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# ASSESSMENT OF MORPHOLOGICAL DIVERSITY IN MUNGBEAN (*Vigna radiata* L. Wilczek) GENOTYPES USING DUS DESCRIPTORS

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**ABSTRACT**

A standardized framework for evaluating new varieties is provided by the Distinctness, Uniformity, and Stability (DUS) testing criteria for mung beans (*Vigna radiata* L.). Genetic diversity within the genotypes can be determined by grouping based on DUS descriptors. In order to identify important yield-related DUS traits, screen elite germplasm for high-yield breeding, and provide a theoretical foundation and useful reference for the effective improvement and selective breeding of new mung bean varieties, this study conducted a systematic, multi-dimensional analysis and thorough evaluation of mung bean germplasm resources. 35 mungbean genotypes, including 3 checks from IIPR Kanpur, U.P., PAU Punjab, and JNKVV, Jabalpur, M.P., were analyzed and categorized for the study at the College of Agriculture, JNKVV Jabalpur (MP) in *kharif*, 2023. A Randomized Complete Block Design (RCBD) with 3 replications is used for the assessment. For the majority of the variables under investigation, including hypocotyl anthocyanin coloration, flowering time, plant growth habit, plant habit, stem color, stem pubescence, leaflet lobes, leaf shape, leaf color, leaf vein color, petiole color, flower petal color, pod color, pod pubescence, pod position, plant height, pod curvature, pod length, seed color, seed lusture, seed shape, and seed size, the phenotypic studies showed polymorphism. The standard descriptors can be used as markers to characterize the crop species, and genotype characterization is crucial for preserving genetic purity during seed production, using germplasm, and implementing conservation programs.

***Keywords*:** DUS descriptors, Genetic diversity, Genetic purity, Mungbean, Standardized framework.

## Introduction

Mungbean, *Vigna radiata* (L.) Wilczek, is a popular pulse crop in Madhya Pradesh and across India, also known as moong, goldengram, and greengram. Mungbean genetic diversity is believed to originate primarily from Central Asia (Kumar and Kumar, 2014). It is a significant source of protein (240g/kg) and a variety of micronutrients for India's vegetarian population (Nair *et al.*, 2013). It is a short-duration, self-pollinating crop that does well in a range of environments (Rai *et al.*, 2024). Its genome size is 579 Mb/1C, and its chromosomal count is 22 (2n = 2x = 22) (Parida *et al.*, 1990; Kang *et al.*, 2014). Mungbean is a member of the Papilionaceae subfamily of the Fabaceae family. This plant's potential to fix nitrogen through Rhizobium-containing root nodules, its wide range of adaptation, and its ability to flourish in low moisture circumstances all contribute to its agricultural utility.

However, the mung bean industry faces significant challenges in yield enhancement, stable nutritional and edible quality, breeding varieties with broad-spectrum stress resistance (Meena *et al.*, 2025), indeterminate growth types that require multiple harvests, susceptibility to diseases and insect pests, and pod shattering (Sabatina *et al*., 2021) due to increasingly complex climate change and changing market demands. One of the main obstacles to the production and productivity of pulses in our nation is the lack of high-yielding varieties that are more resilient to environmental changes (Joshi *et al*., 2022). The key to solving these issues is increasing agricultural productivity per unit of land, which can be accomplished by creating new plant varieties and using improved farming practices (Lavanya *et al*., 2008; Tahir *et al*., 2020).

According to the standard procedures outlined in the Protection of Plant Varieties and Farmers' Rights Act (PPV & FRA, 2001), Distinctness, Uniformity, and Stability (DUS) characterization is essential for accurate varietal registration, identification, and duplication prevention (Rai *et al*., 2023). The International Union for the Protection of New Varieties of Plants (UPOV) established the DUS intellectual property system in 1961 to encourage innovation in the production of new plant varieties (Janghel *et al*., 2020). In nations that uphold Plant Breeder's Rights (PBR) laws, this prerequisite is crucial (Singh *et al*., 2006).

In light of these factors, the current experiment was founded to describe mungbean germplasm using DUS descriptors in order to assess genotype grouping and germplasm variability characteristics for mungbean improvement (Protection of Plant Varieties and Farmers' Rights Authority, 2007). DUS testing is essential to the production and certification of premium seeds since it is easy to analyze, economical, and independent of experimental technologies (Kaur *et al*., 2020).

## Materials and Methods

A thorough assessment of 35 mungbean genotypes, including 3 checks (Table 1), was conducted during the 2023 *Kharif* season at the Seed Breeding Farm, Department of Genetics and Plant Breeding, College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh. Each genotype was carefully planted in 2 rows with a space of 10 cm between plants and 30 cm between rows using a Randomized Complete Block Design with 3 replications. We used established farming procedures to monitor 5 randomly selected plants for each genotype and replication. Following the Distinctness, Uniformity, and Stability (DUS) guidelines, the study examined a variety of traits at different stages of growth, such as anthocyanin coloration at the cotyledon stage, eleven distinctive traits at 50% flowering, pod characteristics at the green pod stage, and seed attributes at maturity (Table 2). This systematic methodology improved the classification of mungbean genotypes and their potential for agricultural improvement by producing a comprehensive, complete examination of the agro-morphological and seed trait diversity (Fig. 1).

