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# Assessment of genetic variability in advance breeding lines of wheat

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## Abstract
A set of sixty pre-released promising genotypes of wheat were used to study variability, correlation and path coefficient analysis for yield and yield contributing traits in wheat. The high magnitude of genotypic and phenotypic coefficient of variation were observed for ear weight, grain yield/plant, biological yield/plant, peduncle length, sedimentation value, number of effective tillers/plant, number of ear/plant and ear length. High heritability coupled with high genetic advance as percentage of mean was observed for grain yield/plant, biological yield/plant, ear weight, peduncle length and sedimentation value, indicating that heritability may be due to additive gene action and simple selection based on these traits may be effective. Grain yield/plant revealed significant positive association with biological yield/plant, number of effective tillers/plant, ear weight, ear length, number of ear/plant, 1000 grain weight, harvest index and plant height. Hence, improvement of grain yield can be achieved by improving these traits. Biological yield/plant exerted high positive direct effect on grain yield/plant, followed by number of spikelets/spike, harvest index, ear length, number of ear/plant, peduncle length and ear weight. It indicated that these characters had a high association with grain yield/plant and selection for these traits would lead to increase in yield.

**Keywords:** Wheat, genetic variability, correlation and path-coefficient

## Introduction
Wheat (*Triticum aestivum* L.) is the world's second most important staple food crop for more than 35 percent of world's population next to the rice. It produces about 20% food resources of the world with high productivity and occupying a prominent position. India is the second largest wheat producer in the world with a production level of 101.20 million tonnes. Madhya Pradesh is the second largest producer state of wheat with area, production and productivity of 5.52 million hectare, 17.35 million tonnes and 3143 kg/ha, respectively[3] . For improvement of yield in Plant Breeding programme, genetic variability plays a very crucial role and lack of variability limits selection for plant improvement. Yield, a complex polygenic trait is influenced by a large number of factors. The genetic architecture of economic yield must be resolved with the genetic condition of all other characters influencing it directly or indirectly. So the study of genetic variability with the help of suitable genetic parameters such as genotypic and phenotypic coefficient of variation, heritability and genetic advance are necessary to start efficient breeding programme. According to [13] heritability and genetic advance are complementary aspects. Moreover, estimates of heritability can also be used to predict genetic advance under selection, so that the plant breeder can anticipate genetic gain from single generation of selection. Genotypic and phenotypic correlation was worked out according to [21] and path analysis as per [10]. Therefore, the present study was undertaken to estimate the genetic parameters of variability and association analyses among yield and yield attributing traits.

## Materials and Methods
The experimental material comprised of 60 promising genotypes of wheat, procured under All India Coordinated Research Project on Wheat, Jabalpur (M.P) during *Rabi* 2017-18. These genotypes were grown in a Randomized Complete Block Design (RCBD) with two replications at Seed Breeding Farm, JNKVV, Jabalpur. All the agronomic practices were made to raise the healthy crop. Each plot consisted of four rows of 4.0 meter length. Data were recorded on five randomly and competitive plants of each genotype from each replication for nineteen quantitative traits *viz*. days to 50% heading, days to maturity, plant height (cm), number of effective tillers/plant, number of spikelets/spike, number of ears/plant, number of

grains/ear, ear length (cm), ear weight (g), peduncle length (cm), biological yield/plant (g), 1000-grain weight (g), grain yield/plant (g), harvest index (%), canopy temperature ($^0$C), chlorophyll content (%), relative water content (%), protein content (%) and sedimentation value (ml). Average of the data from the sampled plants in respect of different quantitative characters were used for various statistical analyses. The genotypic and phenotypic coefficients of variation were computed by formula suggested by [6]. Heritability in broad sense was calculated by formula suggested by [13]. Coefficients of correlation were estimated by using formula suggested by [21] and path coefficient analysis as per [10].

