Journal homepage www.jzs.uos.edu.krd
Journal of Zankoi Sulaimani
Part-A- (Pure and Applied Sciences)

Correlation and path coefficient analysis of grain yield with yield components of bread wheat (*Triticum aestivum* L.) variety Adana-99

Shang Haseeb Abdulqader Noori & Shwana Ahmad Hussain Ghafoor

University of Sulaimani - College of Agricultural Sciences – Sulaimani – Iraqi Kurdistan Region
E-mail: Shang.Abdalqadr@univsul.edu.iq , Shwana.Hussain@univsul.edu.iq

Article info

Original: 31/12/ 2017
Revised: 04/02/2018
Accepted: 07/02/2018
Published online:

Key Words:
Wheat, Correlation coefficient, path analysis, direct and indirect effect on grain yield.

Abstract

The study performed to determine the relationship between yield and yield components of wheat (*Triticum aestivum* L.) variety Adana-99, using data from a factorial experiment; 6 planting dates and 6 plant densities in CRBD within three replications. Results of the path coefficient confirmed that, grain yield was positively and highly significant associated with plant height, number of days to flowering, number of days to maturity, spike length, number of spikes/m^2, number of seeds/spike, 1000 grain weight, biological yield, harvest index and grain yield. Path coefficient analysis showed that the magnitude of positive direct effect on grain yield was highest through number of days to maturity which was (0.657) and followed by biological yield (ton/ha) which was (0.650), whereas number of days to flowering with (-0.425) recorded maximum negative direct effect on grain yield. The results suggest that all the characters showing highly significant correlation with grain yield in the process selection much attention should be given to them as these characters in future wheat breeding programs for increasing yield.

Introduction:

Wheat (*Triticum aestivum* L.) is one of the world's important cereal crops and is used as staple food in many regions of the world. It is grown under both irrigated and rain-fed conditions. It belongs to family Gramineae ***[1]***. Wheat yield is a complex trait, depending on genetic and environmental factors and their interactions. The actual yield is a result of the value of yield components as well: plant high, the number of productive tillers, number of spikelet/spike, number of grain/spike, grain mass/spike, number of spikes/m^2, 1000 grain mass and others ***[2; 3]***. The characters affecting and influencing yield need to be identified and selection has to be done with those characters which show a close correlation with grain yield ***[4]***. In agronomic and breeding studies, correlation coefficients are generally used to determine the relation of grain yield and its components. Simple correlation coefficients detected that 1000 grain weight, number of grains/spike, and plant height recorded significant and positive correlations with grain yield ***[5]*** days to maturity had a positive and significant correlation with spike length and biological yield and grain yield ***[6]***, grain yield had positive correlation with spike length and grains/spike, while negative correlation with plant height and tillers/plant observed by ***[7]***. A negative relationship between days to flowering and grain yield/plant reported in their studies in advanced wheat lines ***[8, 9*** and ***10]***. Estimation of the correlation between yield and its components alone is not sufficient to understand the importance of each one of these components in determining the grain yield ***[11, 12*** and ***13]*** . Correlation is the simultaneous variation of two variables. It is often desirable to observe and measure the relationship between two characters. Correlation may be positive or negative. Positive correlation shows that increase in a single trait causes simultaneous increase in the other. Negative correlation reflects the increase in one trait is associated with a decrease in the

other ***[14]***. Correlation analysis is commonly practiced to determine the relationship of grain yield with its component characters. Grain yield is a quantitative trait, which is a function of many parameters have associations among themselves and can affect the grain yield directly or indirectly. For this reason, determination of the relationship between grain yield and other characters is necessary when indirect selection is made for higher grain yield. It is sensible to know whether a yield component has a direct or indirect effect on grain yield while making a selection for higher yield ***[15]***.

The path analysis is used to find the direct or indirect effects of some yield components on grain yield in relation to yield with other components. Many researchers have been done on wheat breeding in which both correlation and path analysis methods were simultaneously used. Some researchers reported a positive and significant correlation between plant height and grain yield in many studies ***[16, 17*** and ***18]*** it was shown that seed numbers/spike has a positive effect on grain yield ***[19*** and ***20]***. In correlation, a path analysis conducted by a large number of researchers, it has been observed that 1000 grain weight has a positive effect on yield***,*** followed by spike length and days to flowering, while plant height and grains/spike had a negative direct effect on yield and days to maturity associated a positive direct effect and negative indirect effect on grain yield via harvest index***,*** while biological yield had the highest direct effect on grain yield refers to followed by weight of main spike, they show that the biological yield and weight of main spike can be used as criteria for selection to improve the yield of wheat grain ***[7, 21,22*** and ***23]***.

