

# Estimation of variability, character association and path analysis in bread wheat (*Triticum aestivum* L.)

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## ABSTRACT

An experiment was conducted on 24 genotypes for 12 characters to estimate the variability, character association and path analysis for yield and yield contributing components in bread wheat (*Triticum aestivum* L.). As per analysis of variance character plant height, number of tillers/plant, spike length, awn length, grain yield/plant and biological yield/plant were found to be promising for further selection. Grain yield shows highly significant positive correlation with number of tillers/plant, number of spikelet/spike and harvest index, revealed by correlation analysis. Whereas, as per path coefficient analysis spike length shows highest positive direct effect on grain yield followed by number of tillers/plant, 100 grains weight, days to maturity, awn length, plant height, number of spikelet/spike, harvest index, days to flowering, biological yield/plant and number of grains/spike. Genotypes WP-710/1, HD-3128, TALL-2, DBW-730 and TALL-3 are found to be promising for character grain yield and can be selected for future hybridization program.

## 1. Introduction

Wheat is the third largest produced cereal crop in the world after maize and rice, and second largest cereal crop produced on Indian subcontinent. Wheat is rich source of carbohydrates and dietary fibre. The total production of wheat in India during cropping year 2017-18 was 99.87 million tonnes from an area of 29.65 million hectares with productivity of 33.68 q/ha (Agricultural Statistics at a Glance 2018)<sup>[1]</sup> which is much lower than productivity of wheat in China (54.163 q/ha). Apart from agronomical factors of crop production yielding capacity of variety is also an important aspect for high productivity.

In late 1960s green revolution in India takes place which leads to development of high yielding variety of wheat in India, developed varieties were short in height and were prone to lodging. These dwarf varieties boost the production of wheat in India, development of such varieties free the country from foreign export. Though from 1970-71 to 2017-18 productivity of wheat increases upto 257% but to meet the future demand of such vast population size there is need to increase productivity of wheat, for which high yielding varietal development is necessary.

Variability present among germplasm is the main factor responsible for varietal improvement. Therefore, utilization and evaluation of genetic variability to fulfill the breeding objective is necessary. Assessment of variability for yield and its component characters becomes absolutely essential before planning for an appropriate breeding strategy for genetic improvement.<sup>[2]</sup> Yield is a quantitative character associative with the performance of several other characters which are correlated among themselves, association between two such traits is evaluated by correlation analysis. So, character association is an essential tool for improvement in yield and associated characters. Though, from correlation analysis the magnitude of association between two characters can be measured, but to know the causes of association and direct

and indirect effect of particular character through other characters path analysis is required.

## 2. Materials and Methods

A field experiment was conducted at village Dhanauri, district Haridwar (Uttarakhand) which comprises of the evaluation of 24 genotypes of wheat for 12 different quantitative characters viz. days to flowering, plant height (cm), number of tillers/plant, spike length (cm), awn length (cm), number of spikelet/spike, number of grains/spike, 100 grains weight(gm), grain yield/plant (gm), biological yield/plant (gm), harvest index (%) and days to maturity in rabi season of cropping year 2017-18. Experimental field is situated in sub-humid and sub-tropical climatic region near the tarai belt of Western Uttar Pradesh. The experiment was conducted under randomized complete block design plotting technique with three replications. The planting material was timely sown under irrigated conditions in three replications.

Variability parameters viz. mean, range, PCV, GCV and ECV were estimated as variability parameters, phenotypic, genotypic and environmental coefficient of variability were estimated by analysis of variance by following (Johnson 1955).<sup>[3]</sup> Correlation coefficient were calculated by analysis of variance and covariance as suggested by (Searle 1961)<sup>[4]</sup>. The path coefficient analysis to know the direct and indirect effect of characters was done by following (Dewey and Lu 1959).<sup>[5]</sup>

