Character association and Path coefficient analysis for yield attributing traits in Wheat (*Triticum aestivum* L.)

ABSTRACT

The present investigation was carried out to estimate the nature and magnitude of variability parameters and characters associations among 19 genotypes of wheat for 12 characters. The experiment was laid out in Randomized Completely Block Design with 3 replications during rabi, 2022-23 at Research Farm of Genetics and plant breeding AKS University, Stana, (M.P). The Analysis of variance indicated that the mean sum of squares due to genotypes were highly significant for all the traits. Seed Yield per Plant also demonstrated considerable genetic variability (GCV: 17.37%, PCV: 18.60%) with high heritability (87.20%) and a genetic advancement of 14.95, confirming its potential for genetic enhancement. Seed yield per plant is strongly correlated with the number of productive tillers (0.808**), biological yield (0.354**), number of seeds per spike (0.357**), and harvest index (0.327*), making these traits vital for breeding programs focused on yield improvement. Days to 50% flowering positively correlates with plant height (0.590**), number of seeds per spike (0.471**), test weight (0.319**), and harvest index (0.330**), but negatively with days to maturity (-0.428**) and biological yield (-0.378**).

Keywords: *Wheat, Variability, correlation, path analysis*

1. INTRODUCTION

Wheat is a vital global food crop and holds a significant place in Indian agriculture, ranking second after rice. As a key cereal, it supports food security, poverty alleviation, and livelihoods (Kumar *et al.*, 2017). Contributing around 30% to the nation's food basket, wheat is cultivated extensively as a staple crop (Singh *et al*., 2023). Grain yield components show varied relationships with yield and each other (Edae*et al.*, 2014).

Simple correlation analysis indicates the degree of association between the traits, but it can't provide reasons for the association. The better understanding of the association is provided by the path coefficient analysis (Shah *et al*., 2010; Desheva, 2016). It helps in partitioning of correlation coefficients into direct and indirect effects and in the assessment of the relative contribution of each component character to the yield (Verma *et al*., 2019). Noopur *et al*. (2019) noted that the information related to the nature and extent of association among the various yield attributes, the direct and indirect effects of each component on the yield are helpful in formulating an effective breeding strategy. The aim of the study was to determine the interrelationship and the direct and indirect effects of some yield components among themselves and with the grain yield in the common winter wheat.

2. MATERIALS AND METHODS

The experimental materials for this study consisted of 19 wheat treatmentsand one standard variety used as a check. PBW 343, JW 2030, MALWA SAKTI, PASSWAN, RUCHI NSW 450,PAIGAMBARI,SIHORI SHARBATI,MP 1215,RATAN,JW 273,GW 366,SD 2526,HD 2967,HI 1633,PISI,SONALIKA,JW 3211,MP 1106,LOCAL VARIETY.All the 19 genotypes were grown in Randomized Block Design (RBD) with 3 replicationsduringrabi 2023 atResearch Farm Genetics & Plant Breeding of AKS University, Satna, M.P.

3. STATISTICAL ANALYSIS

The analysis of variance (ANOVA) for the design of experiment was carried out following the procedure outlined by Panse and Sukhatme (1967). The genotypic variance was calculated using the formula suggested by Burton and Devane (1953). The coefficient of genotypic and phenotypic variation was calculated using Burton's (1952) formula, providing a measure of the extent of variation within the population. The genetic advance as a percentage of the mean was calculated using the formula given by Robinson and Comstock (1949). The association among different characters at both genotypic and phenotypic levels was determined using the method outlined by Searle *et al.* (1971). Direct and indirect effects were estimated using path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959).

4. RESULTS AND DISCUSSION

The results of analysis of variance (ANOVA) indicated significant differences among the genotypes for most of the traits studied, suggesting a high degree of genetic variability(Table 1). This variability is crucial for the selection and improvement of these traits in breeding programs. The significant differences among genotypes highlight the potential for selecting superior genotypes with desirable traits for further breeding (Shara*et al.*, 2016).

