

## **Genetic characterization and character association study in bread wheat (*Triticum aestivum* L.) for grain yield and yield attributing traits**

### **Abstract**

Present research work was carried out at the research farm of Department of Genetics and Plant Breeding, Rama University, Kanpur to investigate the pattern of genetic variability and heritability in the elite genotypes of wheat germplasm. In current study 27 wheat genotypes including checks entries viz., HD 2967 AND PBW 152 have been evaluated in randomized block design in 3 replication and the observations have been recorded on the eleven metric traits viz., Days to 50% flowering, Days to maturity, Flag leaf area (cm<sup>2</sup>), Tillers per plant, plant height (cm), spike length (cm), Spikelet per spike, Grain yield per plant (g), Biological yield per plant (g), Test weight (g) and Harvest index (%). The analysis of variance showed significant mean sum of squares due to all traits under study. High estimates of heritability were observed for all of the traits viz., grain yield per plant (98.90%) followed by test weight (95.53%) and harvest index (94.88 %), whereas, high estimates of genetic advance (>20%) in per cent over mean was recorded for the traits grain yield per plant (44.26%) followed by spike length (36.12%) and Test weight (28.51%), High heritability accompanied with high genetic advance for the traits showed additive gene action and the selection for such traits would be rewarding.

**Keywords:** *Wheat, Triticum aestivum, genetic variability, heritability, genetic advance.*

## Introduction

The wheat is a hexaploid (allohexaploid) species ( $2n = 6x = 42$ ) having AABBDD with A, B and D genome. The species of bread wheat may be divided into diploid, tetraploid and hexaploid species with chromosome number  $2n=14=AA$ ,  $2n=14=BB$ ,  $2n=28=AABB$  and  $2n=42=AABBDD$  respectively with basic chromosome number ( $x$ ) = 7 (Sleper and Poehlman, 2006). However, genetic studies reveal that *Triticum urartu* is diploid and was used as the donor of the A genome instead of *Triticum monococcum* (Dvorak et al., 1993) and *Aegilops speltoides*, which is wild diploid. It is used as a potential donor for the B genome. Wheat is a self-pollinating annual plant of the genus *Triticum* in the family Gramineae and is the world's most famous energy-rich grain. It is known as the "King of Grains" due to its acreage, high productivity, and prominent position in the international food grain trade. Currently, it is cultivated on an area of approximately 225 million hectares worldwide, with an average production of 3 tons/ha. This indicates that there are significant differences between different cropping environments (Singh et al., 2008). It supplies about 25% of protein and 20% of the calories consumed by human beings from the daily diet. According to FAOSTAT, India is the second largest wheat producer in the world after China. Total food grain production is estimated to rise 2.66% to a new record- 344.43 MT for- 2021-22 crop year higher than 291.9 MT last year. In addition, India is set to harvest a record wheat production of 115.75 MT in the 2020-21 crop year on the back of food grain according to latest government of India. According to the Department of Agriculture and Farmers Welfare, the estimated wheat production in India during the year 2021-22 was 106.84 million tonnes. This is higher by 2.96 million tonnes than the last five years' average wheat production of 103.88 million tonnes. However, the final estimates of production of major crops for the year 2022-23 have been released by the same department. As per the estimates, the wheat production during 2022-23 is estimated at record 1105.54 Lakh tonnes which is higher by 28.12 Lakh tonnes than previous year's wheat production of 1077.42 Lakh tonnes and by 48.23 Lakh tonnes than the average wheat production of 1057.31 Lakh tonnes (Source: [www.livemint.com](http://www.livemint.com) May, 2022).

Genetic variability is a natural phenomenon, and for any crop species to effectively utilise it, systematic collection, appraisal, and classification based on economic characteristics are required. The necessary level of genetic diversity for effective use of direct and indirect selection. Understanding the genetic architecture of various traits and the direct and indirect selection criteria aids in developing breeding plans that maximise genetic variety for plant improvement.

Keeping the above facts in view the present investigation has been carried out to understand the pattern of genetic variability present among available germplasms.

The complex attribute of grain yield is greatly influenced by numerous environmental variables, biotic and abiotic challenges, such as water logging, salt, etc. Direct selection for yield in crop breeding programmes could be deceptive due to the complexity of the environment. As a result, knowledge of the genetic variability and the correlation between morph-agronomic variables and grain production are essential for successful selection. The correlation coefficient helps to clarify how many qualities relate to grain yield. Breeders can choose genotypes that possess a group of desired features by studying the associations between various variables.

