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CHARACTER ASSOCIATION AND PATH ANALYSIS OF GRAIN YIELD AND ITS CONTRIBUTING CHARACTERISTICS IN DIVERSE WHEAT VARIETIES (*TRITICUM AESTIVUM* L.)

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ABSTRACT

The experimental set comprised 40 wheat varieties assessed using a Randomized Block Design (RBD) with three replications, and data were collected for twelve characteristics during *rabi*, 2021 at Niger Research Station, Navsari Agricultural University, Vanarasi. This study aimed to assess the correlation and path coefficients of yield and its contributing traits. The correlation analyses showed a significant positive relationship between grain yield per plant and spike length, grains per spike, filled grains per spike, straw yield per plant and harvest index at both genotypic and phenotypic levels. Hence, special consideration should be given to these traits when selecting for grain yield improvement. Genotypic path coefficient analysis indicated that harvest index had the most significant positive direct impact on grain yield per plant, straw yield per plant, filled grains per spike, days to heading, spike length, test weight and gluten content. Therefore, focusing on these traits in selection processes will likely contribute to wheat yield improvement.
Keywords **:** Wheat, Correlation, Path analysis, Grain yield

Introduction

Wheat is the second most important cereal staple food crop in the world after rice, which dominates all other cereal crops in area and production and provides around 20 per cent of total food calories to the world's population. Hexaploid wheat (AABBDD), accounts for over 95 per cent of all wheat farmed today and it is used to make bread and other baked goods (Debasis and Khurana, 2001). The components contributing to grain yield often display diverse associations with both the overall grain yield and among each other. Investigating these associations through character association studies improves the comprehension of plant breeders, enabling them to enhance yield by indirectly selecting highly heritable traits linked to yield. Utilizing correlation and path analysis proves beneficial in identifying the appropriate cause-and-effect relationships between yield and specific yield components (Khan *et al.*, 2003).

Moreover, the grain yield is impacted both directly and indirectly by its diverse components, presenting a intricate scenario for breeders when aiming for desirable selections. Consequently, the path coefficient analysis introduced by Wright (1921), which dissects the correlation coefficient into direct and indirect effects of variables, offers a more accurate representation of the relationship. Therefore, character association studies and path analysis offer insights into the characters influencing yield, allowing breeders to employ this information for selecting superior accessions from gene banks.

Material and Methods

The current study was conducted at the Research Farm of Niger Research Station, Navsari Agricultural University, Vanarasi, during the rabi season of 2021-22. The experimental material consisted of 40 wheat genotypes obtained from the Wheat Research Station in Bardoli, Navsari Agricultural University, Navsari. Observations were made on five randomly selected plants for twelve quantitative traits, including days to heading, plant height (cm), effective tillers per plant, spike length (cm), grains per spike, filled grains per spike, days to maturity, test weight, grain yield per plant (g), straw yield per plant (g), harvest index (%) and gluten content (%).

Genotypic (rg) and phenotypic (rp) correlation coefficients were calculated following the established procedure recommended by Miller *et al.* (1958). Fisher's method (1936) was employed to test the significance of the phenotypic correlation. It is important to note that a simple correlation coefficient does not reveal the cause-and-effect relationship between two variables. To address this limitation, path analysis, as suggested by Wright (1921) and Dewey and Lu (1959), was adopted to dissect the genotypic correlation between variables related to seed yield, distinguishing between the direct and indirect effects of these variables on yield.

