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ASSESSMENT OF CAUSE AND EFFECT RELATIONSHIP BETWEEN DIFFERENT CHARACTER COMBINATIONS ON YIELD AND QUALITY OF BREAD WHEAT (*TRITICUM AESTIVUM* L.)

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Abstract

The entities of the exiting investigation consist of 20 promising lines of bread wheat that were laid in a randomized block design (RBD) with three replications, aiming to examine the correlation and path coefficient analysis with respect to eight quantitative/qualitative characters. The mutual association of plant characters is determined by the correlation coefficient whereas path analysis splits the correlation coefficient into the measure of direct and indirect effects so that the relative contribution of each component character to the yield could be assessed. The grain yield incredibly showed a considerable positive association with the number of effective tillers plant^{-1}, spike length, number of grains spike^{-1}, 1000 grain weight, and harvest index both at the genotypic and phenotypic levels. There was a negative and nominal association between grain yield and protein content whereas yield contributing characters observed a positive and insignificant relationship with protein content. Path analysis reflected that harvest index, 1000 grain weight, and the number of grains spike^{-1} acquired the greatest and positive direct effect with grain yield. Consequently, the current investigation divulged the significance of the number of effective tillers plant^{-1}, spike length, number of grains spike^{-1}, 1000 grain weight, and harvest index as selection criteria for the nomination of elite wheat lines in the breeding population for the advancement of yield in bread wheat.

Key words : Correlation coefficient, path analysis, wheat.

Introduction

High yield is the prime objective in all the breeding programmes, but yield is the dependent character that depends on the number of the constellation of yield contributing characters such as tiller plant-^{1} that contributes to raising plant population per unit area; spike length, grains spike^{-1}, 1000 grain weight which form "sink" and the harvest index which are considered directly related to yield (Abrar *et al*. 2011). Apart from that, yield has low heritability and direct selection is not sufficiently effective. Hence it is desirable to go for indirect selection for yield enhancement. Some biometrical techniques provide information about the relative contribution of various component traits towards yield and aid in the selection of superior genotypes from the breeding populations. Such techniques include correlation and path coefficient analysis (Singh and Narayanam, 2015). Mutual association of plant characters which is determined by the correlation coefficient is used to find out the degree (strength) and direction of the relationship between two or more variables. Thus, helps in determining the yield components on which indirect selection can be based on improvement in yield. Hence, knowledge of the association of the yield components with yield and among themselves would be helpful in enhancing the yield considerably. The degree of relationship is generally measured in terms of statistical correlation which varies from -1 to +1. Path coefficient analysis divides the correlation coefficient into the measure of direct and indirect effects so that the contribution of each component character to the yield could be assessed (Singh and Narayanam, 2015). The path analysis together with the correlation coefficient would give a better understanding of the cause and effect relationship between the different character combinations (Yasin and Singh, 2010). Therefore, an experiment was executed to select a strategy for higher production of wheat with the purpose to ascertain the mutual relationship among eight selected traits in bread wheat and find out path analysis of the characters having direct and indirect effects on yield.

Materials and methods

The essences for the current research comprises 20 promising wheat lines that were acquainted from IARI, New Delhi, and Durgapura Research Station, Jaipur-Rajasthan. Table 1 unveils actual information about the 20 bread wheat lines used in the present investigation. The field experiment with plant geometry of 1x5m was laid out in a randomized block design consisting of three replications at the experimental research farm, School of Agriculture, Suresh Gyan Vihar University, Jagatpura-Jaipur. Geographically, Suresh Gyan Vihar University is situated at 26.55 N latitude, 75.46 E longitude, and at an altitude of 431 m above sea level. All the recommended cultural practices were applied to grow a healthy wheat crop. The data was noted on eight characters *viz.,* number of effective tillers plant-1, spike length (cm), number of grains per spike, plant height (cm), harvest index (%), 1000 grain weight (gram), protein (%) and yield kg plot^{-1}, which were subjected to various biometrical and statistical analysis to estimate their mutual association and direct and indirect effect towards yield. The correlation coefficient from replicated data requires estimates of variances for different characters and covariance for various character combinations. The variance and covariance components used to compute the correlation coefficient among yield and yield attributes of bread wheat was work out as per the formula suggested by Nadaranjan and Gunasekaran (2008)

