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Trait Association and their Contribution in Yield Improvement in Spring Wheat (*Triticum aestivum* L)

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Abstract

The present investigation was conducted at the Breeder Seed Production Unit, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, M.P., India during November to April, (*Rabi* season), 2021 to 2022 analyse grain yield and its attributing traits of wheat by correlation and path coefficient analysis. The twenty genotypes were in randomized complete block design with three replications. The results indicated that the biological yield per plant had highly significant correlation followed by harvest index with a moderate positive value and is significant with the grain yield per plant. Similarly the analysis of direct and indirect effects shows that the plant height, flag leaf length, flag leaf width, days to 50% flowering, grains per spike, biological yield per plant, and harvest index had positive direct effect on grain yield per plant. Hence it may be considered that traits namely, plant height, flag leaf length, flag leaf width, days to 50% flowering, grains per spike, biological yield per plant, and harvest index may be utilized for yield improvement breeding strategies in wheat. However, biological yield and harvest index will be given prime importance during selection of traits, due to their significant association and having a direct or indirect effect in crop yield improvement.

Keywords: Correlation, path analysis, yield, traits

1. Introduction

Wheat (*Triticum aestivum* L.) being a food of global significance to 40% of the world's population, provides energy and 20% of daily dietary protein in comparison to any other cereal crop (Anonymous, 2018). Although, the demand of grains has been increased, not just because of increasing population, but also due to increase in individual per capita income and alternative uses of grains (Anonymous, 2020). Fischer et al. 2014 predicted that the likely increase in the worldwide demand of grains between 2005–07 and 2050 is around 44%. However, roughly 1.2 billion people rely on wheat for protein and energy in the developing countries. And this demand of wheat will further amplify by 60% in these areas next to 2050. Consequently, raising the probable yield through breeding is crucial to counterpart the comprehensive demand (Anonymous, 2020).

The prime objective of plant breeding programs is to increase yield, while it also seek to improve one or more traits at the same time (Mandal et al., 2017, Yusuf et al., 2017). Since, grain yield is a complex quantitative trait, resulting from an interaction of various related traits (Acquaah, 2009, Kiranmai et al., 2016). Thus, it should be evaluated through its related traits, like number of productive tillers, spike length, 1000-grain weight and number of spikelets per spike etc. (Li et al., 2020). Correlation analysis is generally used as an efficient tool to discover the association between diverse traits in genetically diverse population for crop improvement (Kharel et al., 2018). The study of various traits and their relationship with each other is an imperative approach designed to split the genetic barrier of yield. Though, the correlation studies helps in determining the composition of a complex traits i.e. grain yield, it does not provide an precise magnitude of direct and indirect effect in the direction of the yield (Vaghela et al., 2021). As a reason, now–a –days breeders also wants to know their cause and effect relationship through path analysis procedure. A path coefficient analysis is a standardized partial regression coefficient and as such provides the direct effect of one trait upon other and permits the separation of correlation coefficient into direct and indirect effects (Dewey and Lu, 1959, Phougat et al., 2017). The path coefficients illustrate direct influence of independent variable upon dependent variable (Lidansky, 1988). In agriculture, path coefficient analysis have been used by plant breeders to assist in identifying traits that are functional as selection criterion to advance the crop yield (Dewey and Lu, 1959, Milligan et al., 1990).

Nevertheless, efficiency in yield improvement can be improved by exploiting the association between yield and its attributing traits. As such through correlation and path-coefficient analysis, it would be possible to elucidate the most important traits that would help in achieving improvement (Zaman et al., 2011). Thus correlation analysis along with path analysis provide a better understanding of the association of different characters with grain yield (Avinashe et al., 2014).

For several field crops, the studies related to the understanding and development of wheat are being directed by the regular analysis of the genetic variability among the genotypes because grain yield is a compound trait and is highly affected by numerous genetic factors and environmental fluctuation (Sharma et al., 2020). Therefore, the efforts were made in present investigation to analyse grain yield and its attributing traits of wheat by correlation and path coefficient analysis.