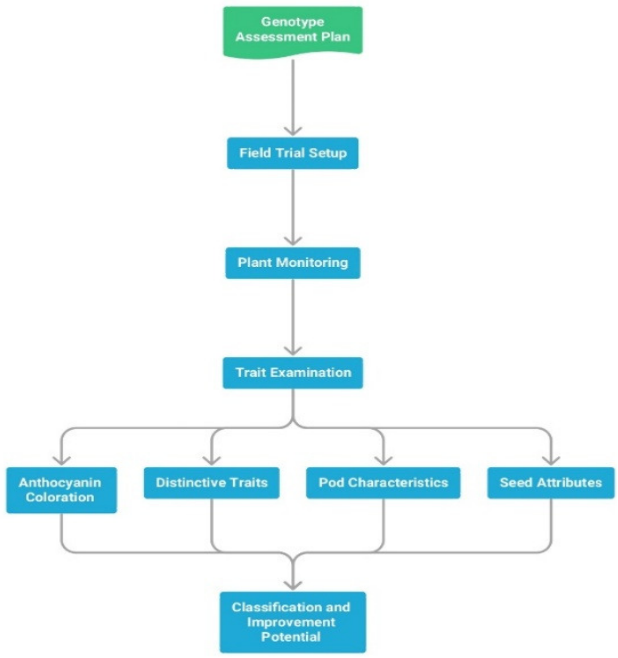


**Fig. 1 :** Agro-Morphological Assessment of Mungbean Varieties

**Table 1:** Mungbean Genotypes used in present study

| S. No. | Genotypes | S. No. | Genotypes | S. No. | Genotypes | S. No. | Genotypes |
|---|---|---|---|---|---|---|---|
| 1. | KH 2241 | 10. | IC 76499 | 19. | EC 396399 | 28. | PDM-139 |
| 2. | IC 314523 | 11. | IC 103821 | 20. | OMG-1045 (PMR) | 29. | EC 520026 |
| 3. | IC 348964 | 12. | MH-2-15 | 21. | CO 6 | 30. | EC 520029 |
| 4. | IPM 99-125 | 13. | IC 305291 | 22. | HUM-1 | 31. | EC 520038 |
| 5. | TARM 2 | 14. | IPM 312-2 | 23. | IC 373199 | 32. | EC 520041 |
| 6. | COGG 8 | 15. | PANT MUNG 6 | 24. | IC 417873 | 33. | VIRAT (CHECK 1) |
| 7. | RMG-1028 | 16. | PUSA 9531 | 25. | IC 73395 | 34. | SHIKHA (CHECK 2) |
| 8. | PDM-54 | 17. | IPM 302-2 | 26. | LGG-460 | 35. | MH 421 (CHECK 3) |
| 9. | PDM-11 | 18. | IC 121301 | 27. | IC 119033 | | |

**Table 2:** DUS descriptors used during the study

| S.no. | Characteristics | Stages of Observation | States |
|---|---|---|---|
| 1. | Hypocotyl: anthocyanin colouration | Cotyledons unfolded | • Absent<br>• Present |
| 2. | Time of flowering | 50% plants with atleast one open flower | • Early (<40 days)<br>• Medium (40-50days)<br>• Late (>50 days) |
| 3. | Plant: growth habit | 50% flowering | • Erect<br>• Semi-erect<br>• Spreading |
| 4. | Plant: habit | 50% flowering | • Determinate<br>• Indeterminate |
| 5. | Stem: colour | 50% flowering | • Green<br>• Green with purple splashes<br>• Purple |
| 6. | Stem: pubescence | 50% flowering | • Absent<br>• Present |
| 7. | Leaflet: lobes (terminal) | 50% flowering | • Absent<br>• Present |
| 8. | Leaf: shape (terminal) | 50% flowering | • Deltoid<br>• Ovate<br>• Lanceolate<br>• Cuneate |
| 9. | Leaf: colour | 50% flowering | • Green<br>• Dark green |
| 10. | Leaf: vein colour | 50% flowering | • Green<br>• Greenish purple<br>• Purple |
| 11. | Petiole: colour | 50% flowering | • Green<br>• Green with purple splashes<br>• Purple |
| 12. | Flower: colour of petal (standard) | 50% flowering | • Yellow<br>• Light yellow |
| 13. | Pod: colour of premature pod | Fully developed green pods | • Green<br>• Green with pigmented sutre |
| 14. | Pod: pubescence | Fully developed green pods | • Absent<br>• Present |
| 15. | Pod: position | Fully developed green pods | • Above canopy<br>• Intermediate<br>• Not visible |
| 16. | Plant: height | Fully developed green pods | • Short (<50 cm)<br>• Medium (50-70 cm)<br>• Long (>70 cm)) |
| 17. | Pod: curvature of mature pod | Harvest maturity | • Straight<br>• Curved |
| 18. | Pod: length (mature pod) | Harvest maturity | • Short (<8 cm)<br>• Medium (8-10 cm)<br>• Long (>10 cm) |
| 19. | Seed: colour | Mature seeds | • Yellow<br>• Green<br>• Mottled<br>• Black |
| 20. | Seed: lusture | Mature seeds | • Shiny<br>• Dull |
| 21. | Seed: shape | Mature seeds | • Oval |

