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# Correlation coefficient analysis for grain yield and its contributing traits in bread wheat (*Triticum aestivum* L. em. Thell)

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**Abstract**

This research paper investigates the correlation coefficients between grain yield and its contributing traits in bread wheat (*Triticum aestivum* L. em. Thell), highlighting the significance of various morphological and physiological characteristics in enhancing wheat productivity. Wheat is a crucial global cereal crop, providing substantial nutritional benefits and serving as a primary food source for a significant portion of the world's population. The study analyzed 139 treatments comprising 19 diverse genotypes, including both parental lines and their derived F1 and F2 generations, evaluated under a Randomized Block Design across three replications during the *Rabi* season. Key traits assessed included biological yield, productive tillers per plant, harvest index, and thousand-grain weight, with data collected on thirteen quantitative characters.

The findings revealed a strong positive genotypic correlation of grain yield per plant with biological yield (0.257), productive tillers (0.427), harvest index (0.464), and number of grains per ear (0.371) in the F1 generation. Similarly, in the F2 generation, significant positive correlations were observed with biological yield (0.302), productive tillers (0.276), and harvest index (0.436). While phenotypic correlations were generally lower than genotypic ones, they reinforced the importance of these traits in yield improvement. The results suggest that breeding programs focusing on these key traits can effectively enhance wheat yield potential, emphasizing the critical role of genetic selection in improving agronomic outcomes. Overall, the study provides valuable insights for wheat breeders aiming to develop high-yielding, resilient wheat varieties through strategic selection and hybridization.

**Keywords:** Bread wheat, grain yield, correlation and F1

## Introduction

Wheat (*Triticum aestivum* L., 2n=42) is the most important cereal in the world and was one of the first crops to be domesticated some 10000 years ago (Harlan and Zohary, 1966) [12]. Wheat holds a prominent position among cereals due to its large cultivation area and its nutritional contribution, providing about 20% of the global population's caloric intake. It is a primary food source for nearly two billion people, or 36% of the world's population. Globally, wheat accounts for around 55% of the carbohydrates and 20% of the food calories consumed.

The wheat plant is rhizomatous, indicating its connection to the grass family, with its shoots producing several leafy culms, or tillers. The number of culms per plant depends on both its genetic makeup and environmental conditions. These culms are cylindrical, typically hollow with solid nodes, and gradually narrow toward the top internode, known as the peduncle, which supports the spike. The inflorescence, also referred to as the 'ear' or 'head,' is a spike made up of florets (Spikelets) arranged in a zig-zag pattern along the flat rachis. Each floret contains two bract-like structures called the lemma and palea, along with three stamens and a pistil that has two styles with a feathery stigma. Pollination in wheat is mainly through self-pollination.

Wheat is mainly grown during *Rabi* season and has wide adaptability. The most favourable climatic condition for wheat cultivation is cool and moist weather during the vegetative growth period followed by dry, warm weather for the grain to mature. The optimum temperature range for ideal germination of wheat seed is 20-25 °C.

In India, it is grown mostly in the plains whereas in the hills it is cultivated in the mountainous region of North India & Nilgiris and Palani hills in South India. For the convenience of testing & finding out the correct adaptability the country is divided into six different wheat growing zones namely Northern Hill Zone (NHZ), North Western Plains Zone (NWPZ), North Eastern Plains Zone (NEPZ), Central Zone (CZ), Peninsular Zone (PZ), and Southern Hill Zone (SHZ). The zone–wise total percentage of acreages of wheat crops are 2.9%, 40.1%. 33.2%, 18.1%, 5.4% and 0.4% respectively. (Status paper on wheat, DWD, Ghaziabad)

Wheat is used by human beings in form of flour for making Chapaties, Semolina and Pasta products. It is also used for preparation of bread, biscuits, cookies, cracks, noodles, dalia, maida, vermicelli, etc. Wheat straw is also used for animal feed as fodder and for packaging materials. Wheat is more nutritive as compared to the other cereals. Wheat contains good nutrition profile nearly 70% carbohydrates, 12% protein, 1.7% fat,1.8% ash, 2.0% reducing sugar, 6.7% pentosans, 5.9% starch, 2% fiber, 12% moisture and 314 Kcal/100 g of food. It is also a good source of minerals and vitamins *viz*., calcium (37 mg/100 g), iron (4.1 mg/100 g), thiamine (0.45 mg/100 g), riboflavin (0.13 mg/100 g) and nicotinic acid (5.4 mg/100 g) (Lorez and Kulp, 1990) [15].

