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# Exploring the Chickpea Genotypes through Morphological Characterization for Improved Breeding

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Morphological characterization is a valuable approach used to examine observable traits in crop plants, enabling the identification, classification, and understanding of genetic variations within diverse genotypes. This supports breeders in selecting desirable traits and improving breeding programs. Thus, the aim of this study is to investigate the morphological characterization of 40 chickpea genotypes, focusing on 20 morphological traits, following the DUS testing guidelines proposed by PPV & FRA, GOI, 2007. The experimental study was carried out utilizing the

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randomized complete block design (RCBD) at the Seed Breeding Farm, Department of Plant Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M. P. Through the examination of these traits, distinct patterns were identified among the chickpea genotypes. Among the 20 traits analyzed, 5 traits exhibited a monomorphic pattern, 8 traits displayed a dimorphic pattern, 6 traits demonstrated a trimorphic pattern, while the remaining 1 trait revealed a polymorphic pattern. These results indicate a substantial degree of genetic variability within the studied chickpea genotypes, emphasizing the diverse nature of these traits that can be harnessed for targeted breeding efforts and highlighting the immense potential for the development of improved chickpea varieties.

*Keywords: Morphological; characterization; DUS; variation; breeding.*

## 1. INTRODUCTION

Chickpea, *Cicer arietinum* L., is a *Rabi* season annual legume crop that is popularly known as Gram, Chana, Egyptian pea, Bengal gram, and Garbanzo bean. With a cultivation history dating back around 7,500 years, it is among the earliest cultivated legumes. Globally, chickpea holds the third most significant position among pulses, following common bean and field pea given by Aggarwal et al [1]. It belongs to genus Cicer, family Fabaceae and subfamily Papilionoidae. This diploid pulse crop (2n=2x=16), with a genome size of 738 Mbp and approximately 28,269 genes, is self-pollinating in nature Varshney et al. [2]. It is believed to be originated in South Eastern Turkey and was subsequently introduced to India and other regions of the world. Notably, chickpea encompasses two main types: the small, angular *desi* type and the large, irregular *kabuli* type. Within the *Cicer* genus, *Cicer arietinum* L. stands out as the extensively cultivated species worldwide. Chickpea production takes place in over 50 countries, with major contributions from India, Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Mexico, Canada, and the United States. India is the leading producer, accounting for 70% of the global chickpea production. In India, it occupies a substantial area of 11.20 million hectares, yielding a remarkable 13.98 million metric tons, with an average productivity of 1249 kg/ha. Specifically, in Madhya Pradesh, chickpea covers an area of 2.80 million hectares, resulting in a production of 3.61 million metric tonnes and an average productivity of 1291 kg/ha [3].

Morphological characterization involves the study of observable morphological traits in various crop species. It can be used to identify and classify various genotypes based on their morphological traits, thereby aiding in the identification of different chickpea varieties and detecting genetic variations or mutations within a population. Moreover, morphological characterization provides additional information about genotypes enabling the breeders for the better understanding of genetic basis of morphological traits. Additionally, morphological characterization provides insights into the phylogeny, helping to understand the evolutionary framework, origin, development, and functional significance of traits across different genotypes explained by Nandedkar et al. [4]. This characterization method serves as a valuable tool as it assists breeders in identifying desirable traits, selecting superior individuals for breeding, monitoring genetic diversity, and utilizing molecular markers for trait selection. In order to enhance seed yield, it is beneficial to focus on morphological characteristics that are closely associated with yield and play a significant role in increasing the yield. Morphological characterization of crop plants carries importance at both local and global levels. At the local level, it offers essential insights for farmers, breeders, and researchers to identify well-suited varieties for specific agro-climatic conditions, improve crop management practices, and boost overall productivity. On a global scale, morphological characterization plays a critical role in conserving germplasm, assessing genetic diversity, and advancing the development of enhanced crop varieties, thereby contributing to food security, sustainability, and adaptation to evolving environmental conditions. Based on the aforementioned information, this study aimed to assess and classify 40 chickpea genotypes using qualitative DUS descriptors which enable the identification and differentiation of genotypes, thereby providing valuable insights for future chickpea improvement programs.

