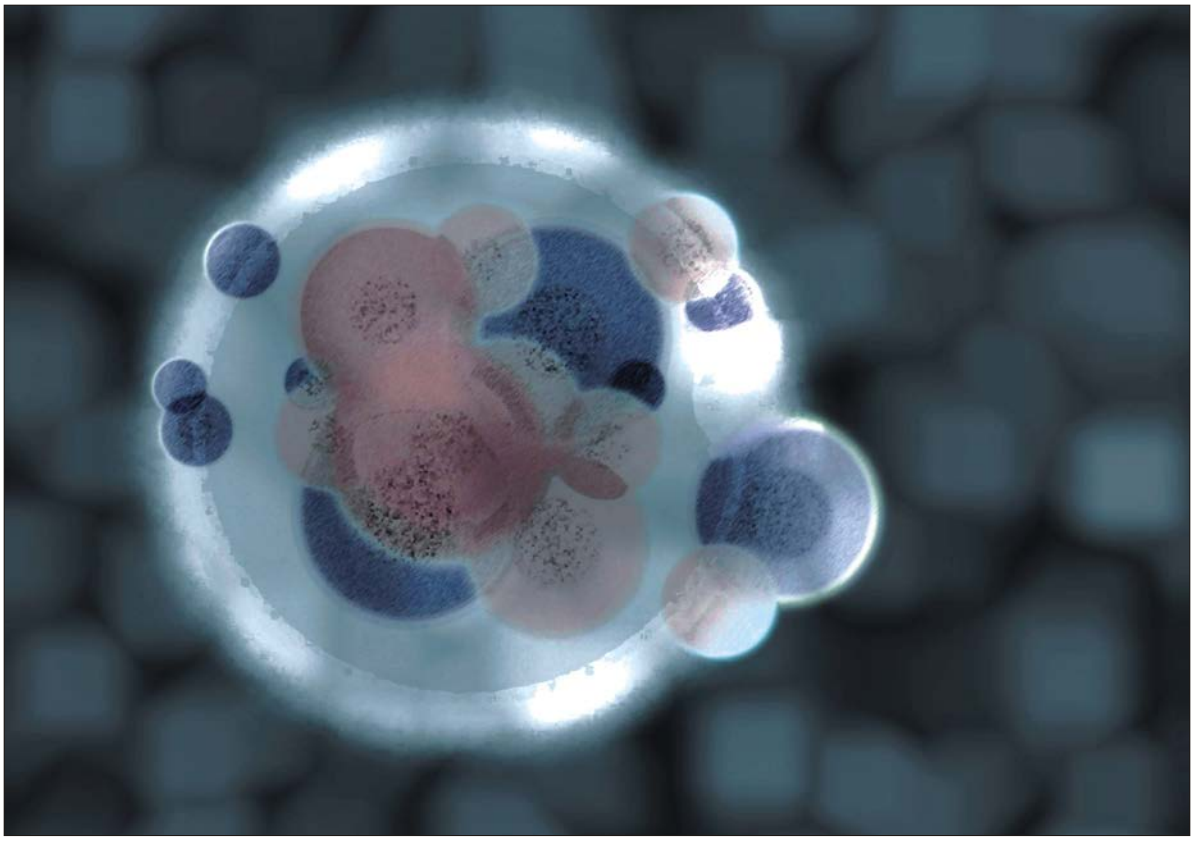

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Genetic Analysis of Some Biometric Characters in Bread Wheat (*Triticum aestivum* L.)