4.1. Genotypic correlation coefficient analysis

The genotypic correlation analysis reveals crucial links between wheat traits and seed yield(Table 2). Days to 50% flowering positively correlates with plant height (0.590**), number of seeds per spike (0.471**), test weight (0.319**), and harvest index (0.330**), but negatively impacts biological yield (-0.378**) and days to maturity (-0.428**).Days to maturity shows a positive link with plant height (0.391**) and number of seeds per spike (0.410**), but negatively affects test weight (-0.225*), biological yield (-0.261*), and seed yield (-0.464**). The number of productive tillers strongly correlates with seed yield (0.808**), biological yield (0.315**), and ear number (0.913**), highlighting its importance for yield improvement. Plant height is positively linked to biological yield (0.497**) but negatively impacts seed yield (-0.445**), indicating the balance between growth and reproduction(Upadhyay and Katel 2024).The traits like the number of ears per plant (0.313**) and seeds per spike (0.357**) positively influence yield, while ear length boosts spikelet number (0.302**) and test weight (0.340**). Harvest index correlates with seed yield (0.327*), while biological yield connects with seed yield per plant (0.354**) and tiller number (0.315**).Seed yield per plant is highly influenced by tillers (0.808**), seed count (0.357**), and harvest index (0.327*), but negatively affected by plant height (-0.445**), necessitating trade-off management in breeding strategies(Haydar *et al.*, 2020).

4.2. Phenotypic correlation coefficient analysis

The phenotypic correlation analysis reveals key relationships between wheat agronomic traits and seed yield(Table 2). Days to 50% flowering positively correlated with plant height (0.578**), seeds per spike (0.424**), test weight (0.316*), and harvest index (0.326*), but negatively impacted days to maturity (-0.414**) and biological yield (-0.373**), suggesting early flowering boosts seed production and grain quality at the cost of biomass. Days to maturity, while positively linked to plant height (0.363**), was negatively associated with ear length (-0.394**), seeds per spike (-0.352**), biological yield (-0.254**) and seed yield per plant (-

0.409**), indicating that longer maturity favors vegetative growth over seed production. The number of productive tillers per plant was strongly correlated with ears per plant (0.934**), biological yield (0.307*), and seed yield (0.949**), making it a critical trait for yield improvement. Plant height positively correlated with biological yield (0.492**) but negatively with seed yield (-0.416**), reflecting a trade-off between vegetative growth and seed production. Ears per plant had a positive link to biological yield (0.296*) and productive tillers, with no significant negative correlations, making it favorable for breeding. Ear length positively influenced the number of spikelets per ear (0.283) and seeds per spike (0.325*), further boosting yield potential. The number of seeds per spike showed positive correlations with flowering time (0.424**) and seed yield (0.308*) but was negatively affected by maturity duration (-0.352**), highlighting the need for balancing seed number and maturation. Test weight correlated positively with seed yield (0.295*), underlining its role in grain quality. Biological yield was positively associated with tiller number, ears per plant, and seed yield (0.327*), but negatively with harvest index (-0.726**), indicating the importance of balancing biomass and grain production. Harvest index had a positive correlation with seed yield (0.314*) but was negatively linked to biological yield, emphasizing the need for efficient resource use. Seed yield per plant strongly correlated with tillers (0.949**), seeds per spike (0.308*), biological yield (0.327*), and harvest index (0.314*), demonstrating the importance of these traits for maximizing yield in wheat breeding programs (Joshi *et al*., 2008).

