**Estimation of genetic variability for grain yield and its contributing traits in black gram [*Vigna mungo* (L.) Hepper]**

**Abstract**

The present investigation was conducted during *Kharif* 2024 at the Organic Research Farm (HRF), Karguanji, Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (U.P.), to assess the genetic variability, heritability, genetic advance, and correlation among thirteen morphological and yield-contributing traits in twelve black gram (*Vigna mungo* L.) genotypes. Analysis of variance revealed highly significant differences among genotypes for all the traits studied, indicating the presence of considerable genetic variability. The widest range of variation was observed for number of pods per plant (19.27–54.73), followed by harvest index (15.47–42.60%) and plant height (24.41–44.50 cm). Genotypic and phenotypic correlation analysis revealed that seed yield per plant was positively and significantly correlated with number of pods per plant, number of seeds per pod, biological yield per plant, and harvest index, suggesting that these traits are major contributors to yield and should be emphasized during selection. Among the evaluated genotypes, T-65, Shekhar-1, KU-321, IPU-09-16, Azad Urd-1, and KU-99-22 were identified as superior performers for seed yield. These genotypes hold potential for use in future breeding and hybridization programs aimed at yield improvement in black gram.

**Key words:** genetic variability, heritability, genetic advance, seed yield, morphological traits, yield improvement

**Introduction**

Black gram (Vigna mungo L. Hepper), also known as urdbean, is an important short-duration, self-pollinated leguminous pulse crop belonging to the family Fabaceae, sub-family Papilionoideae, with a diploid chromosome number of 2n=22. It holds a vital place in traditional agricultural systems of South and Southeast Asia. India is regarded as the primary center of origin and diversification of black gram (Vavilov, 1926), where it has been cultivated since ancient times for both food and soil health benefits. Black gram is essentially a tropical crop but has wide agro-climatic adaptability. It is cultivated across all the three principal cropping seasons in India—kharif, rabi, and zaid. Its short duration (60–90 days), drought tolerance, and ability to grow in residual soil moisture make it suitable for rainfed, semi-irrigated, and intercropping systems. The crop plays a pivotal role in crop diversification and resource-use efficiency (AICRP on MULLaRP, 2020).

The seeds of black gram are highly nutritious, containing approximately 24% protein, 1.4% fat, 3.2% minerals, 59.6% carbohydrates, and a calorific value of 347 kcal per 100 g (Parveen et al., 2011). Notably, it possesses the highest phosphoric acid content among pulses, making it a valuable dietary component for protein and phosphorus intake. It is also a good source of calcium, iron, and vitamins, promoting bone health and hemoglobin formation. Apart from its dietary value, black gram plays a critical role in sustainable agriculture. Being a legume, it enriches soil fertility through symbiotic nitrogen fixation, improves soil structure, and contributes to agro-ecological sustainability. It is often used as a green manure and fodder crop. Its cultivation helps reduce dependence on synthetic fertilizers and enhances the long-term productivity of cropping systems (Choudhary et al., 2018).

Black gram is grown as a sole crop or in various cropping systems such as intercropping, mixed cropping, catch cropping, and sequential cropping. It is particularly suited to rice fallows, where it is cultivated under residual soil moisture after paddy harvest, contributing to efficient land and water use (Yashoda et al., 2016). Its compatibility with cereals, oilseeds, and vegetables in intercropping systems has made it a popular choice among farmers. Despite its importance, black gram productivity remains low due to several biotic and abiotic stresses. Major production constraints include susceptibility to yellow mosaic virus, powdery mildew, and root rot, along with terminal drought and nutrient deficiencies. Moreover, poor harvest index, indeterminate growth habit, and asynchronous maturity further limit yield potential (Priya et al., 2018). One of the critical hindrances in the genetic improvement of black gram is the narrow genetic base, largely due to repeated use of closely related genotypes in breeding programs. The lack of adequate variability and the absence of suitable ideotypes for different agro-ecological zones pose significant challenges for breeders. This restricts the development of high-yielding, stress-resilient cultivars (Gowsalya et al., 2016).