M. Safeer-ul-Hassan, M. Munir, M.Y. Mujahid, N.S. Kisana, Zahid Akram and A. Wajid Nazeer
Department of Plant Breeding and Genetics, University of Arid Agriculture, Rawalpindi, Pakistan

Abstract: Twenty four wheat genotypes including a check variety (Margalla-99) were planted in a Randomized Complete Block design with three replications during 2001-02 at National Agricultural Research Center, Islamabad. Data were recorded and analyzed on days to heading, days to maturity, plant height, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, 1000-grain weight and yield per plot. The genotypes were highly significant for all the traits except for yield per plot where a significant difference was observed among the genotypes. Maximum heritability was observed for days to heading (97.80%) and days to maturity (87.60%), while a minimum value of 24.27% was observed for yield per plot. Value of genetic advance ranged from a minimum of 0.06 for grain weight per spike to a maximum of 9.79 for yield per plot. The calculated correlation coefficients indicated that number of spikelets per spike, days to maturity and plant height were significantly positive correlated with grain yield per plot, while a non significant correlation was observed between grain yield per plot and number of grains per plot, days to heading, grain weight per spike, 1000-grain weight and spike length. Genotype V_4 and V_{15} performed better for most of the traits and can be considered for release as varieties after further evaluation.

Key words: Wheat, heritability, genetic advance, correlation, genetic analysis

INTRODUCTION

Wheat being the staple food of the majority of people plays a remarkable role in meeting the diversified food requirements of both urban and rural populations of Pakistan. Wheat contributes about 84% of the total cereal intake in Pakistan, where bread of different types constitute the main food[1]. Pakistan is the 10th biggest wheat producer, contributing about 2% of the global wheat supply. Wheat occupies an area of 8.5 million ha that is the largest area in Pakistan under any single crop[2].

Wheat production has increased from 3.3 million tones in 1948 to over 21 million tones in 2000-01. The productivity remained stagnant up to 1967 when it took off with the introduction of semi dwarf varieties of wheat, the ushering in of green revolution. Since then the gradual improvement in wheat yield has occurred. The average yield of tall varieties before the green revolution was 808 kg ha^{-1}, while the average yield of semi dwarf varieties is 1,601 kg ha^{-1}. The production during 1999-00 was 21.1 million tones with the average yield of 2,491 kg ha^{-1}[3].

Development of high yielding wheat cultivars with desirable quality has been one of the major objectives of wheat breeding programmes through out the world. Extensive testing of wheat genotypes under different environments had been practiced for developing relatively stable cultivars[4]. Need for continuous breeding wheat varieties is obvious from the fact that a variety released for commercial purpose gradually deteriorates due to various reasons and goes out of cultivation. Yield in any crop is a very complex trait and is a result of various components and the study of association between any two traits or among all the traits is of immense importance to make improvement in the yield. Although the production of wheat grain has made a significant advancement in the country towards attaining self sufficiency, still using more inputs and improving the genetic make up of the crop can maximize the productivity.

As the inputs are scarce and expensive, more emphasis should be laid on genetic improvement. The present study was conducted with the following objectives:

- To select the most promising genotypes for cultivation in Rawalpindi/Islamabad area
- To evaluate and screen potential genotypes for various traits
- To compute heritability (Broad Sense) of some biometric characters
- To determine simple correlation among different traits

MATERIALS AND METHODS

The experiment was conducted at the wheat experimental area of National Agricultural Research

Corresponding Author: Muhammad Safeer-ul-Hassan, Street No. 1, House No. 6, Girja Road, Sadiq Colony, Dhoke Syedian, Rawalpindi, Pakistan Tel: 051-5568889 E-mail: safeer210@yahoo.com

Table 1: Name/pedigree and selection history of 24 wheat genotypes sown at NARC during 2001-02