Wheat is world's leading cereal crop, cultivated in an area of about 221.24 million hectares with a production of 771.64 million tons and productivity of 3.49 metric tons per hectare (USDA 2023). India's wheat production has touched the landmark figure of 107.74 million tonnes from 30.45 million hectares (13.47% of global area) registering an all-time highest crop productivity of 35.37 quintals per hectare (FAO, 2022) [10].

Wheat has second rank after paddy both in area and production, occupying 31.40 million ha area with production of 110.55 million tons and the productivity of 35.21 quintals per hectare (UPAg -DA&FW, 2022-23).

Genetic diversity is essential for developing improved wheat varieties, and wheat offers a wide range of genetic variability. Wheat breeders globally are focused on improving wheat's yield and adaptation to different conditions. The process of selection and hybridization is commonly employed to pool favorable traits and enhance wheat's genetic potential.

To ensure continued improvement in wheat production, the breeding program must utilize both indigenous and exotic germplasm to create varieties with better adaptability, higher yields, and resilience. Germplasm serves as a valuable resource in identifying donor parents that contribute desired traits, such as disease resistance and higher productivity. Selection is used to pool favorable genes, while hybridization combines favorable genes to produce better-performing genotypes.

A range of biometrical techniques are commonly applied for assessing plant genetics, with Line × Tester analysis being frequently utilized by breeders as it provides valuable genetic insights into the studied material. Improving yield can be accomplished by directly selecting for grain yield and its contributing traits. Correlation analysis is crucial for understanding the strength and direction of the relationship between yield and its component traits. At the same time, path coefficient analysis evaluates the direct and indirect effects of independent factors on dependent variables, aiding breeders in identifying key yield components and the underlying connections between two traits. In general, the genotypic correlation coefficients were higher than the phenotypic correlation coefficients for most traits, except for a few specific combinations.

## Materials and Methods

Basic material consisting of 19 (15 lines and 4 testers) morphological diverse genotypes *viz.*, K 402, K 1006, HD 3086, HD 2967, DBW 107, HI 1612, PBW 644, DBW 398, PBW 386, HD 3171, DBW 252, K 1711, K 1616, DBW 173, K307, DBW 187, DBW 222, GW 322 and K 1317 were obtained from the germplasm maintained at Section of *Rabi* Cereals of the university in order to develop material to be evaluated for the study.

The experimental material consisted of 139 treatments (19 parents + 60 F1s+ 60 $F_2$s) was sown in a Randomized Block Design with three replications at Student Instruction Farm, C.S. Azad University of Agriculture and Technology, Kanpur-208002 (U.P.) during *Rabi*, 2023-24. Each parent and F1s were planted in single row while each $F_2$s was planted in two rows of 3 meter length plots with inter and intra-row spacing of 22.5 cm and 10 cm, respectively. Recommended cultural practices and fertilizer dose were applied to raise good crop.

Data recorded for 13 characters *viz.*, days to 50% heading, days to maturity, plant height (cm), flag leaf area ($cm^2$), number of leaves/main tiller, number of productive tillers per plant, ear length (cm), number of spikelets per ear, number of grains per ear, biological yield (g), grain yield per plant (g), harvest index (%) and 1000-grain weight (g).

