**Evaluation of Seed Quality Parameters and Vigour Tests of Field Emergence in Barley (*Hordeum vulgare* L.) Germplasm**

**Abstract:**

The present investigation was carried out during 2024–2025 at the laboratories and Organic Research Farm, Karguanji, Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi. To evaluate the efficacy of seed viability and vigour tests of standard germination and field emergence, and to assess the variability among different barley (*Hordeum vulgare* L.) genotypes for seed quality parameters. A total of twenty genotypes were analysed using standard ISTA (1999) protocols with three replications under controlled and field conditions. Observations were recorded on standard germination, seedling length, seedling dry weight, seed weight, seed density, vigour index I and II, field emergence index, seedling establishment, and mean emergence time. Statistical analysis was performed as per the method described by Panse and Sukhatme (1967). The results revealed significant variation among genotypes for all studied traits, indicating substantial genetic diversity. Among the evaluated genotypes, BH 393, BH 942, and RD 2552 exhibited superior performance across most parameters, whereas PL 751 and BH 932 were consistently ranked lower. The findings highlight the importance of seed vigour and viability assessments in predicting field performance and aid in selecting superior genotypes for barley improvement and seed production programs.

**Keywords**:

Barley genotypes; seed viability; seed vigour; germination; field emergence; vigour index; ISTA method; genetic variability; seed quality.

**Introduction**

Barley (Hordeum vulgare L.) is the fourth most important cereal crop globally, following wheat, rice, and maize. It is primarily cultivated for food, feed, and malt production and is well adapted to diverse agro-climatic conditions, including marginal lands and harsh environments (Baik & Ullrich, 2008). In India, barley is mainly grown in the rabi season and serves as an essential staple and industrial crop. Its short growing season, drought tolerance, and ability to thrive on low-input soils make it a crucial component in sustainable agriculture, especially under rainfed and organic farming systems (Kumar et al., 2019).

Seed quality is a decisive factor for successful crop establishment, particularly under variable field conditions. High-quality seeds with superior viability and vigour can significantly enhance seedling emergence, uniform stand establishment, and ultimately, crop productivity (McDonald, 1998). In this context, the evaluation of seed quality parameters is not only critical for identifying elite genotypes but also vital for seed certification, storage, and seed technology advancements.

Seed viability, defined as the potential of a seed to germinate under favorable conditions, is a basic quality parameter, whereas seed vigour reflects the seed’s ability to perform under a wide range of environmental conditions (ISTA, 1999). Vigour testing provides a more comprehensive evaluation of seed performance and is increasingly recognized as a better predictor of field emergence than standard germination alone (Powell, 2006). Therefore, integrating vigour tests in genotype evaluation programs can improve seed selection for enhanced field performance.

Several vigour indices such as seedling length, seedling dry weight, vigour index I and II, field emergence index, and mean emergence time have been effectively used to assess seed performance under controlled and field conditions (Rana et al., 2020). These parameters provide insights into the physiological status of seeds and their readiness to withstand biotic and abiotic stresses during the early growth stages. Consequently, such tests are widely used in breeding and seed production programs for genotype screening. Genotypic differences in seed quality parameters, especially seed vigour, have been reported in various cereal crops including barley. Studies have shown that genetic makeup, physiological maturity at harvest, and post-harvest seed handling influence seed vigour and viability considerably (Demir & Mavi, 2008). Identifying high-vigour genotypes can lead to the development of superior seed lots with higher field emergence potential, a trait of utmost importance in organic and low-input agriculture.

In India, limited studies have been conducted to comprehensively evaluate seed vigour traits across diverse barley genotypes under both laboratory and field conditions. Given the shift toward organic and sustainable farming systems, the identification of barley genotypes with high inherent seed vigour has become increasingly important to ensure early crop establishment and productivity without heavy external inputs (Singh et al., 2021). This calls for the integration of both viability and vigour testing approaches in varietal evaluation programs. The International Seed Testing Association (ISTA, 1999) has standardized a range of physiological and vigour tests that are effective in estimating seed quality. However, the applicability and reliability of these tests in predicting field emergence under varying agro-climatic conditions need further validation through comparative studies on region-specific germplasm. Moreover, statistical evaluation of seed quality traits using robust analytical methods enhances the credibility and reproducibility of results in seed research (Panse & Sukhatme, 1967). The present investigation was carried out to evaluate seed viability and vigour attributes in selected barley genotypes and to assess their efficacy in predicting standard germination and field emergence. The study also aimed to identify high-performing genotypes for future use in seed production and breeding programs. The findings are expected to contribute significantly to the understanding of genotype-specific seed quality dynamics under organic and marginal production systems.