## 2. MATERIALS AND METHODS

The present investigation was carried out at Seed Breeding Farm, Department of Plant

Breeding and Genetics, College of Agriculture, JNKVV, Jabalpur, M. P. The experimental material comprised of 40 advanced breeding lines of *desi* chickpea, including three check varieties *viz.* JG12, JG24 and JG36 obtained from the breeding material of JNKVV, Jabalpur and ICRISAT, Hyderabad. The advanced breeding lines were evaluated in three replications during *Rabi* 2021-22 using randomized complete block design (RCBD) with a plot size of 4.8m$^2$ comprising of 4 rows with each row of 4.0 meter length. Row to row and plant to plant spacing was maintained at 30.0cm × 10.0cm. The recommended agronomic and plant protection practices were carried out for the successful raising of the crop. Five competitive plants were randomly selected from each genotype in each replication to record the data. National DUS testing guidelines approved by the Protection of Plant Varieties and Farmers Right Authority (PPV&FRA) in 2007 were followed since the beginning of the trial to the harvesting for recording of all the observations. Table 1 presents a comprehensive overview of qualitative traits, their corresponding descriptors, and the specific observation stages. Fig. 1 visually displays the diversity of morphological and seed attributes in advanced chickpea breeding lines constructed using Excel.

**Table 1. Guidelines for the morphological characterization of chickpea based on DUS characters by PPV&FRA**

| Sl no | Characteristics | States | Stage of observation |
|---|---|---|---|
| 1 | Stem anthocyanin colouration | Absent/Present | Before flowering |
| 2 | Stem height at initiation of first flower | Low (< 8 nodes)/ Medium (8-15 nodes)/ High (> 15nodes) | First flowering |
| 3 | 50% flowering | Extra early (<40 days)/ Early (40-60 days)/ Medium (61-80ndays)/ Late (> 80 days) | First flowering |
| 4 | Plant growth habit | Erect (0-15 from vertical)/ Semi-erect (16-60 from vertical)/ Spreading (61-80 from vertical) | 50% flowering |
| 5 | Plant foliage color | Light green/ Medium green/ Dark green/ Greenish purple | |
| 6 | Leaflet size | Small (<10 mm)/ Medium (10-15 mm)/ Large(> 15 mm) | |
| 7 | Leaf pattern | Simple/ Compound/ Pinnate | |
| 8 | Flower number per peduncle | Single/ Twin | |
| 9 | Flower colour | White/ Pink/ Blue | |
| 10 | Flower strips on standard | Absent/ Present | |
| 11 | Peduncle length | Short (>5 mm)/ Medium (5-10 mm)/ Long (>10 mm) | Pod development |
| 12 | Plant height | Short(<45 cm)/ Medium (45-65 cm)/ Tall (>65 cm) | Fully developed green pod |
| 13 | Pod size | Small (<15 mm)/ Medium (15-20 mm)/ Large (> 20 mm) | Harvest maturity |
| 14 | No of seeds per pod | One/ More than one | |
| 15 | Seed colour | Beige/ Creamy beige/ Green/ Yellow/ Orange/ Brown/ Dark Brown/ Grey/ Black | 30 days after harvest |
| 16 | Seed size | Very small (<20 g)/ Small (20-25 g)/ Medium (26-35 g)/ Large (36-45 g)/ Very large (>45 g) | |
| 17 | Seed shape | Pea shaped/ Owl's head/ Angular | |
| 18 | Seed testa texture | Rough/ Smooth/ Tuberculated | |
| 19 | Seed ribbing | Absent /Present | |
| 20 | Seed type | Desi/Kabuli | |

## 3. RESULTS AND DISCUSSION

Morphological characterization plays a crucial role as the initial step in comprehensively describing and classifying plant materials. By examining the distinctness, uniformity, and stability of morphological characteristics, researchers can assess the essential traits necessary for effective categorization. Furthermore, a profound understanding of these morphological characters serves as a valuable tool in identifying desirable traits, designing novel populations, and facilitating the transfer of advantageous genes. The utilization of standardized descriptors for describing the characteristics of crop species not only enhances their better utilization but also contributes to the conservation of germplasm. Therefore, the classification of 40 *desi* chickpea genotypes into different groups was done based on the variations in their morphological characteristics using DUS descriptors were presented in Table 2 and Fig. 1. The pictorial representation of all morphological characters was visualized in Fig. 2. No variation for the leaf pattern was found among the genotypes as all of them have shown pinnate leaf pattern. Stem anthocyanin colouration was observed before flowering. Variation was observed for anthocyanin pigment revealed that the pigment is predominant in 39 genotypes and only 1 genotype lacked the pigment. On the basis of stem: height at initiation of first flower, genotypes was grouped into two groups. 21 genotypes were medium insertion with 8-15 nodes and remaining 19 genotypes were high insertion of first flower with >15 nodes.