Varieties	Name/Pedigree	Selection history
V_1	MAXIPAK65	118156-0PAK
V_2	KAUZ/BAU	CM103329-10M-030M-020Y-010M-2Y-010Y-0M-0SY-0AP
V_3	SAFI-1	CM103448-39M-030M-020Y-010M-4Y-010Y-0M-0AP
V_4	KAUZ*2//K134(60)/VEE	CM105812-0T0PY-15M-030Y-020Y-010M-2Y-010Y-0M-0SY-0AP
V_5	AMSEL/TUI	CM107503-12Y-020Y-010M-3Y-010M-1Y-0M-0AP
V_6	VEE/MJI//2*TUI	CM112685-0T0PY-12M-020Y-010M-2Y-010M-5Y-0AP
V_7	SAMAR-8	CM1127930T0PY-22M-020Y-010M-3Y-0M-0AP
V_8	CHAM-4	CM39816-1S-1AP-0AP
V_9	ATTILA-3	CM85836-4Y-0M-0Y-14M-0Y-5M-0Y-1SJ-0Y-0AP
V_{10}	MYNA/VUL//TURACO/3/TURACO	CMBW89Y01234-0T0PM-18Y-010M-4Y-0M-0AP
V_{11}	KAUZ//KAUZ/STAR	CMBW90M4994-0T0PY-13M-015Y-015M-5Y-0B-0AP
V_{12}	KAUZ/GEN	CRG1782-55B-0Y-030M-7Y-2Y-0M-0AP
V_{13}	QUATM-1	ICW92-0261-0AP-4AP-0L-1AP-0AP
V_{14}	ANDALIBE-1	ICWN2-0275-4AP-0L-3AP-0AP
V_{15}	DAJAJ-1	ICW92-0281-1AP-2AP-0L-1AP-0AP
V_{16}	CHAM-6	CM39992-8M-7Y-0M-0AP
V_{17}	KAUZ 's'/SERI	CM103322-0AP-0L-2AP-0AP-0BR-0AP
V_{18}	ANGI-3	ICW92-0326-12AP-0L-3AP-0L-1AP-0AP
V_{19}	ANGI-2	ICW92-0326-12AP-0L-7AP-0L-1AP-0AP
V_{20}	KHATAF-1	ICW93-0008-0BR-2AP-0L-3AP-0AP
V_{21}	BASHIQ-1	ICW93-0045-1AP-0L-1AP-0L-2AP-0AP
V_{22}	BANA-5	ICW93-0073-2AP-0L-4AP-0L-1AP-0AP
V_{23}	HUBARA-2	ICW94-0392-0L-3AP-3AP-2AP-0APS-0AP
V_{24}	MARGALLA-99	Local check

Center, Islamabad. Twenty three genotypes (Table 1) of wheat received from International Center for Agricultural Research in Dry Areas (ICARDA), Syria, along with a check, Margalla-99 were planted during 2001-02 in a Randomized Complete Block design with three replications. Each plot consisted of six rows with two meter length and row-to-row distance was kept as 25 cm. A fertilizer doze of 90 kg nitrogen and 90 kg phosphorus ha^{-1} was applied before sowing with a single irrigation. Data were recorded for the following traits, days to heading, days to maturity, plant height, spike length, number of spikelets per spike, number of grains per spike, grain weight per spike, 1000-grain weight and yield per plot. Four central rows (2 m^2) were harvested for grain yield per plot. The data for all above mentioned characters were subjected to analysis of variance[5] and heritability (Broad Sense) estimates were worked out according to the procedure elaborated by Singh and Chaudhry[6].

Simple correlation coefficient between grain yield and various agronomic characters were also computed according to formula given by Steel and Torrie[5].

RESULTS AND DISCUSSION

Results revealed that differences among the genotypes for days to heading were highly significant (Table 2). The genotype V_7 and V_{13} took maximum days to heading that is 127 and 126.3 days, respectively (Table 3). The genotype V_{23} took minimum days to heading that is 111.3 days followed by V_{15} that took 113 days to heading (Table 3). Genotypes differed highly significantly for days to maturity (Table 2). The genotype V_{13} and V_7 took maximum days to maturity i.e. 164 and 163.7 days, respectively (Table 3). The genotype V_{20} took minimum days to maturity i.e. 156.7 which had differed non significantly with genotype V_{24} and V_{21} for days to maturity, with mean value of 158 days each (Table 3). Differences among the genotypes for plant height were highly significant (Table 2). The genotypes V_{24} attained maximum plant height i.e. 97.07 cm, followed by V_4 that attained a mean height of 93.20 cm (Table 3). The genotypes V_{13} and V_{23}, V_8 and V_{21} differed a little for minimum plant height i.e. 76.33, 76.47, 76.47 and 76.87 cm, respectively (Table 3). For spike length the difference among the genotypes were highly significant (Table 2). The genotypes V_{13} showed the highest value of 11.87 cm followed by V_{24} with mean value 10.74 cm (Table 3). The genotypes V_3 gave the lowest mean value of 7.88 cm (Table 3).