## 3. Results and Discussions

Analysis of variance provided the information about high variability among 12 characters for all 24 genotypes. The information regarding mean, range, PCV, GCV and ECV of all 12 characters is provided in Table 1. As per Table 1, in case of character days to flowering the general mean was 86.85 with range 82.33-92.33 and GCV, PCV and ECV were 3.11, 3.22 and 0.83 respectively, the minimum days to flowering was

recorded in case of genotype HACS-3949 (82.33 days) and the maximum days to flowering was shown by genotype TALL-1 (92.33 days). Character plant height (cm) showed wide range i.e. 73.00-151.00 and general mean 91.99, the GCV, PCV and ECV were estimated 20.96, 21.02 and 1.59 respectively. The maximum plant height was attained by genotype TALL-2 (151.00 cm) and the minimum plant height was attained by genotype HACS-3949 (73 cm). Character number of tillers/plant showed range 4.47 to 7.87 with general mean 6.24, in case of number of tillers/plant GCV, PCV and ECV were estimated 14.17, 16.95 and 9.30 respectively. Genotype HD-3128 (7.87) showed maximum number of tillers/plant whereas genotype DBW-60 (4.47) shows minimum number of tillers/plant. In case of character spike length (cm) range is estimated between 8.00 to 13.17 with general mean 10.21 the GCV, PCV and ECV was estimated 12.73, 13.13 and 3.22 respectively, genotype WP-709/1 (13.2 cm) shows maximum spike length whereas genotype HACS-3949 (8.0 cm) shows minimum spike length. For character awn length (cm) the range was recorded in between 5.03 to 14.73 with general mean 7.24 the GCV, PCV and ECV was estimated 27.02, 28.21 and 8.11 respectively, genotype HACS-3949 (14.73 cm) shows maximum awn length and genotype PBW-530 (5.03 cm) showed minimum awn length. The range for character number of spikelet/spike (cm) was 17.33-23.00 with general mean 19.64. The GCV, PCV and ECV for number of spikelet/spike was estimated 7.16, 8.24 and 4.08 respectively, genotype TALL-2 (23.00) showed maximum number of spikelet/spike whereas genotype DBW-60 (17.33) showed minimum number of spikelet/spike. Range for character number of grains/spike was 46.00-70.00 with general mean 59.60. The GCV, PCV and ECV was estimated 9.38, 11.79 and 7.14 respectively, genotype DBW-62-1(70) produced maximum number of grains/spike whereas genotype PBW-660 (46.00) produced minimum number of grains/spike. Character 100 grains weight (gm) ranges from 3.57 to 5.65 with general mean 4.51, the GCV, PCV and ECV was estimated 10.84, 11.15 and 2.61 respectively. The maximum 100 grains weight (gm) was showed by genotype HACS-3949 (5.65 gm) and minimum 100 grains weight (gm) was recorded in case of genotype WP-709/1 (3.57 gm). Character grain yield/plant (gm) ranges 3.57 to 5.65 with general mean 4.51, the GCV, PCV and ECV was estimated 10.84, 11.15 and 2.61 respectively. The maximum grain yield/plant was produced by genotype WP-710/1 (21.10 gm) whereas minimum grain yield/plant was produced by genotype RAJ-4037 (10.41 gm). Character biological yield/plant (gm) ranges from 25.00 to 36.47 with general mean 31.03, the GCV, PCV and ECV was estimated 16.33, 18.42 and 8.52 respectively. The maximum biological yield/plant was produced by genotype TALL-3 (36.47 gm) and genotype RAJ-4422 (25 gm) produced minimum biological yield/plant. Character harvest index (%) ranges from 35.78 to 56.56 with general mean 44.48, the GCV, PCV and ECV was estimated 11.84, 17.26 and 12.56 respectively. The maximum harvest index was accounted by genotype DBW-730 (56.56) and minimum harvest index was accounted by genotype TALL-1 (35.78). Character days to maturity ranges from 130.33 to 139.00 with general mean 134.86, the GCV PCV and ECV was estimated 1.88, 2.00 and 0.68 respectively. The minimum days to maturity was shown by genotype HACS-3949 (130.33) and

maximum days to maturity was shown by genotype RAJ-4037 (139.00).