The aim of this study was to determine the correlations and path coefficient analysis of yield and its components in bread wheat and assess their suitability's in a breeding program.

Material and Methods

In order to detect the direct and indirect correlations and path coefficient of grain yield with its component. A variety of bread wheat namely; (Adana-99) during the winter season of 2015-2016 was cultivated in 6 different planting dates combined with 6 different plant densities using CRBD factorial design within three replications at the Qlyasan Agricultural Research Station, College of Agricultural Sciences, University of Sulaimani.

This research was done by using both simple correlation and path coefficient analysis which indicated the direct and indirect effect on the dependent variable (grain yield), with the other characters were studied.

Studied characters

Studied Ten characters, namely, plant height (cm), number of days to flowering, number of days to maturity, spike length (cm), number of spikes/m^2, number of seeds/spike, 1000 grain weight (gm), grain yield (ton/ha), biological yield (ton/ha) and harvest index were studied.

Correlation Analysis

The correlation coefficient was carried to determine the degree of association of characters with yield and other characters in each environment. Phenotypic correlations were calculated between characters in each environment by using the formula given by ***[24]***.

Path Coefficient Analysis

The path coefficient analysis was carried out as suggested by ***[24, 25, 26,*** and ***27]***, through (Analysis of Moment Structures) AMOS Ver. 18 Software.

Result and Discussion

Table (1) indicated the means value of interaction effects between both factors; planting dates and plant densities on grain yield and its components. Maximum number of plant height was 108.333 cm produced by the interaction effect between (15th Nov. 2015 under the plant density of 220 kg/ha). Maximum number of days to flowering, number of days to maturity, spike length and number of seeds/spike was 146.667, 186.333, 9.407 cm and 44.333, respectively produced by the combination between (15th Nov. 2015 under the plant density of 120 kg/ha). The maximum value of spikes/m^2 was 726.667 exhibited by the combination

between (5th Dec. 2015 under the planting density of 220 kg/ha). The maximum value of 1000 grain weight was 50.100 g recorded by interaction between (15th Nov. 2015 under the plant density 140 kg/ha). The maximum values of grain yield was 6.888 kg/ha recorded by the interaction between (5th Dec. 2015 under the plant density 200 kg/ha). The maximum value of biological yield was 17.273 ton/ha produced by the combination between (15th Nov. 2015 under the plant density of 200 kg/ha), whereas the maximum values of harvest index was 0.577 recorded by the combination between (15th Jan. 2016 under the plant density of 120 kg/ha).

Delay in planting date, decreases the period of vegetative and reproductive growth stages and reduces the grain yield. The decrease of grain yield in late planting date could be due to the fact that plant vegetative stage faces intense heat of the season, which results in a decrease of vegetative growth stage, production of fewer vegetative organs, decrease of assimilation, early flowering, increases of flowers loss and infertility, and decrease of grain yield and its components ***[28]***. Low yield of many limiting factors for production, with different planting densities of wheat, which affect the proper growing crop due to balanced competition for production resources among plants, affects the yield and its components among the important agronomic factors ***[29]***.

Table-1: Means value for some agronomic characters.