### Estimation of Correlation coefficients

The estimates of phenotypic and genotypic correlation were corked out as given under:

### Genotypic correlation

$$r_{xy}(g)= Cov._{xy}(g) / [V_x(g).V_y(g)]^{0.5}$$

Where,

$Cov._{xy}(g)$ = genotypic covariance between character X and y was obtained as follows:

$Cov._{xy}(g) = [Cov._{xy}(p) – Cov._{xy}(e)]$

$V_x(g)$ and $V_y(g)$ = Genotypic variance for the characters x and y respectively.

r = number of replications.

### Phenotypic correlation

$$r_{xy}(p) = Cov._{xy}(p) / [V_x(p). V_y(p)]^{0.5}$$

Where,

$Cov._{xy}(p)$ = Phenotypic correlation between the character x and y and this was obtained as follows:

$Cov._{xy}(p) = Cov._{xy}(g) + Cov._{xy}(e)$

$V_x(p)$ and $V_y(p)$= Phenotypic variance for the characters x and y, respectively.

xy (e) = the error variance obtained from the ANNOVA of x and y characters.

### Test of significance of correlation coefficients:

The significance of phenotypic coefficient was tested against r‶ values from r‶ Table of Fisher and Yates (1938) [24] for (n-2) degree of freedom where n‶ is number of treatments.

## Results and Discussion

Correlation study was carried out between all the thirteen characters at genotypic and phenotypic levels. The phenotypic and genotypic correlation coefficient of F1 and F2 computed among the thirteen characters under study has been presented in Table 1 and Table 2 respectively.

### Genotypic Correlation ($F_1$ Generation)

The grain yield per plant exhibited high positive significant association at genotypic level in F1 with biological yield per plant (0.257), productive tiller per plant (0.427) Harvest Index (0.464), 1000 Grain Weight (0.221) and number of grains per ear (0.371) while number of leaves per main tiller (0.167) shows significant association. Ear length (-0.039) shows non-significant negative association with grain yield while days to 50% heading (0.081), days to maturity (0.093), plant height (0.010), flag leaf area (0.058) and number of spikelet per ear (0.079) shows non-significant positive correlation with grain yield.

These findings suggest that these traits play a crucial role in determining grain yield, consistent with earlier studies (Kumar *et al.*, 2011; Khan *et al*., 2018) [14, 13]. A higher number of productive tillers ensures more spikes and grain production, aligning with previous research highlighting the importance of tiller number (Singh *et al.*, 2015) [19].

Other traits, such as number of leaves per main tiller (0.167), also showed a significant positive correlation, albeit weaker, indicating a secondary role in yield determination. On the contrary, ear length (-0.039) displayed a non-significant negative correlation with grain yield, suggesting it does not directly contribute to yield enhancement.

Non-significant positive correlations with grain yield were observed for traits like days to 50% heading (0.081), days to maturity (0.093), plant height (0.010), and flag leaf area (0.058). These findings indicate that while these traits may influence overall plant development, their contribution to yield is relatively limited.

Additionally, days to 50% heading had a positive significant correlation with days to maturity (0.717), while ear length (-0.309) and 1000 grain weight (-0.197) showed significant negative correlations. Days to maturity also showed a positive significant association with harvest index (0.210) but was negatively correlated with ear length (-0.267).

These results align with previous studies emphasizing the importance of harvest index in wheat yield improvement (Tian *et al.*, 2011) [21].

### Phenotypic Correlation (F1 Generation)

The grain yield per plant exhibited high positive significant association at phenotypic level in F1 with productive tillers/plant (0.403), number of grains per ear (0.361), biological yield /plant (0.254) Harvest Index (0.474) and 1000 Grain Weight (0.185) and while ear length (-0.036) shows significant negative association. Days to 50% heading (0.076), days to maturity (0.062) plant height (0.027) flag leaf area (0.054), number of leaves/ main tiller (0.089), number of spikelet per ear (0.085) shows non-significant positive correlation with grain yield.

The findings confirm that these traits are critical for yield enhancement in wheat, reinforcing the results observed at the genotypic level. However, the phenotypic correlation coefficients were generally lower than the genotypic ones, indicating that environmental factors might mask the full genetic potential of these traits (Maqbool *et al.*, 2010) [16].