| | | | |
|---|---|---|---|
| | | | • Drum shaped |
| 22. | Seed: size (weight of 100 seeds) | Mature seeds | • Small (<3g)<br>• Medium (3-5g)<br>• Large (>5g) |

## Results and Discussion

In the process of species diversification, morphological traits are crucial since they are influenced by both natural selection and human breeding methods (Meyer and Purugganan, 2013; Olsen and Wendel, 2013). Genetic diversity is indicated by morphological features (Feng *et al.*, 2026). 22 DUS (Distinctness, Uniformity, and Stability) characteristics were evaluated in an examination of 35 distinct mungbean genotypes, including 3 checks. 18 of these descriptors had differences, according to the results. The traits have been meticulously recorded at various stages of plant development using both visual inspection and quantitative methods, demonstrating their efficacy in distinguishing various genotypes.

Crop yields are directly impacted by the characteristics of early flowering, maturity, pod length, and seed weight (Tripathy *et al.*, 2015; Gayacharan *et al.*, 2020). Growth patterns, leaflet morphology, and the presence of trichomes on leaves and pods are some of the factors that affect plant structure. Green-hypocotyl mungbeans are preferred over purple ones in the bean sprouting sector (Tomooka *et al.*, 2002; Nair *et al.*, 2013). Because of its qualitative characteristics, mungbean seeds' shape, color, and sheen have a significant impact on customer decisions. Smaller mungbean seeds are more valuable and command higher prices than larger seeds in the eastern regions of India. According to Tomooka *et al.* (2002) and Nair *et al.* (2013), completely formed pods with a black color are chosen for their ability to reduce seed staining, and seeds with a bright green sheen are generally preferred over those with a lacklustre appearance.

### Plant morphological characters

A fundamental component of classical taxonomy is the use of plant diagnostic features to identify and determine varietal purity. Growth behaviors, plant stature, petiole color, and overall plant height are examples of observable morphological traits that are typically used for varietal differentiation. With the exception of plant height, which is measured during the stage of full pod development, these morphological findings are typically recorded during the 50% flowering stage (Rai *et al.*, 2024; Rahangdale *et al.*, 2023).

The genotypes are divided into 3 categories based on plant growth habit: erect (2 genotypes), semi-erect (32 genotypes), and spreading (1 genotype) (Fig 2). The genotypes are divided into two categories when it comes to plant habit: determinate (8 genotypes) and indeterminate (27 genotypes) (Fig. 3). Genotypes with green petioles (8 genotypes) and green petioles with purple splashes (27 genotypes) make up the petiole color classification. It is important to note that no genotypes have only purple petioles (Fig. 4). Based on plant height measurements, the genotypes are divided into three groups: short (<50 cm, with a total of 34 genotypes), medium (50 cm- 70 cm, with only 1 genotype), and no genotypes were discovered to be long (>70 cm) (Fig 5) (Table 3 and Table 4).

Similar results were reported by Rai *et al.* (2024), who used DUS descriptors to detect significant heterogeneity in growth habit, plant height, and pigmentation features across mungbean genotypes. Irfan *et al.* (2025) reported broad morpho-agronomic variability associated with plant growth habit and stature, suggesting the utility of these traits in germplasm characterization and crop improvement programs. Desta *et al.* (2024) also found significant phenotypic diversity for vegetative and plant architectural traits among diverse mungbean accessions.

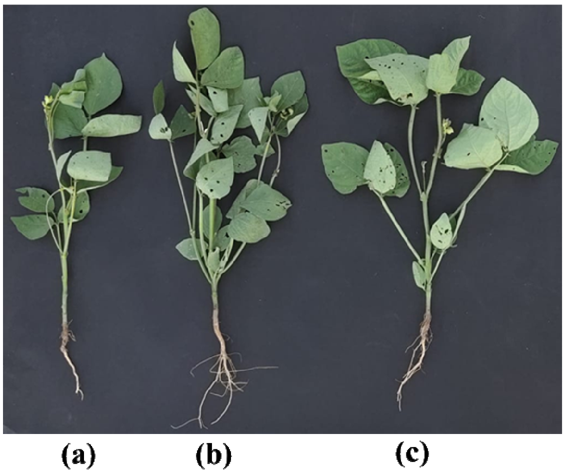


**Fig 2. Plant: Growth habit (a) Erect (b) Semi-erect (c) Spreading**

(a) (b)

**Fig 3. Plant: Habit (a) Determinate (b) Indeterminate**

(a) (b)

**Fig 4. Petiole: color (a) Green (b) Green with purple splashes**

(a) (b)

**Fig 5. Plant: Height (a) Medium (b) Short**

### Stem morphological characters

The categorization of genotypes by looking at stem morphological characteristics at various stages of crop growth, such as hypocotyl anthocyanin pigment, stem color, and stem pubescence. This tactic is essential for identifying and protecting the distinctive genetic traits and genotype ownership rights. According to the DUS rules, anthocyanin coloration in the hypocotyl was found during the cotyledon unfolded stage, whereas the other two characteristics were observed after the 50% flowering stage (Rai *et al.*, 2024; Rahangdale *et al.*, 2023).