Based on the variations in the days to 50% flowering, 4 genotypes were categorized into early (40-60 days) and 36 genotypes were categorized into medium (61-80). Considering the growth habit of the plant, 13 genotypes were classified into erect, 22 genotypes were classified into semi erect and 5 genotypes were classified into spreading type. Plant that exhibits a tall stature and a semi-erect to erect growth habit is well-suited for mechanical harvesting. Based on the leaf color, genotypes were categorized into three groups *viz.*, light green, medium green and dark green. Among them 9 genotypes were light green, 20 genotypes were medium green and 11 genotypes were dark green. According to the leaflet size genotypes were grouped into three categories. Small leaflet size (< 10 mm) was recorded in 2 genotypes, medium leaflet size (10-15 mm) was recorded in 27 genotypes and large leaflet size (> 15 mm) was observed in 11 genotypes. All the genotypes were examined for flower per peduncle and it was recorded that 39 genotypes showed single flower per peduncle and only one genotype showed double flower per peduncle Flower color serves as a prominent and easily identifiable visual trait, making it an important characteristic for distinguishing between different genotypes Traits like flower color, leaf morphology, and seed size can be genetically controlled and inherited. Therefore, they are commonly used as markers to study genetic diversity, determine genetic relatedness, and identify specific traits of interest suggested by Harisha et al. [5]. Flower color was monomorphic for all the genotypes showing pink in color, out of them 37 genotypes containing the strips over the flower and the remaining 3 were not containing the strips.

Variations were observed with respect to peduncle length and based on that, 12 genotypes were recorded with short peduncle length (<5 mm), 24 genotypes were recorded with medium peduncle length (5-10 mm) and remaining 4 genotypes were recorded with large peduncle length (>10 mm). The study of plant height at fully developed stage revealed that current experimental genotypes can be categorized into two groups *i.e.* medium and tall. 22 genotypes exhibited medium plant height (45-65 cm) and 18 genotypes exhibited tall (>65cm) plant height. At harvest maturity stage, pod size and no of seeds per pod were recorded. Significant difference was found among the genotypes for pod size and based on this genotypes were classified into 3 groups. Small pod size (<15 mm) was found in 4 genotypes, medium pod size (15-20 mm) was found in 16 genotypes and large pod size (>20 mm) was found in 20 genotypes. Among the 40 genotypes, 34 genotypes were containing single seed per pod and the remaining 6 genotypes were containing double seed per pod.

Difference among the genotypes were also found in seed color, 11 genotypes showed yellow color, 23 genotypes showed brown color and remaining 6 genotypes showed dark brown color. According to the seed size genotypes were again grouped into four categories based on the 100 seed weight at 10% moisture content. Out of which 4 genotypes were shown very small seed size, 12 genotype were shown small seed size (<20 gm), 23 genotype were shown medium seed size (20-25 gm) and lastly 1 genotype were shown large seed size (26-35 gm). Seed color and seed size are highly desirable traits among consumers and

have significant implications for effective marketing strategies. Based on the seed testa texture genotypes were categorized into two parts indicating rough and smooth containing 10 and 30 genotypes respectively. There is no significant difference was observed for seed ribbing and seed shape among all the genotypes as all of them showing the presence of ribbing with angular seed shape.