Results presented in Table 2 indicated highly significant differences among the genotypes of number of spikelets per spike. The genotype V_{12} had the highest value of 20.20 followed by the genotype V_{13} with the mean value of 20.07 spikelets per spike (Table 3). The genotype V_6 had the lowest number of spikelets per spike with the mean value of 15.93 (Table 3). All the genotypes showed highly significant differences for number of grains per spike (Table 2). The genotypes V_4 had maximum number of grains per spike with a mean value of 65 followed by the genotype V_{13} with the mean value of 63.67 grains per spike. The genotype V_2 and V_5 gave minimum number of grains per spike i.e. 44.67 each (Table 3).

There were highly significant differences among all the genotypes for grain weight per spike (Table 2). The

Table 2: Mean squares and their significance of the traits for 24 wheat genotypes sown at NARC during 2001-02

Source of variation	Degree of freedom	Days to heading	Days to maturity	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of grains per spike	Grain weight per spike (g)	1000-grain weight (g)	Yield per plot (g)
Treatment	23	51.860**	11.708**	100.70**	2.823**	4.10**	105.71**	0.190**	27.01**	35991.06*
Replication	2	15.931	6.931	292.29	0.526	7.88	85.54	0.006	11.99	95555.55
Error	46	0.380	0.525	22.07	0.365	1.69	31.71	0.057	6.05	21932.36

Significant at the 0.001% level

Table 3: Means and their significant of some agronomic traits for 24 wheat genotypes sown at NARC during 2001-02