Seven of the genotypes under investigation lacked anthocyanin coloration in the hypocotyl, while 28 genotypes had it (Fig 6). 20 of the individuals had green stems, 15 had green stems with purple splashes, and none had stems that were entirely purple. These individuals were divided into 3 groups (Fig 7). All 35 genotypes were found to share stem pubescence, or the presence of stem hairs (Table 3 and Table 4).

In mungbean, Singh *et al.* (2014) and Kaur *et al.* (2017) characterized and grouped genotypes similarly based on stem morphological traits. By noting significant variations in stem color, pubescence, and plant architecture across mungbean accessions, Desta *et al.* (2024) emphasized the significance of germplasm characterisation. Similar to this, Irfan *et al.* (2025) highlighted the importance of pubescence traits and stem pigmentation in breeding research and varietal identification.

(a) (b)

**Fig 6. Hypocotyle: Anthocyanin colouration (a) Present (b) Absent**

(a) (b)

**Fig 7. Stem: Color (a) Green with purple splashes (b) Green**

### Leaf morphological characters

The study highlights the significance of leaf-related characteristics in affecting genotype productivity, including leaflet lobes, leaf color, leaf vein color, and leaf shape. This is due to the fact that plants primarily produce food in their leaves. In order to classify the genotypes into different groups, the leaf characteristics were meticulously documented during the 50% flowering stage (Rahangdale *et al*., 2023; Rai *et al*., 2024; Irfan *et al*., 2025).

There were no leaflet lobes in any of the 35 genotypes examined. The majority of genotypes (30) had green leaves when categorized by leaf color, while a smaller subset (5 genotypes) had dark green leaves (Fig. 8). There was a difference in the color of the leaf veins, 7 genotypes had green veins, while a greater number of 28 genotypes had more common greenish-purple veins. Purple leaf veins were not seen in any of the genotypes (Fig. 9). Furthermore, an oval leaf morphology was consistently displayed by all 35 genotypes, indicating a homogeneity in this particular trait (Table 3 and Table 4).

(a) (b)

**Fig 8. Leaf: Color (a) Dark green (b) Green**

(a) (b)

**Fig 9. Leaf: Vein color (a) Green (b) Greenish purple**

Rahangdale *et al.* (2023) and Rai *et al.* (2024), who emphasized the importance of leaf morphological descriptors in genotype identification and diversity assessment, reported similar results regarding uniformity in leaf shape and variation in leaf color and vein pigmentation in mungbean germplasm characterization studies.

**Flower morphological characters**

In this study, the morphological characteristics of the flowers more especially, the color of the petals and the timing of flowering were used to classify the genotypes. When half of the plants had at least one fully blossomed flower and again when they reached the 50% flowering stage, the traits were meticulously recorded.

The genotypes were categorized according to when they flowered. 27 genotypes in all showed early blooming, finishing their flowering cycle in less than 40 days. 8 genotypes exhibited a somewhat short flowering window, lasting between 40 and 50 days. Interestingly, no genotypes with a late flowering time defined as more than 50 days were discovered. Additionally, bloom color was used to classify the genotypes. 6 genotypes had yellow petals, but the bulk of the 29 genotypes had pale yellow petals (Fig. 10). Color difference provides additional insight into the diverse characteristics of the genotypes being studied (Table 3 and Table 4).

Rai *et al.* (2024) revealed similar diversity in flowering time and floral features. Using DUS descriptors for varietal characterization, they found variations in flowering length and flower color among mungbean genotypes. Similarly, among mungbean accessions from various geographic locations, Desta *et al.* (2024) found notable phenotypic variability for flowering and floral features. Additionally, significant variation in days to flowering and related morpho-agronomic features was reported by Irfan *et al.* (2025), highlighting their significance in germplasm evaluation and breeding programs.