Unlike other major pulses like chickpea and pigeon pea, black gram has received limited global research attention. It is not a mandate crop under any CGIAR center, resulting in fewer international collaborations, restricted funding, and limited access to advanced genomic resources (Ghafoor et al., 2000). This has hindered comprehensive improvement efforts in terms of varietal development, biotic resistance, and abiotic stress tolerance. Assessing genetic variability among black gram genotypes is crucial to enhance selection efficiency and accelerate breeding programs. Studies on genetic parameters such as genotypic and phenotypic coefficients of variation, heritability, genetic advance, and correlation among traits help identify superior genotypes and traits associated with yield improvement (Panigrahi et al., 2022). These analyses form the foundation for trait-specific improvement under different environmental conditions.

There is immense scope for black gram improvement through the exploitation of available germplasm, incorporation of modern breeding tools like marker-assisted selection, and genetic introgression from wild relatives. Focused research on physiological traits, stress tolerance, and yield components, along with the integration of organic and sustainable farming practices, can significantly enhance the productivity and profitability of black gram cultivation. Strategic breeding backed by genomic resources and phenotypic evaluation is imperative for developing region-specific, high-yielding, and climate-resilient varieties.

**Materials and Methods**

The present investigation was conducted during the Kharif season of 2024 at the Department of Genetics and Plant Breeding, Institute of Agricultural Sciences, Bundelkhand University, Jhansi (Uttar Pradesh), India. The experimental material comprised twelve genotypes of black gram (*Vigna mungo* L. Hepper), selected to assess the extent of genetic variability and association among yield-contributing traits.

The experiment was laid out in a Randomized Block Design (RBD) with three replications. Each genotype was sown in five rows per replication, with a row length of 1 meter. The spacing between rows and plants was maintained at 30 cm and 10 cm, respectively. Standard agronomic practices and recommended package of practices were followed uniformly across the experimental field to ensure optimal crop growth and minimize environmental variability.

Observations were recorded on thirteen quantitative traits, namely: days to 50% flowering, days to 75% maturity, plant height (cm), number of primary branches per plant, number of clusters per plant, number of pods per plant, pod length (cm), number of seeds per pod, 100-seed weight (g), seed yield per plant (g), biological yield per plant (g), harvest index (%), and protein content (%). Data for days to 50% flowering and days to 75% maturity were recorded on a plot basis, while data for the remaining traits were recorded from five randomly selected competitive plants per plot, and their mean values were used for statistical analysis.

To estimate the extent of genetic variability among the genotypes, the genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed as per the method proposed by Burton (1952). Broad-sense heritability (h²), genetic advance (GA), and genetic advance as a percentage of the mean (GAM) were calculated using the formulae suggested by Johnson et al. (1955). These genetic parameters provided insights into the magnitude of genetic variability, the extent of environmental influence, and the potential for selection-based improvement.

All statistical analyses were performed using standard biometrical procedures to ensure the reliability and accuracy of results for further interpretation and discussion.

**Result and Discussion**

The results of the present investigation revealed considerable variation among the twelve black gram genotypes for all the thirteen quantitative traits studied (Table 1). The analysis of variance (ANOVA) showed that the mean sum of squares due to genotypes was highly significant for all the traits, indicating the presence of ample genetic variability within the experimental material. This significant variation reflects the potential for effective selection and improvement of yield and yield-contributing traits. These findings are in line with earlier reports by Ravikumar et al. (2020) and Patel et al. (2021), who also observed significant differences among black gram genotypes for a range of agronomic characters, thus validating the existence of substantial genetic variability within the crop.

A wide range of variation was observed in traits such as number of pods per plant, harvest index, and plant height. Specifically, the number of pods per plant exhibited the widest range (19.27 to 54.73), followed by harvest index (15.47% to 42.60%) and plant height (24.41 cm to 44.50 cm). The wide variability in these traits offers an opportunity for identifying and selecting genotypes with superior performance. These findings were corroborated by the results of Suguna et al. (2017) and Mohanlal et al. (2018), who also reported considerable variability in similar yield-related traits among black gram germplasm collections.