**Results and Discussions**

The analysis of variance indicated that the mean sum of squares due to genotypes were highly significant for all the studied traits *viz*., days to 50% heading, plant height, number of grains/spike, grain yield/plant, biological yield/plant, 1000 grain weight, harvest index sedimentation value, relative water content, and chlorophyll content. The findings of [27, 26, 15, 1, 31] for all yield related traits are similar to that of the present findings**.**

Eight traits *viz*., ear weight (21.23%, 17.96%), grain yield/plant (20.49%, 17.94%), biological yield/plant (19.36%, 17.86%), peduncle length (15.28%, 13.22%), sedimentation value (14.72%, 14.70%), number of effective tillers/plant (12.53%, 8.31%), number of ear/plant (12.47%, 7.70%) and ear length (12.38%, 10.66%) exhibited high GCV and PCV. The above results are in agreement with the findings of [18] for grain yield/plant and biological yield/plant; [33] for grain yield/plant and sedimentation value; [37] for grain yield/plant, biological yield/plant and ear weight; [23] for grain yield/plant and effective tillers/plant; [25] for number of spikelets/spike; [2] for grain yield/plant and biological yield/plant; [8] for grain yield/plant, biological yield/plant, number of effective tillers/plant, number of spikelets/spike and ear length; [17] for grain yield/plant, biological yield/plant and number of effective tillers/plant; [7] for number of grain yield/plant, effective tillers/plant and peduncle length; [28] for biological yield/plant, grain yield/plant, number of effective tillers/plant and peduncle length; [30] for grain yield/plant and number of effective tillers/plant; [17] for grain yield/plant and canopy temperature; [4] for grain yield/plant; [1] for grain yield/plant, biological yield/plant and number of ear/plant (Table 1). However low PCV and GCV were recorded for days to 50% heading (5.40%, 4.30%) and days to maturity (2.12%, 1.55%). The finding of [14] for days to 50% heading; [8] for days to maturity were similar to the present finding which indicated that there is limited scope for improvement.

High heritability coupled with high genetic advance as percentage of mean was observed for traits viz. grain yield/plant (73.30%, 30.94%), biological yield/plant (85.10%, 33.96%), ear weight (71.60%, 31.31%), peduncle length (74.90%, 23.57%) and sedimentation value (99.70%, 30.24%), indicating that these traits may be governed by additive gene action and simple selection for these traits may be effective. These results are in agreement with the findings of [36, 20, 5] for grain yield/plant; [38, 15, 9] for peduncle length; [22] for sedimentation value; [5] for ear weight and biological yield/plant. Those characters representing high values of heritability and genetic advance emerge as ideal traits for improvement through selection due to high variability and transmissibility. (Table 1)

Results of correlation studies revealed positive and highly significant association of days to 50 percent heading with canopy temperature (0.41), days to maturity (0.23), whereas significant negative with number of spikelets/spike (-0.34), relative water content (- 0.33), number of grains/ear (-0.33) and grain yield/plant (-0.22). Days to maturity showed highly significant and positive correlation with plant height (0.29), ear length (0.24), relative water content (0.24), protein content (0.22) and biological yield/plant (0.21) and highly significant negative association with harvest index (-0.22). Number of effective tillers/plant expressed significant positive correlation with number of ear/plant (0.96), grain yield/plant (0.59), biological yield/plant (0.47), harvest index (0.35) and ear length (0.18), whereas significant and negative with canopy temperature (-0.14). Number of spikelets/spikes showed highly significant positive association with number of grains/ear (0.94), ear length (0.52), biological yield/plant (0.50), grain yield/plant (0.44), whereas highly significant and negative with canopy temperature (-0.25). Ear length recorded highly significant and positive correlation with biological yield/plant (0.62), grain yield/plant (0.58), ear weight (0.54), number of grains/ear (0.50), relative water content (0.37) and 1000 grain weight (0.35). Ear weight recorded highly significant and positive association with grain yield/plant (0.45), biological yield/plant (0.39), 1000 grain weight (0.35) number of grains/ear (0.24). Number of ear/plant recorded high significant and positive correlation with grain yield/plant (0.56), biological yield/plant (0.44) and harvest index (0.35). Number of grains/ear expressed a highly significant and positive correlation with biological yield/plant (0.47), relative water content (0.41), grain yield/plant (0.40), while highly significant and negative with canopy temperature (-0.31). Thousand grain weight recorded highly significant and positive association with grain yield/plant (0.43), biological yield/plant (0.32) and harvest index (0.26). Harvest index exhibited highly significant and positive correlation with grain yield/plant (0.38), canopy temperature (0.27).