Traits like days to 50% heading (0.076), days to maturity (0.062), and plant height (0.027) showed non-significant positive correlations with grain yield, similar to the genotypic analysis. Notably, ear length (-0.036) showed a significant negative association with grain yield, further suggesting its limited utility in yield selection.

### Genotypic Correlation (F2 Generation)

The grain yield per plant exhibited high positive significant association at genotypic level in F2 with biological yield per Plant (0.302), productive tiller per plant (0.276) harvest index (0.436) and 1000 grain weight (0.299). Ear length (-0.049), days to 50% heading (-0.070), number of leaves per main tiller (-0.069) and number of spikelet per ear (-0.012) shows non-significant negative association with grain yield while days to maturity (0.043), plant height (0.006), flag leaf area (0.070) and number of grain per ear (0.053) shows non-significant positive correlation with grain yield.

These findings align with the F1 results, suggesting consistency in the importance of these traits across generations. Non-significant negative associations were observed for ear length (-0.049), days to 50% heading (-0.070), and number of spikelets per ear (-0.012), while positive non-significant correlations were found for days to maturity (0.043) and number of grains per ear (0.053).

The days to 50% heading showed a strong positive correlation with days to maturity (0.698), while ear length (-0.247), flag leaf area (-0.206), and 1000 grain weight (-0.325) exhibited significant negative correlations. Similar trends were observed for days to maturity, which showed a negative correlation with flag leaf area (-0.168).

### Phenotypic Correlation (F2 Generation)

The grain yield per plant exhibited high positive significant association at phenotypic level in F2 with Biological Yield per Plant (0.287), productive tiller per plant (0.256) harvest index (0.457) and 1000 grain weight (0.227). Days to 50f% heading (-0.054) and number of leaves per main (-0.048) shows non-significant negative association with grain yield while days to maturity (0.020), plant height (0.008), flag leaf area (0.056) ear length (0.001) number of spikelet per ear (0.010) and number of grain per ear (0.045) shows non-significant positive correlation with grain yield.

The significant positive correlation with biological yield indicates that efforts to enhance overall plant growth and biomass accumulation can translate into higher grain yields. Similarly, the association with productive tillers highlights the importance of tillering ability in determining grain yield. Increased tillering is associated with greater resource capture and enhanced yield potential (Shao *et al*., 2017) [25], suggesting that genetic selection for this trait could be beneficial in breeding programs aimed at yield enhancement.

The results highlight that, despite the lower phenotypic correlation values compared to genotypic ones, these traits remain crucial for yield improvement. Non-significant negative associations were observed for days to 50% heading (-0.054) and number of leaves per main tiller (-0.048).

**Table 1:** Estimates of Genotypical correlation coefficients computed between 13 characters of wheat in F1 Generation.

| Parent/ Hybrids | Days to 50% Heading | Days to maturity | Plant Height (cm.) | Flag leaf area | No of leaves/ main tiller | Productive tiller/ plant | Ear length | No of spikelet/ear | No of grains/ ear | Biological yield/ plant | Harvest index | 1000 grain weight | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Heading | 1.000 | 0.717** | -0.011 | 0.043 | -0.078 | 0.008 | -0.309** | -0.083 | -0.062 | -0.019 | 0.058 | -0.197** | 0.081 |
| Days to maturity | | | 0.070 | 0.031 | -0.066 | 0.055 | -0.267** | -0.126 | -0.101 | -0.154* | 0.210** | -0.034 | 0.093 |
| Plant Height (cm.) | | | | -0.041 | 0.302** | 0.009 | -0.042 | -0.158* | 0.091 | 0.166* | -0.116 | -0.029 | 0.010 |
| Flag leaf area | | | | | -0.192** | 0.149* | 0.201** | 0.389** | 0.043 | -0.124 | 0.202** | 0.287** | 0.058 |
| No of leaves /main tiller | | | | | | -0.135* | -0.203** | -0.073 | 0.203** | -0.038 | 0.176** | -0.130* | 0.167* |
| Productive tiller /plant | | | | | | | 0.178** | 0.266** | 0.268** | 0.324** | 0.013 | 0.194** | 0.427** |
| Ear length | | | | | | | | 0.574** | 0.196** | 0.025 | -0.005 | 0.267** | -0.039 |
| No of spikelet/ear | | | | | | | | | 0.037 | -0.112 | 0.213** | 0.189** | 0.079 |
| No of grains/ear | | | | | | | | | | 0.212** | 0.072 | 0.087 | 0.371** |
| Biological yield/plant | | | | | | | | | | | -0.722** | 0.071 | 0.257** |
| Harvest index | | | | | | | | | | | | 0.105 | 0.464** |
| 1000 grain weight | | | | | | | | | | | | | 0.221** |
| Grain yield/plant | | | | | | | | | | | | | 1.000 |