(a) (b)

**Fig 10. Flower: Colour of petal (standard) (a) Yellow (b) Light yellow**

## Pod morphological characters

When the pods were fully grown and green, their color, hairiness, and position were examined. When the ripe pods were harvested, their length and curvature were measured (Kaur *et al.*, 2017). 32 genotypes with green pods and 3 genotypes with green pods with pigmented sutures were the two distinct groups that resulted from the classification based on the color of the pods before they are fully mature (Fig 11). Remarkably, there was no appreciable variation in the pod pubescence trait among the 35 genotypes. There was heterogeneity among the 5 genotypes in terms of pod position, with some displaying an unclear location and most of the 30 genotypes having pods above the canopy (Fig 12). Additionally, the study categorized genotypes based on mature pod characteristics. In terms of pod length, the genotypes were divided into three categories: no genotypes were found to have long pods (>10 cm), 28 genotypes had short pods (<8 cm), and 7 genotypes had medium pods (8–10 cm) (Fig 13). An additional classification was made based on the presence of curvature in mature pods, with 11 genotypes having curved pods and 24 genotypes showing straight pods. The detailed analysis of pod morphological traits highlights the importance of these traits in the domains of plant breeding and genetics and provides a deeper understanding of the genetic variation in mungbeans and its possible impact on plant productivity (Table 3 and Table 4).

(a) (b)

**Fig 11. Pod: Colour of premature pod (a) Green (b) Green with pigmented suture**

(a) (b)

**Fig 12. Pod: Position (a) Intermediate (b) Above canopy**

Similar research by Irfan *et al.* (2025) and Rai *et al.* (2024) revealed significant variation in pod morphological parameters among mungbean genotypes and emphasized their importance in breeding programs and germplasm evaluation.

(a) (b)

**Fig 13. Pod: Length (mature pod) (a) Medium (b) Short**

## Seed morphological characters

Throughout the mature seed stage, basic characteristics such as color, lustre, form, and size were analyzed in a thorough investigation of seed morphological characteristics across multiple plant genotypes. Unlike other common hues like yellow, mottled, or black, all 35 genotypes notably showed a consistent green seed color. There was little diversity in the seeds' lustre; only 2 genotypes had dull seeds, whereas 33 genotypes had shining seeds (Fig. 14). In terms of morphology, the majority of the genotypes (32) showed drum-shaped seeds, whereas a smaller fraction (3 genotypes) showed oval-shaped seeds (Fig. 15). With a range of 1.36g to 4.77g for 100 seeds, the seed size showed a broader variety. Consequently, the seeds were separated into three size groups: 9 genotypes of small seeds weighing less than 3g, 18 genotypes of medium seeds weighing between 3g and 5g, and 8 genotypes of large seeds weighing more than 5g. This thorough analysis highlights the genetic diversity in seed traits, which is crucial for understanding plant genetics and breeding (Table 3 and Table 4).

Kaur *et al*. (2017) and Mounika *et al*. (2020), who noted notable variations in seed color, luster, shape, and size among mungbean genotypes, revealed similar heterogeneity in seed morphological features. Similar findings were reported by Rai *et al*. (2024), Desta *et al*. (2024), and Irfan *et al*. (2025), who emphasized the significance of seed-related features in germplasm characterisation and breeding initiatives

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**(a)** **(b)**

**Fig 14. Seed: Lusture (a) Dull (b) Shiny**

**(a)** **(b)**

**Fig 15. Seed: Shape (a) Oval (b) Drum**

**Table 3 :** Morphological Traits in Individual Mungbean Genotypes

| S. No. | Germplasm | Anthocyanin coloration | Time of flowering | Plant growth habit | Plant habit | Stem color | Stem pubescence | Leaflet lobes | Leaf shape | Leaf color | Leaf vein color | Petiole color |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **KH 2241** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **2** | **IC 314523** | Absent | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **3** | **IC 348964** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **4** | **IPM 99-125** | Absent | Medium | Erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **5** | **TARM 2** | Present | Medium | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Dark green | Greenish purple | Green-purple |
| **6** | **COGG 8** | Absent | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **7** | **RMG-1028** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green |
| **8** | **PDM-54** | Present | Early | Semi | Indeter- | Green | Present | Absent | Ovate | Green | Greenish | Green- |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | erect | minate | | | | | | purple | purple |
| **9** | **PDM-11** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Green | Green-purple |
| **10** | **IC 76499** | Present | Medium | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **11** | **IC 103821** | Present | Early | Erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **12** | **MH-2-15** | Present | Medium | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **13** | **IC 305291** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **14** | **IPM 312-2** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **15** | **PANT MUNG 6** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **16** | **PUSA 9531** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Dark green | Green | Green-purple |
| **17** | **IPM 302-2** | Present | Medium | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **18** | **IC 121301** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green |
| **19** | **EC 396399** | Present | Early | Spre-ading | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **20** | **OMG-1045 (PMR)** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **21** | **CO 6** | Present | Medium | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **22** | **HUM-1** | Absent | Medium | Semi erect | Determ-inate | Green | Present | Absent | Ovate | Green | Green | Green |
| **23** | **IC 373199** | Present | Early | Semi erect | Determ-inate | Green | Present | Absent | Ovate | Green | Green | Green-purple |
| **24** | **IC 417873** | Absent | Early | Semi erect | Determ-inate | Green | Present | Absent | Ovate | Green | Green | Green-purple |
| **25** | **IC 73395** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green |
| **26** | **LGG-460** | Present | Medium | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Dark green | Greenish purple | Green-purple |
| **27** | **IC 119033** | Present | Early | Semi erect | Determ-inate | Green | Present | Absent | Ovate | Green | Greenish purple | Green |
| **28** | **PDM-139** | Present | Early | Semi erect | Determ-inate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green |
| **29** | **EC 520026** | Present | Early | Semi erect | Determ-inate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **30** | **EC 520029** | Absent | Early | Semi erect | Determ-inate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **31** | **EC 520038** | Present | Early | Semi erect | Determ-inate | Green -purple | Present | Absent | Ovate | Dark green | Green | Green-purple |
| **32** | **EC 520041** | Present | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Green | Greenish purple | Green |
| **33** | **Virat (check 1)** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |
| **34** | **Shikha (check 2)** | Absent | Early | Semi erect | Indeter-minate | Green | Present | Absent | Ovate | Dark green | Green | Green |
| **35** | **MH 421 (check 3)** | Present | Early | Semi erect | Indeter-minate | Green -purple | Present | Absent | Ovate | Green | Greenish purple | Green-purple |

