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CORRELATION AND PATH COEFFICIENT ANALYSIS OF SOME QUANTITATIVE TRAITS IN WHEAT

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ABSTRACT

Wheat (*Triticum aestivum* L.) is an important cereal crop of cool climates, and plays a key role in the food and nutritional security of India. The objective of this study was to establish the inter-relationship and direct and indirect effect of various wheat components on yield. Thirty-seven wheat genotypes and three check varieties were studied for correlation and path coefficient analysis of some quantitative traits in wheat at Kisan (P.G), College, Simbhaoli in India. Generally, the estimates of genotypic correlation coefficients were higher than the corresponding phenotypic correlation coefficients for all the character combinations. Seed yield was significantly and positively associated with number of spikelets plant^{-1}, followed by number of effective tillers and 100-seed weight at both phenotypic and genotypic levels. Seed yield showed a significant negative association with number of seeds spikelet^{-1} at genotypic level. Among the significant inter-relationships, the association of days to 75% spike emergence with days to maturity and 100-seed weight were significant and positive, but were negative and significantly associated with number of seeds spikelet^{-1} and number of grains spike^{-1}. Similarly, the associations of spike length with number of seeds spikelet^{-1}, and number of spikelets plant^{-1} and number of effective tillers were negative and significant. The association of number of spikelets plant^{-1} with number of effective tillers was also positive and highly significant. Path coefficient analysis revealed that the magnitude of positive direct effect on seed yield was highest through number of spikelets plant^{-1}, followed by number of grains spike^{-1} and 100-seed weight; whereas protein content followed by number of seeds spikelet^{-1} and number of effective tillers exhibited high, but negative direct effect on seed yield plant^{-1}.

Key Words: Genotypic correlation, protein, *Triticum aestivum*

RÉSUMÉ

Le blé (*Triticum aestivum* L.) est une culture céréalière importante des climats plus frais, jouant un rôle clé dans la sécurité alimentaire et nutritionnelle de l'Inde. L'objectif de cette étude était d'établir les relations entre différents composants du blé et leurs effets directs et indirects sur le rendement. Trente-sept génotypes de blé et trois varietés-témoins ont été étudiés pour vérifier la corrélation et l'analyse du coefficient de certains caractères quantitatifs du blé au collège Kisan (PG) à Simbhaoli en Inde. Généralement, les estimations des coefficients de corrélation du génotype étaient plus élevées que les coefficients de corrélation phénotypique correspondante pour toutes les combinaisons de caractères. Le rendement en grains est significativement et positivement associé à un nombre d'épillets par plante, suivi par le nombre de talles effictives et le poids de 100 grains à la fois aux niveaux phénotypiques et génotypiques. Le rendement en grains a montré une association négative significative avec le nombre de grains par épillet au niveau du génotype. Parmi les inter-relations significatives, l'association des jours à 75% d' émergence d'épis avec des jours de la maturité ainsi que le poids de 100 grains a été significative et positive, mais était négative et significativement associée au nombre de grains par épillet et le nombre de grains par épis. De façon similaire, les associations de la longueur d'épis avec le nombre de grains par épillet, ainsi que le nombre d'épillets plante et le nombre de talles effectives ont été négatives et significatives. L'association du nombre d'épillets par plante avec le nombre de talles effectives était également positive et hautement significative. L'analyse du coefficient de passage a révélé que l'ampleur de l'effet direct positif sur le rendement des grains a été la plus élevée quant au nombre d'épillets par plante, suivie par le nombre de grains par épis et le poids de 100 grains, alors que la teneur en protéines suivie par le nombre de grains par épillet et le nombre de talles effectives, exhibaient un effet direct élevé mais négatif sur le rendement en grains par plante.

Mots Clés: Corrélation génotypique, protéines, T*riticum aestivum*

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.em. Thell., (Singh *et al.*, 2008) more commonly called bread wheat. Wheat is widely grown the world-over and stands first among the cereals both in area and production.

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). It is also widely recognised 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. 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

Thirty seven diverse wheat genotypes and three check varieties were used in this study. These lines were planted in a randomised block design at the Research Farm of Kisan (P.G.) College in India during *rabi* season of 2007-08. All the genotypes and checks were sown in a randomised complete block design with three replications. In each replication, 40 treatments were grown in 2 m long rows and the spacing of 25 cm between rows.

Initially, extra seed was planted which was later thinned to maintain an optimum population density. Ten randomly selected plants from each treatment were tagged for recording the observations on the following characters, viz., days to 75% spike emergence, area of flag leaf, spike length, number of grains spikelet$^{-1,}$ number of spikelets plant^{-1}, days to maturity, protein content, plant height, number of effective tillers, number of grains spike^{-1}, 100-seed weight and seed yield plant^{-1}.