Among the tested genotypes, T-65, Shekhar-1, KU-321, IPU-09-16, Azad Urd-1, and KU-99-22 exhibited superior performance in terms of seed yield per plant. These genotypes can serve as promising donors for yield improvement programs. Their consistent performance under field conditions indicates their suitability for further evaluation in multilocation trials and potential inclusion in hybridization programs. The exploitation of such elite genotypes has been emphasized by Sharma et al. (2020) and Raj et al. (2019), who highlighted the utility of high-performing genotypes in varietal development and genetic enhancement programs.

The analysis of genetic variability revealed that the phenotypic coefficient of variation (PCV) was marginally higher than the corresponding genotypic coefficient of variation (GCV) for all the studied traits. This slight difference suggests a moderate influence of the environment on the expression of these characters, but the predominance of genetic factors remains evident. These observations are in agreement with the reports of Jyothsana et al. (2016), Gowsalya et al. (2016), and Thamodharan et al. (2017), who found similar patterns of PCV and GCV in black gram and related legume crops.

High estimates of PCV were observed for seed yield per plant, number of pods per plant, and number of clusters per plant, indicating that these traits are under the influence of high genetic variability and offer greater scope for improvement through direct selection. The high variability in seed yield per plant implies that selection pressure can be effectively applied to improve yield in subsequent generations. These findings are consistent with those reported by Natarajan et al. (2019), Singh and Yadav (2021), Kumari et al. (2020), and Chakraborty et al. (2021), who also emphasized the significance of these traits in yield enhancement programs.

Traits like 100-seed weight, number of seeds per pod, number of primary branches per plant, plant height, biological yield per plant, number of pods per cluster, and harvest index exhibited moderate estimates of PCV, reflecting a balanced contribution of both genetic and environmental factors in their expression. The moderate variability in these traits suggests that while selection may be effective, it may require additional cycles to realize significant genetic gains. Similar results have been reported by Sowmini and Jayamani (2013) for plant height and number of primary branches, Hemalatha et al. (2017) for 100-seed weight and plant height, and Tank et al. (2018) for biological yield, number of pods per cluster, and harvest index.

The consistency of significant mean squares and wide variability across traits reaffirms that the present set of genotypes comprises a rich genetic base and harbors substantial potential for genetic improvement. The presence of high genetic variability is a prerequisite for effective selection and breeding of high-yielding and stress-resilient varieties. The identification of high-yielding genotypes and traits exhibiting higher GCV and PCV values can accelerate crop improvement efforts in black gram.

The outcomes of this study are further supported by the reports of Choudhary et al. (2018) and Kumar and Meena (2022), who emphasized the importance of exploring genetic variability and utilizing it efficiently in selection-based breeding programs. Their studies also concluded that traits with high heritability and genetic advance can be used as reliable selection indices for yield improvement in black gram.

Overall, the significant variability observed in the present study indicates that these genotypes can be exploited effectively in genetic improvement programs. Traits with high PCV and GCV, especially those related to seed yield, should be prioritized in selection schemes. Additionally, the promising genotypes identified in this study may serve as valuable genetic resources for future breeding efforts aimed at developing high-yielding, stable, and climate-resilient black gram cultivars.