**Conti…**

| **S. No.** | **Germplasm** | **Flower color** | **Premature pod color** | **Pod pube-scence** | **Pod position** | **Plant height** | **Mature pod curvature** | **Mature pod length** | **Seed color** | **Seed lusture** | **Seed shape** | **Seed size** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **KH 2241** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| **2** | **IC 314523** | Light yellow | Green | Present | Indeter-minate | Short | Curved | Short | Green | Shiny | Drum | Large |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | **IC 348964** | Yellow | Green-pigmented suture | Present | Above canopy | Medium | Straight | Short | Green | Shiny | Oval | Large |
| 4 | **IPM 99-125** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 5 | **TARM 2** | Yellow | Green-pigmented suture | Present | Indeter-minate | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 6 | **COGG 8** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Large |
| 7 | **RMG-1028** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Large |
| 8 | **PDM-54** | Light yellow | Green | Present | Indeter-minate | Short | Straight | Short | Green | Shiny | Oval | Small |
| 9 | **PDM-11** | Light yellow | Green | Present | Indeter-minate | Short | Straight | Short | Green | Shiny | Drum | Small |
| 10 | **IC 76499** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Medium |
| 11 | **IC 103821** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Small |
| 12 | **MH-2-15** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Small |
| 13 | **IC 305291** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 14 | **IPM 312-2** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 15 | **PANT MUNG 6** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 16 | **PUSA 9531** | Light yellow | Green | Present | Above canopy | Short | Straight | Medium | Green | Shiny | Drum | Small |
| 17 | **IPM 302-2** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Large |
| 18 | **IC 121301** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 19 | **EC 396399** | Light yellow | Green | Present | Above canopy | Short | Curved | Medium | Green | Shiny | Drum | Large |
| 20 | **OMG-1045 (PMR)** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 21 | **CO 6** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Large |
| 22 | **HUM-1** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Medium |
| 23 | **IC 373199** | Light yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Dull | Drum | Small |
| 24 | **IC 417873** | Light yellow | Green | Present | Above canopy | Short | Straight | Medium | Green | Shiny | Drum | Small |
| 25 | **IC 73395** | Light yellow | Green | Present | Above canopy | Short | Curved | Medium | Green | Shiny | Drum | Small |
| 26 | **LGG-460** | Yellow | Green | Present | Above canopy | Short | Curved | Medium | Green | Shiny | Drum | Medium |
| 27 | **IC 119033** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Medium |
| 28 | **PDM-139** | Light yellow | Green | Present | Indeter-minate | Short | Straight | Short | Green | Shiny | Oval | Small |
| 29 | **EC 520026** | Yellow | Green pigmented suture | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| 30 | **EC 520029** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Shiny | Drum | Medium |
| 31 | **EC 520038** | Light yellow | Green | Present | Above canopy | Short | Straight | Medium | Green | Shiny | Drum | Medium |
| 32 | **EC 520041** | Light yellow | Green | Present | Above canopy | Short | Curved | Short | Green | Dull | Drum | Large |
| 33 | **Virat (check 1)** | Light | Green | Present | Above | Short | Straight | Medium | Green | Shiny | Drum | Medium |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | yellow | | | canopy | | | | | | | |
| **34** | **Shikha (check 2)** | Yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |
| **35** | **MH 421 (check 3)** | Yellow | Green | Present | Above canopy | Short | Straight | Short | Green | Shiny | Drum | Medium |