The data were analysed using the procedure of Panse and Sukhatme (1961) for estimation of variance and coefficient of variances. Genotypic correlations were computed using variance and co-variances as suggested by Johnson *et al.* (1955). Path coefficient analysis was performed as suggested by Deway and Lu (1959).

RESULTS

Correlation coefficients at phenotypic and genotypic levels are presented in the Table 1. Significant ($P<0.05$) and positive correlations were observed between days to 75% spike emergence and days to maturity both at phenotypic and genotypic levels. A significant ($P<0.05$) and negative correlation existed at the genotypic level for days to 75% spike emergence with grains spikelet^{-1} and grains spike^{-1}. The area of the flag leaf showed no significant correlation with all the traits both phenotypic and genotypic. Similarly, spike length and grains spikelet^{-1} showed no significant ($P>0.05$) correlation with any other trait at the phenotypic level. However, at genotypic level, the spike length presented a positive significant correlation with plant height, but significant negative correlations with grains spikelet^{-1}, spikelets plant^{-1} and effective tillers plant^{-1}. Similarly, at the genotypic level, grains spikelet^{-1} revealed positive and significant correlation with grains spike^{-1}, but negative and

TABLE 1. Phenotypic and genotypic correlation coefficients among different morphological, maturity, yield and quality traits in wheat (*Triticum aestivum* L.) in India

Characters	Traits	1	2	3	4	5	6	7	8	9	10	11	12
Days to 75% spike emergence	P	1.000	0.132	0.130	-0.121	-0.106	0.382*	0.029	0.081	-0.035	-0.247	0.291	0.033
	G	1.000	0.106	0.160	-0.495**		0.378*	0.052	0.105	-0.037	-0.446**	0.470**	0.037
Leaf area of flag leaf (cm)	P		1.000	0.169	-0.066	-0.096	0.156	0.142	0.113	-0.124	-0.106	-0.059	-0.062
	G		1.000	0.214	-0.287	-0.110	0.145	0.146	0.113	-0.164	-0.211	-0.117	-0.060
Spike length (cm)	P			1.000	-0.123	-0.263	-0.133	0.030	0.272	-0.270	0.217	0.205	0.054
	G			1.000	-0.491**	-0.308*	-0.170	-0.051	0.349*	-0.308*	0.284	0.251	0.100
Grains spikelet^{-1}	P				1.000	-0.094	0.074	-0.084	-0.111	-0.018	0.151	-0.133	-0.006
	G				1.000	-0.114	0.060	-0.316*	-0.341*	-0.277	0.338*	-0.152	-0.362*
Spikelets plant^{-1}	P					1.000	0.013	-0.170	-0.081	0.780**	0.214	-0.101	0.617**
	G					1.000	0.053	-0.210	-0.098	0.871**	0.238	-0.131	0.759**
Days to maturity	P						1.000	0.128	-0.207	-0.055	0.037	0.070	0.005
	G						1.000	0.145	-0.247	-0.037	0.037	0.106	0.005
Protein content (%)	P							1.000	0.068	-0.326*	0.065	0.158	-0.220
	G							1.000	0.058	-0.404**	0.065	0.224	-0.263
Plant height (cm)	P								1.000	-0.059	-0.138	0.078	0.039
	G								1.000	-0.088	-0.160	0.118	0.060
Number of effective tillers	P									1.000	0.024	-0.035	0.628**
	G									1.000	0.038	-0.064	0.716**
Number of grains spike^{-1}	P										1.000	-0.116	0.210
	G										1.000	-0.192	0.242
100-seed weight (g)	P											1.000	0.270
	G											1.000	0.302*
Seed yield plant^{-1} (g)	P												1.000
	G												1.000

**, * Significant at 1.0 and 5.0 per cent levels, respectively; P = Phenotypic, G = Genotypic
1 = Days taken to 75% spike emergence, 2 = Leaf area index, 3 =Spike length (cm), 4 = Number of seeds spikelet^{-1}, 5 = Number of spikelets plant^{-1}, 6 = Days to maturity, 7 = Protein content (%), 8 = Plant height (cm), 9 = Number of effective tillers, 10 = Number of grains spike^{-1}, 11= 100-seed weight (g), and 12 = Grain yield plant^{-1} (g)

significant correlation with protein content, plant height and grain yield plant^{-1}. The number of spikelets plant^{-1} showed positive and significant correlation with effective tillers plant^{-1} and grain yield plant^{-1} at both the phenotypic and the genotypic levels. Days to maturity had no significant correlation with all the traits except days to 75% spike emergence at both levels.