The correlation coefficient of the experimental data is presented in Table 2. As per Table 2, days to flowering shows highly significant positive correlation with plant height at both genotypic and phenotypic level, significant positive correlation with days to maturity at both genotypic and phenotypic level, highly significant negative correlation with harvest index at genotypic level and significant negative correlation with awn length and 100 grains weight at both genotypic and phenotypic level and with number of grains/spike and harvest index at genotypic and phenotypic level respectively. Character plant height shows highly significant positive correlation with spike length, number of spikelet/spike, biological yield/plant and days to maturity at both genotypic and phenotypic level respectively, highly significant negative correlation with index at genotypic level and significant negative correlation with 100 grains weight at both genotypic and phenotypic level and with harvest index at phenotypic level only (Tripathi *et al.* 1973)<sup>[6]</sup>. Character number of tillers/plant shows highly significant positive correlation with grain yield/plant and biological yield/plant at both genotypic and phenotypic level and with harvest index at genotypic level only. Character spike length shows highly significant positive correlation with number of spikelet/spike, number of grains/spike and days to maturity at both genotypic and phenotypic level, significant positive correlation with biological yield/plant and harvest index at both genotypic and phenotypic level respectively and high significant negative correlation with harvest index at genotypic level only. Character awn length shows highly significant positive correlation with 100 grains weight at both genotypic and phenotypic level and highly negative correlation with days to maturity at both genotypic and phenotypic level respectively (Redhu *et al.* 1995)<sup>[7]</sup>. Character number of spikelet/spike shows highly significant positive correlation with number of grains/spike, grains yield/plant and biological yield/plant at both genotypic and phenotypic level. Character number of grains/spike shows significant positive correlation with biological yield/plant at genotypic level, highly significant negative correlation with harvest index at genotypic level and significant negative correlation with 100 grains weight at genotypic level. Character grains yield/plant shows highly significant and positive correlation with harvest index at both genotypic and phenotypic level and with biological yield/plant at genotypic level (Kyosev and Desheva 2015)<sup>[8]</sup>.

The results of direct and indirect effect of different characters on yield at genotypic level have been presented in Table 3. As per Table 3, highest direct positive genotypic effect on grain yield was shown by spike length (2.597) followed by number of tillers/plant (1.522), 100 grains weight (0.857), plant height (0.618), number of spikelet/spike (0.521), harvest index (0.448), days to flowering (0.393), biological yield/plant (0.254), and number of grains/spike (0.170) (Joshi *et al.* 2007)<sup>[9]</sup>.

Highest indirect positive effect on grain yield via component days to flowering was shown by plant height (2.890), days to maturity (1.507), spike length (1.139) and biological yield/plant (0.986) (Natrajan *et al.* 1988)<sup>[10]</sup>. While negative indirect effect by days to flowering was shown by 100 grains weight (-1.555) further followed by awn length (-1.302), harvest index (-1.251), number of grains/spike (-1.151), number of tillers/plant (-1.069) and number of spikelet/spike (-