Varieties/ genotypes	Days to heading	Days to maturity	Plant height (cm)	Spike length (cm)	Number of spikelets per spike	Number of grains per spike	Grain weight per spike	1000-grain weight (g)	Yield per plot (g)
V_1	122.7B*	160.7EF	83.40C-H	10.57BC	18.40A-D	61.00A-C	2.30A-D	42.27E-I	866.00EF
V_2	116.0H-J	159.3G-J	85.07C-F	8.80F-I	16.20EF	44.67H	1.57H	46.50B-D	900.00D-F
V_3	121.3CD	162.7BC	86.27B-F	7.887I	17.40C-F	51.67D-H	1.86E-H	40.63E-I	1133.00A-C
V_4	113.0L	162.3C	93.20AB	10.63BC	19.40A-C	65.00A	2.62A	43.50C-I	1200.00A
V_5	120.0E	159.0H-K	92.87AB	9.033E-H	17.67C-F	44.67H	1.85F-H	43.33C-I	1033.00A-F
V_6	120.3DE	162.0CD	80.07E-H	9.533D-F	15.93F	46.00GH	2.33A-C	51.60A	1000.00A-F
V_7	127.0A	163.7AB	86.27B-F	9.667C-F	17.00D-F	51.67D-H	2.02C-G	47.27BC	1000.00A-F
V_8	120.0E	160.0E-H	76.47H	8.433G-I	16.87D-F	54.67B-G	1.97C-G	40.13G-I	833.30F
V_9	121.0C-E	162.3C	86.27C-G	9.133E-G	18.73A-D	47.00F-H	1.95C-H	44.63B-E	1100.67AB
V_{10}	118.0F	158.7IJK	92.87AB	10.71B	17.27C-F	54.33C-G	2.33A-C	43.73C-H	1100.00A-D
V_{11}	122.0BC	158.7IJK	81.07D-H	9.200E-G	19.00A-D	56.00A-F	1.97C-G	40.03HI	1166.67AB
V_{12}	123.0B	162.7BC	87.33B-E	9.933B-E	20.20A	61.33A-C	2.13B-G	39.60I	1066.67A-E
V_{13}	126.3A	164.0A	76.33H	11.87A	20.07AB	63.67AB	2.41AB	40.20F-I	966.67B-F
V_{14}	117.0F-H	160.7EF	83.80C-H	10.23B-D	17.93B-F	47.00A-E	2.37A-F	40.00HI	1166.67AB
V_{15}	113.0L	160.7EF	87.93B-D	10.25B-D	18.87A-D	62.00A-C	2.59A	48.63AB	1200.00A
V_{16}	116.7G-I	158.0K	79.40F-H	8.067HI	16.20EF	55.33B-F	1.83GH	39.83HI	1166.67AB
V_{17}	120.0E	159.7F-I	79.13F-H	9.200E-G	17.27C-F	53.33C-H	2.10B-G	43.77C-H	1133.33A-C
V_{18}	117.3FH	160.3E-G	85.73B-F	9.173E-G	17.67C-F	60.00A-D	2.28A-D	42.50D-I	1033.33A-F
V_{19}	115.7IJ	160.0E-H	84.87C-F	9.667C-F	18.00B-F	56.00A-F	2.13A-D	42.63D-I	833.33F
V_{20}	114.0KL	156.7L	89.40A-C	8.233G-I	17.93B-F	47.67F-H	1.94D-H	44.43C-E	1100.00A-D
V_{21}	115.0JK	158.0K	76.87GH	8.847F-I	18.20A-E	58.33A-E	2.25A-E	42.63D-I	1066.67A-E
V_{22}	115.0JK	161.0DE	82.40C-H	9.480D-F	19.40A-C	58.33A-E	2.31A-D	44.20C-F	1133.33A-C
V_{23}	111.3M	158.3JK	76.47H	8.933F-H	17.53C-F	53.67C-H	2.25A-D	44.17C-G	933.33C-F
V_{24}	122.0BC	158.0K	97.07A	10.74B	19.00A-D	50.67E-H	2.05B-G	41.83E-I	1000.00A-F

Mean values having different letters in the same row differ significantly. * Significant at 0.05 probability level

Table 4: Estimates of heritability and genetic advance for some traits of 24 wheat genotypes sown at NARC during 2001-02

Traits	Heritability (B.S.)	Genetic advance
Days to heading	97.80	4.29
Days to maturity	87.60	1.69
Plant height	54.20	2.18
Spike length	69.10	0.56
Number of spikelets per spike	32.00	0.17
Number of grains per spike	43.70	1.53
Grain weight per spike	43.50	0.06
1000-grain weight	53.50	1.11
Yield per plot	24.27	9.79

genotype V_4 and V_{15} showed highest mean values for grain weight per spike i.e. 2.62 and 2.59 g, respectively (Table 3). The genotype V_2 gave minimum mean value for grain weight per spike i.e. 1.57 g (Table 3). The differences among the genotypes for 1000-grain weight were highly significant (Table 2). The genotype V_6 showed highest value for 1000-grain weight i.e. 51.60 g flowed by a genotype V_{15} that gave a mean value of 48.63 g (Table 3). V_{12} showed lowest mean value for this character i.e. 39.60 g (Table 3). Significant differences among genotypes for yield per plot were observed (Table 2). The genotype V_4 and V_{15} went highest for yield per plot with a mean yield of 1200 g (Table 3). The genotype V_{19} gave minimum value for yield per plot i.e. 833.33 g (Table 3).

Highly significant differences were observed among the genotypes for all the characters except yield per plot where only a significant difference was observed. The critical review of the Table 3 revealed that the genotype V_4 gave the highest grain yield per plot and was also at the top for other characters like number of grains per spike and grain weight per spike. Its performance was also good for other characters like days to heading and number of spikelets per spike. Genotypes V_{15} remained on the second position as a whole, its grain yield per plant was equal to that of V_4 and it remained on second position for the characters like days to heading, grain weight and 1000-grain weight. These results indicate that the genotypes V_4 and V_{15} can be considered for the release as variety or may be useful for further cross breeding programme.