**Materials and Methods**

**2.1 Experimental Materials**

The experimental material comprised twenty diverse genotypes of barley (Hordeum vulgare L.), viz., BH 932, BH 933, BH 934, BH 935, BH 936, BH 937, BH 938, BH 939, BH 940, BH 941, BH 942, BH 393, BH 885, BH 927, BG 25, BG 105, DWR UB 52, RD 2552, K 551, and PL 751. All genotypes were procured from the Agricultural Research Station (ARS), Durgapura, Jaipur (Rajasthan), and evaluated during the rabi season of 2024–2025.

**2.2 Methods**

The study was conducted at the Department of Seed Science and Technology, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.). The investigation involved both laboratory and field-based experiments to evaluate seed quality parameters. The experimental design, observations, and standard procedures followed are described below:

**2.2.1 Laboratory Parameters**

**1. Standard Germination Test (%):**

Standard germination was tested according to ISTA rules (ISTA, 2004). For each genotype, 100 seeds were used per replication with three replications. Seeds were placed on moistened between paper (BP) towels and incubated at 25 ± 1°C and 90–95% relative humidity in a seed germinator. Final counts were recorded on the 7th day, and only normal seedlings were considered. Germination percentage was calculated as the number of normal seedlings expressed as a percentage of total seeds sown.

**2. Seedling Length (cm):**

At the time of final germination count, 10 normal seedlings were randomly selected from each replication. The length of each seedling was measured from the root tip to the shoot apex, and the average seedling length per genotype was computed.

**3. Seedling Dry Weight (mg):**

Following the germination test, 10 normal seedlings per replication were collected and dried in a hot air oven at 80 ± 1°C for 24 hours. The dried seedlings were weighed using an analytical balance, and the average seedling dry weight was calculated in milligrams.

**4. Seed Weight (g):**

For each genotype, three replications of 100 seeds were taken, weighed using an electronic balance, and the mean weight per 100 seeds was recorded.

**5. Seed Density (g/cc):**

Seed density was determined by the water displacement method. The weight of 100 seeds was recorded, and the volume of water displaced by these seeds (in cm³) was measured. The seed density was then calculated using the formula:

**Seed Density (g/cc)** = Weight of 100 seeds (g) / Volume of water displaced (cm³).

**6. Vigour Index–I:**

Seedling vigour index–I was calculated by multiplying standard germination percentage with average seedling length (cm), as per the method of Abdul-Baki and Anderson (1973).

**Vigour index–I** = Standard Germination (%) x Average seedling length

(cm)

**7. Vigour Index–II:**

Seedling vigour index–II was calculated by multiplying the germination percentage with average seedling dry weight (g).

**Vigour index–II** = Standard Germination (%) x Average seedling dry

weight (g)

**2.3 Field Parameters**

Field evaluation was carried out during rabi 2024–2025 at the Organic Research Farm (HRF), Karguanji, under the Department of Seed Science and Technology, Bundelkhand University, Jhansi. The experiment was laid out in a factorial randomized block design (FRBD) with three replications. Each genotype was sown in plots using 100 seeds per replication. The following field parameters were recorded:

**8. Field Emergence Index (%):**

Daily counts of emerged seedlings were recorded from the 1st to the 21st day after sowing. The field emergence index, indicating the speed of emergence, was calculated using the formula proposed by Maguire (1962).

**Field emergence index** =

No. of seedlings emerged No of seedlings emerged

+……+

First day of sowing Day of last count

**9. Seedling Establishment (%):**

Final seedling count was taken when no further emergence occurred. Seedling establishment percentage was calculated by expressing the number of emerged seedlings as a percentage of the total seeds sown.