Planting Dates x Plant Density (Kg/ha)	Plant height (cm)	No. of days to flowering	No. of days to maturity	Spike length (cm)	No. of spikes /m^2	No. of seeds/ spike	1000 grain weight (g)	Grain yield (ton/ha)	Biol. yield (ton/ha)	Harvest index
15th Nov. 2015× 120	100.333	146.667	186.333	9.407	435.000	44.333	49.400	5.556	11.085	0.501
15th Nov. 2015× 140	102.333	145.667	185.333	7.743	480.000	42.933	50.100	6.116	12.453	0.491
15th Nov. 2015× 160	104.333	144.667	184.333	8.163	541.667	41.300	45.607	6.515	16.188	0.402
15th Nov. 2015×180	104.333	144.667	183.333	7.363	576.667	38.467	43.393	6.686	17.197	0.389
15th Nov. 2015× 200	106.333	143.667	182.333	7.453	578.333	35.733	42.070	6.803	17.273	0.394
15th Nov. 2015× 220	108.333	142.667	181.333	6.550	661.667	33.767	38.330	6.227	14.975	0.416
5th Dec. 2015× 120	85.333	136.667	178.333	7.210	365.000	43.767	42.957	5.425	10.197	0.533
5th Dec. 2015×140	87.333	135.667	176.333	6.787	388.333	40.700	39.460	6.085	10.975	0.554
5th Dec. 2015×160	93.333	134.667	175.333	6.657	441.667	36.000	36.630	6.468	11.213	0.576
5th Dec. 2015× 180	95.000	134.667	174.333	6.150	628.333	32.600	36.840	6.741	13.467	0.514
5th Dec. 2015× 200	94.333	133.667	173.333	5.977	713.333	30.633	35.110	6.888	14.483	0.476
5th Dec. 2015× 220	90.000	132.667	172.333	5.917	726.667	27.667	34.873	6.336	15.472	0.409
25th Dec. 2015× 120	95.333	119.667	161.333	7.290	405.000	38.633	41.360	4.992	9.782	0.511
25th Dec. 2015×140	80.000	118.667	160.333	6.557	440.000	36.133	40.473	5.440	10.363	0.525
25th Dec. 2015×160	84.333	116.667	160.333	6.260	478.333	33.733	39.373	5.799	10.573	0.549
25th Dec. 2015× 180	75.333	115.667	159.333	6.543	610.000	29.500	37.953	5.931	12.007	0.494
25th Dec. 2015× 200	90.333	115.667	158.333	6.133	581.667	28.967	35.033	5.903	11.963	0.494
25th Dec. 2015× 220	92.333	114.667	157.333	6.480	583.333	27.933	33.873	6.104	14.177	0.431
15th Jan. 2016×120	65.000	106.667	141.333	6.287	386.667	29.233	39.970	4.222	7.315	0.577
15th Jan. 2016×140	68.333	105.667	140.333	6.080	415.000	26.233	38.387	4.539	7.730	0.554
15th Jan. 2016× 160	75.333	103.667	140.333	6.137	463.333	23.633	35.560	4.754	8.547	0.556
15th Jan. 2016×180	80.333	102.667	139.333	5.747	521.667	24.000	34.887	5.070	9.513	0.534
15th Jan. 2016×200	88.000	101.667	139.333	5.563	545.000	24.433	33.073	5.290	10.377	0.510
15th Jan. 2016×220	84.000	100.667	138.667	6.143	568.333	24.667	32.420	5.432	11.110	0.489
5th Feb. 2016×120	70.333	89.667	121.333	6.953	323.333	30.200	36.480	3.015	7.257	0.416
5th Feb. 2016×140	75.333	88.667	120.333	5.487	351.667	25.567	33.870	3.205	7.675	0.417

5th Feb. 2016× 160	*76.333*	*89.000*	*119.333*	*5.603*	*390.000*	*23.167*	*33.953*	*3.485*	*8.532*	*0.408*
5th Feb. 2016×180	*80.333*	*87.667*	*118.333*	*5.470*	*386.667*	*21.800*	*32.707*	*3.779*	*8.692*	*0.435*
25th Feb. 2016×200	*82.333*	*86.667*	*117.333*	*5.407*	*460.000*	*22.233*	*32.543*	*4.069*	*9.408*	*0.432*
5th Feb. 2016×220	*84.333*	*85.667*	*116.333*	*5.223*	*518.333*	*19.400*	*31.627*	*4.290*	*9.439*	*0.455*
25th Feb. 2016× 120	*50.333*	*74.667*	*106.333*	*5.827*	*251.667*	*22.733*	*35.910*	*1.961*	*5.927*	*0.331*
25th Feb. 2016×140	*50.333*	*73.667*	*105.333*	*5.913*	*298.333*	*21.800*	*36.283*	*2.191*	*6.500*	*0.337*
25th Feb. 2016×160	*55.333*	*72.667*	*104.33*	*5.267*	*366.667*	*20.933*	*33.667*	*2.451*	*7.063*	*0.347*
25th Feb. 2016×180	*58.333*	*71.667*	*103.333*	*5.183*	*456.667*	*20.733*	*32.960*	*2.701*	*7.523*	*0.359*
25th Feb. 2016× 200	*62.333*	*70.667*	*102.333*	*5.177*	*490.000*	*20.367*	*30.960*	*2.956*	*7.928*	*0.373*
25th Feb. 2016×220	*62.333*	*69.667*	*101.333*	*4.900*	*518.333*	*19.767*	*30.020*	*3.281*	*8.888*	*0.369*
Grand means	*82.167*	*109.954*	*146.815*	*6.306*	*481.852*	*29.547*	*37.170*	*4.908*	*10.646*	*0.460*