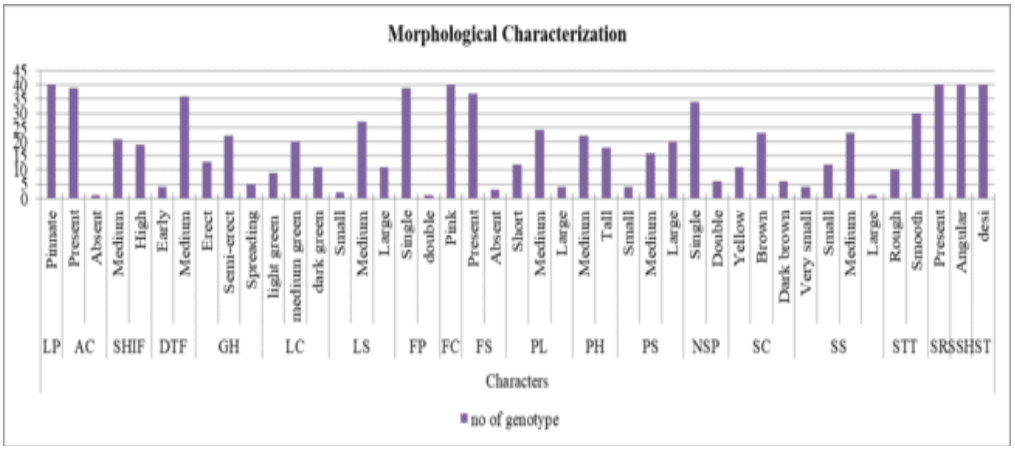
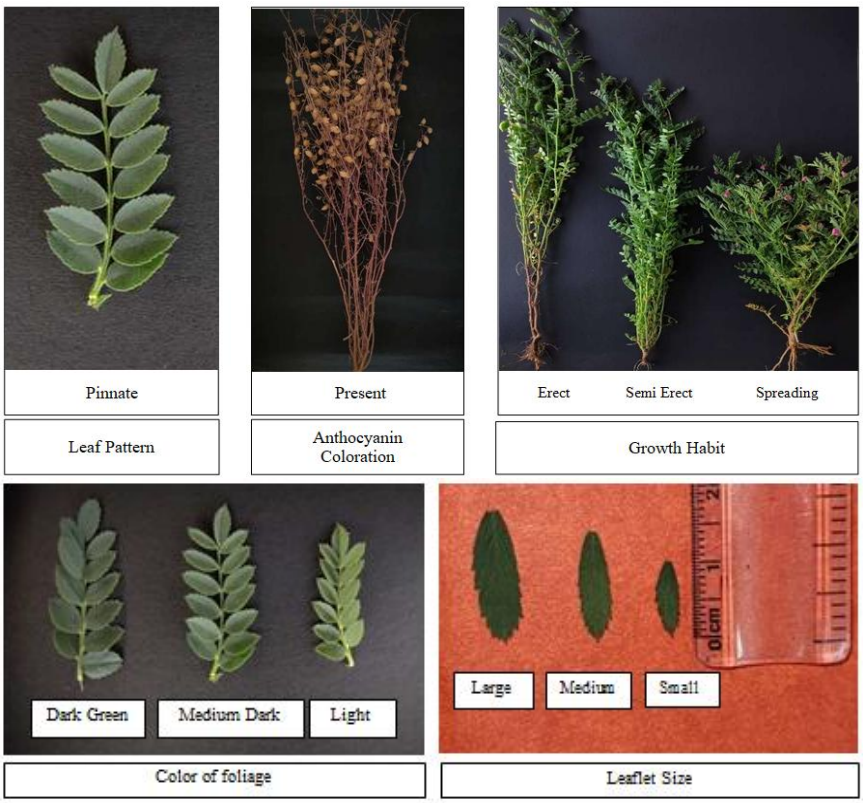



**Fig. 1. Diversity representation of morphological and seed attributes in advanced breeding lines of chickpea**

*Where, LP- Leaf pattern, AC- Anthocyanin colouration, SHIF- Stem height at initiation of first flower, DTF-Days to 50% flowering, GH-Growth habit, LC-Leaf color, LS-Leaflet size, FP-Flower per peduncle, FC-Flower color, FS-Flower strips, PL-Peduncle length, PH-Plant height, PS-Pod size, NSP-No of seeds per pod, SC-Seed color, SS-Seed size, STT-Seed testa texture, SR-Seed ribbing, SSH-Seed shape, ST-Seed type*