Result and Discussion

The genotypic (r_g) and phenotypic (r_p) correlation coefficients for twelve characters are presented in Table 1 and 2. Days to heading registered non-significant and positive association with plant height (r_g = 0.152 and r_p = 0.047), spike length (r_g = 0.064 and r_p = 0.048) and grains per spike (r_g = 0.120 and r_p = 0.080) at both genotypic and phenotypic levels. Plant height had highly significant and positive correlation at both phenotypic and genotypic levels with spike length (r_g = 0.611** and r_p = 0.353**) and filled grains per spike (r_g = 0.448** and r_p = 0.240**). Test weight (r_g = 0.713** and r_p = 0.472**) and straw yield per plant (r_g = 0.456** and r_p = 0.273**) had highly significant and positive correlation with effective tillers per plant at both genotypic and phenotypic levels. Spike length showed highly significant and positive correlation with straw yield per plant (r_g = 0.430** and r_p = 0.348**), grains per spike (r_g = 0.683** and r_p = 0.443**), filled grains per spike (r_g = 0.583** and r_p = 0.347**) and harvest index (r_g = 0.573** and r_p = 0.459**). Grains per spike depicted positive and highly significant association with filled grains per spike (r_g = 0.760** and r_p = 0.813**) and harvest index (r_g = 0.706** and r_p = 0.538**) at both genotypic and phenotypic levels. Filled grains per spike showed highly significant and positive correlation with straw yield per plant (r_g = 0.504** and r_p = 0.301**) and harvest index (r_g = 0.874** and r_p = 0.672**). Days to maturity depicted non-significant and positive correlation with straw yield per plant (r_g = 0.023 and r_p = 0.041) and harvest index (r_g = 0.180 and r_p = 0.154). Straw yield had showed highly significant and positive correlation with harvest index (r_g = 0.547** and r_p = 0.521**).

Grain yield per plant had showed highly significant and positive correlation with spike length (r_g = 0.614** and r_p = 0.490**), grains per spike (r_g = 0.694** and r_p = 0.505**), filled grains per spike (r_g = 0.871** and r_p = 0.624**), straw yield per plant (r_g = 0.756** and r_p = 0.781**) and harvest index (r_g = 0.961** and r_p = 0.935**) at both genotypic and phenotypic levels. This trait had showed significant positive genotypic correlation and highly significant positive phenotypic correlation with the traits, plant height (r_g = 0.380* and r_p = 0.274**), effective tillers per plant (r_g = 0.399* and r_p = 0.253**) and test weight (r_g = 0.342* and r_p = 0.259**). Days to heading (r_g = 0.195 and r_p = 0.138) and days to maturity (r_g = 0.172 and r_p = 0.150) were non-significant and positively correlated at genotypic and phenotypic level, while gluten content showed non-significant negative correlation (r_g = -0.022 and r_p = -0.029) at both genotypic and phenotypic levels with grain yield.

The research findings were similar with that of outcomes of Rameez *et al.* (2012) for test weight, Dutamo *et al.* (2015) for days to maturity, effective tillers per plant, spike length, test weight and harvest index, Dabi *et al.* (2016) for days to heading, days to maturity, harvest index, and plant height, Ibrahim *et al.* (2019) for days to heading, days to maturity and grains per spike, Devesh *et al.* (2021) for days to maturity, plant height, test weight and gluten content, Milkessa *et al.* (2022) for days to maturity, harvest index, effective tillers per plant and spike length and Chauhan *et al.* (2022) for days to heading, days to maturity, spike length, grains per spike, straw yield per plant and harvest index.

In the current study, it was observed that the genotypic correlation values were generally higher than their corresponding phenotypic correlations for most of the traits. This suggests that there is less influence from the environment, indicating an inherent relationship among the studied characters. A significant and favorable inherent correlation was identified between grain yield and all the traits under examination, except for gluten content. This highlights that all these traits possess an intrinsic association with grain yield, emphasizing their importance in enhancing grain yield, and improvements in these specific characters can contribute to the enhancement of grain yield.

Path coefficient analysis

The information presented in Table 3 and Figure 2 indicates that there is a non-significant yet positive correlation (0.195) between Days to heading and grain yield per plant. The direct effect of Days to heading on grain yield per plant was observed to be positive (0.0479). Plant height demonstrated a positive and significant correlation with grain yield per plant (0.380*), but the direct effect of plant height on grain yield per plant was minimal and negative (-0.0050). Effective tillers per plant exhibited a positive and significant association with grain yield per plant (0.399*). Additionally, the direct effect of effective tillers per plant on grain yield was negligible and negative (-0.0153).