Correlation coefficients at phenotypic level are presented in the table 2. Results of correlation studies revealed positive and highly significant association of grain yield/plant with biological yield/plant (0.88), number of effective tillers/plant (0.59), ear length (0.58), number of ear/plant (0.56), ear weight (0.45), 1000 grain weight (0.43) and harvest index (0.38). The above mentioned findings are in agreement with the findings of [12, 11, 15, 24, 8] for biological yield/plant and harvest index; [27, 12, 26] for number of effective tillers/plant and 1000 grain weight; [15, 16] for plant height; [36] for number of ear/plant and 1000 grain weight; [25] for 1000 grain weight; [27] for 1000-grain weight; [14] for 1000 grain weight and harvest index; [28] for biological yield/plant and ear weight; [29] for biological yield/plant, harvest index, ear length, 1000 grain weight and plant height. Overall correlation study indicated that the traits viz., number of effective tillers/ plant, number of ear/plant, ear weight, biological yield /plant, thousand grain weight and harvest index may play important role in the improvement of yield.

Path coefficient analysis was carried out using coefficient of all the traits with grain yield per plant and are presented in table 3. The substantial positive direct effect on grain yield was exerted by biological yield per plant (0.89), number of spikelets per spike (0.69), harvest index (0.38), ear length (0.12) and number of ear per plant (0.10). These traits should given importance, while practicing selection, aimed at improvement of grain yield in wheat. Path coefficient analysis was studied considering 14 component traits, out of which traits viz., biological yield/plant, number of spikelets/spike, harvest index, ear length, number of ear/plant, peduncle length and ear weight had significant positive direct effect with grain yield/plant. These traits may be rewarding for improving the grain yield. These results are in agreement with the findings of [35, 23, 32, 24] for harvest index and biological yield/plant; [34] for biological yield/plant and number of tiller/plant; [19] for harvest index; [39] for number of tiller/plant. On the basis of path analysis, traits viz., biological yield/plant, harvest index, number of tiller per plant have been found most important traits for the improvement of seed yield as they exhibited substantial positive direct effect.

On the other hand, the maximum negative direct effect was exerted by number of grains/ear (-0.6291), followed by plant height (-0.1710). The rest of the traits showed moderate to low positive or negative direct effect on grain yield/ plant. Majority of indirect effects of various independent traits *via* other traits were extremely low of either signs. Only few traits had higher to moderate positive or negative indirect effects.

Number of grains/ear exerted high indirect effect on grain yield/plant via, days to 50% heading (0.2821) and harvest index (0.1249) whereas, negative indirect effect via, number of spikelets/spike (-0.6272), ear length (-0.3918), biological yield/plant(-0.3380), plant height (-0.3106) and ear weight (-0.2230). Biological yield/plant showed high indirect effect on grain yield/plant via, ear length (0.6082), number of spikelets/spike (0.5059), plant height (0.4863), number of grains/ear (0.4775), number of effective tillers/plant (0.4304), ear weight (0.3977), number of ear/plant (0.3797), days to maturity (0.2994) and 1000 grain weight (0.2865), whereas negative indirect effect via, days to 50% heading (-0.2290) and harvest index(-0.2104). Hence these indirect effects should also be kept in the mind while selection for better yield.