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

**Table 2:** Estimates of Phenotypic correlation coefficients computed between 13 characters of wheat in F1 Generation

| Parent/Hybrids | Days to 50% Heading | Days to maturity | Plant Height (cm.) | Flag leaf area | No of leaves/ main tiller | Productive tiller/ plant | Ear length | No of spikelet/ ear | No of grains/ ear | Biological yield/ plant | Harvest index | 1000 grain weight | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Heading | 1.000 | 0.616** | 0.012 | 0.045 | -0.047 | 0.005 | -0.252** | -0.066 | -0.057 | -0.017 | 0.055 | -0.154* | 0.076 |
| Days to maturity | | | 0.031 | 0.026 | -0.030 | 0.056 | -0.251** | -0.125 | -0.104 | -0.154* | 0.188** | -0.020 | 0.062 |
| Plant Height (cm.) | | | | -0.036 | 0.116 | 0.005 | -0.032 | -0.117 | 0.095 | 0.168** | -0.102 | -0.020 | 0.027 |
| Flag leaf area | | | | | -0.081 | 0.146* | 0.202** | 0.371** | 0.045 | -0.124 | 0.197** | 0.267** | 0.054 |
| No of leaves/ main tiller | | | | | | -0.070 | -0.093 | -0.035 | 0.094 | -0.034 | 0.105 | -0.080 | 0.089 |
| Productive tiller/ plant | | | | | | | 0.172** | 0.254** | 0.262** | 0.314** | 0.013 | 0.181** | 0.403** |
| Ear length | | | | | | | | 0.539** | 0.191** | 0.023 | -0.003 | 0.244** | -0.036 |
| No of spikelet/ear | | | | | | | | | 0.044 | -0.087 | 0.189** | 0.177** | 0.085 |
| No of grains/ear | | | | | | | | | | 0.213** | 0.070 | 0.083 | 0.361** |
| Biological yield/plant | | | | | | | | | | | -0.706** | 0.067 | 0.254** |
| Harvest index | | | | | | | | | | | | 0.081 | 0.474** |
| 1000 grain weight | | | | | | | | | | | | | 0.185** |
| Grain yield/plant | | | | | | | | | | | | | 1.000 |