**Table 1. Mean values of genotypes for thirteen different characters**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.**  **No.** | | **Genotype** | **Days to 50 per cent flowering** | **Days to 75 per cent maturity** | **Plant height (cm)** | | **Number of Pb per plant** | | | **Number of clusters per plant** | | | **Number of pods per cluster** | | **Number of pods per plant** | | | **Pod length (cm)** | | | **Number of seeds per pod** | **100-seed weight (gm)** | | **Biological yield per plant**  **(gm)** | | | **Seed yield per plant**  **(gm)** | | **Harvest index (%)** |
| 1. | | Vallabh Urd-1 | 37.67 | 68.67 | 41.00 | | 2.75 | | | 11.47 | | | 2.73 | | 31.87 | | | 4.30 | | | 6.00 | 4.98 | | 21.83 | | | 6.93 | | 31.88 |
| 2. | | Azad Urd-1 | 36.67 | 69.33 | 38.18 | | 3.25 | | | 7.87 | | | 2.43 | | 19.73 | | | 4.43 | | | 7.00 | 5.41 | | 18.93 | | | 4.90 | | 26.04 |
| 3. | | IPU-131 | 39.33 | 70.33 | 31.94 | | 3.18 | | | 7.51 | | | 2.93 | | 22.37 | | | 4.33 | | | 5.67 | 4.90 | | 20.30 | | | 6.63 | | 32.68 |
| 4. | | KU-321 | 37.67 | 70.00 | 44.50 | | 2.77 | | | 10.67 | | | 3.40 | | 36.07 | | | 4.27 | | | 6.33 | 4.49 | | 20.39 | | | 5.73 | | 28.65 |
| 5. | | KU-99-22 | 39.45 | 71.00 | 43.47 | | 3.11 | | | 13.40 | | | 2.83 | | 38.33 | | | 4.33 | | | 6.33 | 4.42 | | 26.13 | | | 6.70 | | 25.58 |
| 6. | | KU-010-1 | 38.00 | 72.00 | 30.15 | | 2.54 | | | 9.20 | | | 3.25 | | 29.73 | | | 4.33 | | | 6.33 | 3.96 | | 17.52 | | | 4.57 | | 26.14 |
| 7. | | Shekhar-1 | 39.33 | 77.33 | 39.42 | | 2.77 | | | 8.01 | | | 2.87 | | 21.73 | | | 4.24 | | | 5.67 | 3.97 | | 15.17 | | | 3.11 | | 20.78 |
| 8. | | Shikha-1 | 37.67 | 72.00 | 33.36 | | 3.49 | | | 11.60 | | | 3.50 | | 43.93 | | | 4.31 | | | 6.33 | 4.57 | | 19.69 | | | 6.03 | | 30.77 |
| 9. | | T-9 | 35.33 | 69.67 | 39.52 | | 2.77 | | | 9.80 | | | 3.60 | | 33.57 | | | 4.52 | | | 6.33 | 4.70 | | 22.50 | | | 6.53 | | 29.01 |
| 10. | | IPU-09-16 | 36.00 | 68.00 | 33.53 | | 3.56 | | | 11.14 | | | 2.92 | | 32.87 | | | 4.38 | | | 6.00 | 4.39 | | 19.53 | | | 5.13 | | 26.27 |
| 11. | | KU-96-3 | 34.33 | 66.00 | 30.26 | | 3.25 | | | 9.68 | | | 3.87 | | 36.20 | | | 4.00 | | | 6.00 | 4.73 | | 20.50 | | | 5.87 | | 27.41 |
| 12. | | T-65 | 39.67 | 76.33 | 32.21 | | 2.53 | | | 9.27 | | | 2.69 | | 25.02 | | | 3.90 | | | 5.33 | 3.90 | | 18.77 | | | 4.43 | | 23.83 |
|  | | GM | 37.86 | 70.98 | 35.76 | | 3.05 | | | 10.33 | | | 3.11 | | 32.23 | | | 4.32 | | | 6.50 | 4.26 | 19.70 | | | | 5.24 | | 26.31 |
|  | | SE | 0.59 | 1.12 | 1.19 | 0.10 | | | | 0.52 | | | 0.20 | | 1.65 | | | 0.06 | | | 0.29 | 0.13 | 0.94 | | | | 0.35 | | 1.64 |
|  | | CD at 5% | 1.65 | 3.16 | 3.34 | 0.27 | | | 1.45 | | | | 0.57 | | 4.63 | | | 0.16 | | | 0.82 | 0.35 | 2.63 | | | | 0.99 | | 4.60 |
|  | CD at 1% | | 2.18 | 4.18 | 4.43 | 0.35 | | 1.93 | | | | 0.75 | | | 6.13 | | 0.22 | | | 1.09 | | 0.47 | 3.48 | | | 1.31 | | 6.09 | |
|  | CV (%) | | 2.68 | 2.74 | 5.77 | 5.41 | | 8.68 | | | 11.24 | | | 8.85 | | 2.33 | | | 7.81 | | | 5.12 | 8.23 | | 11.64 | | | | 10.78 |