### **Experimental materials and methods:**

Present experiment was carried out at research farm of Rama university mandhana, Kanpur. The experimental material for the present investigation comprised of 27 wheat genotypes including two checks viz., HD 2967 and PBW 52, from germplasm materials available in “Department of Genetics and Plant Breeding, Rama University, Mandhana, Kanpur. The experiment was sown in randomized block design at the experimental field. Each plot consists two rows of 2.5 m spacing of 5cm plant to plant with in the row and 20 cm between the rows. Fertilizer was applied at the rate of 120 kg N, 60 kg P and 40 kg K. These accessions were raised and followed recommended packages and practices during *Rabi* season, 2022-23 to grow a healthy crop. The observation on 11 quantitative characters viz., Days to 50% flowering, Days to maturity, Flag leaf area (cm<sup>2</sup>), Tillers per plant, plant height (cm), spike length (cm), spikelets per spike, grain yield per plant (g), biological yield per plant (g), Test weight (g) and harvest index (%), were recorded to estimate genetic variability, heritability and genetic advance.

### **Statistical analyses:**

Data recorded from all the 27 different genotypes including the check entries for the eleven different highly heritable trait have been subjected to following statistical analysis Analysis of variance (**Panse and Shukhatme, 1988**), Estimation of Heritability (**Hanson *et al.*, 1956**) and Genetic advance as per cent of mean (**Johnson *et al.*, 1955**).

## Results and Discussion

### Analysis of variance:

Analysis of variance for all the 27 genotypes including two check entries varied significantly for almost all the traits under study (Table 1.).

**Table. 1: ANOVA for 11 traits of wheat germplasm for randomized block design**

| Source of variation               | Replications | Treatments | Error |
|-----------------------------------|--------------|------------|-------|
| df                                | 2            | 26         | 52    |
| Days to 50% Flowering             | 5.22         | 16.69**    | 0.93  |
| Days to maturity                  | 5.86         | 19.99**    | 1.74  |
| Plant Height (cm)                 | 3.61         | 139.07**   | 10.03 |
| Number of tillers per plant       | 2.193        | 4.473**    | 0.242 |
| Spike length (cm)                 | 3.304        | 5.621**    | 0.517 |
| Number of spikelets per spike     | 3.231        | 5.000**    | 1.41  |
| Flag leaf area (cm <sup>2</sup> ) | 1.8          | 36.54**    | 0.7   |
| 1000 grains weight (g)            | 3.76         | 51.54**    | 1.88  |
| Biological yield per plant (g)    | 2.31         | 15.71**    | 1.24  |
| Harvest index (%)                 | 3.74         | 112.22**   | 2.16  |
| Grain yield per plant (g)         | 0.57         | 5.341**    | 0.153 |

\*, \*\* Significant at 5% and 1% level of probability respectively.

### Mean performance of the entries:

Studies on range, mean, coefficient of variation (CV) and standard deviation (SD) for various trait such Days to 50% flowering, Days to maturity, Plant height (cm), Number of tillers per plant, Spike length (cm), number of spekelets per spike, Flag leaf area (cm<sup>2</sup>), 1000 grain weigh (g), Biological yield (g), harvest index (%) and Grain yield per plant. Wide range of variability was noted for all the eleven traits under study. phenological traits under study such as Days to 50 % flowering (78.88-88.08 days), Days to maturity (117.44-126.11 days), Plant height (66.18-101.93 cm), Tillers per plant (9.17-11.49), Spike length (9.63-14.09 cm), Flag leaf area (25.45-38.77 cm<sup>2</sup> days), Test weight (26.55-40.22 g), Biological yield (12.33-19.77 g), Harvest index (36.14- 57.44 %) and Grain yield per plant (7.99-12.87 g) have exhibited wade range of genetic variability (Table no. 2)