**Table 1:** Estimation of mean, range and different genetic parameters for different traits

| S. No. | Traits | Range | General Mean | GCV (%) | PCV (%) | h2(bs) (%) | GA % |
|---|---|---|---|---|---|---|---|
| 1 | DFH | 60.5-73.5 | 67.43 | 4.30 | 5.41 | 63.30 | 7.05 |
| 2 | DM | 112.50-122.50 | 118.51 | 1.55 | 2.12 | 53.40 | 2.33 |
| 3 | PH | 68.16-108.99 | 97.24 | 8.08 | 9.02 | 80.20 | 14.90 |
| 4 | NET/P | 6.83-10.68 | 9.19 | 8.31 | 12.53 | 44.10 | 11.37 |
| 5 | NS/S | 14.33-19.66 | 17.36 | 6.94 | 8.21 | 71.30 | 12.07 |
| 6 | EL | 8.10-13.75 | 10.81 | 10.67 | 12.39 | 74.20 | 18.92 |
| 7 | EW | 1.25-4.02 | 2.83 | 17.96 | 21.23 | 71.60 | 31.31 |
| 8 | PL | 10.55-24.67 | 19.77 | 13.23 | 15.28 | 74.90 | 23.57 |
| 9 | NE/P | 6.75-10.53 | 9.11 | 7.70 | 12.47 | 38.10 | 9.79 |
| 10 | NG/E | 41.00-56.67 | 49.72 | 7.41 | 8.59 | 74.40 | 13.16 |
| 11 | TGW | 35.15-51.15 | 43.27 | 8.51 | 8.83 | 92.90 | 16.91 |
| 12 | BY/P | 31.99-65.62 | 47.56 | 17.87 | 19.36 | 85.10 | 33.96 |
| 13 | HI | 31.63-44.83 | 37.10 | 8.03 | 9.63 | 69.60 | 13.80 |
| 14 | CC | 41.40-55.15 | 49.24 | 4.41 | 8.09 | 29.60 | 4.94 |
| 15 | CT | 20.20-26.65 | 23.25 | 8.07 | 9.49 | 72.30 | 14.14 |
| 16 | RWC | 70.17-88.98 | 77.64 | 6.42 | 7.31 | 77.30 | 11.63 |
| 17 | PC | 11.27-14.42 | 12.71 | 7.49 | 7.64 | 96.30 | 15.15 |
| 18 | SDS | 34.29-59.11 | 47.71 | 14.70 | 14.73 | 99.70 | 30.24 |
| 19 | GY/P | 11.13-24.44 | 17.61 | 17.54 | 20.49 | 73.30 | 30.94 |

**Abbreviation**

DFH- Days to 50% heading, DM- Days to maturity, PH- Plant height (cm), NET/P- Number of effective tillers/plant, NS/S- Number of spikelets/spike, EL- Ear length (cm), EW- Ear weight (g), PL- Peduncle length (cm), NE/P- Number of ears/plant, NG/E- Number of grains/ear, TGW- 1000-grain weight (g), BY/P- Biological yield/plant (g), HI- Harvest index (%), CC- Chlorophyll content (%), CT- Canopy temperature (°c), RWC- Relative water content (%), PC- Protein content (%), SDS- Sedimentation value (%), GY/P- Grain yield/plant.

