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Correlation and path coefficient analysis of some quantitative traits in wheat (*Triticum aestivum* L.)

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Abstract
aSHIATS, Allahabad India, The data was recorded from each line for sixteen quantitative characters to obtain information among 30 genotypes of wheat. Result revealed that significant positive correlation of seed yield per plant existed with days to maturity, grain filling period, and number of spikelets per spike, harvest index and negative association with spike length with awn, thereby, allowing selection criteria of the plant materials for yield improvement. Yield contributing characters like number of productive tillers per plant, grain filling period, number of spikelet per spike and weight of 1000 kernel had highest positive direct effects on grain yield. The traits days to 50% heading, days to 50% flowering, flag leaf length, number of productive tillers per plant, grain filling period, number of grain per spike, number of spikelet per spike, weight of 1000 kernel, harvest index and Grain weight per spike are the major determinants on grain yield.

Keywords: Correlation and Path Coefficient analysis in bread wheat. (*Triticum aestivum* L.)

Introduction

Wheat (*Triticum aestivum* L.) is an important cereal crop of cool climates, and plays an important role in the food and nutritional security of India. In India, 86% of the cultivated area under wheat represents hexaploid spring type belonging to (*Triticum aestivum* L). More commonly called bread wheat. Wheat is widely grown in the world and stands first among the cereals both in area and production (Singh *et al*. 2008) [20]. Most of the agronomic characters in crop plants are quantitative in nature. Yield is one such character that results due to the actions and interactions of various component characters (Grafius, 1960) [11]. This is a complex quantitative character, which is influenced by a number of yield contributing characters. So, the selection for desirable types should not only be based on yield, the other yield components should also be considered. It is also widely recognized that genetic architecture of yield can be resolved better by studying its component characters. This enables the plant breeder to breed for high yielding genotypes with desired combinations of traits. Linear correlation between yield and several of its components can present a confusing picture due to inter-relationships between component characters themselves. Yield contributing components are interrelated with each other by bonding a complex relationship and also highly influenced by the environmental conditions. Understanding the relationship between yield and its components is of paramount importance for making the best use of these relationships in selection. Direct selection for yield is often misleading in wheat because wheat yield is polygenically controlled. For effective utilization of the genetic stock in crop improvement, information of mutual association between yield and yield components is necessary. It is, therefore, necessary to know the correlation of various component characters with yield and among themselves. The correlation coefficients between yield and yield components usually show a complex chain of interacting relationship. Path coefficient analysis partitions the components of correlation coefficient into direct and indirect effects and illuminates the relationship in a more meaningful way. The success of a breeding program depends largely upon the amount of genetic variability present in the population and the extent to which the desired traits are heritable. Grain yield has been reported to be influenced by
high direct effects of number of tillers per plant and flag leaf area, the number of grains per
panicle and 1000-grain weight (Yang 1986), grains per panicle, days to maturity, number of productive tillers, days to flowering (Sadeghi 2011) and panicle length and grains per panicle (Ullah *et al.* 2011). Partitioning of total correlation into direct and indirect effect by path analysis helps to select genotype most effectively (Falconer 1989). Therefore, an attempt was undertaken to estimate genetic variability, association among desired traits and their direct and indirect effects towards grain yield of wheat. The objective of this study was to establish the inter-relationship and direct and indirect effects of various wheat components among themselves and with yield.