0.195). Highest positive indirect effect on grain yield via plant height was recorded in case of number of spikelet/spike (1.953) followed by days to maturity (1.883), biological yield/plant (1.831), plant height (0.990), number of tillers/plant (0.714), spike length (0.274) and number of grains/spike (0.127). While, the highest negative indirect effect for the same was recorded highest in case of 100 grains weight (-1.262) followed by harvest index (-1.138) and awn length (-0.817). Highest positive indirect effect on grain yield via number of tillers/plant was recorded in case of biological yield/plant (0.974) followed by harvest index (0.422), awn length (0.210), days to maturity (0.167), 100 grains weight (0.096), number of spikelet/spike (0.068) and plant height (0.039). While, the highest negative indirect effect on grain yield via number of tillers/plant was shown by days to flowering (-0.405) followed by spike length (-0.252) and number of grains/spike (-0.009) (Paroda *et al.* 1970)<sup>[11]</sup>. Highest positive indirect effect on grain yield via spike length was recorded in case of plant height (1.337), days to maturity (0.987), number of spikelet/spike (0.817), number of grains/spike (0.813), biological yield/plant (0.634) and days to flowering (0.547). While, the highest negative indirect effect on grain yield via spike length was recorded in case of harvest index (-0.717) followed by number of tillers/plant (-0.320), awn length (-0.306) and 100 grains weight (-0.056). Highest indirect positive effect on grain yield via awn length was recorded in case of 100 grains weight (1.447) followed by number of tillers/plant (0.405), biological yield/plant (0.356), number of spikelet/spike (0.283) and harvest index (0.190). Indirect negative effect on grain yield via awn length was recorded highest in case of days to maturity (-1.282) followed by days to flowering (-0.951), number of grains/spike (-0.684), spike length (-0.466) and plant height (-0.403). Highest positive indirect effect on grain yield via number of spikelet/spike was recorded in case of plant height (1.418) followed by number of grains/plant (1.380), biological yield/plant (1.293), spike length (0.985), days to maturity (0.557), 100 grains weight (0.272), awn length (0.224) and number of tillers/plant (0.104). While, negative indirect effect on grain yield via number of spikelet/spike was recorded highest in case of days to flowering (-0.113) followed by harvest index (-0.007). Highest positive indirect effect on grain yield via number of grains/spike was recorded in case of biological yield/plant (2.928) followed by spike length (2.259), plant height (1.862), number of spikelet/spike (0.994) and days to maturity (0.517). While the negative indirect effect on grain yield via number of

grains/spike was recorded highest in case of 100 grains weight (-2.948) followed by days to flowering (-2.894), harvest index (-2.703), awn length (-0.355) and number of tillers/plant (-0.054). Positive indirect effect on grain yield via 100 grains weight was recorded highest in case of awn length (0.356) followed by harvest index (0.220), number of spikelet/spike (0.084) and number of tillers/plant (0.046). While negative indirect effect on grain yield via 100 grains weight was recorded highest in case of plant height (-0.293) followed by days to flowering (-0.280), days to maturity (-0.248), number of grains/spike (-0.211), biological yield/plant (-0.059) and spike length (-0.021). Highest positive indirect effect on grain yield via biological yield/plant was recorded in case of number of tillers/plant (3.269) followed by spike length (2.702), number of grains/spike (2.383), days to flowering (2.019), awn length (0.997), plant height (0.976) and number of spikelet/spike (0.569) (Pathak *et al.* 1985)<sup>[12]</sup>. Highest negative indirect effect on grain yield via biological yield/plant was recorded in case of harvest index (-0.901) followed by 100 grains weight (-0.671) and days to maturity (-0.231). Highest positive indirect effect on grain yield via harvest index was recorded in case of 100 grains weight (1.362) followed by number of tillers/plant (1.066) and awn length (0.714). Negative indirect effect on grain yield via harvest index was recorded highest in case of number of grains/spike (-2.954) followed by days to flowering (-1.438), biological yield/plant (-1.209), days to maturity (-0.792), plant height (-0.422), spike length (-0.106) and number of spikelet/spike (-0.034). Highest positive indirect effect on grain yield via days to maturity was recorded in case of plant height (2.354) followed by spike length (1.984), days to flowering (1.454), number of spikelet/spike (0.928), number of tillers/plant (0.427) and number of grains/spike (0.198). Highest negative indirect effect on grain yield via days to maturity was recorded in case of awn length (-1.693) followed by 100 grains weight (-1.329), harvest index (-0.278) and biological yield/plant (0.109).

#### 4. Conclusion

Result of present study revealed that considerable genetic variability exists among 24 genotypes for most of the characters. Whereas, character association and path analysis revealed that number of tillers/plant, number of spikelet/spike, harvest index and biological yield/plant are the important yield attributing traits. Selection of these traits could be taken under consideration for future hybridization program.