Protein content was not significantly correlated with plant height, effective tillers plant^{-1}, grains spike^{-1}, 100-seed weight and grain yield plant^{-1} at both levels, except the negative correlation with effective tillers plant^{-1} at the genotypic level. Plant height showed no significant correlation with effective tillers plant^{-1}, grains spike^{-1}, 100-seed weight and grain yield plant^{-1} both at the phenotypic and genotypic levels. Similarly, grains spike^{-1} and 100-seed weight were not significantly correlated with each other or with grain yield plant^{-1} at the phenotypic and genotypic levels, except the positive correlation between 100-seed weight and grain yield plant^{-1} at the genotypic level.

Path coefficient analysis. Path coefficient analysis was carried out using coefficient of all the traits with grain yield plant^{-1} (Table 2). Maximum direct effect on grain yield plant^{-1} was contributed mostly by number of spikelets plant^{-1} (0.766), followed by number of grains spike^{-1} (0.295) and 100-seed weight (0.149). On the other hand, the maximum negative direct effect was exhibited by protein content (-0.329), followed by number of seeds spikelet^{-1} (-0.297) and number of effective tillers plant^{-1} (-0.170). The rest of the traits showed moderate to low positive or negative direct effect on grain yield plant^{-1}. The high direct effect from days taken to 75% spike emergence came *via* grains spikelet^{-1} (0.147), but spikelets plant^{-1} recorded negative indirect effect.

The flag leaf area did not reveal prominent indirect effects *via* other traits on the grain yield plant^{-1}. Spike length recorded a high positive indirect effect *via* grains spikelet^{-1}, and high indirect effect *via* spikelets plant^{-1} on the grain yield plant^{-1}. Grains spikelet^{-1} caused a high negative indirect effect *via* grains spike^{-1} on the grain yield plant^{-1}. Spikelets plant^{-1} revealed high

TABLE 2. Path analysis at (genotypic level) showing direct (bold values) and indirect effects different morphological, quantity and quality traits in wheat (*Triticum aestivum* L.) in India

Characters	Characters											Genotypic correlation with grain yield plant^{-1}
	1	2	3	4	5	6	7	8	9	10	11	
Days taken to 75% spike emergence	**0.099**	0.004	-0.008	0.147	-0.123	-0.015	-0.017	0.006	0.006	-0.132	0.070	0.037
Leaf area index (cm)	0.011	**0.039**	-0.011	0.085	-0.085	-0.006	-0.048	0.007	0.028	-0.062	-0.017	-0.060
Spike length (cm)	0.016	0.008	**-0.052**	0.146	-0.236	0.007	0.017	0.021	0.052	0.084	0.037	0.100
Seeds spikelet^{-1}	-0.049	-0.011	0.026	**-0.297**	-0.087	-0.002	0.104	-0.021	0.047	0.100	-0.171	-0.362*
Spikelets plant^{-1}	-0.016	-0.0 04	0.016	0.034	**0.766**	-0.002	0.069	-0.006	-0.148	0.070	-0.019	0.759**
Days to maturity	0.038	0.006	0.009	-0.018	0.041	**-0.040**	-0.048	-0.015	0.006	0.011	0.016	0.005
Protein content (%)	0.005	0.006	0.003	0.094	-0.160	-0.006	**-0.329**	0.004	0.069	0.019	0.033	-0.263
Plant height (cm)	0.010	0.004	-0.018	0.101	-0.075	0.010	-0.019	**0.061**	0.015	-0.047	0.018	0.060
Effective tillers	-0.004	-0.006	0.016	0.082	0.667	0.001	0.133	-0.005	**-0.170**	0.011	-0.009	0.716**
Grains spike^{-1}	-0.044	-0.008	-0.015	-0.100	0.182	-0.001	-0.021	-0.010	-0.007	**0.295**	-0.029	0.242
100-seed weight (g)	0.047	-0.005	-0.013	0.342	-0.100	-0.004	-0.074	0.007	0.011	-0.057	**0.149**	0.302*

Residual effect = 0.2313; **, * Significant at 1.0 and 5.0 per cent levels, respectively; 1 = Days taken to 75% spike emergence, 2 = Leaf area index, 3 =Spike length (cm), 4 = Number of seeds spikelet^{-1}, 5 = Number of spikelets plant^{-1}, 6 = Days to maturity, 7 = Protein content (%), 8 = Plant height (cm), 9 = Number of effective tillers, 10 = Number of grains spike^{-1}, 11 = 100-seed weight (g) negative indirect effect *via* effective tillers plant^{-1} on the grain yield plant^{-1}.

Days taken to maturity and protein content did not show a indirect effect *via* other traits on the grain yield plant^{-1}, except a negative effect in protein content via spikelets plant^{-1}. Plant height showed a moderate positive indirect effect via grains spikelet^{-1} on the grain yield plant^{-1}. The most significant and high indirect effect on the grain yield plant^{-1} was evident from effective tillers plant^{-1} and grains spike^{-1} *via* spikelets plant^{-1} and in case of 100-seed weight *via*, grains spikelet^{-1}.