4.3. Path coefficient analysis

4.3.1. Genotypic path coefficient analysis

The genotypic path analysis revealed valuable insights into the traits influencing seed yield per plant (Table 3). Days to 50% flowering exhibited a negative direct effect (-0.630), indicating that earlier flowering contributes positively to yield, though its overall influence was limited due to weak indirect effects, resulting in a weak correlation (0.048). Days to maturity had a strong negative direct effect (-1.117), with earlier maturity significantly enhancing seed yield, as indicated by its correlation (-0.464**). The number of productive tillers per plant showed a moderate positive direct effect (0.293) and a strong correlation (0.808**), making it one of the most influential traits for improving seed yield. Plant height displayed a strong positive direct effect (1.113), but its indirect negative effects through days to 50% flowering (-0.372) and biological yield per plant (-0.714) resulted in a negative overall correlation (-0.445**), suggesting that taller plants might reduce yield due to resource allocation inefficiencies (Regar*et al*, 2023).

The number of ears per plant had a small positive direct effect (0.070) with a weak overall influence on seed yield (correlation = 0.073). Ear length demonstrated a negative direct effect (-0.759), with weak positive contributions from indirect effects, resulting in a weak correlation (0.181), indicating that longer ears do not directly enhance yield. Similarly, the number of spikelets per ear showed minimal direct impact (0.081) on seed yield, while the number of seeds per spike had a moderate positive correlation (0.357**) due to strong indirect effects via days to maturity (0.459), despite a weak negative direct effect (-0.145). Test weight exhibited a small positive direct effect (0.055) and weak positive correlation (0.324*), suggesting its role in improving grain quality and yield.

Biological yield per plant emerged as the most critical trait, with the highest positive direct effect (1.435) on seed yield. Despite negative indirect effects from traits like plant height (-0.714) and the number of productive tillers per plant (-0.452), its strong positive correlation (0.354**) underscores its importance in yield determination. Harvest index also showed a strong positive direct effect (1.203), confirming its significance in improving yield by enhancing resource efficiency, with a positive correlation (0.327*). Overall, the analysis highlighted that the number of productive tillers per plant, biological yield per plant, and harvest index are the most influential traits for achieving higher seed yield, while traits like days to maturity and plant height require careful consideration due to their complex relationships with yield(Shara*et al.*, 2016).

4.3.2. Phenotypic path coefficient analysis

The phenotypic path coefficient analysis reveals the intricate relationships between various traits and their influence on seed yield in wheat(Table 4). Days to 50% flowering shows a direct positive effect on seed yield (0.107), suggesting that early flowering can enhance yield, supported by positive indirect effects through traits like plant height and number of seeds per spike. However, it also has negative indirect effects through biological yield, indicating potential trade-offs. Days to maturity has a direct negative effect on yield (-0.290), but its positive indirect effects through traits like ear length and biological yield per plant suggest it can still contribute positively when balanced with other traits. The number of productive tillers per plant, despite its direct negative effect (-0.358), has strong positive indirect effects through the number of ears per plant and biological yield, indicating its potential for yield improvement if managed properly. Plant height directly boosts yield (0.126) but needs to be balanced with its negative indirect effects, particularly on biological yield. The number of ears per plant shows a strong direct positive effect on yield (0.470), highlighting its importance as a key yield component, although it must be balanced with biological yield to avoid negative impacts. Ear length has a direct negative effect on yield (-0.277) but can contribute positively when paired with other favorable traits. The number of spikelets per ear has a small direct positive effect (0.018) and contributes modestly to yield improvement. The number of seeds per spike has a direct negative effect (-0.081), suggesting that simply increasing seed number per spike may not always benefit yield, emphasizing the need for balance. Test weight has a direct negative effect on yield (-0.127), but its positive indirect effects through traits like days to maturity indicate that it can still be optimized for yield improvement. Biological yield per plant (1.238) and harvest index (1.116) have strong direct positive effects on seed yield, making them critical targets for yield enhancement. However, significant negative indirect effects highlight the need to balance these traits with other factors to maximize yield efficiently(Shrief*et al.*, 2019).

CONCLUSION

The study revealed substantial variability in traits like days to 50% flowering, maturity, number of productive tillers, plant height, and seed yield, with traits such as productive tillers and biological yield showing high genetic variability, suggesting strong potential for improvement through selective breeding. Correlation analyses identified significant associations between seed yield and traits like productive tillers, biological yield, and harvest index, while plant height and days to maturity showed negative correlations, indicating trade-offs that need consideration in breeding programs. Path coefficient analysis revealed that biological yield and harvest index had strong direct positive effects on seed yield, while traits like plant height and days to flowering had negative indirect effects, illustrating the complex interactions between traits.