**Table 1. Estimation of range, mean and coefficient of variation components for 12 characters of 24 genotypes in bread wheat (*Triticum aestivum* L.)**

| Characters                 | Range |        | Mean  | Coefficient of Variation |       |       |
|----------------------------|-------|--------|-------|--------------------------|-------|-------|
|                            | Min.  | Max.   |       | GCV                      | PCV   | ECV   |
| Days to Flowering          | 82.33 | 92.33  | 86.85 | 3.11                     | 3.22  | 0.83  |
| Plant height(cm)           | 73.00 | 151.00 | 91.99 | 20.96                    | 21.02 | 1.59  |
| No. of tillers/ plant      | 4.47  | 7.87   | 6.24  | 14.17                    | 16.95 | 9.30  |
| Spike length(cm)           | 8.00  | 13.17  | 10.21 | 12.73                    | 13.13 | 3.22  |
| Awn length(cm)             | 5.03  | 14.73  | 7.24  | 27.02                    | 28.21 | 8.11  |
| No. of spikelet/spike (cm) | 17.33 | 23.00  | 19.64 | 7.16                     | 8.24  | 4.08  |
| No. of grains/spike        | 46.00 | 70.00  | 59.60 | 9.38                     | 11.79 | 7.14  |
| 100 grains weight(gm)      | 3.57  | 5.65   | 4.51  | 10.84                    | 11.15 | 2.61  |
| Grain yield/plant (gm)     | 10.41 | 21.10  | 13.86 | 19.50                    | 24.41 | 14.68 |

|                             |        |        |        |       |       |       |
|-----------------------------|--------|--------|--------|-------|-------|-------|
| Biological yield/plant (gm) | 25.00  | 36.47  | 31.03  | 16.33 | 18.42 | 8.52  |
| Harvest index (%)           | 35.78  | 56.56  | 44.48  | 11.84 | 17.26 | 12.56 |
| Days to maturity            | 130.33 | 139.00 | 134.86 | 1.88  | 2.00  | 0.68  |

\* and \*\* denote significance at 5% and 1% level of probability, respectively

GCV = Genotypic coefficient of variation

PCV = Phenotypic coefficient of variation

ECV = Environmental coefficient of variation

**Table 2. Estimation of genotypic and phenotypic correlation coefficients for yield and yield contributing 12 characters in 24 bread wheat (*Triticum aestivum* L.) genotypes.**