Heritability and genetic advance: High heritability (Broad Sense) estimates (97.80) with high genetic advance (4.29) were observed for days to heading (Table 4). These results are in confirmatory with those of Amin *et al.*[7] they reported high heritability coupled with high genetic advance for this character. High heritability estimates indicate the additive gene effect for this trait. Heritability

Table 5: Correlation coefficients among various traits of wheat genotypes sown at NARC during 2001-02

Characters	Grain weight per spike	Yield per plot	Number of grains per spike	Number of spikelets per spike	Days to heading	Days to maturity	Plant height	Spike length
1000-grain weight	0.1779^{NS}	-0.1672^{NS}	-0.3868^{NS}	-0.3569*	-0.2006^{NS}	0.1060^{NS}	0.1081^{NS}	0.0128^{NS}
Grain weight per spike		0.3344^{NS}	0.7182**	0.4563**	-0.2388^{NS}	0.2888^{NS}	0.0112^{NS}	0.6586**
Yield per plot			0.1514^{NS}	0.1190^{NS}	-0.1551^{NS}	0.0040^{NS}	0.0421^{NS}	-0.2150^{NS}
Number of grains per spike				0.6091**	-0.0751^{NS}	0.2938^{NS}	-0.1472^{NS}	0.5086**
Number of spikelets per spike					0.1210^{NS}	0.2895^{NS}	0.1943^{NS}	0.5627**
Days to heading						0.5192**	-0.0270^{NS}	0.2778*
Days to maturity							-0.0761^{NS}	0.3838**
Plant height								0.2554^{NS}

*, **: Significance at 0.05 and 0.01 probability levels, respectively, NS: Non significant

estimates and genetic advance suggest that selection can be practiced for this character in subsequent generations. High heritability estimates (87.60) with low genetic advance (1.69) were observed for days to maturity (Table 4). Low genetic advance indicates slight chances of improvement for this character in subsequent generations. El-Shazly *et al.*[8] in an experiment on different wheat genotypes reported similar results for days to maturity.

Plant height showed moderate heritability (54.20) along with the moderate genetic advance of 2.18 (Table 4). Similar results were also observed by Gupta and Verma[9], Bhullar *et al.*[10]. A careful selection is needed in case of plant height. Heritability estimates for spike length were moderate (69.10) but on higher side along with the low genetic advance of 0.57 (Table 4). Similar results were found by Tripathi *et al.*[11]. They suggested that making effective selection for appropriate parent is very important in case of moderately high heritability and low genetic advance. These results are also supported by Abid and Shahid[12], Gupta and Ahmed[13].

Number of spikelets per spike showed low heritability estimates (32.00) along with the low genetic advance of 0.17 (Table 4). Tahir *et al.*[14] in an experiment of heritability of grain yield and protein contents in wheat found similar results for number of spikelets per spike. Number of grains per spike showed low heritability (broad sense) estimates (43.70) along with the low value of genetic advance i.e. 1.53 (Table 4). It means that care must be taken for these characters and in future they can be used only after passing through an intensive selection criterion. These results are also supported by Amin *et al.*[7], Abid and Shahid[12].

Grain weight per spike showed low value for heritability (42.50) with least genetic advance value of 0.06. So selection based on grain weight per spike may not be effective for further breeding work. Moderate heritability estimates (53.50) along with the low genetic advance 1.11 are observed in case of 1000-grain weight (Table 4). Moderate heritability along with low genetic advance indicates slight chance of improvement in subsequent generations. These results are in agreement with Ajmal *et al.*[15] and Amin *et al.*[7]. Yield per plot showed lower values of heritability (24.27), but highest genetic advance (9.79) (Table 4), it means that environment played a great role in getting these results so a careful selection should be observed in case of yield per plot. These results are in confirmatory with that of Bhullar *et al.*[10]

Simple correlation coefficients were observed for all possible combinations of eight different characters (Table 5).