2. Materials and Methods

This experiment was carried out during November to April, (*Rabi* season), 2021 to 2022 at the Breeder Seed Production Unit, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, M.P., India situated at an elevation of about 306.06 m above from the sea level to determine the most suitable traits to improve the yield and measure them as a selection criteria through studying and analyzing the correlation and path coefficient. The experiment was conducted in a randomized complete block design with three replications, to study the twenty-one set of genotype including six parents viz, JW–1203, WB–02, GW–322, HI–1633, HI–1634 and MP–3382 and their 15 F_1's. The characters studied were, Days to 50% heading, plant height, days to maturity, spike length, spikelet spike^{-1}, grains spike^{-1}, tiller plant^{-1}, flag leaf length, flag leaf width, thousand kernel weight, biological yield plant^{-1}, harvest index, grain yield per plant as an selection index to improve grain yield on five randomly selected plants in each replications.

2.1. Data analysis

Correlation coefficient and path coefficients were analysed by using R Statistical Software version 4.2.1. Correlations coefficient were computed by using the formula as given below: $r=(Cov(xy)/\sigma_x\times\sigma_y)\times100$

Where, r=Correlation coefficient

Cov (xy)=Covariance between the characters 'x' and 'y'

σ_x and σ_y=variance of the character 'x' and 'y' respectively.

Whereas, path coefficients were obtained by solving the simultaneous equations, which express the basic relationship between correlations and path coefficients.

3. Results and Discussion

The pearson correlation coefficient analysis were perfomed using R statistical software and were presented in Table 1, Figure 1 and 2. Correlation coefficient analysis measures the direction and degree of relationships involving a variety of traits. Degree of correlation is considered as weak (0–0.3), moderate (0.3–0.7) and strong (0.7–1.0). The high significant correlation between yield attributing traits indicates that, the unit percentage increase in one of the traits will cause a unit increase in the erstwhile related traits.

It was found that the grain yield per plant has positive and

Table 1: Pearson correlation coefficient for yield and yield attributing traits (p<0.05)

Traits	DH50	PH	DM	SL	SPS	GPS	TPP	FLL	FLW	TKW	BYPP	HI	GYPP
DH50	1.00	0.19	0.70***	0.35	0.27	0.00	-0.38	0.43	-0.02	-0.02	0.08	-0.26	0.02
PH		1.00	0.16	0.29	0.78***	-0.09	-0.06	-0.20	-0.05	0.13	0.27	-0.01	0.26
DM			1.00	0.29	0.14	-0.05	-0.21	0.12	0.10	0.13	0.10	-0.02	0.10
SL				1.00	0.42	0.53*	-0.11	0.52*	0.03	-0.07	-0.09	-0.50	-0.20
SPS					1.00	0.25	0.08	0.07	-0.17	0.03	0.15	-0.12	0.12
GPS						1.00	0.03	0.45*	0.15	-0.06	0.15	-0.26	0.07
TPP							1.00	-0.12	-0.08	-0.08	0.31	0.43*	0.40
FLL								1.00	-0.01	-0.24	0.01	-0.38	-0.08
FLW									1.00	0.28	0.22	0.04	0.22
TKW										1.00	0.18	0.31	0.25
BYPP											1.00	0.22	0.95***
HI												1.00	0.49*
GYPP													1.00

Where, DH50: Days to 50% flowering; PH: Plant height; DM: Days to maturity; SL: Spike length; SPS: Spikelet spike^{-1}; GPS: Grains spike^{-1}; TPP: Tiller plant^{-1}; FLL: Flag leaf length; FLW: Flag leaf width; TKW: Thousand karnel weight; BYPP: biological yield plant^{-1}; HI: Harvest index; GYPP: Grain yield plant^{-1}