**Table 2. Analysis of variance for different characters in black gram**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **S.No.** | **Characters** | **Replication** | **Varieties** | **Error** |
| **[2]** | **[11]** | **[22]** |
| 1. | Days to 50 per cent flowering | 0.20 | 5.93\*\* | 1.03 |
| 2. | Days to 75 per cent maturity | 1.37 | 23.32\*\* | 3.78 |
| 3. | Plant height | 0.48 | 87.28\*\* | 4.25 |
| 4. | Number of primary branches per plant | 0.01 | 0.39\*\* | 0.03 |
| 5. | Number of clusters per plant | 0.25 | 17.79\*\* | 0.80 |
| 6. | Number of pods per cluster | 0.02 | 0.58\*\* | 0.12 |
| 7. | Number of pods per plant | 1.37 | 255.88\*\* | 8.13 |
| 8. | Pod length | 0.01 | 0.15\*\* | 0.01 |
| 9. | Number of seeds per pod | 0.41 | 1.34\*\* | 0.26 |
| 10. | 100-seed weight | 0.02 | 0.52\*\* | 0.05 |
| 11. | Biological yield per plant | 1.11 | 27.01\*\* | 2.63 |
| 12. | Seed yield per plant | 0.13 | 6.54\*\* | 0.37 |
| 13. | Harvest index | 1.84 | 54.84\*\* | 8.04 |

\*, \*\* Significant at 5 and 1 per cent respectively

Table 3. Variability parameters for different characters in black gram

**Table. 3 Estimates of Genotypic Coefficient of Variation (GCV), Phenotypic Coefficient of Variation (PCV), Heritability (h²%), and Genetic Gain (GG%) for Yield and Yield-Contributing Traits in Black Gram Genotypes**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **S. No.** | **Characters** | **GCV (%)** | **PCV (%)** | **h2 (%)** | **GG%** |
| 1. | Days to 50 per cent flowering | 3.38 | 4.31 | 61.28 | 5.44 |
| 2. | Days to 75 per cent maturity | 3.60 | 4.52 | 63.25 | 5.89 |
| 3. | Plant height | 14.71 | 15.80 | 86.68 | 28.22 |
| 4. | Number of primary branches per plant | 11.37 | 12.59 | 81.54 | 21.15 |
| 5. | Number of clusters per plant | 23.02 | 24.60 | 87.57 | 44.38 |
| 6. | Number of pods per cluster | 12.54 | 16.84 | 55.48 | 19.25 |
| 7. | Number of pods per plant | 28.20 | 29.56 | 91.03 | 55.43 |
| 8. | Pod length | 5.01 | 5.52 | 82.26 | 9.36 |
| 9. | Number of seeds per pod | 9.26 | 12.11 | 58.46 | 14.59 |
| 10. | 100-seed weight | 9.36 | 10.66 | 76.97 | 16.91 |
| 11. | Biological yield per plant | 14.47 | 16.65 | 75.58 | 25.92 |
| 12. | Seed yield per plant | 27.38 | 29.75 | 84.69 | 51.91 |
| 13. | Harvest index | 15.01 | 18.48 | 65.98 | 25.12 |

**Conclusion**

The findings attained from the concurrent assessment of variability parameters disclosed that the characters, viz. number of pods per plant, biological yield per plant, number of clusters per plant and plant height should be given due consideration as the major components in determining yield in a selection programme aimed at improving genetic potential of black gram.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Author (s) hereby declare that no generative AI technologies such as Large Language models (chatgpt, copilot, etc) and text- to- image generators have been used during writing or editing of this manuscript.

Competing interests

Authors have declared that no competing interests exist.

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