**Table 2:** Phenotypic correlation coefficient among various traits in wheat

| | DFH | DM | PH | NET/P | NS/S | EL | EW | PL | NE/P | NG/E | TGW | BY/P | HI | CC | CT | RWC | PC | SDS | GY/P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DFH** | 1.000 | 0.2347** | -0.2847** | -0.1167 | -0.3418** | -0.2906** | -0.1387 | 0.1097 | -0.1175 | -0.3346** | -0.1742 | -0.2331* | -0.0036 | -0.2131* | 0.4141** | -0.3353** | 0.0190 | 0.0938 | -0.2176* |
| **DM** | | 1.000 | 0.2946** | -0.0136 | 0.1543 | 0.2359** | 0.1460 | 0.1012 | -0.0184 | 0.1212 | -0.0994 | 0.2063* | -0.2190* | -0.0289 | -0.0780 | 0.2355** | 0.2168* | 0.1914* | 0.0911 |
| **PH** | | | 1.000 | 0.1694 | 0.4292** | 0.5439** | 0.1516 | 0.3122** | 0.1548 | 0.4007** | 0.0829 | 0.4607** | -0.2713** | -0.0334 | -0.5261** | 0.4779** | 0.1302 | 0.0001 | 0.3147** |
| **NET/P** | | | | 1.000 | 0.1980* | 0.1825 | -0.0560 | 0.1351 | 0.9585** | 0.1598 | 0.0974 | 0.4669** | 0.3508** | -0.0677 | -0.1472 | 0.1052 | 0.0646 | -0.1038 | 0.5886** |
| **NS/S** | | | | | 1.000 | 0.5239** | 0.2907 | -0.0801 | 0.1650 | 0.9396** | 0.1576 | 0.5054** | -0.1035 | 0.1759 | -0.2512** | 0.4014** | 0.0202 | -0.0360 | 0.4367** |
| **EL** | | | | | | 1.000 | 0.5399** | 0.0130 | 0.2054* | 0.5043** | 0.3513** | 0.6166** | -0.0258 | 0.0429 | -0.3238** | 0.3677** | 0.0302 | -0.0542 | 0.5832** |
| **EW** | | | | | | | 1.000 | -0.1066 | -0.0556 | 0.2418** | 0.3510** | 0.3864** | 0.1398 | -0.0134 | -0.1400 | 0.1158 | 0.0028 | 0.0785 | 0.4490** |
| **PL** | | | | | | | | 1.000 | 0.1371 | -0.0804 | 0.0266 | 0.1302 | -0.0235 | -0.1998* | -0.0953 | -0.0392 | 0.0514 | -0.0360 | 0.1105 |
| **NE/P** | | | | | | | | | 1.000 | 0.1247 | 0.0986 | 0.4359** | 0.3537** | -0.0342 | -0.1099 | 0.0483 | 0.1020 | -0.0707 | 0.5598** |
| **NG/E** | | | | | | | | | | 1.000 | 0.1326 | 0.4680** | -0.0973 | 0.1400 | -0.3078** | 0.4091** | -0.0165 | -0.0639 | 0.4048** |
| **TGW** | | | | | | | | | | | 1.000 | 0.3157** | 0.2644** | -0.0606 | -0.0922 | -0.0147 | -0.0324 | -0.0749 | 0.4280** |
| **BY/P** | | | | | | | | | | | | 1.000 | -0.0973 | 0.0075 | -0.3936** | 0.4198** | 0.0399 | 0.0548 | 0.8805** |
| **HI** | | | | | | | | | | | | | 1.000 | -0.0957 | 0.2666** | -0.3690** | -0.0424 | -0.2803** | 0.3789** |
| **CC** | | | | | | | | | | | | | | 1.000 | 0.1960 | 0.0655 | 0.0318 | 0.1268 | -0.0493 |
| **CT** | | | | | | | | | | | | | | | 1.000 | -0.5469** | -0.5660** | -0.0275 | -0.2510** |
| **RWC** | | | | | | | | | | | | | | | | 1.000 | -0.0048 | 0.0289 | 0.2176* |
| **PC** | | | | | | | | | | | | | | | | | 1.000 | 0.6597** | 0.0203 |
| **SDS** | | | | | | | | | | | | | | | | | | 1.000 | -0.0769 |
| **GY/P** | | | | | | | | | | | | | | | | | | | 1.000 |