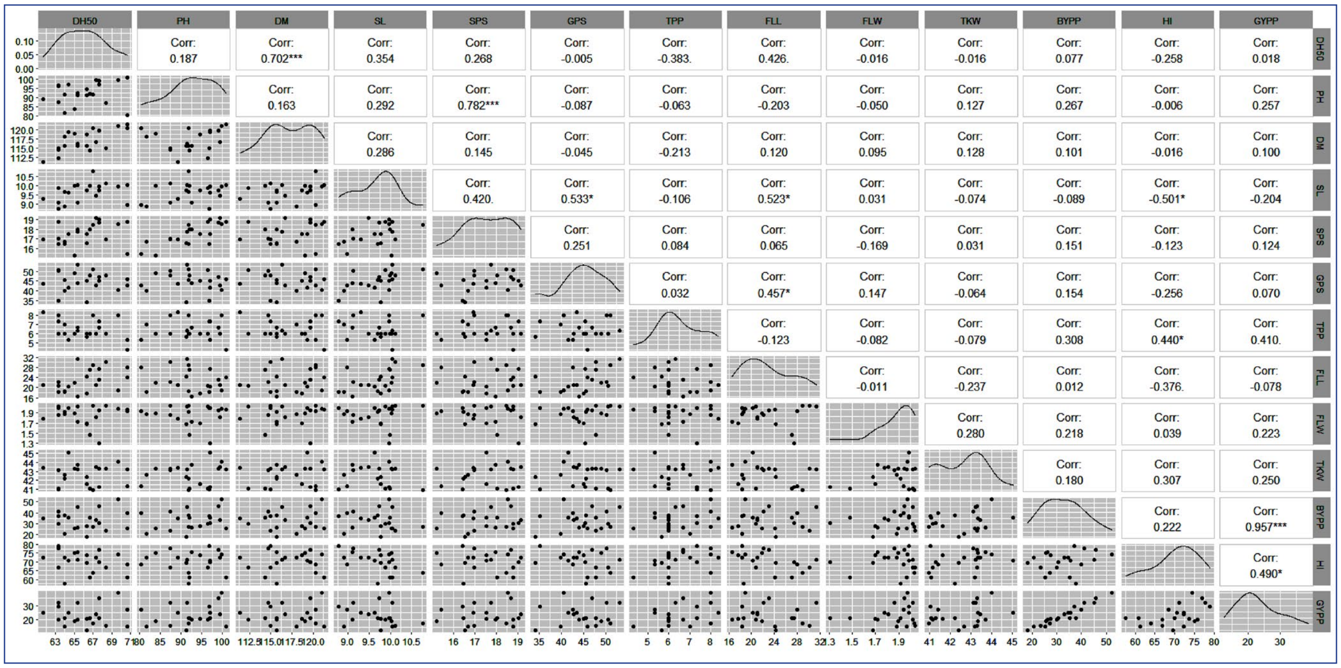

Figure 1: Diagramatic representation of correlation analysis through scatter plot for all the yield attributing traits

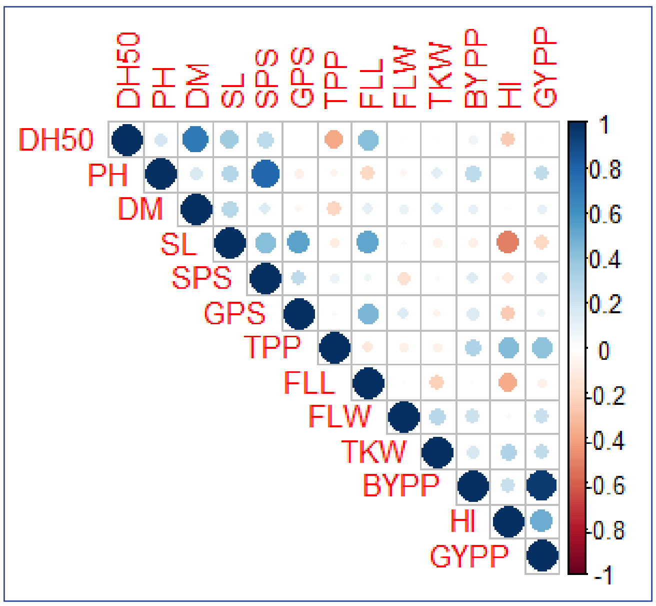

Figure 2: Diagonal representation of pearson coefficient for yield attributing traits at significance level ($p<0.05$); Where; DH50: Days to 50% flowering; PH: Plant height; DM: Days to maturity; SL: Spike length; SPS: Spikelet spike^{-1}; GPS:Grains spike^{-1}; TPP:Tiller plant^{-1}; FLL: Flag leaf length; FLW: Flag leaf width; TKW: Thousand karnel weight; BYPP: biological yield plant^{-1}; HI: Harvest index; GYPP: Grain yield plant^{-1}