Spike length demonstrated a highly significant and positive correlation with grain yield per plant (0.614**), and its direct effect on grain yield was observed to be positive (0.0421). Grains per spike showed a positive and highly significant association with grain yield per plant (0.694**), but it had a negative direct effect on grain yield per plant (-0.0214). The indirect effect of this trait on grain yield per plant was positive through days to heading (0.0057), spike length (0.0288), filled grains per spike (0.0569), test weight (0.0127), straw yield per plant (0.1257), harvest index (0.4938), and gluten content (0.0004). Filled grains per spike exhibited a highly significant and positive correlation with grain yield per plant (0.871**), and it had a positive direct effect on grain yield (0.0749). Days to maturity showed a positive and non-significant association with grain yield per plant (0.172) and had a negligible and negative direct effect on grain yield per plant (-0.0282).

Test weight demonstrated a positive and significant association with grain yield per plant (0.342*), and it had a positive direct effect on grain yield per plant (0.0328). Straw yield per plant showed a positive and highly significant correlation with grain yield per plant (0.756**), exerting a positive direct effect on grain yield per plant (0.3281). Harvest index displayed a highly significant and positive correlation with grain yield per plant (0.961**), and it had a positive direct effect on grain yield per plant (0.6984). Gluten content exhibited a non-significant and negative correlation with grain yield per plant (-0.022), and it had a negligible yet positive direct effect on grain yield per plant (0.0018).

In the current investigation, an attempt was made to identify the key component traits influencing grain yield per plant in forty diverse wheat genotypes through genotypic path analysis. The findings revealed that the most substantial positive and direct impact on grain yield per plant was attributed to harvest index, followed by straw yield per plant, filled grains per spike, days to heading, spike length, test weight, and gluten content. This implies that these characteristics could offer significant advancements during the selection process for improving grain yield. Similar results were reported by Rameez *et al.* (2012), Chauhan *et al.* (2022), and Milkessa *et al.* (2022). Certain traits, such as days to maturity, grains per spike, effective tillers per plant and plant height, displayed a negative direct effect on grain yield per plant. However, these traits are recognized to exert an indirect positive influence on grain yield per plant through other characters. Similar findings were also reported by Chauhan *et al.* (2022). In this study, the residual effect at the genotypic level was determined to be 0.033, indicating that there may be negligible component traits responsible for influencing grain yield per plant beyond those considered in this investigation. The results of the path analysis suggest that emphasis should be placed on selecting for filled grains per spike, days to heading, spike length, test weight, harvest index, straw yield per plant and gluten content to achieve a selection advantage in enhancing grain yield.

Conclusion

The current experiment concludes that grain yield per plant demonstrated highly significant and positive correlations with spike length, grains per spike, filled grains per spike, straw yield per plant, and harvest index at both genotypic and phenotypic levels. As a result, these traits should be prioritized for enhancing yield in wheat breeding. Path coefficient analysis revealed that filled grains per spike, days to heading, spike length, test weight, harvest index, straw yield per plant, and gluten content exerted strong and positive direct effects on grain yield per plant. Consequently, these traits are identified as the most crucial contributors to grain yield, emphasizing the need to place greater emphasis on them for improving wheat yield.

Table 1: Genotypic correlation coefficient of grain yield per plant with other characters in wheat