| Characters                  | Level  | Days to Flowering   | Plant height (cm)   | No. of tillers/plant | Spike length (cm)  | Awn length (cm)      | No. of spikelet/spike (cm) | No. of grains/spike | 100 grains weight (gm) | Grain yield/plant (gm) | Biological yield/plant (gm) | Harvest index (%) | Days to maturity |
|-----------------------------|--------|---------------------|---------------------|----------------------|--------------------|----------------------|----------------------------|---------------------|------------------------|------------------------|-----------------------------|-------------------|------------------|
| Days to Flowering           | G<br>P | 1.00                |                     |                      |                    |                      |                            |                     |                        |                        |                             |                   |                  |
| Plant height(cm)            | G<br>P | 0.520**<br>0.504**  | 1.00                |                      |                    |                      |                            |                     |                        |                        |                             |                   |                  |
| No. of tillers/plant        | G<br>P | -0.230<br>-0.178    | 0.021<br>0.018      | 1.00                 |                    |                      |                            |                     |                        |                        |                             |                   |                  |
| Spike length(cm)            | G<br>P | 0.211<br>0.208      | 0.500**<br>0.485**  | -0.143<br>-0.117     | 1.00               |                      |                            |                     |                        |                        |                             |                   |                  |
| Awn length(cm)              | G<br>P | -0.244<br>-0.233*   | -0.100<br>-0.095    | 0.120<br>0.097       | -0.119<br>-0.099   | 1.00                 |                            |                     |                        |                        |                             |                   |                  |
| No. of spikelet/spike (cm)  | G<br>P | -0.040<br>-0.038    | 0.491**<br>0.425**  | 0.043<br>0.029       | 0.350**<br>0.310** | 0.081<br>0.041       | 1.00                       |                     |                        |                        |                             |                   |                  |
| No. of grains/spike         | G<br>P | -0.260<br>-0.155    | 0.162<br>0.129      | -0.006<br>0.078      | 0.381**<br>0.309** | -0.213<br>-0.153     | 0.598**<br>0.426**         | 1.00                |                        |                        |                             |                   |                  |
| 100 grains weight(gm)       | G<br>P | -0.287<br>-0.264*   | -0.291*<br>-0.285*  | 0.054<br>0.038       | -0.021<br>-0.001   | 0.369**<br>0.338**   | 0.096<br>0.126             | -0.263<br>-0.176    | 1.00                   |                        |                             |                   |                  |
| Grain yield/plant (gm)      | G<br>P | 0.016<br>0.011      | 0.177<br>0.142      | 0.693**<br>0.534**   | -0.004<br>-0.001   | 0.115<br>0.066       | 0.484**<br>0.313**         | 0.093<br>0.057      | 0.164<br>0.132         | 1.00                   |                             |                   |                  |
| Biological yield/plant (gm) | G<br>P | 0.200<br>0.185      | 0.478**<br>0.421**  | 0.604**<br>0.533**   | 0.267*<br>0.217    | 0.100<br>0.091       | 0.503**<br>0.356**         | 0.287*<br>0.177     | -0.066<br>-0.056       | 0.792**<br>0.729       | 1.00                        |                   |                  |
| Harvest index (%)           | G<br>P | -0.327**<br>-0.235* | -0.409**<br>-0.279* | 0.338**<br>0.195     | -0.390**<br>0.243* | 0.069<br>0.010       | -0.004<br>-0.011           | -0.342**<br>-0.148  | 0.318**<br>0.209       | 0.495**<br>0.556**     | -0.126<br>-0.134            | 1.00              |                  |
| Days to maturity            | G<br>P | 0.287*<br>0.287*    | 0.451**<br>0.421**  | 0.097<br>0.106       | 0.391**<br>0.359** | -0.338**<br>-0.288** | 0.204<br>0.155             | 0.048<br>0.068      | -0.261*<br>-0.237*     | -0.049<br>-0.065       | -0.023<br>-0.034            | -0.077<br>-0.066  | 1.00             |

**Table 3. Path coefficient analysis showing the genotypic direct (bold) and indirect effect of the characters on grain yield in bread wheat (*Triticum aestivum* L.).**

| Characters                 | Days to Flowering | Plant height (cm) | No. of tillers/plant | Spike length (cm) | Awn length (cm) | No. of spikelet/spike (cm) | No. of grains / spike | 100 grains weight (gm) | Biological yield/plant (gm) | Harvest index (%) | Days to maturity | Grain yield/plant (gm) |
|----------------------------|-------------------|-------------------|----------------------|-------------------|-----------------|----------------------------|-----------------------|------------------------|-----------------------------|-------------------|------------------|------------------------|
| Days to Flowering          | <b>0.393</b>      | 2.890             | -1.069               | 1.139             | -1.302          | -0.195                     | -1.151                | -1.555                 | 0.986                       | -1.251            | 1.507            | 0.069                  |
| Plant height(cm)           | 0.990             | <b>0.618</b>      | 0.714                | 0.274             | -0.817          | 1.953                      | 0.127                 | -1.262                 | 1.831                       | -1.138            | 1.883            | 0.625                  |
| No. of tillers/plant       | -0.405            | 0.039             | <b>1.522</b>         | -0.252            | 0.210           | 0.068                      | -0.009                | 0.096                  | 0.974                       | 0.422             | 0.167            | 1.007                  |
| Spike length(cm)           | 0.547             | 1.337             | -0.320               | <b>2.597</b>      | -0.306          | 0.817                      | 0.813                 | -0.056                 | 0.634                       | -0.717            | 0.987            | -0.008                 |
| Awn length(cm)             | -0.951            | -0.403            | 0.405                | -0.466            | <b>0.857</b>    | 0.283                      | -0.684                | 1.447                  | 0.356                       | 0.190             | -1.282           | 0.371                  |
| No. of spikelet/spike (cm) | -0.113            | 1.418             | 0.104                | 0.985             | 0.224           | <b>0.521</b>               | 1.380                 | 0.272                  | 1.293                       | -0.007            | 0.557            | 1.120                  |