**10. Mean Emergence Time (Days):**

Mean emergence time (MET) was calculated using the formula given by Ellis and Roberts (1980):

MET = Σ(n × t) / Σn

Where, n = number of seeds emerged on day t; t = days after sowing; Σn = total number of seeds emerged.

**2.4 Statistical Analysis**

The experimental data recorded for various seed quality and field emergence parameters were subjected to analysis of variance (ANOVA) using the method suggested by Panse and Sukhatme (1967). The significance of differences among genotypes was tested at 5% and 1% probability levels. The standard error (SEm) and critical difference (CD) were calculated for each parameter to interpret treatment effects.

**Results and Discussion**

**3.1 Analysis of Variance (ANOVA)**

The analysis of variance (ANOVA) revealed highly significant differences among the twenty barley genotypes for all seventeen viability and vigour parameters studied (Table 1). This indicates the presence of considerable genetic variability, which is essential for selection and crop improvement. Similar findings have been reported by Mavi et al. (2010) and Chandel et al. (2021), emphasizing that genotypic variability in seed traits serves as a foundation for breeding programs targeting enhanced seed performance.

**3.2 Mean and Range of Seed Quality Parameters**

The range and mean values of seed viability and vigour traits across twenty genotypes are presented in Table 2. Considerable variation was observed in all traits, confirming the diversity among genotypes.

**Standard Germination (%)**

Standard germination ranged from 65.67% in PL 751 to 92.67% in BH 393, with an overall mean of 77.65%. Ten genotypes exhibited values above the mean, notably BH 393, BH 942, and RD 2552. The high germination percentage in these genotypes suggests better seed physiological quality, corroborating the results of Rahimi et al. (2020).

**Seedling Length (cm)**

Seedling length ranged from 34.46 cm (BH 932) to 45.80 cm (BH 885), with a mean of 39.71 cm. Seven genotypes including BH 885, BH 942, and BH 941 showed superior performance. Seedling length is an important vigour parameter and its higher value indicates rapid and healthy seedling growth (Baalbaki et al., 2009).

**Seedling Dry Weight (mg)**

Dry weight of seedlings varied from 14.30 mg (PL 751) to 20.83 mg (BH 927). Eleven genotypes recorded higher values than the mean (18.22 mg), suggesting better biomass accumulation, an indicator of seed metabolic activity and early growth potential (Khodarahmpour et al., 2012).

**Seed Weight (g)**

Seed weight ranged from 2.75 g (PL 751) to 4.88 g (BH 942), with an overall mean of 3.96 g. Half of the genotypes exhibited seed weight above the mean, and seed weight is known to be positively associated with seedling vigour and field establishment (Ghassemi-Golezani et al., 2010).

**Seed Density (g/cc)**

Seed density varied from 1.00 g/cc in PL 751 to 1.19 g/cc in BH 941. Seven genotypes had density values above the overall mean (1.04 g/cc). High seed density often correlates with better storability and field emergence under adverse conditions (Copeland & McDonald, 2001).

**Vigour Index-I and II**

Vigour index-I showed a wide range from 2284.29 (PL 751) to 3938.17 (BH 942), with an overall mean of 3097.90. Eight genotypes performed better than the average, indicating stronger growth potential. Vigour index-II ranged from 0.94 (PL 751) to 1.88 (BH 393), and nine genotypes surpassed the mean value of 1.42. These indices combine germination capacity with growth parameters and are reliable indicators of seed performance (Abdul-Baki & Anderson, 1973).

**Field Emergence Index and Mean Emergence Time**

Field emergence index ranged from 7.59% (PL 751) to 10.14% (BH 393), with thirteen genotypes scoring above the mean (9.10%). Mean emergence time varied from 8.85 days (BG 105) to 10.85 days (BH 393), indicating genotype-specific differences in emergence speed. Faster emergence enhances crop competitiveness and establishment (Ellis & Roberts, 1980).