	DTH	PH	ET	SL	GPS	FGPS	DTM	TW	SYPP	HI	GC
DTH	**1.00**										
PH	0.15^{NS}	**1.00**									
ET	-0.19^{NS}	-0.15^{NS}	**1.00**								
SL	0.06^{NS}	0.61^{**}	0.02^{NS}	**1.00**							
GPS	0.12^{NS}	0.46^{NS}	0.24^{NS}	0.68^{**}	**1.00**						
FGPS	0.36^{*}	0.44^{**}	0.34^{*}	0.58^{**}	0.76^{**}	**1.00**					
DTM	0.87^{**}	0.13^{NS}	-0.17^{NS}	0.09^{NS}	0.07^{NS}	0.31^{NS}	**1.00**				
TW	-0.05^{NS}	0.02^{NS}	0.71^{**}	0.16^{NS}	0.38^{*}	0.33^{*}	-0.06^{NS}	**1.00**			
SYPP	-0.05^{NS}	0.36^{*}	0.45^{**}	0.43^{**}	0.38^{*}	0.50^{**}	0.02^{NS}	0.30^{NS}	**1.00**		
HI	0.23^{NS}	0.30^{NS}	0.31^{*}	0.57^{**}	0.70^{**}	0.87^{**}	0.18^{NS}	0.28^{NS}	0.54^{**}	**1.00**	
GC	-0.26^{NS}	-0.17^{NS}	0.35^{*}	-0.17^{NS}	0.22^{NS}	0.13^{NS}	-0.35^{*}	-0.09^{NS}	-0.05^{NS}	0.00^{NS}	**1.00**
GYPP	0.19^{NS}	0.38^{*}	0.39^{*}	0.61^{**}	0.69^{**}	0.87^{**}	0.17^{NS}	0.34^{*}	0.75^{**}	0.96^{**}	-0.02^{NS}

*, ** significant at 5 % and 1 % levels, respectively

Table 2: Phenotypic correlation coefficient of grain yield per plant with other characters in wheat

	DTH	PH	ET	SL	GPS	FGPS	DTM	TW	SYPP	HI	GC
DTH	**1.00**										
PH	0.04^{NS}	**1.00**									
ET	-0.08^{NS}	-0.09^{NS}	**1.00**								
SL	0.04^{NS}	0.35^{**}	0.03^{NS}	**1.00**							
GPS	0.08^{NS}	0.22^{*}	0.15^{NS}	0.44^{**}	**1.00**						
FGPS	0.25^{**}	0.24^{**}	0.21^{*}	0.34^{**}	0.81^{**}	**1.00**					
DTM	0.73^{**}	0.17^{NS}	-0.10^{NS}	0.06^{NS}	0.05^{NS}	0.23^{*}	**1.00**				
TW	-0.04^{NS}	-0.05^{NS}	0.47^{**}	0.12^{NS}	0.27^{**}	0.23^{*}	-0.08^{NS}	**1.00**			
SYPP	-0.06^{NS}	0.26^{**}	0.27^{**}	0.34^{**}	0.24^{**}	0.30^{**}	0.04^{NS}	0.19^{*}	**1.00**		
HI	0.19^{*}	0.21^{*}	0.22^{*}	0.45^{**}	0.53^{**}	0.67^{**}	0.15^{NS}	0.24^{**}	0.52^{**}	**1.00**	
GC	-0.18^{*}	-0.12^{NS}	0.26^{**}	-0.16^{NS}	0.13^{NS}	0.08^{NS}	-0.30^{**}	-0.08^{NS}	-0.07^{NS}	0.01^{NS}	**1.00**
GYPP	0.13^{NS}	0.27^{**}	0.25^{**}	0.49^{**}	0.50^{**}	0.62^{**}	0.15^{NS}	0.25^{**}	0.78^{**}	0.93^{**}	-0.02^{NS}

*, ** significant at 5 % and 1 % levels, respectively

Table 3: Direct and indirect effects (Genotypic path matrix) of eleven characters on grain yield per plant in wheat