Correlation among studied characters

The correlations are helpful in determining the principal components influencing final grain yield, they provide an incomplete representation of the relative importance of direct and indirect influences on the individual factors involved ***[30]***. Determining correlation coefficient analysis among the studied characters shown in Table (2). Grain yield recorded positive and highly significant correlation with all studied characters. Plant height recorded positive and highly significant correlation with number of days to flowering, number of days to maturity, spike length, number of spikes/m^2, number of seeds/spike, 1000 grain weight, biological yield , and grain yield, in order (r= 0.872**, r= 0.860**, r= 0.627**, r= 0.597**, r= 0.696**, r= 0.527** ,r= 0.856** and r=882**), respectively. Some authors also reported positive and significant correlations between yield and plant height ***[31, 32***, ***33*** and ***34]***. Number of days to flowering exhibited positive and highly significant correlation with number of days to maturity, spike length, number of spikes/m^2, number of seeds/spike, 1000 grain weight, biological yield, harvest index and grain yield, in order (r= 0.996**, r= 0.779**, r= 0.477**, r= 0.882**, r= 0.749**, r= 0.808**, r= 0.456** and r= 912**), respectively. A number of days to maturity recorded positive and highly significant correlation with the spike length, number of spikes/m^2, number of seeds/spike. 1000 grain weight, biological yield, harvest index and grain yield, in order (r= 0.770**, r= 0.490**, r= 0.881**, r= 0.735**, r= 0.804**, r= 0.484** and r=925**), respectively. The previous researcher observed that days to 75% maturity had a positive correlation with 1000 grain weight. Plant height had a highly significant positive correlation with biological yield of plant; it suggested that with the increase in plant height there was highly significant increase in biological yield of plant ***[12]***.

Spike length exhibited positive and highly significant correlated with number of seeds/spike, 1000 grain weight, biological yield and grain yield, in order (r= 0.893**, r= 0.915**, r= 0.491** and r= 0.548**), respectively. The number of spikes/m^2 was recorded positive and highly significant correlation with biological yield and grain yield, in order (r= 0.788** and r=0.713**), respectively. The number of seeds/spike was recorded positive and highly significant correlated with 1000 grain weight, biological yield and grain yield, in order (r= 0.891**, r= 0.552** and r= 0.677**), respectively. Whereas correlated positive and significantly with harvest index, which was (r= 0.414*), 1000 grain weight recorded positive and highly significant correlation with biological yield and grain yield, in order (r= 0.402** and r= 0.478**), respectively. Biological yield correlation positive and highly significant with grain yield which was (r= 0.877**), and harvest index gave positive and highly significant correlated with grain yield was (r= 0.511**). Similar results are agreement with a Positive correlation of grain yield with number of seeds/spike, plant height, and 1000 grain weight, with support the present studies ***[35*** and ***36]***. Positive and highly significant correlations recorded between grain yield and harvest index reported by ***[37]***.

Table-2: Correlation coefficient analysis among the studied characters.

Characters	Plant height (cm)	No. of days to flowering	No. of days to maturity	Spike length (cm)	No. of spikes/ m^2	No. of seeds/spike	1000 grain weight (g)	Biol. yield (ton/ha)	Harvest index	Grain yield (ton/ha)
Plant height (cm)	1									
No. of days to flowering	0.872**	1								
No. of days to maturity	0.860**	0.996**	1							
Spike length (cm)	0.627**	0.779**	0.770**	1						
No. of spikes/m^2	0.597**	0.477**	0.490**	$0.037^{n.s}$	1					
No. of seeds/spike	0.696**	0.882**	0.881**	0.893**	$0.097^{n.s}$	1				
1000 grain weight (g)	0.527**	0.749**	0.735**	0.915**	$-0.050^{n.s}$	0.891**	1			
Biol. yield (ton/ha)	0.856**	0.808**	0.804**	0.491**	0.788**	0.552**	0.402**	1		
Harvest index	$0.322^{n.s}$	0.456**	0.484**	$0.271^{n.s}$	$0.075^{n.s}$	0.414*	$0.288^{n.s}$	$0.047^{n.s}$	1	
Grain yield (ton/ha)	0.882**	0.912**	0.925**	0.548**	0.713**	0.677**	0.478**	0.877**	0.511**	1