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

**Table 3:** Estimates of Genotypic correlation coefficients computed between 13 characters of wheat in F2 Generation.

| Parent/ Hybrids | Days to 50% Heading | Days to maturity | Plant Height (cm.) | Flag leaf area | No of leaves/ main tiller | Productive tiller/ plant | Ear length | No of spikelet/ ear | No of grains/ ear | Biological yield/ plant | Harvest index | 1000 grain weight | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Heading | 1.000 | 0.698** | -0.009 | -0.206** | -0.001 | -0.071 | -0.247** | -0.039 | -0.036 | -0.050 | -0.023 | -0.325** | -0.070 |
| Days to maturity | | | 0.099 | -0.168** | 0.072 | -0.075 | -0.093 | -0.098 | -0.045 | -0.006 | 0.051 | -0.132* | 0.043 |
| Plant Height (cm.) | | | | 0.077 | -0.190** | -0.121 | -0.011 | -0.112 | -0.086 | 0.050 | -0.020 | 0.036 | 0.006 |
| Flag leaf area | | | | | -0.452** | 0.083 | 0.189** | 0.135* | -0.137* | -0.010 | 0.064 | 0.337** | 0.070 |
| No of leaves /main tiller | | | | | | -0.165* | -0.175** | -0.145* | 0.007 | 0.144* | -0.195** | -0.451** | -0.069 |
| Productive tiller /plant | | | | | | | 0.176** | 0.257** | 0.222** | 0.172** | 0.073 | 0.156* | 0.276** |
| Ear length | | | | | | | | 0.679** | 0.402** | 0.158* | -0.154* | 0.218** | -0.049 |
| No of spikelet/ear | | | | | | | | | 0.452** | 0.089 | -0.087 | 0.057 | -0.012 |
| No of grains/ear | | | | | | | | | | 0.304** | -0.241** | -0.095 | 0.053 |
| Biological yield/plant | | | | | | | | | | | -0.715** | 0.132* | 0.302** |
| Harvest index | | | | | | | | | | | | 0.117 | 0.436** |
| 1000 grain weight | | | | | | | | | | | | | 0.299** |
| Grain yield/plant | | | | | | | | | | | | | 1.000 |

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

**Table 4:** Estimates of Phenotypic correlation coefficients computed between 13 characters of wheat in F2 Generation.

| Parent/ Hybrids | Days to 50% Heading | Days to maturity | Plant Height (cm.) | Flag leaf area | No of leaves/ main tiller | Productive tiller/ plant | Ear length | No of spikelet/ ear | No of grains/ ear | Biological yield/ plant | Harvest index | 1000 grain weight | Grain yield/ plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Heading | 1.000 | 0.614** | 0.007 | -0.126 | 0.057 | -0.071 | -0.177** | 0.005 | -0.025 | -0.048 | -0.007 | -0.259** | -0.054 |
| Days to maturity | | | 0.092 | -0.151* | 0.065 | -0.057 | -0.094 | -0.088 | -0.040 | -0.013 | 0.039 | -0.116 | 0.020 |
| Plant Height (cm.) | | | | 0.071 | -0.084 | -0.122 | -0.008 | -0.097 | -0.080 | 0.052 | -0.020 | 0.037 | 0.008 |
| Flag leaf area | | | | | -0.165* | 0.075 | 0.171** | 0.119 | -0.131* | -0.009 | 0.054 | 0.313** | 0.056 |
| No of leaves/ main tiller | | | | | | -0.041 | -0.069 | -0.058 | 0.011 | 0.047 | -0.077 | -0.150* | -0.048 |
| Productive tiller /plant | | | | | | | 0.169** | 0.203** | 0.203** | 0.155* | 0.073 | 0.141* | 0.256** |
| Ear length | | | | | | | | 0.624** | 0.361** | 0.127 | -0.087 | 0.197** | 0.001 |
| No of spikelet/ear | | | | | | | | | 0.373** | 0.080 | -0.059 | 0.052 | 0.010 |
| No of grains/ear | | | | | | | | | | 0.285** | -0.224** | -0.084 | 0.045 |
| Biological yield/plant | | | | | | | | | | | -0.708** | 0.115 | 0.287** |
| Harvest index | | | | | | | | | | | | 0.084 | 0.457** |
| 1000 grain weight | | | | | | | | | | | | | 0.227** |
| Grain yield/plant | | | | | | | | | | | | | 1.000 |

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

## Conclusion

The study demonstrates that grain yield per plant is significantly associated with key traits such as biological yield, productive tillers per plant, harvest index, and 1000 grain weight in both F1 and F2 generations. These traits should be prioritized in wheat breeding programs to enhance yield potential. The results also suggest that genotypic correlations are generally stronger than phenotypic ones, emphasizing the importance of selecting for these traits at the genetic level.

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