seed index (r= -0.13^{NS}) and harvest index (%) (r = -0.32^{NS}) negative and non-significant. In F2 hybrids, this trait has non-significant positive correlation with seed index (r = 0.11^{NS}) and harvest index (%) (r = 0.00^{NS}). However negatively non-significant linkage was recorded with grains yield per plant (g) (r = -0.07^{NS}) and biological yield per plant (g) (r = -0.14^{NS}).

Seed index (g): According to correlation study, grain yield (r = 0.01^{NS}), biological yield per plant (r = 0.00^{NS}) and harvest index (%) (r = 0.10^{NS}) were positive and non-significant. For F_2 hybrids, harvest index (%) (r = 0.28^{NS}) was positive and non-significant. However negatively non-significant linkage was recorded with grain yield per plant (r= -0.33^{NS}), while it was negatively significant correlated with biological yield per plant (r = -0.69**).

Grain yield plant^{-1} (g): According to correlation study, biological yield per plant (r = 0.79**), was strongly positive whereas non-significant positive relationship with harvest index (%) (r= 0.17^{NS}) was observed. For F_2 hybrids, biological yield per plant (r= 0.77**) and harvest index (%) (r= 0.59**) had a linkage of strongly significant and positive with this character.

Biological yield plant^{-1} (g): According to correlation study, harvest index (%) (r = -0.43^{NS}) had under the relationship of non-significant and negative. For F_2 hybrids, harvest index (%) (r = 0.03^{NS}) was under the linkage of positive and non-significant. These results are closed to the study of Kumar *et al*. (2016) who also reported positive results with tillers per plant and grain yield per plant (g). Bhutto *et al*. (2016) likewise uncovered the outcomes that spikelets per spike, tillers per plant and grains per spike were completely and emphatically connected with height of plant. Mecha *et al*. (2017) announced that the grain yield is positively correlated with length of spike, spikelets per spike, grains per spike and seed index. Kumar *et al*. (2014) showed their outcomes that the majority of the parameters such as grains per spike, harvest index and grains per spike were emphatically and fundamentally related with grain yield per plant. Other research Khan & Hassan, (2017) studied on grain yield and its related traits, which exhibited that results that most of the traits were positive and significant with grain yield per plant like spike length, 1000-grain weight, and grains per spike. Abd El-Mohsen *et al*. (2012) uncovered that most characters were decidedly corresponded with grain yield per plant such as tillers per plant, spikelets per spike, length of spike, grains per spike and thousand (1000) grain weight, although contrarily associated qualities were days to half heading and plant tallness

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Table 3. Correlation coefficient (r) between various traits of parents

Traits	Days to 75% heading	Days to 75% maturity	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}	Number of grains spike^{-1}	Seed index (g)	Grain yield plant^{-1} (g)	Biological yield plant^{-1} (g)
Days to 75% maturity	0.09^{NS}									
Plant height (cm)	0.02^{NS}	0.96**								
Tillers plant^{-1}	-0.21^{NS}	0.08^{NS}	0.17^{NS}							
Spike length (cm)	0.67**	0.21^{NS}	0.20^{NS}	-0.07^{NS}						
Spikelets spike^{-1}	0.54*	0.77**	0.74**	0.20^{NS}	0.38^{NS}					
Number of grains spike^{-1}	0.67**	0.72**	0.63*	0.05^{NS}	0.57*	0.89**				
Seed index (g)	-0.46^{NS}	0.42^{NS}	0.42^{NS}	-0.20^{NS}	-0.22^{NS}	0.02^{NS}	-0.13^{NS}			
Grain yield plant^{-1} (g)	0.06^{NS}	0.68**	0.72**	0.62*	0.12^{NS}	0.74**	0.62*	0.01^{NS}		
Biological yield plant^{-1} (g)	0.21^{NS}	0.76**	0.71**	0.36^{NS}	0.18^{NS}	0.82**	0.79**	0.00^{NS}	0.79**	
Harvest index (%)	-0.27^{NS}	-0.14^{NS}	-0.02^{NS}	0.26^{NS}	-0.13^{NS}	-0.21^{NS}	-0.32^{NS}	0.10^{NS}	0.17^{NS}	-0.43^{NS}

*, ** indicates significant level at 5 and 1% of probability level, respectively.
NS indicates non-significant level at 5 and 1% of probability level, respectively.