Genotypic correlation coefficient:

$$r_g = \frac{\sigma_{g(x.y)}}{\sqrt{\sigma^2_{gx} \cdot \sigma^2_{gy}}}$$

Phenotypic correlation coefficient:

$$r_p = \frac{\sigma_{p(x.y)}}{\sqrt{\sigma^2_{p_x} \cdot \sigma^2_{p_y}}}$$

Where r is the intensity of correlation between different variables, $\sigma_g\,(x.y)$ and $\sigma_p\,(x.y)$ are genotypic and phenotypic covariances respectively between the variable x and y. σ_g and σ_p are genotypic and phenotypic variances respectively. The path analysis was carried out according to the procedure described by Dewey and Lu (1959) that consists of the calculation of direct effects, indirect effects, and residual effects.

Results and Discussion

Correlation coefficient

It is perceived from the present investigation that the genotypic correlation coefficient was higher than the phenotypic correlation coefficient for all the traits under study (Table 2). It means that there is a genetically strong association between two characters, lessened by the significant interaction of the environment (Singh and Narayanam, 2015). Further, it was observed from the Table 2, that at 1% level of significance ($P<0.01$), yield kg plot^{-1} demonstrated significant and positive association with 1000 grain weight (0.423** and 0.388**), harvest index (0.417** and 0.379**), tillers per plant (0.391** and 0.320**), number of grains per spike (0.378** and 0.312**) spike length (0.365** and 0.301**) and plant height (0.333** and 0.268**) both at genotypic and phenotypic levels. These findings are in close agreement with those of Ali and Shakor (2012) and Birhanu *et al.,* (2017). It is because yield is not an independent character but a product of a constellation of yield contributing characters such as tillers per plant which contributes to raising plant population per unit area; spike length, grains per spike and 1000grain weight which form 'sink' and the harvest index which are considered directly related to yield (Abrar *et al*., 2011). Among yield contributing characters, numbers of effective tillers plant^{-1} reported a positive and strong association with harvest index (0.321** and 0.307**) and 1000 grain weight (0.333** and 0.311**) whereas it indicated a negative and significant association with the number of grains spike^{-1} (-0.361** and -0.389**) both at genotypic and phenotypic levels. Similar results were also reported by Preeti *et al.* (2018). In wheat, an increased supply of carbohydrates in the early stage of growth leads to a proportionate increase in the initiation and development of effective tillers. With the development of effective tillers bearing spikes, there is an increase in the leaf number which helps in the improvement of photosynthetic activity of the plant. Thus, results increase in the total biomass production and proper biosynthesis of nutrients especially starch and other essential materials from the leaves which are translocated towards the filling of grains within the spikes resulting development of bold grains. It was found that at both genotypic and phenotypic levels, spike length revealed a positive and strong correlation with the number of grains spike^{-1} (0.410** and 0.394**) and 1000 grain weight (0.319** and 0.311**). These results are in conformity with the findings reported by Manoj *et al.,* (2013) and

Table 1: List of 20 wheat varieties/genotypes with their pedigree and genetic characteristics.