Materials and Methods

The experimental material comprised of thirty diverse wheat genotypes along with check NW 4035 obtained from Genetics and Plant Breeding SHIATS, Allahabad. The experiment was laid out in Randomized Block Design with three replications during *Rabi* 2014-15 at Field Experimentation Centre, Department of Genetics and Plant Breeding, SHIATS, Allahabad. Each genotype was sown in single row of 2 meter length following a spacing of 22.5cm between rows and 5 cm between plant. The recommended doses of fertilizers @ 120:60:60 N: P_2O_5: K_2O kg per hectare was applied and all recommended agronomic package of practices were follow for raising normal healthy crop. The data was recorded on five randomly selected plants for each lines for 16 quantitative traits *viz.*, days to 50% heading, days to 50% flowering, flag leaf length(cm), flag leaf width(cm), plant height(cm), days to maturity, number of productive tillers per plant, grain filling period, number of spikelet per spike, number of grain per spike, grain weight per spike(g), spike length(cm), harvest index, weight of 1000 kernel(g), biological yield per plant(g) and yield per plant(g). The statistical procedure as suggested by Panse and Sukhatme (1961), Wright (1921, 1960) and elaborated by Dewey and Lu (1959) [7] was adopted for estimation of direct and indirect contribution of various characters to grain yield calculated through Path coefficient analysis.

Results

Highly significant and positive correlation with seed yield was found for days to maturity (0.46), grain filling period (0.42), and number of spikelets per spike (0.35), harvest index (1.06) (Table 1) at genotypic level, whereas negative association was seen between seed yield and spike length with awn (-0.26). While at the phenotypic level however (table 2), grain filling period, number of spikelet per spike and harvest index showed positive correlation with seed yield. These results are in conformation with Subhashchandra *et al.* (2007), Inamullah *et al*. (2006) [12], Singh *et al.* (2003), Mondal *et al.* (2004), Singh *et al*. (1998), Kumar *et al.* (1986) and Buller *et al*. (1985).

Correlation coefficient analysis at genotypic level (r_g) (Table -1)

Among the yield components, days to 50% heading showed significant and positive correlation with days to 50% flowering (0.76), plant height (0.29), flag leaf length (0.27), spike length with awn (0.42), days to maturity (0.72), number of spikelet per spike (0.54). (Add discussion)

Significant and positive correlation for days to 50% flowering with flag leaf length (0.45), flag leaf width (0.38),number of productive tillers per plant (0.22),spike length with awn (0.54), days to maturity (0.74),number of spikelet per spike (0.28) and grain weight per spike (0.39). The trait number of productive tillers per plant showed positive correlation with days to maturity (0.58) and number of grain per spike (0.42). Spike length with awn also showed positive significant correlation with weight of 1000 kernel (0.49) and grain weight per spike (0.25). Days to Maturity also showed positive significant correlation with number of grain per spike (0.50), number of spikelet per spike (0.54), harvest index (0.23) and grain weight per spike (0.22). Grain filling period exhibited positive significant association with number of grain per spike (0.29) and harvest index (0.43). Number of grain per spike also showed positive significant correlation with number of spikelet per spike (0.60) and harvest index (0.22). Significant and positive correlation was found between number of spikelet per spike and harvest index (0.35). Significant and positive correlation was found between weight of 1000 kernel and Grain weight per spike (0.34).

Correlation coefficient analysis at phenotypic level (r_p) (Table -2)

Days to 50% heading showed positive significant correlation with days to 50% flowering (0.73), plant height (0.29), flag leaf length (0.24) spike length with awn (0.34) days to maturity (0.73) and number of spikelet per spike (0.35). Days to 50% flowering showed positive significant correlation with flag leaf length (0.33) Number of productive tillers per plant (0.22) spike length with awn (0.39) days to maturity (0.45) and grain weight per spike (0.25). Number of productive tillers per plant flowering showed positive significant correlation with days to maturity (0.34). Spike length with awn (cm) showed positive significant correlation with weight of 1000 kernel (0.36) and grain weight per spike (0.23). Days to Maturity showed positive significant correlation with grain filling period (0.32) and number of spikelet per spike (0.24). Number of grain per spike showed positive significant correlation with number of spikelet per spike (0.43). Weight of 1000 kernel showed positive significant correlation with grain weight per spike (0.35).