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Table: 1 Analysis of variance for yield and its contributing characters

Traits	Replications (df=2)	Treatments (df=18)	Error (df=36)
Days to 50% flowering	38.44	41.45**	1.23
Days to maturity	2.96	43.32**	3.06
Number of productive tillers/plant	7.32	22.08**	1.98
Plant Height	1.97	119.72**	2.71
Number of ears per plant	2.96	19.60**	2.63
Ear Length	17.55	26.46**	2.29
Number of spikelets per ear	8.70	24.46**	3.76
Number of seeds per spike	0.12	27.30**	3.86
Test weight	6.21	99.15**	0.72
Biological yield per plant	38.78	142.77**	10.43
Harvest index	0.58	290.73**	2.40
Seed yield per plant	23.58	207.56**	26.53

, ** significant at 5 and 1 per cent probability levels, respectively

Table 2: Estimates of at genotypic(upper diagonal) and phenotypic (lower diagonal)correlation coefficient for component characters with grain yield per plant

Traits	DFF	DM	NPT	PH	NEP	EL	NSE	NSS	TW	BYP	HI	SYP
DFF	**1.000**	-0.428**	-0.010	0.590**	-0.052	0.038	-0.124	0.471**	0.319**	-0.378**	0.330**	0.048
DM	-0.414**	**1.000**	0.199	0.391**	0.131	-0.449	-0.071	0.410**	-0.225*	-0.261*	-0.001	-0.464**
NPT	-0.009	0.184	**1.000**	-0.103	0.913**	-0.052	0.167	-0.173	-0.148	0.315**	0.201	0.808**
PH	0.578**	0.363	-0.099	**1.000**	-0.084	0.151	-0.071	0.270	-0.114	0.497**	0.138	-0.445**
NEP	-0.037	0.150	0.934**	-0.074	**1.000**	0.088	0.188	-0.297**	-0.177	0.313**	0.195	0.073
EL	0.041	-0.394**	-0.075	0.131	0.067	**1.000**	0.302**	0.340**	-0.016	0.111	-0.159	0.181
NSE	-0.115	-0.068	0.138	-0.072	0.123	**0.283**	**1.000**	-0.102	-0.279	-0.174	0.107	0.129
NSS	0.424**	-0.352**	-0.201	0.250	-0.239	0.325*	-0.072	**1.000**	0.042	-0.154	-0.098	0.357**
TW	0.316*	-0.213	-0.149	-0.110	-0.162	-0.008	-0.260	0.048	**1.000**	0.157	0.160	0.324*
BYP	-0.373**	-0.254**	0.307*	0.492**	0.296*	0.109	-0.156	-0.136	0.156	**1.000**	-0.729**	0.354**
HI	0.326*	0.003	0.190	0.138	0.179	-0.150	0.096	-0.091	0.158	-0.726**	**1.000**	0.327*
SYP	0.042	-0.409**	0.949**	-0.416**	0.065	0.136	0.101	0.308*	0.295*	0.327*	0.314*	**1.000**

, ** significant at 5 and 1 per cent probability levels, respectively

Days to 50% Flowering = DFF, Days to Maturity = DM, Number of Productive Tillers per Plant = NPT, Plant Height = PH, Number of Ears per Plant = NEP, Ear Length = EL, Number of Spikelets per Ear = NSE, Number of Seeds per Spike = NSS, Test Weight = TW, Biological Yield per Plant = BYP, Harvest Index = HI, Seed Yield per Plant = SYP.