**Table. 2: The mean performance of genotypes for 11 characters in wheat germplasm**

| S. No. | Genotypes   | Days to 50% Flowering | Days to maturity | Plant Height (cm) | Tillers per plant | Spike length (cm) | spikelets/spike | Flag leaf area (cm <sup>2</sup> ) | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Grain yield per plant (g) |
|--------|-------------|-----------------------|------------------|-------------------|-------------------|-------------------|-----------------|-----------------------------------|-----------------|--------------------------------|-------------------|---------------------------|
| 1      | NW 5054     | 80.97                 | 123.06           | 66.18             | 10.59             | 14.09             | 17.5            | 33.7                              | 28.24           | 17.74                          | 45.7              | 10.3                      |
| 2      | CRDC-4      | 85.48                 | 124.23           | 86.23             | 10.27             | 10.78             | 17.44           | 28.63                             | 32.09           | 17.87                          | 49.61             | 11.05                     |
| 3      | CHAP-10     | 81.52                 | 121.09           | 84.38             | 10.08             | 10.23             | 15.9            | 32.82                             | 36.63           | 14.76                          | 53.71             | 10.05                     |
| 4      | TUKURU      | 78.11                 | 124.11           | 101.93            | 9.67              | 10.63             | 17.48           | 32.54                             | 35.08           | 15.55                          | 36.14             | 7.99                      |
| 5      | SR-89       | 84.41                 | 123.26           | 89.36             | 9.3               | 11.06             | 17.89           | 29.45                             | 26.55           | 17.97                          | 48.7              | 10.94                     |
| 6      | SR-86       | 83.25                 | 124.76           | 87.92             | 11.25             | 11.62             | 17.12           | 29.34                             | 32.46           | 18.49                          | 48.78             | 11.21                     |
| 7      | KING BIRD#1 | 82.04                 | 119.56           | 88.69             | 10.64             | 11.92             | 16.35           | 25.45                             | 33.12           | 15.34                          | 47.39             | 9.42                      |
| 8      | SR-177      | 81.56                 | 123.1            | 86.55             | 10.33             | 10.86             | 16.54           | 28.11                             | 29.83           | 12.33                          | 57.44             | 9.26                      |
| 9      | POSTOR      | 83.26                 | 123.3            | 92.57             | 10.54             | 11.14             | 16.81           | 29.65                             | 28.3            | 14.48                          | 46.78             | 8.91                      |
| 10     | NRI 88      | 84.62                 | 126.08           | 89.73             | 10.47             | 10.17             | 17.34           | 34.37                             | 31.55           | 15.04                          | 42.46             | 8.54                      |
| 11     | PGQ         | 83.32                 | 122.69           | 80.24             | 10.63             | 10.36             | 15.72           | 28.88                             | 34.22           | 16.42                          | 49.59             | 10.3                      |
| 12     | K-508       | 83.32                 | 122.25           | 81.15             | 11.08             | 9.7               | 17.97           | 34.27                             | 29.48           | 17.08                          | 51.65             | 10.99                     |
| 13     | RAJ 4120    | 84.01                 | 124.1            | 86.78             | 10.75             | 11.05             | 18.47           | 28.43                             | 36.21           | 19.77                          | 44.87             | 11                        |
| 14     | K-1317      | 80.59                 | 124.23           | 85.07             | 10.9              | 11.23             | 17.19           | 34.4                              | 32.75           | 19.56                          | 37.3              | 9.53                      |
| 15     | K-818       | 79.87                 | 126.09           | 79.67             | 9.79              | 9.77              | 16.75           | 32.73                             | 31.21           | 14.85                          | 50.54             | 9.64                      |
| 16     | AKURI       | 79.09                 | 122.58           | 84.61             | 10.73             | 10.73             | 17.77           | 36.53                             | 28.12           | 16.54                          | 42.95             | 9.28                      |
| 17     | PUSA 2733   | 83.2                  | 124.49           | 86.89             | 10.89             | 10.52             | 17.92           | 38.77                             | 27.92           | 15.93                          | 44.12             | 9.19                      |
| 18     | SR-152      | 79.77                 | 117.44           | 91.45             | 10.39             | 11.37             | 17.56           | 32.89                             | 29.72           | 18.95                          | 39.98             | 9.8                       |
| 19     | RAJ 4037    | 84.71                 | 121.4            | 88.39             | 10.57             | 11.61             | 18.41           | 33.51                             | 28.62           | 19.15                          | 41.24             | 10.12                     |
| 20     | PBW 243     | 83.53                 | 124.96           | 83.37             | 11.49             | 10.79             | 16.58           | 33.95                             | 37.91           | 18.33                          | 53.95             | 12.87                     |
| 21     | DABU        | 85.34                 | 122.43           | 85.33             | 10.61             | 11.21             | 18.47           | 29.86                             | 29.51           | 15.94                          | 51.84             | 10.41                     |
| 22     | RAJ 3404    | 88.08                 | 126.11           | 84.13             | 10.97             | 10.49             | 17.04           | 32.09                             | 31.76           | 16.55                          | 54.25             | 11.13                     |
| 23     | DH 3171     | 83.29                 | 120.06           | 92.14             | 10.65             | 9.63              | 16.48           | 30.72                             | 31.05           | 15.48                          | 43.9              | 8.95                      |
| 24     | HD-2888     | 83.79                 | 125.16           | 95.86             | 10.41             | 9.83              | 16.18           | 30.57                             | 31.75           | 19.28                          | 42.49             | 10.41                     |
| 25     | SONALIKA    | 83.51                 | 120.99           | 91.32             | 10.52             | 9.99              | 15.96           | 27.36                             | 30.79           | 15.76                          | 46.64             | 9.51                      |
| 26     | HD-2967     | 83.69                 | 118.93           | 80.4              | 9.17              | 10.92             | 18.18           | 32.48                             | 37.99           | 16.55                          | 51.05             | 10.61                     |
| 27     | PBW 52      | 80.62                 | 122.87           | 87.14             | 10.24             | 14.08             | 16.48           | 26.05                             | 40.22           | 17.72                          | 53.09             | 11.58                     |
|        | <b>Mean</b> | 82.83                 | 122.94           | 86.57             | 10.47             | 10.95             | 17.16           | 31.37                             | 31.95           | 16.79                          | 47.25             | 10.07                     |
|        | Min         | 78.11                 | 117.44           | 66.18             | 9.17              | 9.63              | 15.72           | 25.45                             | 26.55           | 12.33                          | 36.14             | 7.99                      |
|        | Max         | 88.98                 | 126.11           | 101.93            | 11.49             | 14.09             | 18.47           | 38.77                             | 40.22           | 19.77                          | 57.24             | 12.87                     |
|        | SE(d) ±     | 0.84                  | 1.55             | 3.45              | 0.27              | 0.38              | 0.42            | 0.63                              | 0.82            | 0.6                            | 1.32              | 0.29                      |
|        | C.D. at 5%  | 2.5                   | 1.11             | 5.74              | 1.34              | 1.76              | 1.95            | 1.87                              | 1.75            | 0.7                            | 3.34              | 0.28                      |
|        | C.V. (%)    | 3.11                  | 2.83             | 5.56              | 5.47              | 7.63              | 4.78            | 5.89                              | 3.76            | 3.95                           | 4.19              | 3.16                      |

### **Heritability:**

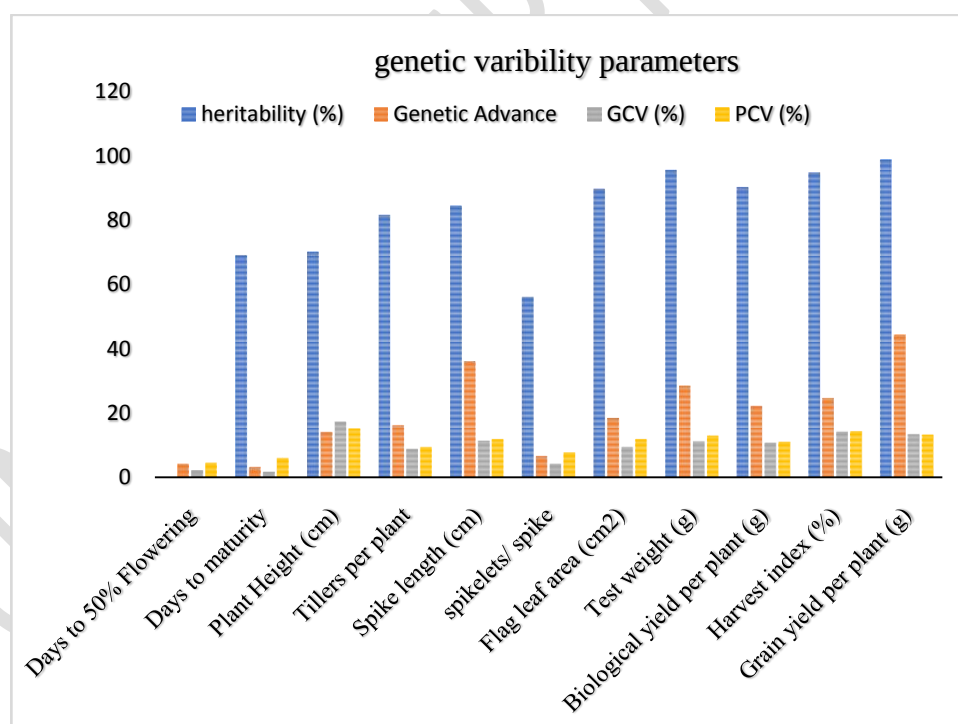
Estimates of broad-sense heritability ( $H^2_{bs}$ ) associated with percent above average (GA) genetic advances for various traits are shown in Table 3 and Fig. 1. Heritability and genetic growth are important selection parameters. High heritability (>60%) was observed for all traits. Viz., grain yield per plant (98.90%), followed by test weight (95.53%), harvest index (94.88%), and biological yield per plant (90.33%). flag leaf area (89.77%), panicle length (84.55%), number of shoots per plant (81.62%), days to 50% flowering (75.99%), plant height (70.22%), time to maturity Days (69.17%) indicates that selection for these traits is more valuable in effective breeding programs, except for number of spikelets per spikelet (56.16%), which had moderate heritability. Plant breeders can focus on these traits to make effective selections for genetic improvement. No such trait was observed in the present study, and its heritability is low compared to the traits examined. Current finding is in close agreement with the finding of Gautam et al., (2017), Gaur, (2019), Sahu et al. (2019), Tarkeshwar et al. (2019), Kumar et al. (2020) and Kumar et al. (2022).

### **Genetic Advance:**

Genetic advance is the enhancement in the mean genotypic value of selected individual over the parental population. High estimates of genetic advance (>20%) in per cent over mean was recorded for the traits grain yield per plant (44.26%) followed by spike length (36.12%), Test weight (28.51%), harvest index (24.69%) and biological yield per plant (22.16%)(Table- 3) and (Fig. 1). While, moderate (10-20%) genetic advance in percent over mean were found for flag leaf area (18.55%), Tillers per plant (16.21%) and plant height (14.11 %). Further, low level (<10%) of genetic advance were observed for number of spikelets per spike, days to 50% flowering and days to maturity. Similar outcome has also been recorded by Kumar et al. (2020), Kumar et al. (2022) in his study on wheat germplasm variability study.

**Table 3: Estimates of PCV, GCV, heritability and genetic advance in 25 germplasm lines of Wheat**

| Genotypes                         | Range  |        |        | Variance |         | $h^2$ (BS) (%) (Hb) | Genetic Advance | Coefficient of Variation |         | % contribution |
|-----------------------------------|--------|--------|--------|----------|---------|---------------------|-----------------|--------------------------|---------|----------------|
|                                   | Min    | Max    | Mean   | var (g)  | var (p) |                     | GA% mean        | GCV (%)                  | PCV (%) |                |
| Days to 50% Flowering             | 78.88  | 85.96  | 82.73  | 3.66     | 4.49    | 75.99               | 4.30            | 2.31                     | 4.56    | 3.11           |
| Days to maturity                  | 119.06 | 127.61 | 124.35 | 5.07     | 6.71    | 69.17               | 3.24            | 1.81                     | 6.08    | 2.77           |
| Plant Height (cm)                 | 66.78  | 102.13 | 86.97  | 37.33    | 46.36   | 70.22               | 14.11           | 17.22                    | 15.13   | 4.78           |
| Tillers per plant                 | 4.57   | 6.89   | 5.88   | 0.27     | 0.31    | 81.62               | 16.21           | 8.82                     | 9.48    | 17.88          |
| Spike length (cm)                 | 8.13   | 12.59  | 9.45   | 1.15     | 1.26    | 84.55               | 36.12           | 11.33                    | 11.89   | 14.55          |
| spikelets/ spike                  | 15.52  | 18.27  | 16.97  | 0.53     | 0.94    | 56.16               | 6.64            | 4.29                     | 7.72    | 11.89          |
| Flag leaf area (cm <sup>2</sup> ) | 24.85  | 37.87  | 30.87  | 9.58     | 10.38   | 89.77               | 18.55           | 9.43                     | 11.88   | 9.45           |
| Test weight (g)                   | 26.25  | 40.32  | 31.96  | 12.25    | 13.03   | 95.53               | 28.51           | 11.15                    | 12.90   | 10.56          |
| Biological yield per plant (g)    | 12.33  | 19.37  | 16.59  | 3.16     | 3.39    | 90.33               | 22.16           | 10.71                    | 11.10   | 7.41           |
| Harvest index (%)                 | 37.74  | 58.84  | 48.86  | 28.45    | 30.31   | 94.88               | 24.69           | 14.12                    | 14.33   | 8.55           |
| Grain yield per plant (g)         | 5.79   | 10.07  | 8.07   | 0.99     | 1.05    | 98.90               | 44.26           | 13.34                    | 13.27   | 9.12           |

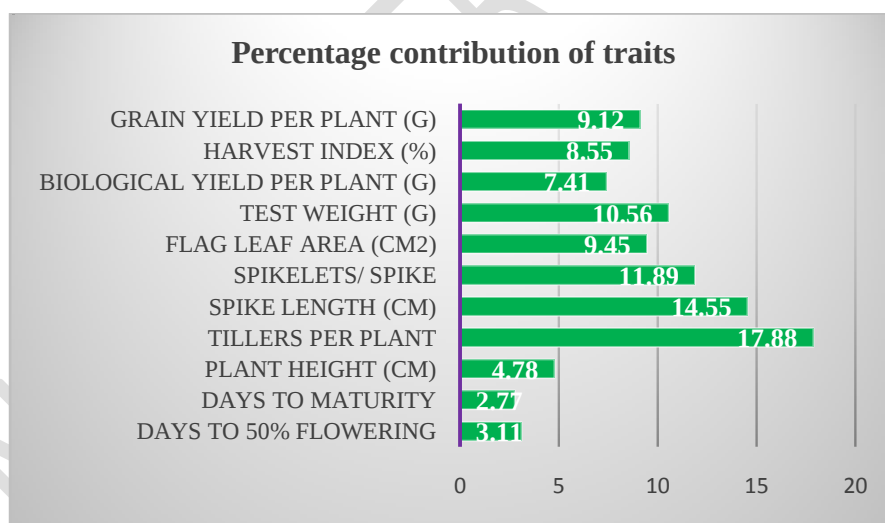


**Figure. 1 Genetic variability param**

### Coefficient of variation:

Highest values of phenotypic coefficient of variation (PCV) along with genotypic coefficient of variation were estimated for grain yield per plant followed by spike length, Test weight, harvest index and biological yield per plant (g) respectively as shown in table 3. The high variance due to genotype as well as phenotype has been observed for some traits like plant height, harvest index, grain yield per plant (g), Test weight and flag leaf area. The highest contribution towards variability was made by days to 50% flowering, days to maturity, plant height and number of spikelets per spike. **Mishra *et al.* (2016), Gautam *et al.* (2017) Suhel *et al.* and (20121)** also reported similar finding for most of the traits in his study.

In term of percentage contribution of each individual traits, tillers per plant (17.88%) have contributed more toward the total genetic variability followed by Spike length (14.55), Spikelet/spike (11.89), Test weight (10.56%), Grain yield per plant (9.12%) and Harvest index (8.55%). While three traits viz., plant height (4.78%), Days to 50% flowering (3.11%) and Days to maturity (2.77%) exhibited very less contribution toward the total genetic variability (Fig. 2).



**Fig. 2** Trait wise contribution (%) towards total genetic variability

### Correlation Coefficients estimates:

The estimation of genotypic and phenotypic correlation coefficients is computed among eleven characters of indigenous lines of wheat under study are presented in Table 4. At genotypic level, days to 50% flowering exhibited highly significant and positive correlation with number of spikelets per spike (0.447<sup>\*\*</sup>) followed by harvest index (0.320<sup>\*</sup>), grain yield per plant (0.428). It

possessed significant negative correlation with spike length ( $-0.316^*$ ). Days to maturity did not exhibit highly significant positive or negative correlation with any of the traits under study. Spike length per plant has shown highly significant and positive correlation with grain yield per plant ( $0.466^{**}$ ) followed by biological yield per plant ( $0.385^*$ ) and number of spikelets per spike ( $0.289$ ). Number of spikelets per spike possessed significant positive association with flag leaf area and biological yield per plant with the correlation coefficient values  $0.565^{**}$  and  $0.376^*$ . Flag leaf area has significant but negative correlation with harvest index ( $-0.347^*$ ). Test weight (1000-grains weight) showed significant positive association with grain yield per plant ( $0.444^{**}$ ) and harvest index ( $0.341^*$ ). The trait biological yield per plant exhibited significant positive correlation with grain yield per plant and harvest index respectively with correlation coefficient of  $0.586^{**}$  and  $0.356^*$  respectively. Further, harvest index showed positive and significant association with grain yield ( $0.708^{**}$ ). Similar finding has also been found been recorded by

### **Conclusion:**

High heritability accompanied with high genetic advance indicated that the heritability is due to additive genetic effect and selection may be effective while high heritability coupled with low genetic advance indicates pre-dominance of non-additive gene action while low heritability is exhibited due to influence of environmental interaction rather than genotypic selection for such characters may not be rewarding. The high magnitude of heritability couple with high genetic advance in per cent of mean was observed for grain yield per plant followed by spike length, test weight, harvest index and biological yield per plant; which indicated that good response to selection is likely to be observed for these characters. The existence of high character heritability with moderate genetic advance for flag leaf area, number of tillers per plant and plant height indicate that these characters may also provide good response to selection owing to their moderate transmissibility and variability.

At genotypic level, days to 50% flowering exhibited highly significant and positive correlation with number of spikelet's per spike followed by harvest index, grain yield per plant. Days to maturity did not exhibit highly significant positive or negative correlation with any of the traits under study. Plant height exhibited highly significant and negative correlation with harvest index followed by grain yield per plant, spike length and flag leaf area. Number of tillers per plant exhibited highly significant and positive correlation with biological yield per plant and grain yield per plant. Test weight (1000-grains weight) showed significant positive association with grain yield per plant and harvest index. The trait biological yield per

plant exhibited significant positive and negative correlation with grain yield per plant and harvest index respectively with correlation coefficient respectively. Further, harvest index showed positive and significant association with grain yield.

Thus, harvest index and grain yield per plant emerged as closely correlated yield attributes. The strong positive association of grain yield with one or more of the above traits has also been observed by previous workers Singh *et al.* 2008; Sharma and Singh, 2009; Anwar *et al.*, 2009; Aydin *et al.*, 2010; Soni *et al.*, 2011; Singh *et al.*, 2012; Vimal *et al.*, 2016; Kushawaha *et al.*, 2018; Sidhu and Gill, 2019, Kumar *et al.*, 2020

**Table 4: Estimates of genotypic correlation coefficient computed between 11 characters wheat germplasm**

| Characters                             | Days to 50% Flowering | Days to maturity | Plant Height (cm) | Tillers per plant | Spike length (cm) | spikelets/ spike | Flag leaf area (cm <sup>2</sup> ) | Test weight (g) | Biological yield per plant (g) | Harvest index (%) | Grain yield per plant (g) |
|----------------------------------------|-----------------------|------------------|-------------------|-------------------|-------------------|------------------|-----------------------------------|-----------------|--------------------------------|-------------------|---------------------------|
| <b>Days to 50% Flowering</b>           | 1.000                 | 0.181            | 0.001             | 0.195             | -0.316*           | 0.447**          | -0.215                            | -0.101          | 0.150                          | 0.370**           | 0.428**                   |
| <b>Days to maturity</b>                |                       | 1.000            | -0.028            | 0.166             | -0.060            | 0.042            | 0.090                             | -0.057          | 0.094                          | 0.105             | 0.159                     |
| <b>Plant Height (cm)</b>               |                       |                  | 1.000             | -0.107            | -0.375*           | -0.108           | -0.237                            | 0.014           | -0.043                         | -0.456**          | -0.428**                  |
| <b>Tillers per plant</b>               |                       |                  |                   | 1.000             | 0.035             | -0.121           | 0.161                             | -0.080          | 0.241                          | 0.034             | 0.225                     |
| <b>Spike length (cm)</b>               |                       |                  |                   |                   | 1.000             | 0.289*           | -0.245*                           | 0.144           | 0.365*                         | 0.024             | 0.466**                   |
| <b>spikelets/ spike</b>                |                       |                  |                   |                   |                   | 1.000            | 0.565**                           | -0.344**        | 0.376*                         | -0.221            | 0.085                     |
| <b>Flag leaf area (cm<sup>2</sup>)</b> |                       |                  |                   |                   |                   |                  | 1.000                             | -0.273          | 0.099                          | -0.347*           | -0.220                    |
| <b>Test weight (g)</b>                 |                       |                  |                   |                   |                   |                  |                                   | 1.000           | 0.130                          | 0.341*            | 0.444**                   |
| <b>Biological yield per plant (g)</b>  |                       |                  |                   |                   |                   |                  |                                   |                 | 1.000                          | 0.356*            | 0.586**                   |
| <b>Harvest index (%)</b>               |                       |                  |                   |                   |                   |                  |                                   |                 |                                | 1.000             | 0.708**                   |
| <b>Grain yield per plant (g)</b>       |                       |                  |                   |                   |                   |                  |                                   |                 |                                |                   | 1.000                     |