**Table 3:** Path analysis (genotypic level) showing direct (bold values) and indirect effects on different traits in wheat

| | DH | DM | PH | NET/P | NS/S | EL | EW | PL | NE/P | NG/E | TGW | BY/P | HI | rGyi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **DH** | -0.0417 | -0.0159 | 0.0175 | 0.0057 | 0.0185 | 0.0131 | 0.005 | -0.0035 | 0.0061 | 0.0187 | 0.0083 | 0.0108 | -0.0047 | -0.2164 |
| **DM** | 0.0067 | 0.0175 | 0.0084 | 0.0035 | 0.0034 | 0.0072 | 0.002 | 0.0024 | 0.0019 | 0.0021 | -0.0028 | 0.0059 | -0.0049 | 0.2264 |
| **PH** | 0.0716 | -0.0816 | -0.1706 | -0.0636 | -0.0941 | -0.1218 | -0.0341 | -0.0621 | -0.0718 | -0.0842 | -0.0167 | -0.0933 | 0.0638 | 0.3934 |
| **NET/P** | 0.0106 | -0.0156 | -0.0291 | -0.0781 | -0.0166 | -0.0181 | 0.0029 | -0.0202 | -0.0782 | -0.0122 | -0.0107 | -0.0378 | -0.0187 | 0.5792 |
| **NS/S** | -0.304 | 0.1348 | 0.3785 | 0.146 | 0.6858 | 0.4395 | 0.2521 | -0.0437 | 0.1027 | 0.6837 | 0.1169 | 0.3904 | -0.1212 | 0.5125 |
| **EL** | -0.0391 | 0.0515 | 0.0891 | 0.0289 | 0.0799 | 0.1248 | 0.0782 | 0.0076 | 0.0302 | 0.0777 | 0.0498 | 0.0854 | -0.0047 | 0.6927 |
| **EW** | -0.0031 | 0.003 | 0.0052 | -0.001 | 0.0095 | 0.0163 | 0.026 | -0.002 | 0.0014 | 0.0092 | 0.0099 | 0.0116 | 0.0069 | 0.5995 |
| **PL** | 0.0034 | 0.0057 | 0.015 | 0.0107 | -0.0026 | 0.0025 | -0.0031 | 0.0412 | 0.0135 | -0.0035 | 0.0009 | 0.0069 | -0.0016 | 0.1421 |
| **NE/P** | -0.0153 | 0.0111 | 0.044 | 0.1046 | 0.0157 | 0.0253 | -0.0056 | 0.0342 | 0.1045 | 0.0093 | 0.0157 | 0.0446 | 0.0251 | 0.5225 |
| **NG/E** | 0.2821 | -0.0768 | -0.3106 | -0.0987 | -0.6272 | -0.3918 | -0.223 | 0.0541 | -0.0558 | -0.6291 | -0.1043 | -0.338 | 0.1249 | 0.4752 |
| **TGW** | -0.0009 | -0.0007 | 0.0004 | 0.0006 | 0.0008 | 0.0018 | 0.0017 | 0.0001 | 0.0007 | 0.0008 | 0.0045 | 0.0015 | 0.0014 | 0.4723 |
| **BY/P** | -0.2291 | 0.2994 | 0.4863 | 0.4304 | 0.5059 | 0.6082 | 0.3977 | 0.1488 | 0.3797 | 0.4775 | 0.2865 | 0.8887 | -0.2104 | 0.8876 |
| **HI** | 0.0425 | -0.1058 | -0.1406 | 0.09 | -0.0664 | -0.0141 | 0.0996 | -0.0148 | 0.0905 | -0.0746 | 0.1142 | -0.089 | 0.3759 | 0.2317 |

**Conclusion**

Considerable genetic variation has been exhibited by genotypes involved in present investigation. Highest PCV and GCV were recorded for ear weight, grain yield/plant, biological yield/plant, peduncle length, sedimentation value, number of effective tillers/plant, number of ear/plant and ear length. High heritability coupled with high genetic advance was observed for grain yield/plant, biological yield/plant, ear weight, peduncle length and sedimentation value, suggested that selection based on these traits may be effective. On the basis of correlation and path analysis, it could be concluded that biological yield/plant, number of effective tillers/plant, ear weight, ear length, number of ear/plant, 1000 grain weight and harvest index were the major yield components. Therefore, direct selection through these traits would be effective.

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