**Field Emergence (%) and Seedling Establishment (%)**

Field emergence ranged between 63.67% (PL 751) and 81.67% (BH 393), with twelve genotypes exceeding the mean (74.33%). Seedling establishment varied from 62.67% to 80.00%, with genotypes like BH 942 and BH 393 showing the highest values. These traits are critical for stand establishment and final yield and are often influenced by both intrinsic seed quality and environmental interactions (Powell, 2006).

**Table: 1 ANOVA for different viability and vigour parameters**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Genotypes** | **Error** |  |
|  | Degrees of freedom | 19 | 40 |  |
| **Sr. No** | **Characters** | **Mean squares** | **Error** | **CV%** |
| **1** | Standard germination (%) | 116.894\* | 5.467 | 3.011 |
| 2 | Seedling length (cm) | 30.678\* | 2.729 | 4.161 |
| 3 | Seedling dry weight (mg) | 11.408\* | 0.380 | 3.383 |
| 4 | Seed weight (g) | 0.791\* | 0.002 | 1.115 |
| 5 | Seed density (g/cc) | 0.010\* | 0.001 | 3.173 |
| 6 | Vigour index-I [SG(%)×SL(CM)] | 642679.201\* | 31516.211 | 5.731 |
| 7 | Vigour index-II [SG(%)×SDW(g)] | 0.182\* | 0.004 | 4.356 |
| 8 | Field emergence index (%) | 1.384\* | 0.313 | 6.142 |
| 9 | Seedling establishment (%) | 69.074\* | 22.221 | 6.393 |
| 10 | Mean emergence time (%) | 0.827\* | 0.237 | 4.992 |
| 11 | Field emergence (%) | 74.667\* | 27.643 | 7.073 |