*. Correlation is significant at the 0.05 level (2-tailed) , $t_{0.05}(34)=2.032$

**. Correlation is significant at the 0.01 level (2-tailed) , $t_{0.01}(34)=2.728$

Path coefficient analysis

Grain yield in wheat is a complex character and is the product of several participating factors affecting yield directly or indirectly. These factors influence grain production both directly and indirectly and the breeder is naturally interested in investigating the extent and type of association of such characters ***[10]***.

From the results in Table (3), it can be noticed that the number of days to maturity produced the highest positive direct effect on the grain yield, which was (0.657) and followed by biological yield (ton/ha) which was (0.650). The number of days to flowering with (-0.425) recorded maximum negative direct effect on grain yield. The character number of days to flowering recorded maximum positive indirect effect in grain yield via number of days to maturity with (0.654) and followed by number of seeds/spike via number of days to maturity was (0.579), while the maximum negative indirect effect recorded by number of days to maturity via number of days to flowering reaching with (-0.423) and followed by number of seeds/spike via number of days to flowering which was (-0.375).

By studying the relation between production and some quantitative characters of wheat, path analysis recorded that plant high had a direct effect on yield ***[38]***. In an investigation on relations between the most important morphological indicators with grain yield demonstrated that the highest direct effect on grain yield belongs to biological yield, they confirm that biological yield can be used as criteria for selection aimed at improving the yield of wheat grain ***[23]***. The positive direct effect on grain yield was also exhibited by grains/spike, while spike length had a negative direct effect on grain yield ***[22]***. Path coefficient analysis revealed the positive direct effect of days to %50 flowering, plant height, number of seeds/spike and the biological yield on grain yield. These characters were limited as most important for selection and improvement of grain yield in the rain-fed wheat breeding program ***[39]***.

Table-3: Estimates of direct and indirect effects, obtained by path coefficient analysis, between the yield components on grain yield.

Characters	*Plant height (cm)*	*No. of days to flowering*	*No. of days to maturity*	*Spike length (cm)*	*No. of spikes/m²*	*No. of seeds/ Spike*	*1000 grain weight (g)*	*Biol. yield (ton/ha)*	*Harvest index*
Plant height (cm)	***0.032***	*0.028*	*0.027*	*0.020*	*0.019*	*0.022*	*0.017*	*0.027*	*0.010*
No. of days to flowering	*-0.370*	***-0.425***	*-0.423*	*-0.331*	*-0.203*	*-0.375*	*-0.318*	*-0.343*	*-0.194*
No. of days to maturity	*0.565*	*0.654*	***0.657***	*0.506*	*0.322*	*0.579*	*0.483*	*0.528*	*0.318*
Spike length (cm)	*-0.017*	*-0.021*	*-0.021*	***-0.027***	*-0.001*	*-0.024*	*-0.025*	*-0.013*	*-0.007*
No. of spikes/m²	*0.020*	*0.016*	*0.016*	*0.001*	***0.033***	*0.003*	*-0.002*	*0.026*	*0.002*
No. of seeds/spike	*0.005*	*0.007*	*0.007*	*0.007*	*0.001*	***0.008***	*0.007*	*0.004*	*0.003*
1000 grain weight (g)	*-0.026*	*-0.037*	*-0.037*	*-0.046*	*0.002*	*-0.044*	***-0.050***	*-0.020*	*-0.014*
Biol. yield (ton/ha)	*0.557*	*0.525*	*0.523*	*0.320*	*0.512*	*0.359*	*0.262*	***0.650***	*0.031*
Harvest index	*0.117*	*0.165*	*0.175*	*0.098*	*0.027*	*0.150*	*0.104*	*0.017*	***0.362***
Grain yield Correlation	***0.882****	***0.912****	***0.925****	***0.548****	***0.713****	***0.677****	***0.478****	***0.877****	***0.511****

Conclusion

Our results obtained from bread wheat (Adana-99) revealed that the interaction effect between planting dates and plant densities on grain yield and its components showed that grain yield correlated highly significant and positively with all the characters. Path coefficient analysis reported that number of days to flowering, spike length and 1000 grain weight in grain yield weakly negative. The direct effect of plant height, number of days to maturity, number of spikes/m^2, number of seeds/spike, biological yield and harvest index was hardly positive, while the number of days to flowering, spike length, and 1000 grain weight had a strongly negative effect. Therefore, the characters of the number of days to flowering, spike length, and 1000 grain weight would be the appropriate selection criteria raise grain yield in bread wheat.