Table 4. Correlation coefficient (r) between various traits of F_2 Crosses

Traits	Days to 75% heading	Days to 75% maturity	Plant height (cm)	Tillers plant^{-1}	Spike length (cm)	Spikelets spike^{-1}	Grains spike^{-1}	Seed index (g)	Grain yield plant^{-1} (g)	Biological yield plant^{-1} (g)
Days to 75% maturity	0.80**									
Plant height (cm)	0.32^{NS}	0.40*								
Tillers plant^{-1}	0.70**	0.35^{NS}	-0.01^{NS}							
Spike length (cm)	-0.27^{NS}	0.08^{NS}	-0.31^{NS}	-0.26^{NS}						
Spikelets spike^{-1}	0.38^{NS}	-0.35^{NS}	-0.57**	-0.08^{NS}	0.66**					
Grains spike^{-1}	-0.11^{NS}	-0.01^{NS}	-0.22^{NS}	-0.09^{NS}	-0.13^{NS}	0.13^{NS}				
Seed index (g)	-0.08^{NS}	0.15^{NS}	0.19^{NS}	-0.32^{NS}	-0.05^{NS}	-0.28^{NS}	0.11^{NS}			
Grain yield plant^{-1} (g)	0.80**	0.58**	0.19^{NS}	0.86**	-0.16^{NS}	-0.22^{NS}	-0.07^{NS}	-0.33^{NS}		
Biological yield plant^{-1} (g)	0.43*	0.06^{NS}	-0.07^{NS}	0.84**	-0.12^{NS}	0.12^{NS}	-0.14^{NS}	-0.69**	0.77**	
Harvest index (%)	0.69**	0.76**	0.44*	0.33^{NS}	-0.19^{NS}	-0.64**	0.00^{NS}	0.28^{NS}	0.59**	0.03^{NS}

*, ** indicates significant level at 5 and 1% of probability level, respectively.
NS indicates non-significant level at 5 and 1% of probability level, respectively.

Regression analysis: Grain yield per plant is decreasing with increase of heading days. However, coefficient of determination (r^2 = 0.06) indicated that this variation in this trait was in relationship with variation in days to heading.

However, coefficient of determination value (r^2 = 0.95) indicating that 95.95 % variation in trait of grain yield was in relationship with the variation in days to maturity. Coefficient of determination value (r^2 = 0.47) indicating that 47.39 % variation in trait of yield of grain was in relationship with the difference in plant height. Coefficient of determination value (r^2 = 0.08) indicating that 8.21 % variation in trait of grain yield was in relationship with the variation in tillers per plant. However, the value of the coefficient of determination (r^2 = 0.51) indicates that 52.99% of the change in grain yield is related to the change in spike length.

efficient of determination value (r^2 = 0.57) indicating that 57.02 % variation in trait of grain yield was in relationship with the variation in spikelets per spike.

The coefficient of determination (r2 = 0.58) shows that with the change of grains, 58.99% of the variation of grain yield was in the relationship of grains per spike.

Coefficient of determination value (r^2 = 0.78) indicating that 78.36 % variation in trait of yield of grain was in relationship with the variation in seed index.

Table-5 Regression coefficients among various traits in wheat cultivars

Traits	Correlation coefficient (r)	Regression coefficient (b)	Coefficient of determination (r^2)
Grain yield per plant vs days to 75% heading	0.06^{NS}	0.04	0.06
Grain yield per plant vs days to 75% maturity	0.68^{**}	-0.00	0.95
Grain yield per plant vs plant height	0.72^{**}	0.02	0.47
Grain yield per plant vs tillers plant^{-1}	0.62^{*}	0.32	0.08
Grain yield per plant vs spike length	0.12^{NS}	0.20	0.51
Grain yield per plant vs spikelets spike^{-1}	0.74^{**}	0.09	0.57
Grain yield per plant vs number of grains spike^{-1}	0.62^{*}	0.00	0.58
Grain yield per plant vs seed index	0.01^{NS}	0.01	0.78

CONCLUSIONS

This study revealed that parent SKD-1 and the cross SKD-1 x Benazir-2013 displayed best execution with greatest grain yield per plant than every one of the tried genotypes. The correlation study revealed that positive and significant relationship of grain yield with different attributes showed that increase in grain yield per plant related to increase in spike length, tillers per plant, spikelets per spike, grains per spike and seed index. Regression analysis recommended that seed index, tillers per plant and spike length may be used for additional development in grain yield per plant in wheat genotypes.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest for the publication of the manuscript.

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