highly significant association with biological yield per plant which was also reported previously by Avinashe et al. (2014). At the same time as in our study, harvest index have positive and significant correlation of about (0.49*) with grain yield per plant which was in accordance with Kumar et al. (2014). Donald (1962) first distinct the harvest index as the economic yield of a wheat crop articulated as a decimal fraction of entire biological yield. As a result crop yield can be improved either by mounting the total dry matter growth or by rising the fraction of economic yield in whole portion of biological yield. Nevertheless, it has been found that most of the traits among parents and F1's just have non–significant relationship, also, spike length and flag leaf length have negative and non–significant relationship with the grain yield per plant. In the study conducted by Fischer, 1975 the correlation coefficient for harvest index between genotypes from one generation to the next was recorded about 0.75. It looks like that the harvest index is heritable to a considerable degree, like grain yield in cereals. In view of the fact that, it involves not only grain yield but also numerous components of biological yield, Hence, it is unavoidably be in command of polygene. It is adjacent to some extent that the use of biological yield and harvest index in cereal breeding has been advocated or examined by Donald, 1962, Singh and Stoskopf, 1971, Rosielle and Frey, 1975a, Fischer, 1975.

Moreover it is suggested that the selection of parental lines in a breeding programs ought to be extended to incorporate material of high harvest index, yet including genotypes of inferior biological yield and grain yield. Although, within most of the cereals there may be unknown sources of "high competence of grain production," unobserved for the reason that their production is low, explicitly, there seems to be a chance to unite a high biological yield with a towering harvest index. In our finding too, both biological yield per plant and harvest index seems to be contributing to grain yield per plant. Hence can be propose as a selection criteria for yield improvement. Similarly, McEwan (1973) had anticipated that the high harvest index of two Mexican semi–dwarf wheats could be pooled with the high biological yield of current New Zealand cultivars. And in the initial yield tests, hybrid stocks have proved promising. A comparable suggestion was also made for pooling the high biological yield of a genotype amongst the field peas with the another genotype of high harvest index of (Donald, 1962). A striking contrast between two sorghum cultivars is reported from Nigeria (Goldsworthy, 1970).

The path coefficient analysis for all the traits studied in the present investigation showed a wide range of direct and indirect relationships with the depended trait. Path coefficient is a standardarized partial regression analysis that partitions the correlation coefficient into direct and indirect effects (Falconer and Mackay, 1996). The present study, have reported that plant height, flag leaf length, flag leaf width, days to 50% flowering, grains per spike, biological yield per plant, and harvest index had positive direct effect on grain yield per plant indicating the influential relationship between these traits as good contributors to grain yield as represented in Table 2. Similar results were also reported by Baye et al. (2020). Biological yield per plant had the highest positive direct effect on grain yield followed by harvest index suggesting selection based on these traits may be effective for yield improvement in bread wheat.