Path coefficient analysis. Path coefficient analysis was carried out using coefficient of all the traits with grain yield plant (Table 3). Maximum direct effect on grain yield plant was contributed mostly by number of spikelets per spike, followed by number of grains per spike (2.92) and 1000-seed weight (0.96). The high direct effect from days taken to 50% heading came *via* number of spikelet per spike (-0.14), but spikelets plant recorded negative indirect effect. The flag leaf area did not reveal prominent indirect effects *via* other traits on the grain yield plantSpike length recorded a high positive indirect effect *via* grains spikelet, and high indirect effect *via* number of spikelets per spike on theyield per plant. Number of grains per spike caused a high negative indirect effect *via* grains per spike on the grain yield plant. Number of·spike revealed high negative indirect effect *via* effective tillers per plant on the yield plant. Days taken to maturity did not show a indirect effect *via* other traits on the grain yield plant. Plant height showed a moderate positive indirect effect via grains spikelet on the grain yield plant. The most significant and high indirect effect on the grain yield plant was evident from effective tillers plant and grains per spike *via* spikelets plant and in case of 1000-kernel weight *via*, grains spikelet. negative indirect effect *via* effective tillers plant on the yield per plant.Days taken to maturity did not show a indirect effect *via* other traits on the yield per plant. Plant height showed a moderate positive indirect effect via grains spikelet on the yield per plant. The most significant and high indirect effect on the yield per plant was evident from effective tillers plant and grains per spike *via*number of spikelets per plant and in case of 1000-kernel weight *via*, grains per spike.

Result Discussion

The genotypic correlation coefficient value for most of the characters were higher in magnitude than the corresponding phenotypic values showing the existence of inherent association among the traits. In the present study, grain yield was positively and significantly correlated with spike length, number of spikelets per spike and number of grains per spike. This is in good agreement with the findings of Gupta *et al.* 1999 and Khan *et al.* 2003. It suggests that yield per plant would increase with increase of these characters. Number of spikelets per spike, harvest index and days to maturity were positively correlated with grain yield. Among the studied characters spikes per plant and grains per spike are the primary yield components and harvest index is the most important physiological trait. Similar association in winter wheat was also reported by Sharma *et al.* (1995) [18] and Shoran (1995) [19].

High positive correlation coefficient reveals that selection based on number of spikes, number of spikelets per spike and number of grains per spike has an equal contribution towards increasing the grain yield. The positive correlation coefficients of grain yield with most of the traits implying that improving one or more of the traits could result in high grain yield for bread wheat. Path coefficient analysis provides an effective means of partitioning correlation coefficients into unidirectional pathway and alternate pathways and thus permits a critical examination of specific factors that produce a given correlation and can be successfully employed in formulating an effective selection strategy Larik (1979) [16]. Mutual relationship between grain yield and its contributing characters revealed that in most of the cases the genotypic correlation coefficient were higher than the phenotypic correlation coefficient indicating the strong inherent relation between the traits but suppressing the effect of the environment, hence which modified the phenotypic expression of these characters by reducing phenotypic coefficient values. Such environmental influence in reducing correlation coefficients in bread wheat was also reported by Agarawal *et al.* (1977) [1] and Deswal *et al.* (1996) [6]. Results show that the direct effects of grain yield with number of spikelets per spike were positive indicating that increase in number of spikelets per spike directly associated with increase in number of grains per spike, 1000-seed weight and ultimately the grain yield per plant. Since these traits had positive phenotypic and genotypic direct effect and correlation with grain yield suggesting the possibility of improving grain yield through direct selection of these traits.

Conclusion

The present study illustrated the existence of wide ranges of variations for most of the traits among durum wheat genotypes and opportunities of the genetic gain through selection or hybridization. Phenotypic and genotypic correlation analysis showed the positive correlation of grain yield with important agro-morphological characters. Hence, improving one or more of the traits could result in high grain yield for bread wheat. Number of spikelets per spike, number of grains per spike and 1000-seed weight had positive phenotypic and genotypic direct effect and correlation with grain yield suggesting the possibility of improving grain yield through direct selection of these traits.