**Table 4 :** Frequency Distribution of Morphological Traits in Mungbean Genotypes

| S. no. | Characteristics | Genotype frequency | Percentage contribution | Name of genotypes |
|---|---|---|---|---|
| 1 | Hypocotyle: anthocyanin colouration | 5 | 15.62 | IPM 99-125, IC 314523, COGG 8, IC 417873, EC 520029 |
| | | 27 | 84.37 | KH 2241, IC 348964, TARAM-2, RMG-1028, PDM-54, PUSA 9531, PANT MUNG 6, IPM 312-2, IC 305291, MH-2-15, IC 103821, IC 76499, PDM-11, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR, CO 6, IC 373199, IC 417873, IC 73395, LGG-460, IC 119033, PDM-139, EC 520026, EC 520038, EC 520041 |
| 2 | Time of flowering | 24 | 75 | KH 2241, IC 314523, IC 348964, COGG 8, RMG-1028, PDM-54, PDM-11, IC 103821, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IC 121301, EC 396399, OMG-1045 (PMR), IC 373199, IC 417873, IC 73395, IC 119033, PDM-139, EC 520026, EC 520029, EC 520038, EC 520041 |
| | | 8 | 25 | IPM 99-125, TARAM-2, IC 76499, MH-2-15, IPM 302-2, CO 6, HUM-1, LGG-460 |
| | | 0 | 0 | NIL |
| 3 | Plant: growth habit | 2 | 6.25 | IPM 99-125, IC 103821 |
| | | 29 | 90.62 | KH 2241, IC 314523, IC 348964, TARAM-2, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, CO 6, HUM-1, IC 373199, IC 417873, OMG-1045 (PMR), IC 73395, LGG-460, IC 119033, PDM-139, EC 520026, EC 520029, EC 520038, EC 520041 |
| | | 1 | 3.12 | EC 396399 |
| 4 | Plant: habit | 8 | 25 | HUM-1, IC 373199, IC 417873, IC 119033, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 24 | 75 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PUSA 9531, PANT MUNG 6, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, IC 73395, LGG-460, EC 520041 |
| 5 | Stem: colour | 19 | 59.37 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041 |
| | | 13 | 40.62 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 0 | 0 | NIL |
| 6 | Stem: pubescence | 0 | 0 | NIL |

| | | | | |
|---|---|---|---|---|
| | | 32 | 100 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041, KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| 7 | Leaflet: lobes (terminal) | 32 | 100 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041, KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 0 | 0 | NIL |
| 8 | Leaf: shape (terminal) | 0 | 0 | NIL |
| | | 32 | 100 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041, KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 0 | 0 | NIL |
| | | 0 | 0 | NIL |
| 9 | Leaf: colour | 28 | 87.5 | IC 348964, IC 314523, KH 2241, IPM 99-125, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, IC 121301, IPM 302-2, OMG-1045 (PMR), CO 6, EC 396399, HUM-1, IC 373199, IC 417873, IC 73395, IC 119033, PDM-139, EC 520026, EC 520029, EC 520041 |
| | | 4 | 12.5 | TARAM-2, PUSA 9531, LGG-460, EC 520038 |
| 10 | Leaf: vein colour | 6 | 18.75 | PDM-11, PUSA 9531, HUM-1, IC 373199, IC 417873, EC 520038 |
| | | 26 | 81.25 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, COGG 8, RMG-1028, PDM-54, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, IC 73395, LGG-460, IC 119033, PDM-139, EC 520026, EC 520029, EC 520041 |
| | | 0 | 0 | NIL |
| 11 | Petiole: colour | 7 | 21.87 | RMG-1028, IC 121301, HUM-1, IC 73395, IC 119033, PDM-139, EC 520041 |
| | | 25 | 78.12 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, COGG 8, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, EC 396399, OMG-1045 (PMR), CO 6, IC 373199, IC 417873, |

| | | | | |
|---|---|---|---|---|
| | | | | LGG-460, EC 520026, EC 520029, EC 520038 |
| | | 0 | 0 | NIL |
| 12 | Flower: colour of petal (standard) | 4 | 12.5 | IC 348964, TARAM-2, LGG-460, EC 520026 |
| | | 28 | 87.5 | KH 2241, IC 314523, IPM 99-125, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 373199, IC 417873, IC 73395, IC 119033, PDM-139, EC 520029, EC 520038, EC 520041 |
| 13 | Pod: colour of premature pod | 29 | 90.6 | KH 2241, IC 314523, IPM 99-125, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 373199, IC 417873, IC 73395, LGG-460, IC 119033, PDM-139, EC 520029, EC 520038, EC 520041 |
| | | 3 | 9.37 | IC 348964, TARAM-2, EC 520026 |
| 14 | Pod: pubescence | 0 | 0 | NIL |
| | | 32 | 100 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041, KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| 15 | Pod: position | 27 | 84.37 | KH 2241, IC 348964, IPM 99-125, COGG 8, RMG-1028, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 373199, IC 417873, IC 73395, LGG-460, IC 119033, EC 520026, EC 520029, EC 520038, EC 520041 |
| | | 5 | 15.62 | IC 314523, TARAM-2, PDM-54, PDM-11, PDM-139 |
| | | 0 | 0 | NIL |
| 16 | Plant: height | 31 | 96.87 | KH 2241, IPM 99-12, IC 314523, TARAM-2, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 417873, IC 373199, IC 73395, LGG-460, IC 119033, PDM-139, EC 520026, EC 520029, EC 520038, EC 520041 |
| | | 1 | 3.12 | IC 348964 |
| | | 0 | 0 | NIL |
| 17 | Pod: curvature of mature pod | 21 | 65.62 | EC 520026, KH 2241, IC 348964, IPM 99-125, TARAM-2, RMG-1028, PDM-54, PDM-11, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, OMG-1045 (PMR), IC 373199, IC 417873, PDM-139, EC 520038 |
| | | 11 | 34.37 | IC 314523, COGG 8, IC 76499, EC 396399, CO 6, |