Days to maturity and thousand karnel weight had negative

Table 2: Direct and Indirect effect relationship among yield attributing traits

Traits	DH50	PH	DM	SL	SPS	GPS	TPP
DH50	0.0349	0.0126	-0.0027	-0.0031	-0.0101	0.0000	-0.0122
PH	0.0066	0.0665	-0.0006	-0.0026	-0.0292	-0.0022	-0.0019
DM	0.0244	0.0106	-0.0038	-0.0026	-0.0052	-0.0012	-0.0067
SL	0.0122	0.0193	-0.0011	-0.0089	-0.0157	0.0130	-0.0035
SPS	0.0094	0.0519	-0.0005	-0.0038	-0.0375	0.0061	0.0026
GPS	0.0000	-0.0060	0.0002	-0.0047	-0.0094	0.0246	0.0010
FLL	0.0150	-0.0133	-0.0005	-0.0046	-0.0026	0.0113	-0.0039
FLW	-0.0007	-0.0033	-0.0004	-0.0003	0.0064	0.0037	-0.0026
TPP	-0.0132	-0.0040	0.0008	0.0010	-0.0030	0.0007	0.0321
TKW	-0.0007	0.0086	-0.0005	0.0006	-0.0011	-0.0015	-0.0026
BYPP	0.0028	0.0180	-0.0004	0.0008	-0.0056	0.0037	0.0100
HI	-0.0091	-0.0007	0.0001	0.0045	0.0045	-0.0064	0.0141

Table 2: Continue...

Traits	FLL	FLW	TKW	BYPP	HI	GYPP	Residual
DH50	0.0108	-0.0003	0.000001	0.0688	-0.0787	0.0200	-0.0056
PH	-0.0050	-0.0008	-0.000006	0.2323	-0.0030	0.2600	-0.0056
DM	0.0030	0.0016	-0.000006	0.0860	-0.0061	0.1000	-0.0056
SL	0.0131	0.0005	0.000003	-0.0774	-0.1513	-0.2000	-0.0056
SPS	0.0018	-0.0027	-0.000001	0.1291	-0.0363	0.1200	-0.0056
GPS	0.0115	0.0024	0.000003	0.1291	-0.0787	0.0700	-0.0056
FLL	0.0251	-0.0002	0.000011	0.0086	-0.1150	-0.0800	-0.0056
FLW	-0.0003	0.0160	-0.000012	0.1893	0.0121	0.2200	-0.0056
TPP	-0.0030	-0.0013	0.000004	0.2668	0.1331	0.4100	-0.0056
TKW	-0.0060	0.0045	-0.000044	0.1549	0.0938	0.2500	-0.0056
BYPP	0.0003	0.0035	-0.000008	0.8605	0.0666	0.9600	-0.0056
HI	-0.0095	0.0006	-0.000014	0.1893	0.3025	0.4900	-0.0056

Where; DH50: Days to 50% flowering; PH: Plant height; DM: Days to maturity; SL: Spike length; SPS: Spikelet spike^{-1}; GPS:Grains spike^{-1}; TPP: Tiller plant^{-1}; FLL: Flag leaf length; FLW: Flag leaf width; TKW:Thousand karnel weight; BYPP: biological yield plant^{-1}; HI:Harvest index; GYPP: Grain yield plant^{-1}

direct effect on grain yield per plant, similar results were are reported by Wolde et al. (2016), Baye et al. (2020). However, we also found negative direct effect of spike length, and spikelet per spike on grain yield per plant. The analysis of correlation coefficient and cause & effect relationship showed that the spike length have a negative and non–significant association with grain yield per plant while it have a positive indirect effect on grain yield via flag leaf length. It may be implied that it may be due to source–sink relationship, although it is non– significant, hence it may be due to some other

unknown causes. However, it is not possible to recognise the parents with high harvest index until biological yield and grain yield are measured. Nevertheless, the harvest index may reflect may factor, at low or high values. As in his study, Goldsworthy (1970) found that the maturity in relation to seasonal climatic conditions, spikelet number and survival, structure of the leaf canopy and sink relationships between the grain and the stem all predisposed the index. Even though the use of harvest index does serve to highlight that a number of varieties, whether for some known reasons or not, encompasses high efficiency in grain production comparative to their biological yields. That clarify that the harvest index deserves full consideration as a possible criterion in the choice of parents.

4. Conclusion

The information of associations among traits and yield clarified their relative importance. Traits which showed positive and significant association were considered for yield improvement in wheat crop. However, some traits had negative association, although they had an influential impact on grain yield due to their indirect effect via other yield attributing traits. Hence, care was taken while just considering the positive and significant association, so that the best fit model was selected for the crop yield improvement program.

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