Characters	DTH	PH	ET	SL	GPS	FGPS	DTM	TW	SYPP	HI	GC	GYPP
DTH	**0.0479**	-0.0007	0.0029	0.0026	-0.0026	0.0271	-0.0246	-0.0016	-0.0174	0.1614	-0.0005	0.195
PH	0.0073	**-0.0050**	0.0023	0.0257	-0.0100	0.0336	-0.0037	0.0007	0.1191	0.2104	-0.0003	0.380^{*}
ET	-0.0093	0.0007	**-0.0153**	0.0011	-0.0052	0.0257	0.0049	0.0234	0.1495	0.2226	0.0006	0.399^{*}
SL	0.0031	-0.0031	-0.0004	**0.0421**	-0.0146	0.0436	-0.0027	0.0053	0.1410	0.4000	-0.0003	0.614^{**}
GPS	0.0057	-0.0023	-0.0037	0.0288	**-0.0214**	0.0569	-0.0020	0.0127	0.1257	0.4938	0.0004	0.694^{**}
FGPS	0.0173	-0.0022	-0.0052	0.0245	-0.0162	**0.0749**	-0.0088	0.0108	0.1655	0.6101	0.0002	0.871^{**}
DTM	0.0418	-0.0006	0.0026	0.0041	-0.0015	0.0233	**-0.0282**	-0.0019	0.0076	0.1267	-0.0006	0.172
TW	-0.0024	-0.0001	-0.0109	0.0068	-0.0082	0.0247	0.0017	**0.0328**	0.1009	0.1971	-0.0001	0.342^{*}
SYPP	-0.0025	-0.0018	-0.0069	0.0181	-0.0082	0.0377	-0.0006	0.0101	**0.3281**	0.3821	-0.0001	0.756^{**}
HI	0.0111	-0.0015	-0.0048	0.0241	-0.0150	0.0654	-0.0050	0.0092	0.1795	**0.6984**	0.00001	0.961^{**}
GC	-0.0125	0.0008	-0.0054	-0.0074	-0.0049	0.0102	0.0099	-0.0029	-0.0173	0.0054	**0.0018**	-0.022

RESIDUAL EFFECT = 0.033

*, ** significant at 5 % and 1 % levels, respectively

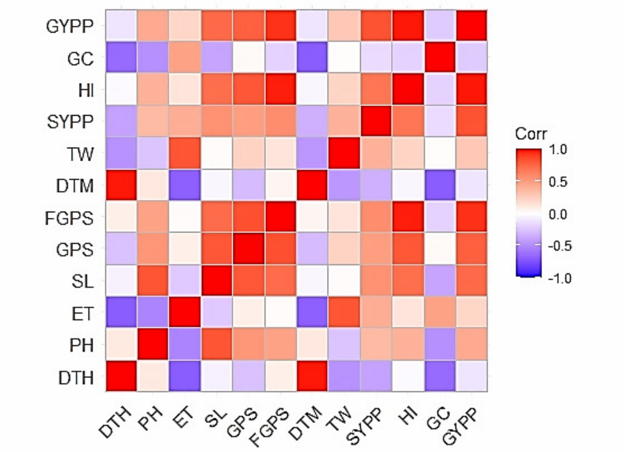

Fig. 1: Heatmap of genotypic correlation for quantitative traits in wheat

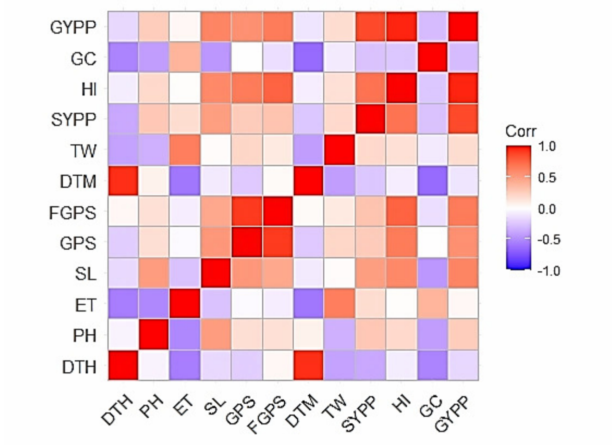

Fig. 1.1: Heatmap of phenotypic correlation for quantitative traits in wheat

DTH = Days to heading	PH = Plant height (cm)	ET = Effective tillers per plant
SL = Spike length(cm)	GPS = Grains per spike	FGPS = Filled grains per spike
DTM = Days to maturity	TW = 1000 grain weight (g)	SYPP = Straw yield per plant (g)
HI = Harvest Index (%)	GC = Gluten content (%)	GY = Grain yield per plant (g)