S.No.	Name of varieties	Pedigree	Genetic characteristics
1	HD-2687	CPAN 2009/HD 2329	Tolerance to yellow and brown rust
2	HD- 2733	ATTILA/3/TUI/CARC//CHEM/CHOTO/4/ ATTILA	Resistance to brown rust and tolerant to leaf blight
3	HD-2781	BOW /C 306 //C591/HW2004	Resistance to brown rust
4	HD-2824	PTO1/CNO79/PRL/GAA/3/HD195	Resistance to brown rust and tolerant to leaf blight
5	HD-2932	KAUZ/STAR//HD 2643	Resistance to brown rust and high zinc content
6	HD-2967	ALD/COC//URES/HD216 0M/HD2278	Wider adaptability and resistance to yellow and brown rust
7	PBW-343	ND/VG 7944//KAL/BB/3/YACO S/4/VEE# 5S	Double dwarf variety with profuse tillering and stiff straw
8	PBW-502	W 485 /PBW 343// RAJ 1482	Resistance to yellow rust, brown rust and karnal bunt
9	PBW-550	WH 594/RAJ 3858//W48	A high degree of resistance to yellow and brown
10	HUW-206	KAVKAZ/BUHO/KALYANSONA/BLUEBIRD	Resistant to all the three rusts
11	HUW-468	CPAN-1962 / TONI //LIRA'S'/ PRL'S	Tolerance to leaf blight
12	HUW-510	HD2788/HUW234//DL230-16	Resistance to brown and black rust, high-temperature terminal tolerance, fit to late sown condition
13	RAJ-1482	NAPO-TOB 'S'/8156/KAL-BB	Good for chapatti quality
14	RAJ-3765	HD 2402/VL639	Tolerance to terminal heat stress condition
15	LOK-1	S308/S331	Wider adaptability and good for chapatti quality
16	DBW-14	RAJ 3765/PBW 343	Tolerant to leaf blight
17	DBW-39	ATTILA/HUI	Resistance to black rust, brown rust and tolerant to leaf blight
18	K-0307	K 8321/UP2003	Tolerance to terminal heat stress condition
19	UP2554	SM4-HSN 24E/CPAN 209	Resistance to rust
20	UP2572	HD 2009/SKA //HD 2329	Resistance to yellow and brown rust

Table 2: Mutual association between yield and yield contributing characters.

Characters		No. of effective tiller plant^{-1}	Spike length (cm)	Number of grains/ Spike	Plant height (cm)	Harvest index (%)	1000 grain weight(g)	Protein content (%)	Yield/plot (kg)
No. of effective tiller plant^{-1}	rg	1.000	0.113	-0.361**	0.179	0.321**	0.333**	0.139	0.391**
	rp	1.000	0.073	-0.389**	0.123	0.307**	0.311**	0.107	0.320**
Spike length (cm)	rg		1.000	0.410**	-0.163	0.215	0.319**	0.094	0.365**
	rp		1.000	0.394**	-0.187	0.193	0.311**	0.072	0.301**
Number of grains /Spike	rg			1.000	0.302**	0.309**	0.389**	0.127	0.378**
	rp			1.000	0.275**	0.288**	0.366**	0.110	0.312**
Plant height (cm)	rg				1.000	0.327**	0.320**	0.119	0.333**
	rp				1.000	0.304**	0.313**	0.104	0.268**
Harvest index	rg					1.000	0.410**	0.131	0.417**
	rp					1.000	0.399**	0.118	0.379**
1000 grain weight	rg						1.000	0.032	0.423**
	rp						1.000	0.017	0.388**
Protein content (%)	rg							1.000	-0.061
	rp							1.000	-0.033
Yield/plot (kg)	rg								1.000
	rp								1.000

* Significant at 5 % probability level; ** Significant at 1 % probability level, rg = genotypic correlation; rp = phenotypic correlation.

Table 3: Direct and indirect contribution of various independent characters on a dependent character.

Characters	No. of effective tiller plant^{-1}	Spike length (cm)	Number of grains/ Spike	Plant height (cm)	Harvest index (%)	1000 grain weight(g)	Protein content (%)	Genotypic/ phenotypic correlation coefficient with yield
No. of effective tiller plant^{-1}	0.038	0.035	0.030	0.074	0.168	0.019	0.027	0.391**
	0.029	0.021	0.022	0.061	0.154	0.015	0.018	0.320**
Spike length (cm)	0.037	0.035	0.049	-0.014	0.135	0.115	0.050	0.365**
	0.023	0.031	0.037	-0.008	0.112	0.109	0.037	0.301**
Number of grains /Spike	0.030	0.055	0.028	0.071	0.187	0.130	-0.123	0.378**
	0.021	0.043	0.023	0.069	0.171	0.122	-0.137	0.312**
Plant height (cm)	0.051	-0.008	0.068	0.036	0.132	0.076	-0.025	0.333**
	0.038	-0.014	0.056	0.032	0.126	0.061	-0.031	0.268**
Harvest index	0.033	-0.007	0.049	-0.014	0.171	0.135	0.050	0.417**
	0.057	-0.009	0.031	-0.008	0.152	0.119	0.037	0.379**
1000 grain weight	0.081	0.043	0.025	0.019	0.167	0.093	-0.005	0.423**
	0.077	0.037	0.02	0.015	0.163	0.085	-0.009	0.388**
Protein content (%)	-0.005	0.050	-0.123	-0.025	0.013	-0.021	-0.123	-0.061
	-0.009	0.037	-0.137	-0.031	0.006	0.015	-0.133	-0.033

Bold number = direct effect.