Flower Number with Peduncle

Pink flower with strips

Flower Color and Strips on standard


Peduncle Length


Plant Height


Pod Size


No of seed per pod


Seed Color

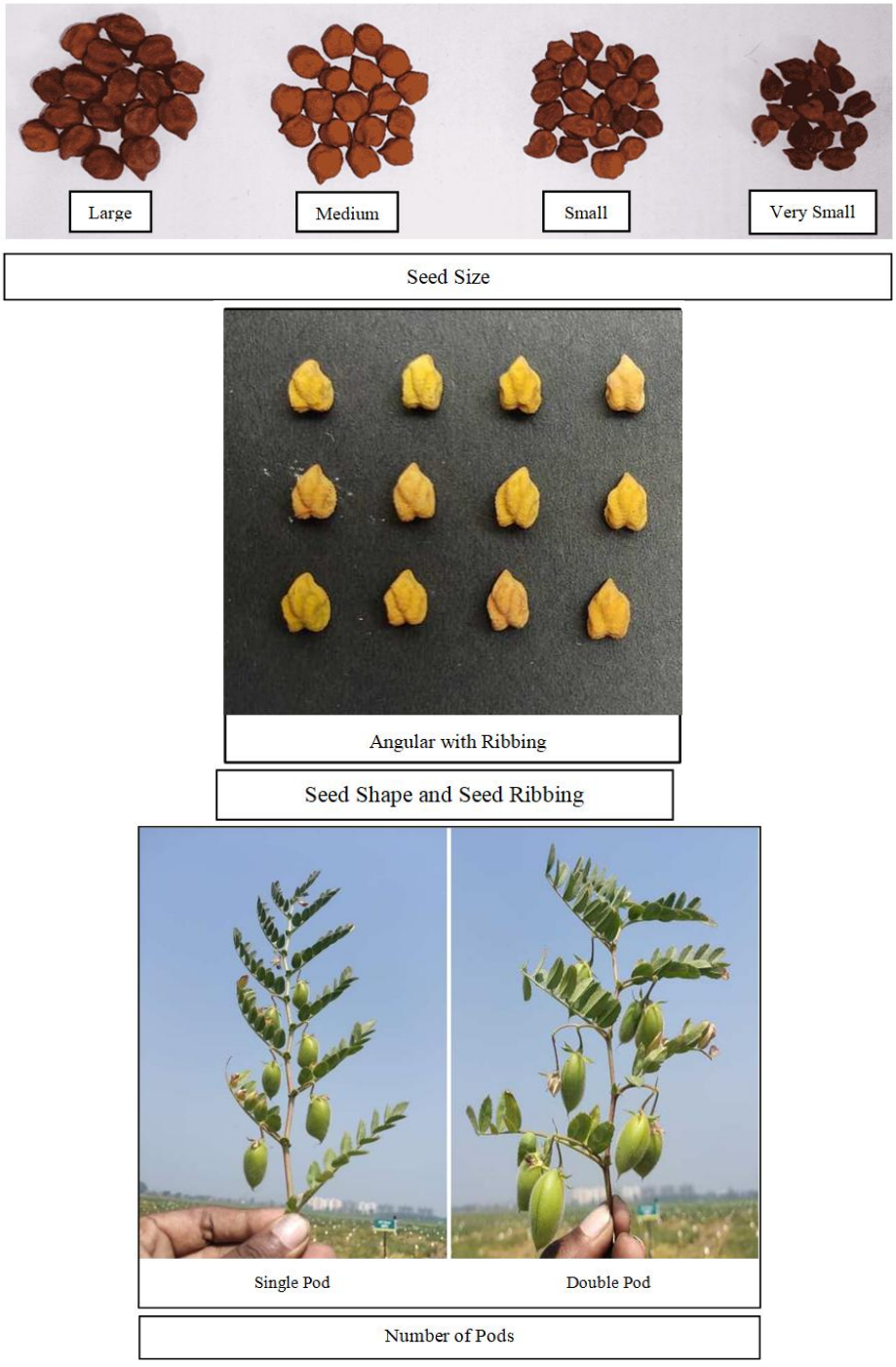



**Fig. 2. Pictorial representation of morphological traits in Chickpea**

Morphological traits have played a crucial role in the process of identifying, distinguishing, characterizing, and evaluating different varieties. Numerous studies, including those by Gediya et al [6], Sangram Singh [7], Kosev and Vasileva [8], Joshi et al. [9], Bayahi and Rezgui [10], Zaccardelli et al. [11], Adem and Tesso [12], Singh et al. [13], Joshi et al. [14], Archak et al. [15], Bodake et al. [16], Heidarv et al. [17], Sarao et al. [18], Lalitha, [19], Upadhyaya et al. [20],Upadhyaya et al. [21] , Thakur et al. [22] have demonstrated the significance of distinctive morphological traits in identifying and characterizing various varieties. These studies have significantly contributed to the understanding of morphological profiles, aiding in the identification, differentiation, and evaluation of different genotypes within the field of research.