A study of Table 5 revealed that correlation between 1000-grain weight (g) and grain weight per spike was non significant. Yield per plot and number of grains per spike were correlated negatively and non significantly with 1000-grain weight. There was a significant negative correlation between 1000-grain weight and number of spikelets per spike. Days to heading were non significantly correlated with 1000-grain weight but this correlation was negative. There was a non significant correlation between 1000-grain weight and days to maturity. Plant height was also non significantly correlated with 1000-grain weight. Similar results were found by Chaudhry *et al.*[16]. Spike length was non significantly correlated with 1000-grain weight as well.

There was a non significant positive correlation between grain weight per spike and yield per plot, similar results were found by Virk and Annad[17]. There was a highly positive significant correlation between grain weight per spike and number of grains per spike; it means that with increase in number of grains per spike there was a significant increase in grain weight per spike. These results are also confirmed by the work of Serwat and Rana[18]. Table 5 showed that there was a highly positive and significant correlation between number of spikelets per spike and grain weight per spike. A negative and non significant correlation was observed between days to heading and grain weight per spike. Days to maturity and plant height were non significantly correlated with grain weight per spike. These results are almost similar to that of Briggs and Aytenfisu[19]. A highly significant and positive correlation was found between spike length and grain weight per spike. Similar results were reported by Amin *et al.*[7].

Data presented in Table 5 showed that there was a non significant positive correlation between yield per plot and number of grains per spike. These results are similar to those of Amin *et al.*[7]. There was a non significant correlation between grain yield per plot and number of spikelets per spike. A non significant negative correlation was found between grain yield per plot and days to heading. These results are similar to those of Zar and Khan[20]. Days to maturity and plant height were non significantly correlated with grain yield per plot. The results obtained from present study were in agreement with the finding of Chaudhry *et al.*[16] , Serwat and Rana[18]. There was a non significant negative correlation between spike length and grain yield per plot.

A positive and highly significant correlation was observed between number of grains per spike and number of spikelets per spike. With an increase in number of spikelets per spike there would be highly significant increase in number of grains per spike[21]. Days to heading and plant height showed non significant but negative correlation with number of grains per spike. Similar results were obtained by Amin *et al.*[7]. There was a non significant correlation between days to maturity and number of grains per spike. Spike length was positively and highly significantly correlated with number of grains per spike. Similar results were obtained by El-Shazly *et al.*[8].

Days to heading, days to maturity and plant height were all non significantly correlated with number of spikelets per spike. Similar results were found by Bhullar *et al.*[10]. There was a highly positive and significant correlation between spike length and number of spikelets per spike.

Highly positive and significant correlation was observed between days to heading and days to maturity. These results suggested that the genotypes that took lesser days to heading were likely to mature earlier and vice versa. Similar results were found by Ahmed *et al.*[22] and Li[23]. A non significant and negative correlation was observed between days to heading and plant height. There was a positive and a significant correlation between days to heading and spike length. Similar results were observed by Amin *et al.*[7].

There was a non significant and negative correlation between days to maturity and plant height. It means that with the increase in days to maturity there was an increase in plant height and the varieties with short maturity period are usually shorter in length too. These results are confirmed by the work of Ashraf[24]. Spike length was significantly and positively correlated with days to maturity. These results are also confirmed by Bhutta and Chaudhry[25].

Plant height was non significantly correlated with spike length. Similar results were reported by Bhutta and Chaudhry[25], Merisinkov *et al.*[26]. Table 5 showed that the correlations of number of spikelets per spike, days to maturity and plant height were significantly positive with grain yield per plot, while a non significant correlation was observed between yield per plot and number of grains per spike. Days to heading, grain weight per spike, 1000-grain weight and spike length also showed a non significant correlation with grain yield.

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