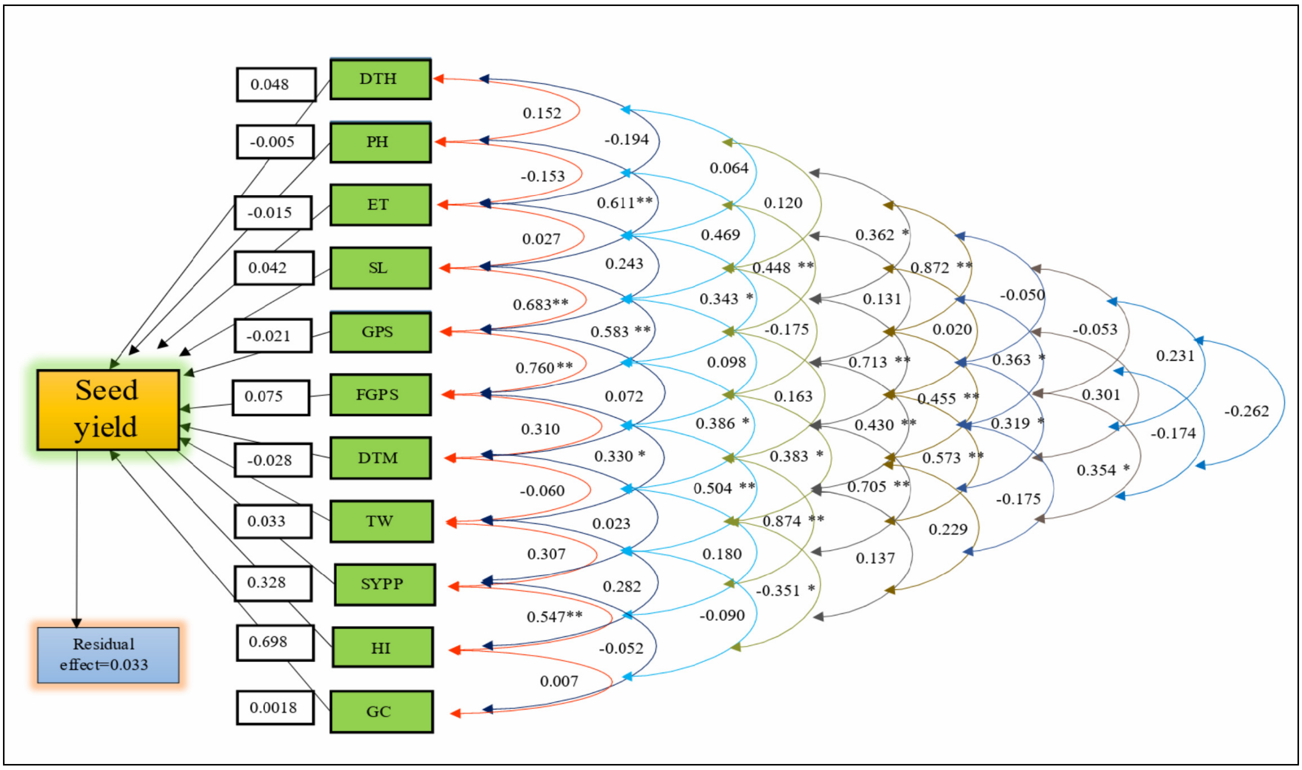

Fig. 2: Genotypic path diagram for grain yield imparted by the component characters

DTH = Days to heading	PH = Plant height (cm)	ET = Effective tillers per plant	SL = Spike length (cm)
GPS = Grains per spike	FGPS = Filled grains per spike	DTM = Days to maturity	TW = 1000 grain weight (g)
SYPP = Straw yield per plant (g)	HI = Harvest Index (%)	GC = Gluten content (%)	GY = Grain yield per plant (g)

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