Table 1: Genotypic correlation (rg) of yield with yield contributing characters

Characters	**Days to 50% heading**	**Days to 50% flowering**	**Plant height(cm)**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Number of productive tillers per plant**	**Spike length with awn (cm)**	**Days to maturity (days)**	**Grain filling period**	**Number of grain per spike**	**Number of spikelet per spike**	**Weight of 1000 kernel (g)**	**Harvest index (%)**	**Grain weight per spike(g)**	**Yield per plant (g)**
Days to 50% heading	1.00	0.76**	0.29**	0.27**	0.52**	0.13	0.42**	0.72**	-0.53**	0.01	0.54**	-0.02	0.02	0.20	0.06
Days to 50% flowering		1.00	0.05	0.45**	0.38**	0.22*	0.54**	0.74**	-0.85**	-0.01	0.28**	0.04	-0.32**	0.39**	-0.10
Plant height (cm)			1.00	0.18	0.24*	-0.48**	0.32**	0.25*	0.07	0.06	0.31**	0.59**	-0.10	0.26*	0.14
Flag leaf length(cm)				1.00	0.07	0.12	0.48**	-0.04	-0.66**	-0.08	-0.00	-0.00	0.45**	0.23*	0.14
Flag leaf width(cm)					1.00	-0.19	0.38**	0.17	-0.18	0.01	0.52**	0.24*	0.20*	0.48**	0.30
Number of productive tillers per plant						1.00	-0.15	0.58**	0.15	0.42**	0.12	-0.60**	-0.07	-0.20	0.15
Spike length with awn (cm)							1.00	0.10	-0.60**	-0.24*	0.13	0.49**	-0.17	0.25*	-0.26*
Days to Maturity								1.00	-0.19	0.50**	0.54**	-0.23*	0.23*	0.22*	0.46**
Grain filling period									1.00	0.29**	0.01	-0.12	0.43**	-0.41**	0.42*

															*
Number of grain per spike										1.00	0.60**	-0.59**	0.22*	0.07	0.19
Number of spikelet per spike											1.00	-0.27**	0.35**	-0.01	0.35**
Weight of 1000 kernel												1.00	-0.10	0.34**	-0.11
Harvest index (%)													1.00	0.01	1.06**
Grain weight per spike(g)														1.00	0.13
Total yield per plant(g)															1.00

*,** Significant at 1.0 and 5.0 per cent levels, respectively

Table 2: Phenotypic correlation (rp) of yield with yield contributing characters

Characters	**Days to 50% heading**	**Days to 50% flowering**	**Plant height(cm)**	**Flag leaf length (cm)**	**Flag leaf width (cm)**	**Number of productive tillers per plant**	**Spike length with awn (cm)**	**Days to maturity (days)**	**Grain filling period**	**Number of grain per spike**	**Number of spikelet per spike**	**Weight of 1000 kernel (g)**	**Harvest index (%)**	**Grain weight per spike(g)**	**Yield per plant (g)**
Days to 50% heading	1.00	0.73**	0.29**	0.24*	0.17	0.12	0.34**	0.46**	-0.26*	-0.01	0.35**	-0.06	0.13	0.13	0.06
Days to 50% flowering		1.00	0.20	0.33**	0.18	0.22*	0.39**	0.45**	-0.59**	-0.04	0.16	-0.03	-0.03	0.25*	-0.05
Plant height (cm)			1.00	0.19	0.04	-0.26*	0.22*	0.11	0.08	0.03	0.15	0.30**	0.15	0.18	0.15
Flag leaf length(cm)				1.00	0.11	0.06	0.27**	0.02	-0.24*	0.04	0.04	-0.04	0.03	0.21*	0.15
Flag leaf width(cm)					1.00	-0.00	0.05	0.08	-0.13	0.10	0.23*	0.03	-0.06	0.11	0.10
Number of productive tillers per plant						1.00	-0.05	0.34**	0.08	0.01	0.05	-0.44**	-0.03	-0.17	0.04
Spike length with awn (cm)							1.00	0.07	-0.25*	-0.17	0.08	0.36**	-0.03	0.23*	-0.12
Days to Maturity								1.00	0.32**	0.04	0.24*	-0.21*	0.03	-0.05	0.17
Grain filling period									1.00	0.09	0.10	-0.11	0.16	-0.25*	0.29**
Number of grain per										1.00	0.43**	-0.17	0.12	0.10	0.1