| | | | | |
|---|---|---|---|---|
| | | | | HUM-1, IC 73395, LGG-460, IC 119033, EC 520029, EC 520041 |
| 18 | Pod: length (mature pod) | 26 | 81.25 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 30529, IPM 312-2, PANT MUNG 6, IPM 302-2, IC 121301, OMG-1045 (PMR), CO 6, HUM-1, IC 373199, IC 119033, PDM-139, EC 520026, EC 520029, EC 520041 |
| | | 6 | 18.75 | PUSA 9531, EC 396399, IC 417873, IC 73395, LGG-460, EC 520038 |
| | | 0 | 0 | NIL |
| 19 | Seed: colour | 0 | 0 | NIL |
| | | 32 | 100 | COGG 8, RMG-1028, PDM-54, IC 76499, MH-2-15, IC 305291, PUSA 9531, IC 417873, IC 373199, HUM-1, CO 6, OMG-1045 (PMR), EC 396399, IC 119033, IC 121301, IPM 302-2, IC 73395, LGG-460, EC 520041, KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, PDM-11, IC 103821, IPM 312-2, PANT MUNG 6, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 0 | 0 | NIL |
| | | 0 | 0 | NIL |
| 20 | Seed: lusture | 30 | 93.75 | KH 2241, IC 314523, IC 348964, IPM 99-125, TARAM-2, COGG 8, RMG-1028, PDM-54, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 417873, IC 73395, LGG-460, IC 119033, PDM-139, EC 520026, EC 520029, EC 520038 |
| | | 2 | 6.25 | IC 373199, EC 520041 |
| 21 | Seed: shape | 3 | 9.37 | IC 348964, PDM-54, PDM-139 |
| | | 29 | 90.62 | KH 2241, IC 314523, IPM 99-125, TARAM-2, COGG 8, RMG-1028, PDM-11, IC 76499, IC 103821, MH-2-15, IC 305291, IPM 312-2, PANT MUNG 6, PUSA 9531, IPM 302-2, IC 121301, EC 396399, OMG-1045 (PMR), CO 6, HUM-1, IC 373199, IC 417873, IC 73395, LGG-460, IC 119033, EC 520026, EC 520029, EC 520038, EC 520041 |
| 22 | Seed: size (weight of 100 seeds) | 9 | 28.12 | PDM-54, PDM-11, IC 103821, MH-2-15, PUSA 9531, IC 373199, IC 417873, IC 73395, PDM-139 |
| | | 15 | 46.87 | KH 2241, IPM 99-125, TARAM-2, IC 76499, IC 305291, IPM 312-2, PANT MUNG 6, IC 121301, OMG-1045 (PMR), HUM-1, LGG-460, IC 119033, EC 520026, EC 520029, EC 520038 |
| | | 8 | 25 | IC 314523, IC 348964, COGG 8, RMG-1028, IPM 302-2, EC 396399, CO 6, EC 520041 |

## Conclusion

The current study on 35 genotypes of mungbean (*Vigna radiata* L. Wilczek) found significant variation in a number of qualitative and quantitative morphological characteristics, underscoring the significance of morphological characterization in crop improvement initiatives, genotype identification, and varietal differentiation. Despite the fact that all genotypes had uniformly green seeds, there was a great deal of variation in the size, shape, and luster of the seeds, suggesting that the materials under study had a high degree of genetic diversity.

The majority of genotypes exhibited semi-erect growth habits, compact plant size, and green petioles with purple splashes, all of which demonstrated the stability and adaption of significant vegetative features. The significance of vegetative morphology in affecting photosynthetic efficiency, plant development, and genotype classification was further highlighted by variations in stem pigmentation, pubescence, leaf color, and leaf vein color. Significant diversity was also seen in floral characteristics including flowering duration and petal color, which may have an impact on maturity grouping, pollination behavior, and reproductive efficiency. Similarly, variations in pod color, pubescence, length, and curvature may have an impact on market acceptance, processing quality, and harvesting efficiency.

Overall, the study showed that morphological descriptors are useful instruments for determining desired features for breeding, preserving varietal purity, and evaluating genetic diversity. For upcoming genetic improvement initiatives targeted at creating high-yielding, consumer-preferred, and climate-resilient cultivars, the observed variety among the mungbean genotypes offers valuable base data. Additionally, our results support the preservation and effective use of mungbean germplasm for food security and sustainable agricultural production.

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## Declarations

**Competing interests:** The authors declare no competing interests.

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