DISCUSSION

Seed yield per plant was significantly and positively correlated with number of spikelets plant^{-1}, number of effective tillers and number of seeds spike^{-1} at genotypic level suggesting that plants with more tillers bear plenty of spikelets plant^{-1} and produce higher seed yield. The above findings conform with earlier reports (Kashif and Khaliq, 2004; Aycicek and Yildirim, 2006; Akram *et al.*, 2008).

The negative association of plant height with number of grains spike^{-1} (Table 1) is due to the fact that an increase in plant height leads to an increase in biological yield, thereby, decreasing the number of grains spike^{-1}. Dwarf wheat genotypes are, by and large, reported to be good yielders.

There was a highly significant negative association between days to 75% spike emergence with number of seeds spikelet^{-1} and days to 75% spike emergence with number of grains spike^{-1}, suggesting that indirect selection for earliness alone may not be beneficial to realise optimum yield.

Number of spikelets plant^{-1} showed highly significant and positive association with number of effective tillers and seed yield both at phenotypic and genotypic levels (Table 1). A significant positive association was found between 100-seed weight and seed yield, which is in agreement with the earlier reports of Bekele (1990). Similarly, days to 75% spike emergence were positively and significantly associated with days to maturity (Table 1) .

A significant positive association was also noticed between number of effective tillers and seed yield. Among other characters, spike length showed positive association with protein content, plant height, number of grains spike^{-1}, number of effective tillers and seed yield. Protein content was positively and significantly associated with number of effective tillers at phenotypic level (Table 1).

Overall, an intensive selection for number of effective tillers, days to 75% spike emergence, number of spikelets plant^{-1} and spike length will automatically improve seed yield in wheat. Since the four traits are correlated among themselves, selection in one of the traits will implicitly result in the improvement of the other traits.

Path coefficient analysis. Knowledge of correlation alone is often misleading as the correlation observed may not be always true. Two characters may show correlation just because they are correlated with a common third one. In such cases, it becomes necessary to use a method which takes into account the causal relationship between the variables, in addition to the degree of such relationship. Path coefficient analysis measures the direct influence of one variable upon the other, and permits separation of correlation coefficients into components of direct and indirect effects. Portioning of total correlation into direct and indirect effects provide actual information on contribution of characters and thus form the basis for selection to improve the yield.

Path coefficient analysis for seed yield showed that traits like number of spikelets plant^{-1}, number of grains spike^{-1}, and 100-seed weight showed highest positive direct effect towards seed yield (Table 2). This means that a slight increase in one of the above traits may directly contributes to seed yield. Similar results were reported by Dhonde *et al*. (2000) and Satya *et al*. (2002). The high positive indirect effect of number of effective tillers *via* number of spikelets plant^{-1} was responsible for its significant positive association with seed yield plant^{-1}. Rana and Sethi (1998) also found similar results.

For flag leaf area, the direct effect was positive, while its association with seed yield was negative, indicating the importance of restricted selection for exploitation of the direct effect noticed. The indirect contribution towards seed yield was exhibited by 100-seed weight *via* number of seeds spikelet^{-1}; while the maximum negative indirect contribution was exhibited by number of seeds spikelet^{-1} *via* 100-seed weight. The indirect contribution of number of spikelets plant^{-1} was positive *via* spike length, number of seeds spikelet^{-1} and protein content. Similarly, the indirect contribution of 100-seed weight was positive *via* days to 75% spike emergence, number of seeds spikelet^{-1} and number of effective tillers.

The present findings are similar to those of Baser *et al*. (2000), Aycecik and Yildirim (2006) and Inamullah *et al.* (2006). The number of grains spike^{-1} contributed positive indirect effect towards seed yield only through number of spikelets plant^{-1}.

Based on path coefficient analysis, the direct and indirect contribution of spikelets plant^{-1}; number of grains spike^{-1} and number of effective tillers plant^{-1} were maximum on seed yield. The above findings revealed that, whatever the character chosen for increasing the seed yield, the improvement could be achieved only through number of spikelets plant^{-1}. All the above characters exhibited indirect effect mostly through number of spikelets plant^{-1}, number of grains spike^{-1} and number of effective tillers. Hence, it may be concluded that number of spikelets plant^{-1} is the main trait which is responsible for the manipulation of seed yield in wheat. Selection for any other yield contributing character will reflect on seed yield only through number of spikelets plant^{-1}.

The residual effects were found to be moderate, which indicates that there may be some more components that are contributing towards seed yield.

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