**Table 2. Morphological characterization of advance desi chickpea genotypes based on DUS descriptors**

| Sl no | Genotype | Anthocyanin coloration | Height at initiation of first flower | Time of 50% flowering | Growth habit | Foliage color | Leaflet size (mm) |
|---|---|---|---|---|---|---|---|
| 1 | JG 2016-14-16-11 | Present | High | Early | Semi-erect | Medium | Medium |
| 2 | ICCV 181108-2 | Present | High | Medium | Semi-erect | Medium | Medium |
| 3 | JG 2020-1614 | Present | Medium | Medium | Semi-erect | Medium | Large |
| 4 | JG 12 x JG 16-1 | Present | Medium | Medium | Erect | Light | Medium |
| 5 | JG 2020-12-16-13 | Present | Medium | Medium | Semi-erect | Medium | Medium |
| 6 | ICCV 191618 | Present | Medium | Medium | Semi-erect | Dark | Medium |
| 7 | ICCV 191608 | Present | High | Medium | Erect | Medium | Medium |
| 8 | ICCV 181667 | Present | Medium | Medium | Semi-erect | Light | Medium |
| 9 | JG 12 x ICC4958 | Present | High | Medium | Spreading | Medium | Small |
| 10 | JG 23 x ICC 251741 | Present | High | Medium | Spreading | Light | Medium |
| 11 | ICCV181109 | Present | High | Medium | Erect | Dark | Large |
| 12 | ICCV191609 | Present | High | Medium | Erect | Medium | Medium |
| 13 | JG 2018-51 | Present | Medium | Medium | Semi-erect | Dark | Medium |
| 14 | ICC181612 | Present | Medium | Early | Semi-erect | Dark | Medium |
| 15 | JG 2021-96029 | Present | Medium | Medium | Erect | Light | Medium |
| 16 | JG 2020-15118 | Present | High | Medium | Spreading | Dark | Medium |
| 17 | ICCV191606 | Present | Medium | Medium | Semi-erect | Medium | Large |
| 18 | ICCV191616 | Present | Medium | Medium | Semi-erect | Light | Large |
| 19 | JG 2020-634958 | Present | Medium | Early | Semi-erect | Medium | Small |
| 20 | JG 2017-49 | Present | Medium | Medium | Semi-erect | Light | Medium |
| 21 | JG 2020-1614 | Present | High | Medium | Semi-erect | Dark | Large |
| 22 | JG 11 x JG 14 | Present | High | Medium | Spreading | Medium | Large |
| 23 | JG 12 x JG 14 | Present | Medium | Medium | Semi-erect | Dark | Medium |
| 24 | ICC181106 | Present | High | Medium | Erect | Medium | Medium |
| 25 | PG 205 | Present | High | Medium | Semi-erect | Dark | Large |
| 26 | ICCV181602 | Present | High | Medium | Spreading | Light | Medium |
| 27 | RVG-204 | Present | High | Medium | Semi-erect | Dark | Medium |
| 28 | ICCV 211207 | Present | High | Medium | Semi-erect | Dark | Medium |
| 29 | ICCV 211202 | Absent | Medium | Medium | Erect | Medium | Medium |
| 30 | ICCV 211204 | Present | Medium | Medium | Erect | Medium | Medium |
| 31 | ICCV 211201 | Present | Medium | Early | Erect | Light | Medium |

| Sl no | Genotype | Anthocyanin coloration | Height at initiation of first flower | Time of 50% flowering | Growth habit | Foliage color | Leaflet size (mm) |
|---|---|---|---|---|---|---|---|
| 32 | ICCV 211208 | Present | High | Medium | Erect | Medium | Large |
| 33 | ICCV 211203 | Present | Medium | Medium | Erect | Medium | Medium |
| 34 | ICCV 211210 | Present | High | Medium | Semi-erect | Medium | Large |
| 35 | ICCV 211209 | Present | High | Medium | Erect | Light | Medium |
| 36 | ICCV 211206 | Present | Medium | Medium | Erect | Dark | Medium |
| 37 | ICCV 211205 | Present | Medium | Medium | Semi-erect | Medium | Large |
| 38 | JG 12 (c) | Present | Medium | Medium | Semi-erect | Medium | Medium |
| 39 | JG 24 (c) | Present | High | Medium | Semi-erect | Medium | Large |
| 40 | JG 36 (c) | Present | Medium | Medium | Semi-erect | Medium | Medium |

**Table 2. Conti...**

| Sl no | Genotype | Leaf pattern | Flower no per peduncle | Flower color | Strips on standard | Peduncle length (mm) | Plant height | Pod size |
|---|---|---|---|---|---|---|---|---|
| 1 | JG 2016-14-16-11 | Pinnate | Single | Pink | Present | Small | Medium | Medium |
| 2 | ICCV 181108-2 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 3 | JG 2020-1614 | Pinnate | Single | Pink | Present | Small | Medium | Medium |
| 4 | JG 12 x JG 16-1 | Pinnate | Single | Pink | Absent | Medium | Medium | Large |
| 5 | JG 2020-12-16-13 | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 6 | ICCV 191618 | Pinnate | Single | Pink | Absent | Medium | Tall | Large |
| 7 | ICCV 191608 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 8 | ICCV 181667 | Pinnate | Single | Pink | Present | Medium | Tall | Small |
| 9 | JG 12 x ICC4958 | Pinnate | Single | Pink | Present | Small | Medium | Small |
| 10 | JG 23 x ICC 251741 | Pinnate | Single | Pink | Present | Large | Tall | Large |
| 11 | ICCV181109 | Pinnate | Single | Pink | Present | Medium | Medium | Large |
| 12 | ICCV191609 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 13 | JG 2018-51 | Pinnate | Single | Pink | Present | Small | Medium | Small |
| 14 | ICC181612 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 15 | JG 2021-96029 | Pinnate | Single | Pink | Present | Small | Medium | Large |
| 16 | JG 2020-15118 | Pinnate | Single | Pink | Present | Medium | Medium | Large |
| 17 | ICCV191606 | Pinnate | Single | Pink | Present | Small | Medium | Large |
| 18 | ICCV191616 | Pinnate | Single | Pink | Present | Small | Tall | Medium |

| Sl no | Genotype | Leaf pattern | Flower no per peduncle | Flower color | Strips on standard | Peduncle length (mm) | Plant height | Pod size |
|---|---|---|---|---|---|---|---|---|
| 19 | JG 2020-634958 | Pinnate | Single | Pink | Present | Medium | Medium | Large |
| 20 | JG 2017-49 | Pinnate | Twin | Pink | Present | Large | Medium | Large |
| 21 | JG 2020-1614 | Pinnate | Single | Pink | Present | Small | Tall | Medium |
| 22 | JG 11 x JG 14 | Pinnate | Single | Pink | Present | Small | Medium | Large |
| 23 | JG 12 x JG 14 | Pinnate | Single | Pink | Present | Small | Medium | Medium |
| 24 | ICC181106 | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 25 | PG 205 | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 26 | ICCV181602 | Pinnate | Single | Pink | Present | Medium | Medium | Large |
| 27 | RVG-204 | Pinnate | Single | Pink | Present | Medium | Medium | Medium |
| 28 | ICCV 211207 | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 29 | ICCV 211202 | Pinnate | Single | Pink | Absent | Medium | Medium | Medium |
| 30 | ICCV 211204 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 31 | ICCV 211201 | Pinnate | Single | Pink | Present | Small | Medium | Small |
| 32 | ICCV 211208 | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 33 | ICCV 211203 | Pinnate | Single | Pink | Present | Large | Medium | Large |
| 34 | ICCV 211210 | Pinnate | Single | Pink | Present | Small | Medium | Medium |
| 35 | ICCV 211209 | Pinnate | Single | Pink | Present | Medium | Medium | Medium |
| 36 | ICCV 211206 | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 37 | ICCV 211205 | Pinnate | Single | Pink | Present | Large | Medium | Large |
| 38 | JG 12 (c) | Pinnate | Single | Pink | Present | Medium | Tall | Medium |
| 39 | JG 24 (c) | Pinnate | Single | Pink | Present | Medium | Tall | Large |
| 40 | JG 36 (c) | Pinnate | Single | Pink | Present | Medium | Medium | Medium |

**Table 2. Conti...**

| Sl no | Genotype | No of seeds per pod | Seed color | Seed size | Seed shape | Seed testa texture | Seed ribbing | Seed type |
|---|---|---|---|---|---|---|---|---|
| 1 | JG 2016-14-16-11 | single | yellow | very small | Angular | smooth | present | Desi |
| 2 | ICCV 181108-2 | single | brown | medium | Angular | smooth | present | