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# PERFORMANCE OF WHEAT GENOTYPES OVER THE ENVIRONMENTS

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**ABSTRACT**

Wheat (*Triticum aestivum* L.) is a crucial global cereal crop, providing essential calories and protein. A field experiment at Birsa Agricultural University, Ranchi (2022-23) evaluated genetic variability using a simple lattice design in three environments: timely sown restricted irrigated, timely sown irrigated and late sown irrigated. With climate change and population growth, developing high-yield, resilient varieties are essential. Drought and heat stress negatively impact yield, grain number, photosynthesis, chlorophyll content and starch synthesis. Analysis of variance revealed significant variability, heritability and genetic advance, indicating opportunities for breeding. Phenotypic (Vp) and genotypic (Vg) variances were high for most traits, with PCV and GCV ranging from 2.82 to 25.78 and 2.76 to 25.49, respectively. Heritability ranged from 84.62% (productive tillers) to 99.83% (1000-grain weight) and genetic advance varied from 5.57% (days to 75% maturity) to 51.94% (grain number per spike).

***Key words :*** Wheat, Heat stress, Genetic variability, Phenotypic and Genotypic variability, Genetic advance.

## Introduction

Wheat (*Triticum aestivum* L.) is a staple crop essential for global food security. It is grown in diversified environments. It is considered as "King of cereals" (Halperin, 1936), which can be grown under diversified environments. The wheat yield witnessed a twofold increase over the past three decades, credited to the amalgamation of advanced agronomic practices and improved germplasm via selective breeding (Lopes *et al*., 2014). The global demand for wheat is projected to surge by 60% by the year 2050, while climate change is anticipated to adversely impact production by 29% within the same timeframe (Dixon *et al*., 2009). Wheat is the second most produced cereal crop contributing 779.03 million metric ton (2021-22) in world. India contributes 12.5% share in total wheat production of world. In Jharkhand, Palamu, Hazaribagh and Godda are wheat growing districts. Enhancing its yield and adaptability to diverse environments is critical for meeting the increasing food demand. Genetic variability within wheat genotypes provides a foundation for selecting superior varieties and improving breeding strategies. This study focuses on evaluating genetic variability in wheat genotypes for yield and its associated components under different environmental conditions. World is divided in to twelve thermal climates and India is divided into fifteen agro-climatic zones which inflates the need for stable varieties to feed the population. To achieve the same i.e. stable variety of wheat which can be grown in all or most of the zones, an experiment was conducted. This experiment is a step towards developing heat and drought tolerant stable and high yielding wheat variety which involves assessing the performance of different wheat genotypes across the environments.

## Materials and Methods

The experiment was conducted on "Stability analysis in wheat (*Triticum aestivum* L.) for heat and drought tolerance" for stability, yield and other quantitative characters was executed in western section of research farm, BAU, Kanke during *Rabi* season 2022-23. Birsa

Agricultural University (BAU), Kanke is located at an elevation of 634 meter above mean sea level with 85°18'48.3" East longitude and 23°25'47.3" North latitude. The experimental materials for the present investigation comprised of twenty-five wheat genotypes (Table 1) in simple lattice design (5 × 5) in three environments namely, timely sown restricted irrigation ($E_1$), timely sown irrigated ($E_2$) and late sown irrigated ($E_3$) as mentioned in Table 2. The observation was recorded for days to 50% flowering, days 75% maturity, productive tiller per 3 linear meters, plant height, spike length, grain number per spike, grain weight per spike (g), 1000-grain weight (g), grain yield per plot/hectare, biological per plot/hectare and harvest index. The statistical analysis was performed using R-programming software. Mean, range and coefficient of variation (CV) were also estimated. Genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were estimated according to Burton (1952); heritability in broad sense ($h^2$bs) was estimated according to Burton and Devane (1953); genetic advance (GA) and genetic advance as per cent of mean (GAPM) were calculated by Johnson *et al*. (1955).

## Results and Discussion

The ANOVA results for different traits across the three environments are summarized in Table 3. Highly significant variations were observed for all traits among genotypes (GEN). The study reveals significant genetic variability among the wheat genotypes for the evaluated traits. This variability is crucial for selecting and breeding high-yielding varieties. In this study, we assessed the yield potential and related traits of twenty-five bread wheat genotypes across three environments. Significant differences were found among the genotypes for all traits, indicating considerable genetic variability. Thirteen traits, including flowering and maturity periods, tiller count, plant height, spike length, grain weight, and yield per plot and hectare, showed highly significant differences. This

**Table 1 :** List of material used in the study and their origin.

| Test Genotypes* | Source | Checks* | Source |
|---|---|---|---|
| HI1665 | ICAR-IARI, Regional station, Indore, MP | NIAW3170 | Agriculture Research Station, Niphad, Maharashtra |
| DBW359 | ICAR-IIWBR, Karnal, Haryana | HD3086 | ICAR-IARI, New Delhi |
| NIAW4028 | Agriculture Research Station, Niphad, Maharashtra | NIDW1149(d) | Agriculture Research Station, Niphad, Maharashtra |
| HI8840(d) | ICAR-IARI, Regional station, Indore, MP | RAJ3765 | RARI, Rajasthan |
| DBW377 | ICAR-IIWBR, Karnal, Haryana | DBW110 | ICAR-IIWBR, Karnal, Haryana |
| HD3388 | ICAR-IARI, Delhi | HI1605 | ICAR-IARI, Regional station, Indore, MP |
| GW547 | JAU-Junagadh, Gujarat | HD2932 | ICAR-IARI, New Delhi |
| UAS478(d) | UAS, Dharwad, Karnataka | MACS6768 | ARI, Pune |
| MP1378 | JNKVV, Jabalpur, MP | WH730 | CCSHAU, Hisar |
| HD3386 | ICAR-IARI, New Delhi | GW322 | JAU-Junagadh, Gujarat |
| NWS2194 | ANDV University of Agriculture, Faizabad, UP | DBW187 | ICAR-IIWBR, Karnal, Haryana |
| WH1402 | Haryana Agriculture University, Hisar | HI1655 | ICAR-IARI, Regional station, Indore, MP |
| CG1040 | CCS-Haryana Agriculture University, Hisar | | |

(*The experimental materials received from ICAR-IIWBR)

**Table 2 :** Specification of different agro-ecological conditions/ environments.

| Environments | Description | Date of sowing |
|---|---|---|
| 1st Environment | Timely sown restricted irrigation condition | 04/11/2022 |
| 2nd Environment | Timely sown irrigated condition | 11/11/2022 |
| 3rd Environment | Late sown irrigated condition | 08/12/2022 |

**Table 3 :** Analysis of Variance for different characters across three environments (Timely sown restricted irrigation ($E_1$), Timely sown irrigated ($E_2$), Late sown irrigated ($E_3$)).

| Source of Variation | Degree of freedom | Days to 50% Flowering | Days to 75% Maturity | Productive Tillers per 3 linear meters | Plant Height (cm) | Spike Length (cm) | 1000 Grain Weight (g) | Grain number per spike | Grain Weight per spike (g) | Grain Yield per plot (kg) | Biological yield per plot (kg) | Grain Yield per Hectare (kg) | Biological yield per Hectare | Harvest index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean sum of squares | | | | | | | | | | | | |
| **GEN** | 24 | 137.72** | 23.38** | 3352.00** (?) | 176.70** | 8.38** | 76.64** | 361.39** | 0.32** (?) | 0.11** (?) | 0.27** (?) | 2680178.00** (?) | 6795692.00** (?) | 0.12** (?) |
| **ENV** | 2 | 478.75** | 1042.03** | 53023.00** | 1159.90** | 13.53** | 74.96** | 741.95** | 14.57** | 2.19** (?) | 3.52 (?) | 54734017.00** (?) | 90499850.00** (?) | 0.31 (?) |
| **GEN:ENV** | 48 | 14.34** | 8.61** | 2679.00** | 16.54 | 0.51** | 10.00** | 22.39** | 0.16** | 0.09** | 0.07 | 2183982.00** | 1778965.00** | 0.01 |
| **ENV:REP** | 3 | 1.51* | 0.77 | 332.00 | 41.55 | 4.25** | 0.46** | 1.86 | 0.04 | 0.2** | 0.00 | 550283.00** | 122900.00 | 0.00 |
| **ENV:REP:B** | 24 | 3.81** | 2.42** | 429.00 | 11.80 | 0.41** | 0.07 | 5.24 | 0.04 | 0.01 | 0.00 | 134950.00 | 99338.00 | 0.00 |
| **ERROR** | 48 | 0.66 | 0.47 | 280.00 | 7.75 | 0.16 | 0.06 | 4.02 | 0.04 | 0.00 | 0.01 | 89825.00 | 158588.00 | 0.00 |

*= significant at 5%; **= significant at 1%.

**Note :** The values appearing as zero are not precisely zero rather tend towards zero.

**Table 4 :** Mean performance for across three different environments.

| S. no. | Characters | Range | Mean | CD @ 5 % | CV |
|---|---|---|---|---|---|
| 1 | Days to 50% flowering | 69.67-88.50 | 79.95 | 1.63 | 1.02 |
| 2 | Days to 75% maturity | 119.17-126.83 | 122.67 | 1.38 | 0.56 |
| 3 | Productive tillers per 3 linear m | 222.34-310.47 | 266.54 | 33.64 | 6.28 |
| 4 | Plant height (cm) | 82.63-103.70 | 94.39 | 5.60 | 2.95 |
| 5 | Spike length (cm) | 5.37-10.57 | 8.63 | 0.80 | 4.63 |
| 6 | 1000- Grain weight (g) | 35.93-53.20 | 43.83 | 0.49 | 0.56 |
| 7 | Grain number per spike | 41.01-66.58 | 52.43 | 4.03 | 3.82 |
| 8 | Grain weight per spike (g) | 2.12-3.49 | 2.82 | 0.40 | 7.09 |
| 9 | Grain yield per plot (kg/ plot) | 0.89-1.37 | 1.13 | 0.12 | 5.30 |
| 10 | Biological yield per plot (kg/ plot) | 2.42-3.34 | 2.79 | 0.20 | 3.58 |
| 11 | Grain yield per hectare (kg/ha) | 4466.67-6841.67 | 5662.33 | 602.60 | 5.29 |
| 12 | Biological yield per hectare (kg/ha) | 12116.67-16675.00 | 13934.00 | 800.70 | 2.86 |
| 13 | Harvest index (%) | 0.33-0.52 | 0.41 | 0.05 | 6.19 |

suggests ample scope for selection in breeding programs, supported by previous research. The high variability may be due to varying sowing dates and environmental conditions, introducing significant variation among the genotypes. The mean performance of the genotypes across three different environments is summarized in Table 4. The range, mean, CD (critical difference) at 5%, and CV (coefficient of variation) were calculated for each character. The data revealed that the widest range of variability was observed for biological yield per hectare (12116.67-16675.00) with mean value 13934.

An extensive analysis of phenotypic and genotypic variances across a range of thirteen traits indicating that phenotypic variance surpasses genotypic variance for all

**Table 5 :** Genetic estimate for different characters across all three environments: $E_1$, $E_2$ & $E_3$.

| Source of variation | Days to 50% Flowering | Days to 75% Maturity | Productive Tillers per 3 linear meters | Plant Height (cm) | Spike Length (cm) | 1000 Grain Weight (g) | Grain Number per spike | Grain Weight per spike (g) | Grain Yield per plot (kg/plot) | Biological Yield per plot (kg/plot) | Grain Yield per Hectare (kg/ha) | Biological Yield per hectare (kg/ha) | Harvest Index (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **$\delta^2$g** | 68.53 | 11.46 | 1541.00 | 84.48 | 4.11 | 38.29 | 178.69 | 0.39 | 0.05 | 0.13 | 1295176.50 | 3318552.00 | 0.03 |
| **$\delta^2$ph** | 69.19 | 11.93 | 1821.00 | 92.23 | 4.27 | 38.35 | 182.71 | 0.43 | 0.06 | 0.14 | 1385001.50 | 3477140.00 | 0.03 |
| **$\delta^2$e** | 0.66 | 0.47 | 280.00 | 7.75 | 0.16 | 0.06 | 4.02 | 0.04 | 0.00 | 0.01 | 89825.00 | 158588.00 | 0.00 |
| **GCV** | 10.35 | 2.76 | 14.73 | 9.74 | 23.47 | 14.12 | 25.49 | 22.16 | 20.10 | 13.07 | 20.10 | 13.07 | 19.06 |
| **PCV** | 10.40 | 2.82 | 16.01 | 10.17 | 23.93 | 14.13 | 25.78 | 23.31 | 20.79 | 13.38 | 20.78 | 13.38 | 20.05 |
| **ECV** | 1.02 | 0.56 | 6.28 | 2.95 | 4.68 | 0.58 | 3.82 | 7.22 | 5.29 | 2.85 | 5.29 | 2.86 | 6.25 |
| **$h^2$** | 99.05 | 96.06 | 84.62 | 91.60 | 96.25 | 99.84 | 97.80 | 90.70 | 83.33 | 92.86 | 93.51 | 95.44 | 100.00 |
| **GA** | 16.97 | 6.83 | 74.39 | 18.12 | 4.09 | 12.74 | 27.23 | 1.22 | 0.45 | 0.73 | 2267.10 | 3666.10 | 0.15 |
| **GA as % of mean** | 21.23 | 5.57 | 27.91 | 19.20 | 47.41 | 29.06 | 51.94 | 43.40 | 40.05 | 26.32 | 40.04 | 26.31 | 37.30 |

**Note :** The values appearing as zero are not precisely zero rather tend towards zero.

examined traits for the pooled environment is presented in Table 5. Notably, the most significant variances were observed in the number of productive tillers per 3 linear meters (phenotypic: 1821.00, genotypic: 1541.00), grain yield per hectare (phenotypic: 1385001.50, genotypic: 1295176.50), and biological yield per hectare (phenotypic: 3477140.00, genotypic: 3318552.00). The genotypic and phenotypic variances varied from high to moderate for the characters, grain number per spike (25.49 and 25.78), spike length (23.47 and 23.93), grain weight per spike (22.16 and 23.31), grain yield per plot (20.10 and 20.79), grain yield per hectare (20.10 and 20.78), harvest index (19.06 and 20.05), productive tillers per 3 linear meters (14.73 and 16.01), 1000-grain weight (14.12 and 14.13), biological yield per plot (13.07 and 13.38), biological yield per hectare (13.07 and 13.38), and plant height (9.74 and 10.17). High heritability (broad-sense) was observed for all the characters which ranged from 83.33% (grain yield per plot) to 100% (harvest index). Genetic advance varies widely among traits, with the high values in productive tillers per 3 linear meters (74.39), grain yield per hectare (2267.10) and biological yield per hectare (3666.10). Moderate genetic advance was exhibited by days to 50% flowering (16.97), plant height (18.12), 1000-grain weight (12.74) and grain number per spike (27.23) while lower values were recorded for days to 75% maturity (6.83), spike length (4.09), grain weight per spike (1.22), grain yield per plot (0.45), biological yield per plot (0.73) and harvest index (0.15). Genetic advance as percent of mean ranges from 5.57% (days to 75% maturity) to 51.94% (grain number per spike). High percentages are recorded for spike length (47.41%), grain number per spike (51.94%), grain weight per spike (43.40%), grain yield per plot (40.05%), grain yield per hectare (40.04%) and harvest index (37.30%) whereas moderate percentages were observed for days to 50% flowering (21.23%), productive tillers per 3 linear meters (27.91%), 1000-grain weight (29.06%), biological yield per plot (26.32%) and biological yield per hectare (26.31%).

A wide range of variation was observed for all traits. Most traits performed better under late sown irrigated conditions, including productive tillers per 3 linear meters, spike length, grain number per spike, grain weight per spike, grain yield per plot/hectare, biological yield per plot/hectare and harvest index (Table 5). High genotypic and phenotypic coefficients of variation were noted for productive tillers per 3 linear meters, plant height, grain number per spike, grain yield per hectare and biological yield per hectare consistent with findings from Bhushan *et al*. (2014), Khan *et al*. (2014), Kumar *et al*. (2014), Manohar *et al*. (2014), Singh *et al*. (2016), Thapa *et al*. (2018) and Bhanu *et al*. (2018). High heritability and high genetic advance were observed for days to 50% flowering, productive tillers per 3 meters, 1000-grain weight, grain number per spike, and biological yield per plot. Traits like days to 75% maturity, spike length, grain number per spike, and biological yield per hectare showed similar results. These findings align with studies by Khokhar *et al*. (2010), Waqas *et al*. (2010), Fellahi *et al*. (2013), Saleem *et al*. (2016) and Jan *et al*. (2020).

## Conclusion

The genetic variability among wheat genotypes for yield and its components under different environments provides valuable insights for breeding programs. Genotypes like HD3086 and HI8840 exhibit high yield potential and adaptability, The study highlights the significant genetic variability among wheat genotypes for yield and its components. The high heritability and genetic advance for key traits provide a strong basis for selecting and breeding high-yielding wheat varieties. The findings can be utilized to enhance wheat breeding programs aimed at improving yield and adaptability to diverse environmental conditions. Analysis revealed significant differences among genotypes across thirteen traits in three environments. High variability was observed in spike length, grain number per spike, and grain length per spike, both genetically and phenotypically. The greatest genetic advancements were seen in grain number per spike, grain yield per hectare, and biological yield per hectare. Moderate to high genetic advances as a percentage of the mean were noted for 1000-grain weight, harvest index, grain yield per plot/hectare, grain weight per spike, spike length, and grain number per spike. Grain yield was strongly and significantly correlated with biological yield across all three environments.

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