|                                    |        |        |        |        |        |        |              |              |              |              |              |        |
|------------------------------------|--------|--------|--------|--------|--------|--------|--------------|--------------|--------------|--------------|--------------|--------|
| <b>No. of grains/spike</b>         | -2.894 | 1.862  | -0.057 | 2.259  | -0.355 | 0.994  | <b>0.170</b> | -2.948       | 2.928        | -2.703       | 0.517        | 0.825  |
| <b>100 grains weight(gm)</b>       | -0.280 | -0.293 | 0.046  | -0.021 | 0.356  | 0.084  | -0.211       | <b>0.980</b> | -0.059       | 0.220        | -0.248       | 0.132  |
| <b>Biological yield/plant (gm)</b> | 2.019  | 0.976  | 3.269  | 2.702  | 0.997  | 0.569  | 2.383        | -0.671       | <b>0.254</b> | -0.901       | -0.231       | 0.606  |
| <b>Harvest index (%)</b>           | -1.438 | -0.422 | 1.066  | -0.106 | 0.714  | -0.034 | -2.954       | 1.362        | -1.209       | <b>0.448</b> | -0.792       | 0.286  |
| <b>Days to maturity</b>            | 1.454  | 2.354  | 0.427  | 1.984  | -1.693 | 0.928  | 0.198        | -1.329       | -0.109       | -0.278       | <b>0.940</b> | -0.205 |

## References

- [1]. Agricultural Statistics At A Glance (2018). Ministry of Agriculture and Farmers Welfare, Govt. of India.
- [2]. Singh, S., C. Singh, and G. M. Lal. "Assessment of Genetic Variability for Yield and Its Component Characters in Rice (*Oryza sativa* L.)." *Research in Plant Biology*, Vol. 1, no. 4, Oct. 2011.
- [3]. Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimation of genetic and environmental variability in soybean. *Agron. J.* **47**: 314-318.
- [4]. Searle SR. Phenotypic, genotypic and environmental correlations. *Biometrika*. 1961; **17**:475-480.
- [5]. Dewey, D.R. and Lu, K.H. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J.* **51**: 515-518.
- [6]. Tripathi, R.S., Agarwal, K.B. and Khan, A.W. (1973). Estimation of variation and heritability of some quantitative characters in durum wheat (*Triticum durum* Desf.). *Indian J. Agric. Sci.* **43**(9): 842-845.
- [7]. Redhu, A.S., Solanki, Y.P.S., Sethi, S.K. and Singh, I. (1995). Genetic diversity in some Indian and exotic wheat varieties. *Crop Improvement*. **22**(2): 214-217.
- [8]. Kyosev and Desheva (2015) Study on variability, heritability, genetic advance and associations among characters in emmer wheat genotypes (*Triticum dicoccon* Schrank). *J. BioSci. Biotechnol*:221-228.
- [9]. Joshi, A.K., Ortiz, F.G., Crossa, J., Singh, G., Sharma, R.C., Chand, R. and Rajendar, P. (2007). Combining superior agronomic performance and terminal heat tolerance with resistance to spot blotch (*Bipolaris sorokiniana*) of wheat in the warm humid Gangetic Plains of south Asia. *Field Crops Res.* **103**(1): 53-61.
- [10]. Natrarajan, C., Thiyagarajan, K. and Rathana S.R. (1988). Association and genetic diversity studies in greengram. *Madras Agri. J.* **75**(7-8): 238-245.
- [11]. Paroda, R.S. and Joshi, A.B. (1970). Correlation, path coefficients and the implication of discriminant function for selection in wheat. *Heredity*. **25**: 383-392.
- [12]. Pathak, N.N. and Nema, D.P. (1985). Genetic advance in landraces of wheat. *Indian J. Agric. Sci.* **55**(7): 176-178.