References

[1] Ijaz, S. and Khan, I.A. "*Molecular characterization of wheat germplasm using microsatellite markers*". Genet Mol Res. Vol. (8), No.3, pp:809-815. (2009).

[2] Jolánkai, M., Szentpétery, Z.S., Hegedůs, Z. "*Pesticide residue discharge dynamics in wheat grain*". Cereal research communications. Vol. (34), No.1, pp:505-509. (2006).

[3] Falaki, A.M., Miko, S., Mohammed, I.B., Abubakar, I.U. and Valencia, J.A. "*Evaluation of some improved bread wheat varieties at Chiyako, Jigawa state, Nigeria*". ARPN Journal of Agricultural and Biological Science. Vol. (4), No.4, pp:4. (2009).

[4] Chhibber, S. and Jain, D. "*Inter correlation studies among yield and its contributing traits in bread wheat genotypes grown in Haryana, India* (*Triticum aestivum* L.) ". International Journal of Current Research and Review, Vol. (6), No.12, pp:12. (2014).

[5] Reza, Nasri, A. K., Farzad P., Saeed V. and Barry, M. "*Correlation, path analysis and stepwise regression in yield and yield component in wheat* (*Triticum aestivum* L.) *under the temperate climate of Ilam province*, *Iran*". Indian Journal of Fundamental and Applied Life Sciences, Vol. (4), No.4, pp:188-198. (2014).

[6] Gelalcha, S. and Hanchinal, R. "*Correlation and path analysis in yield and yield components in spring bread wheat* (*Triticum aestivum* L.) *genotype under the irrigated condition in Southern India*". African Journal of Agricultural Research, Vol. (8), No.24, pp:3186-3192. (2013).

[7] Iftikhar, R., Khaliq, I., Kashif, M., Ahmad, M. and Ullah, S. "*Study of morphological traits affecting grain yield in wheat* (*Triticum aestivum* L.) *under field stress condition*". Middle-East Journal of Scientific Research, Vol. (11), pp:19-23. (2012).

[8] Mohammadi, M., Sharifi, P., Karimizadeh, R. and Shefazadeh, M. K. "*Relationships between grain yield and yield components in bread wheat under different water availability (dry land and supplemental irrigation conditions)*". Notulae Botanicae Horti Agrobotanici Cluj-Napoca, Vol. (40), No.1, pp:195. (2012).

[9] Tsegaye, D., Dessalegn, T., Dessalegn, Y. and Share, G. "*Genetic variability, correlation and path analysis in durum wheat germplasm* (*Triticum durum* Desf)". Agricultural Research and Reviews, Vol. (1), No.4, pp:107-112. (2012).

[10] Zafarnaderi, N., Charizad, S. and Mohammadi, S. "*Relationship between grain yield and related agronomic traits in bread wheat recombinant inbred lines under water deficit condition*". Annals of Biological Research, Vol. (4), No.4, pp:7-11. (2013).

[11] Ali, I. and Shakor, E. "*Heritability, variability, genetic correlation and path analysis for quantitative traits in durum and bread wheat under dry farming conditions*". Mesopotamia Journal of Agriculture, Vol. (40), No.4, pp:27-39. (2012).

[12] Anwar, J., Ali, M., Hussain, M., Sabir, W., Khan, M., Zulkiffal, M. and Abdullah, M. "*Assessment of yield criteria in bread wheat through correlation and path analysis*". Journal of Animal and Plant Sciences, Vol. (19), No.4, pp:185-188. (2009).

[13] Bhutta, W. M., Akhtar, J., Anwar-ul-Haq, M. and Ibrahim, M. "*Cause and effect relations of yield components in spring wheat* (*Triticum aestivum* L.) *under normal conditions*". Caderno de Pesquisa Sér. Bio., Santa Cruz do Sul, Vo. (17), No.1, pp:7-12 (2005).