* \*Significant at 1%
* Significant at 5%

**Table 2: Mean values of different viability and vigour parameters for genotypes of barley**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Genotype | Sr.No | SG | SL | SD W | SW | SD | V-I | V-II | FEI | MET | FE | SE |
| BH 932 | 1 | 70.00 | 34.46 | 16.10 | 4.50 | 1.15 | 2411.62 | 1.13 | 8.67 | 10.21 | 69.67 | 69.67 |
| BH 933 | 2 | 77.67 | 38.87 | 18.03 | 4.04 | 1.01 | 3019.54 | 1.40 | 8.63 | 10.85 | 76.67 | 76.33 |
| BH 934 | 3 | 77.00 | 38.48 | 17.00 | 3.64 | 1.01 | 2964.92 | 1.31 | 9.53 | 9.25 | 73.00 | 72.67 |
| BH 935 | 4 | 73.00 | 38.39 | 18.30 | 3.68 | 1.00 | 2805.64 | 1.33 | 8.72 | 10.04 | 68.33 | 68.00 |
| BH 936 | 5 | 72.33 | 36.27 | 15.87 | 3.76 | 1.06 | 2626.26 | 1.14 | 7.84 | 10.10 | 67.00 | 66.33 |
| BH 937 | 6 | 78.00 | 42.07 | 19.67 | 4.59 | 1.02 | 3285.52 | 1.54 | 9.24 | 9.66 | 77.33 | 76.00 |
| BH 938 | 7 | 75.00 | 38.78 | 18.70 | 3.83 | 1.01 | 2909.45 | 1.40 | 9.73 | 9.35 | 76.00 | 75.33 |
| BH 939 | 8 | 75.33 | 37.25 | 15.03 | 3.53 | 1.11 | 2808.00 | 1.13 | 9.37 | 9.65 | 76.00 | 75.67 |
| BH 940 | 9 | 78.67 | 39.17 | 18.77 | 3.98 | 1.04 | 3078.92 | 1.48 | 9.59 | 9.58 | 76.33 | 76.00 |
| BH 941 | 10 | 82.00 | 44.55 | 20.03 | 4.50 | 1.19 | 3653.88 | 1.64 | 9.47 | 9.85 | 77.33 | 76.67 |
| BH 942 | 11 | 88.00 | 44.75 | 20.63 | 4.88 | 1.03 | 3938.17 | 1.81 | 9.36 | 10.09 | 81.67 | 80.00 |
| BH 393 | 12 | 92.67 | 40.80 | 20.27 | 3.48 | 1.01 | 3780.21 | 1.88 | 10.14 | 9.41 | 81.00 | 80.00 |
| BH 885 | 13 | 80.00 | 45.80 | 20.50 | 3.71 | 1.00 | 3663.06 | 1.64 | 9.24 | 10.43 | 79.67 | 78.67 |
| BH 927 | 14 | 80.33 | 39.52 | 20.83 | 3.34 | 1.08 | 3177.44 | 1.67 | 8.88 | 10.41 | 75.33 | 75.33 |
| BG 25 | 15 | 78.00 | 42.24 | 20.07 | 4.16 | 1.02 | 3296.50 | 1.57 | 9.64 | 8.86 | 73.00 | 73.00 |
| BG 105 | 16 | 72.33 | 38.43 | 17.70 | 4.25 | 1.00 | 2779.11 | 1.28 | 9.23 | 8.85 | 71.67 | 71.00 |
| DWRUB52 | 17 | 74.33 | 37.80 | 16.53 | 3.83 | 1.01 | 2810.93 | 1.23 | 8.02 | 10.02 | 68.00 | 68.00 |
| RD 2552 | 18 | 86.00 | 43.34 | 18.63 | 4.62 | 1.13 | 3726.54 | 1.60 | 9.85 | 9.59 | 80.33 | 79.33 |
| K 551 | 19 | 76.67 | 38.35 | 17.50 | 4.14 | 1.00 | 2938.09 | 1.34 | 9.33 | 9.23 | 74.67 | 74.00 |
| PL 751 | 20 | 65.67 | 34.77 | 14.30 | 2.75 | 1.00 | 2284.29 | 0.94 | 7.59 | 9.58 | 63.67 | 62.67 |
| Overall Mean | | 77.65 | 39.71 | 18.22 | 3.96 | 1.04 | 3097.90 | 1.42 | 9.10 | 9.75 | 74.33 | 73.73 |
| Range | | 65.67-  92.67 | 34.46-  45.80 | 14.30-  20.83 | 2.75-  4.88 | 1.00-  1.19 | 2284.29-  3938.17 | 0.94-  1.88 | 7.59-  10.14 | 8.85-  10.85 | 63.67-  81.67 | 62.67-  80.00 |
| CD | | 3.873 | 2.736 | 1.021 | 0.073 | 0.055 | 294.036 | 0.103 | 0.928 | 0.808 | 8.724 | 7.822 |

**SG = Standard Germination, SL= Seedling length, SDW= seedling dry weight, SW= Seed weight, SD= Seed density V-I = Vigour Index 1, V-II = Vigour Index- 2, FEI = Field emergence index, MET= Mean emergence time, FE= Field emergence, SE = Seedling establishment**

**Conclusion**

The present study revealed substantial genetic variability among twenty barley (Hordeum vulgare L.) genotypes for all the evaluated seed quality parameters, including standard germination, seedling traits, vigour indices, field emergence, and seedling establishment. The highly significant differences observed in ANOVA confirm the presence of sufficient variability, offering scope for the identification and selection of superior genotypes for seed vigour and viability. Genotypes such as BH 393, BH 942, and RD 2552 consistently outperformed others across most of the laboratory and field parameters, indicating their potential as promising candidates for high-quality seed production under both conventional and organic farming systems. In contrast, genotypes like PL 751 and BH 932 exhibited lower performance across key seed quality attributes, suggesting the need for improvement or cautious selection for commercial cultivation. The study also validates the reliability of seed vigour indices (Vigour Index–I and II) and seedling traits (length and dry weight) as effective predictors of field emergence and seedling establishment. These parameters, when integrated with standard germination testing, provide a more holistic assessment of seed quality and potential field performance.

Therefore, the comprehensive evaluation of viability and vigour parameters can serve as a valuable tool for plant breeders, seed technologists, and agronomists to screen and promote barley genotypes with superior seed quality traits. Such genotypes are essential not only for enhancing productivity but also for ensuring successful crop establishment, especially in resource-limited and organic cultivation environments

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