Tofiq *et al.,* (2015). The number of gains spike^{-1} recorded positive and significant association with plant height (302** and 275**), harvest index (309** and 288**) and 1000 grain weight (389** and 366**). The same findings were also reported by Manoj *et al.,* (2013) and Ali and Allah (2017). A positive and significant correlation between the yield contributing components helps the plant breeder to perform an indirect selection for the genetic improvement of yield because generally yield has low heritability and direct selection is not sufficiently effective. Thus, genetic improvement in the yield can be achieved using indirect selection through component characters (number of tillers plant^{-1}, spike length, number of grain spike^{-1}, plant height, harvest index, and 1000 grain weight) with high heritability which in turn aid in the selection of superior genotypes from the breeding population. Moreover, table 2 reflected that both at genotypic and phenotypic levels, the grain yield plot^{-1} had a negative and non-significant association with protein content (-0.061 and -0.033). These findings are in agreement with Matthieu *et al.,* (2010). Wheat breeders have been relatively unsuccessful in producing wheat cultivars with a high grain yield along with high grain protein content. This is mainly because of the inverse relationship that exists between the two characters (Abrar and Tanveer, 2018). According to Lam *et al.*, (1996), the negative relationship between grain yield and grain protein content illustrates the interrelationship between carbon and nitrogen (N) metabolism at the canopy level.

Path analysis

The path analysis is simply a standardized partial regression coefficient, which splits the correlation coefficient into the measure of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent characters on a dependent character. Thus, the correlation in conjugation with the path coefficient can give a better insight into the cause and effect relationship between the different pairs of characters (Yasin and Singh, 2010). In the present study, grain yield act as a resultant variable (dependent factor) and the rest contributing traits as casual variables (independent factors). Therefore, the genotypic and phenotypic correlation coefficient of grain yield along with yield attributes was divided into direct and indirect effects by using path coefficient analysis as it provides a basis for selection of the desirable characters contributing yield from the diverse breeding population. The results depicted in Table 3 indicated that the character harvest index exhibited positive and significant association with yield kg plot^{-1} both at the genotypic and phenotypic level and on partitioning the correlation, it was found that this trait had a maximum positive direct effect (0.171 and 0.152) among the rest. It also had an indirect positive effect on grain yield via the number of tillers plant^{-1} (0.033 and 0.057), number of grains spike^{-1} (0.049 and 0.031), protein content (0.050 and 0.037), and 1000 grain weight (0.135 and 0.119). These results are in conformity with the findings reported by Manoj *et al.,* (2013). Characters such as 1000 grain weight (0.093 and 0.085), number of tillers plant^{-1} (0.038 and 0.029), plant height (0.036 and 0.032), spike length (0.035 and 0.031) and number of grains spike^{-1} (0.028 and 0.023) exhibited a positive direct effect on grain yield and also displayed positive and significant association with grain yield both at genotypic and phenotypic levels. Similar results were also reported by Simerjeet *et al.,* (2019). All these attributes are of economic importance therefore, there is a need to evaluate them further and utilizing such valuable traits concurrently to design a breeding programme for the development of new high yielding varieties of wheat.

Conclusion

The end result of an existing appraisal demonstrates that yield kg plot^{-1} manifested significant and positive association with 1000 grain weight, harvest index, tillers per plant, number of grains per spike, spike length and plant height both at genotypic and phenotypic levels. On partitioning the correlation, the same attributes exhibited a positive direct effect on grain yield and also had an indirect positive effect among themselves on yield kg plot^{-1}. Therefore, the selection for 1000 grain weight, harvest index, tillers per plant, number of grains per spike and spike length would be more effective to bring about simultaneous improvement for yield and other yield components in bread wheat. Thus, it can be assumed that path analysis together with the correlation coefficient would give a better understanding of the cause and effect relationship between the different character combinations.

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