Table 3: Estimates of genotypic path coefficient for component characters with seed yield per plant

Traits	DFF	DM	NPT	PH	NEP	EL	NSE	NSS	TW	BYP	HI	Correl. Value of seed yield per plant
DFF	**-0.630**	0.144	0.006	-0.372	0.032	-0.024	0.078	-0.297	-0.201	0.239	-0.209	0.048
DM	0.255	**-1.117**	-0.222	-0.437	-0.146	0.502	0.080	0.459	0.252	0.292	0.001	-0.464**
NPT	-0.003	0.058	**0.293**	-0.030	0.297	-0.015	0.049	-0.051	-0.043	-0.092	0.059	0.808**
PH	0.658	0.435	-0.115	**1.113**	-0.093	0.168	-0.079	0.300	-0.127	-0.554	0.154	-0.445**
NEP	-0.004	0.009	0.071	-0.006	**0.070**	0.006	0.013	-0.021	-0.012	-0.022	0.014	0.073
EL	-0.029	0.341	0.040	-0.115	-0.067	**-0.759**	-0.230	-0.258	0.012	-0.084	0.121	0.181
NSE	-0.010	-0.006	0.014	-0.006	0.015	0.025	**0.081**	-0.008	-0.023	-0.014	0.009	0.129
NSS	-0.068	0.060	0.025	-0.039	0.043	-0.049	0.015	**-0.145**	-0.006	0.022	0.014	0.357**
TW	0.018	-0.012	-0.008	-0.006	-0.010	-0.001	-0.015	0.002	**0.055**	0.009	0.009	0.324*
BYP	-0.543	-0.375	-0.452	-0.714	-0.449	0.159	-0.250	-0.221	0.225	**1.435**	-1.046	0.354**
HI	0.398	-0.001	0.241	0.166	0.235	-0.191	0.129	-0.118	0.193	-0.877	**1.203**	0.327*

Days to 50% Flowering = DFF, Days to Maturity = DM, Number of Productive Tillers per Plant = NPT, Plant Height = PH, Number of Ears per Plant = NEP, Ear Length = EL, Number of Spikelets per Ear = NSE, Number of Seeds per Spike = NSS, Test Weight = TW, Biological Yield per Plant = BYP, Harvest Index = HI, Seed Yield per Plant = SYP.

Table 4: Estimates of phenotypic path coefficient for component characters with seed yield per plant

Traits	DFF	DM	NPT	PH	NEP	EL	NSE	NSS	TW	BYP	HI	Correl. Value of seed yield per plant
DFF	**0.107**	-0.023	-0.001	0.062	-0.004	0.004	-0.012	0.045	0.034	-0.040	0.035	0.042
DM	0.062	**-0.290**	-0.053	-0.105	-0.043	0.115	0.020	0.102	0.062	0.074	-0.001	-0.409**
NPT	0.003	-0.066	**-0.358**	0.035	-0.335	0.027	-0.050	0.072	0.054	0.110	-0.068	0.949**
PH	0.073	0.046	-0.012	**0.126**	-0.009	0.016	-0.009	0.031	-0.014	-0.062	0.017	-0.416**
NEP	-0.018	0.070	0.440	-0.035	**0.470**	0.032	0.058	-0.112	-0.076	-0.139	0.084	0.065
EL	-0.011	0.109	0.021	-0.036	-0.019	**-0.277**	-0.078	-0.090	0.002	-0.030	0.042	0.136
NSE	-0.002	-0.001	0.002	-0.001	0.002	0.005	**0.018**	-0.001	-0.005	-0.003	0.002	0.101
NSS	-0.034	0.028	0.016	-0.020	0.019	-0.026	0.006	**-0.081**	-0.004	0.011	0.007	0.308*
TW	-0.040	0.027	0.019	0.014	0.021	0.001	0.033	-0.006	**-0.127**	-0.020	-0.020	0.295*
BYP	-0.462	-0.313	-0.380	-0.609	-0.367	0.135	-0.193	-0.168	0.193	**1.238**	-0.899	0.327*
HI	0.365	0.003	0.212	0.154	0.200	-0.167	0.107	-0.101	0.177	-0.811	**1.116**	0.314*