\*, \*\* Significant at 5% and 1% level of probability respectively.

## References

- Dvorak (1993).** The evolution of polyploid wheat: Identification of a genome donor species. *Genome***36**: 21-31.
- Gaur, S.C. (2019).** Genetic improvement through variability, heritability and genetic advance for grain yield and its contributing traits in Wheat (*Triticum aestivum* L. em Thell). *Int. J. Pure App. Biosci.***7**(1): 368-373.
- Gautam; Gaur, S.C.; Gaur, A.K. and Gaur, L.B. (2017).** Genetic variability for quantitative character and their association with grain yield and its component in bread wheat (*Triticum aestivum* L. em. Thell.). *International journal society for scientific development in Agriculture and Technology*, **12**(4): 2581-2586.
- Johnson, H.W.; Robinson, H.F. and Comstock, R.E. (1955).** Genotype and phenotype correlation in Soybean and their implication in selection. *Agron. J.*, **47**: 477-483.
- Kumar, A.; Gaur, S.C.; Tarkeshwar, Singh, R.; Prasad, H.; Yadav, M. and Kumar, K. (2022).** Studies on Genetic Variability, Heritability and Genetic Advance for Grain Yield and Yield Attributing Traits in Bread Wheat (*Triticum aestivum* L. em. Thell.). *Frontiers in Crop Improvement*, **10** (1): 29-31.
- Kumar, K.; Tarkeshwar; Gautam, U.; Yadav, M.; Gaur, S.C. and Sahu, R.K. (2020).** Genetic variability, heritability and genetic advance studies for grain yield and yield attributing traits in bread wheat (*T. aestivum* L. em. Thell). *Int. J. of Curr. Microb. And App. Sci.*, Special Issue-11: 518-523.
- Mishra, Hariom.; Gaur, S.C.; Jaiswal, Ranjana and Kumar, Satyendra (2016).** Analysis of variance, heritability and genetics advance of Morphological traits in Bread Wheat (*Triticum eastivum* L. em. Thell). *National Conference on Science for Rural India*, 231-234.
- Panse, V.G. and Sukhatme, P.V. (1988).** Statistical methods for agricultural worker. ICAR Publ., (II ed.), New Delhi.
- Sahu, R.K.; Tarkeshwar; Yadav, M.; Gaur, S.C.; Dev, A.; Yadav, G.; Yadav, P.K. and Singh, S.P. (2019).** Variability, heritability and genetic advance studies in some bread wheat (*T. aestivum* L. em. Thell) genotypes. *Frontiers in Crop Improvement*, Vol. **7** (2): 135-137.
- Singh, S.K.; Singh, B.N.; Singh, P.K. and Sharma, C.L. (2008).** Correlation and path analysis in some exotic lines in wheat (*Triticum aestivum* L.). *New Botanist*,**35**(1/4): 89-94.

**Sleper John M. Poehlman (2006).** Blackwell Publishing professinol, 2121 State Avenue, Ames, Iowa 50014. pp424.

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**Tarkeshwar; Gaur, S.C.; Singh, S.P. and Sahu, (R.K. 2019).** Studies on genetic variability, heritability and genetic advance for yield and attributing characters in bread wheat (*T. aestivum* L. em. Thell). *Frontiers in Crop Improvement*, Vol. 7 (1): 15.

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