spike															6
Number of spikelet per spike											1.00	-0.10	0.17	-0.03	0.30**
Weight of 1000 kernel												1.00	-0.08	0.35**	-0.10
Harvest index (%)													1.00	-0.07	0.38**
Grain weight per spike(g)														1.00	0.16
Total yield per plant(g)															1.00

*** Significant at 1.0 and 5.0 per cent levels, respectively

Table 3: Genotypic path analysis of direct and indirect effects of different quantitative characters

Characters	Days to 50% heading	Days to 50% flowering	Plant height (cm)	Flag leaf length (cm)	Flag leaf width (cm)	Number of productive tillers per plant	Spike length with awn (cm)	Days to Maturity	Grain filling period	Number of grain per spike	Number of spikelet per spike	Weight of 1000 kernel (g)	Harvest index (%)	Grain weight per spike(g)
Days to 50% heading	4.43	0.69	-1.29	0.58	-1.66	0.70	-1.32	-2.41	-1.73	0.01	1.88	-0.32	-0.07	0.57
Days to 50% flowering	3.43	0.89	-0.63	0.91	-1.20	1.33	-1.71	-2.51	-2.79	-0.03	0.98	0.50	-0.57	1.26
Plant height / cm	1.50	0.15	-3.80	0.62	-0.63	-2.33	-1.13	-1.01	0.20	0.07	1.04	4.73	-0.22	1.07
Flag leaf length/cm	1.36	0.43	-1.26	1.88	0.17	0.45	-1.80	0.79	-2.60	-0.11	-0.38	0.30	0.08	0.71
Flag leaf width/cm	2.03	0.29	-0.67	-0.09	-3.61	-1.77	-1.22	-0.59	-0.63	-0.02	1.90	2.50	0.57	1.54
Number of productive tillers per plant	0.80	0.30	2.28	0.22	1.65	3.89	0.73	-2.88	0.88	0.48	0.93	-7.51	-0.10	-1.86
Spike length with awn / cm	1.86	0.48	-1.37	1.08	-1.40	-0.90	-3.13	-0.35	-2.03	-0.20	0.49	4.62	-0.50	0.96
Days to Maturity	3.13	0.65	-1.13	-0.44	-0.63	3.29	-0.32	-3.40	-0.67	0.33	1.95	-2.26	-0.33	0.45
Grain filling period	-2.27	-0.74	-0.22	-1.45	0.68	1.02	1.89	0.68	3.37	0.22	0.07	-1.55	0.49	-1.52
Number of grain per spike	0.07	-0.04	-0.42	-0.31	0.09	2.77	0.95	-1.68	1.13	0.67	2.01	-6.25	0.87	0.18
No of spikelet per spike	2.32	0.24	-1.10	-0.20	-1.91	1.00	-0.43	-1.84	0.06	0.37	3.59	-2.37	0.76	-0.14
Weight of 1000 kernel	-0.17	0.05	-2.13	0.07	-1.07	-3.45	-1.71	0.91	-0.62	-0.49	-1.01	8.46	-0.54	1.49
Harvest index (%)	-0.34	-0.52	0.87	0.15	-2.12	-0.40	1.63	1.17	1.70	0.61	2.84	-4.75	0.96	1.00

Grain weight per spike/g	0.86	0.38	-1.40	0.45	-1.91	-2.48	-1.03	-0.53	-1.76	0.04	-0.17	4.32	0.33	2.92

Residual effect =0.243

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