[14] Bhutto, L.A., Soomro, Z.A., Ansari, B.A., Jarwar, A.R., Jalbani, B.H. "*Estimation of phenotypic correlation between grain yield and Its main components in Brassica species*". Indus J. of P Sci. Vol. (3), No.4, pp:327-331. (2005).

[15] Meyari, S., Nouri F., Sasani, S., Najafian, G. and Aghayari, F. "*Correlation and path analysis of grain yield and its components of some bread wheat (Triticum aestivum L.) under normal and source restriction conditions*". Int. J. Farming and Allied Sci. Vol. (2), No.23, pp:1065-1069.

[16] Khayatnezhad, M., Zaefizadeh, M., Gholamin, R. and Jamaati-e-Somarin, Sh. "*Study of Genetic Diversity and Path Analysis for Yield in Durum Wheat Genotypes under Water and Dry Condition*". World Applied Sciences Journal, Vol. (9), No.6, pp:655-665. (2010).

[17] Zakizadeh, M., Esmaeilzadeh, M. and Kahrizi, D. "*Study on genetic variation and relationship between plant characteristics and grain yield in long spike bread wheat* (*Triticum aestivum* L.) *genotypes-using multivariate analysis*". Iranian Journal of Crop Sciences, (in Persian),Vol. (12), No.2, pp:18-30. (2010).

[18] Amri, M., Kazemi-Arbat, H. and Rustaei, M. "*Relation Ships of some morphologic and physiologic traits with grain yield and its components in wheat* (*Triticum aestivum* L.)". The 1th national conference of new concepts in agriculture. Islamic Azad University. Savah branch. (2011).

[19] Foroozanfar, M., Bihamta, M.R., Peyghambary, A. and Zeynali, H. "*Evaluation of Bread Wheat Genotypes Under Normal and Water Stress Conditios SNPs for Agronomic Traits*". The Science of Sustainable Agriculture Journal. No.21, pp:33-46. (2011).

[20] Taleei, A. and Bahram-Nejad, B. "*A Study of Relationship Between Yield and Its Components in Landrace Populations of Wheat from Western Parts of Iran Using Multivariate Analysis*". Iranian Journal of Crop Sciences. Sci. Vol. (34), No.4, pp:949-959. (2003).

[21] Mohammadi, A., Majidi, E., Bihamta, M.R. "*Heidari Sharifabad S. Evaluation of drought stress on agro - morphological characteristics in some wheat cultivars*". Pajouhesh & Sazandegi, No.73,pp:184-192. (2007).

[22] D.K. Ayer, A. Sharma, B.R. Ojha and A. Paudel and K. Dhakal. "*Correlation and path coefficient analysis in advanced wheat genotypes*". SAARC. J. Agri. Vol. (15), No.1, pp:1-12. (2017).

[23] Mollasadeghi, V.A.A. Imani, R. Shahryari and M. Khayatnezhad. "*Correlation and path analysis of morphological traits in different wheat genotypes under end drought stress condition*". Middle-East Journal of Scientific Research, Vol. (7). No.2, pp:221-224. (2011).

[24] Sing, R.K. and Chaudhary, B.D. "*Biometrical Methods in Quantitative Genetic Analysis*". Rev. ed, Kalyani Publishers, Ludhiana, New Delhi. India. pp:318. (1985).

[25] Dewey, D.R. and Lu, K.H. "*A correlation and path-coefficient analysis of components of crested wheatgrass grain production*". Agronomy Journal. Vol. (51), pp:515-518. (1959).

[26] Soomro, Z.A. "*Estimation of gene action and selection parameter in quantitative and qualitative traits of (Gossypium hirsutum* L.)", Ph.D. Thesis, Sindh Agri. Unv. Through department of plant breeding and genetics, Faculty of crop production, Tandojam, (2010).

[27] Arbuckle, J.L. "*Amos 18 Users, Guide. Amos Development Corporation*". SPSS Inc., USA. ISBN-13: 978-1-56827-404-1, (2009).

[28] Sreelatha, D., Rao, K.L, Veeraraghavaiah, R. and Padmaja, M. " *Physiological variations in French bean cultivars as affected by sowing dates*". Ann. Agric. Res. Vol. (18), pp:111-114. (1997).

[29] Korres, N.E., Froud-Williams, R.J. "*Effect of winter wheat cultivars and seed rate on the biological characteristics of naturally occurring weed flora*". Weed Res. Vol. (42), No.6, pp: 417. (2002).

[30] L. F. Garcia del Moral, J. M. Ramos, M. B. Garcia del Moral, and M. P. "*Jimenez- Tejada, Ontogenetic approach to grain production in spring barley based on path coefficient analysis*". Crop Sci., Vol. (31), pp:1179-1185. (1991).

[31] Subhani, G.M. and I. Khaliq. "*Path coefficient analysis in wheat*". Pakistan Journal of Scientific and Industrial Research, Vol. (37), No.11, pp:474-476. (1994).

[32] Chaturvedi, B.K. and R.R. Gupta. "*Selection parameters for some grain and quality attributes in spring wheat* (*Triticum aestivum* L.)". Agricultural Science Digest Kernal, Vol. (15), No.4, pp:186-190. (1995).

[33] Sharma, D.J., R.K. Yadav, and R.K. Sharma. "*Genetic variability and association of some yield components in winter-spring nursery of wheat*". Advances in Plant Sciences, Vol. (8). No.1, pp:95-99. (1985).

[34] Khan, H.A., Shaik, M.and Mohammad S. "*Character association and path coefficient analysis of grain yield and yield components in wheat*". Crop Research Hisar. Vol. (17), No.2, pp:229-233. 1999.

[35] Belay, S., Struik, P.C., Nachit, M.M. and Peacock, J.M. "*Ontogenic analysis of yield components and yield stability of durum wheat in water- limited environments*". Euphytica Vol. (71), No.3, pp:211-219. (1993).

[36] Aycecik, M. and Yildirim, T. "*Path coefficient analysis of yield and yield components in bread wheat* (*Triticum aestivum* L.) *genotypes*". Pak J. Bot. Vol. (38), No.2, pp:417-424. (2006).

[37] Sherwan I. T., Sh. H. Abdulqader, D. A. Abdulkhaleq and Sh. J. Hama. "*The Simple Correlation and Path Coefficient Analysis for Yield and Some Yield Components of Durum Wheat in Two Seasons in Iraqi Kurdistan*". Vol. (18), No.3, pp:323-332. (2016).

[38] Hoxha, S., and H. Sulovari. "*The relation of the production with some quantitative characteristic hard wheat literature up date on wheat, barley and Triticaly*". CIMMYT. Vol. (5), No.6. (1999).

[39] Anjani K. S., S. B. Singh, A.P. Singh and A. K. Sharma. "*Genetic variability, characters association and path analysis for seed yield and its component characters in wheat* (*Triticum aestivum* L.) *under rainfed environment*". Indian J. Agric. Res., Vol. (46), No.1, pp: 48-53. (2012).

Appendix 1: Calculated (t)

Characters	Plant height (cm)	No. of days to flowering	No. of days to maturity	Spike length (cm)	No. of spikes/ m^2	No. of seeds/spike	1000 grain weight (g)	Biol. yield (ton/ha)	Harvest index	Grain yield (ton/ha)
Plant height (cm)										
No. of days to flowering	10.365**									
No. of days to maturity	9.843**	63.098**								
Spike length (cm)	4.687**	7.254**	7.040**							
No. of spikes/m^2	4.334**	3.163**	3.281**	$0.215^{n.s}$						
No. of seeds/spike	5.658**	10.922**	10.848**	11.547**	$0.569^{n.s}$					
1000 grain weight (g)	3.617**	6.596**	6.321**	13.205**	$-0.292^{n.s}$	11.446**				
Biol. yield (ton/ha)	9.667**	7.986**	7.891**	3.290**	7.451**	3.857**	2.561*			
Harvest index	$1.986^{n.s}$	2.987**	3.224**	$1.644^{n.s}$	$0.441^{n.s}$	2.652*	$1.755^{n.s}$	$0.276^{n.s}$		
Grain yield (ton/ha)	10.940**	12.947**	14.231**	3.822**	5.936**	5.369**	3.174**	10.645**	3.470**	

**. Correlation is significant at the 0.05 level (2-tailed) ,* $t_{0.05}(34)=2.032$

***. Correlation is significant at the 0.01 level (2-tailed) ,* $t_{0.01}(34)=2.728$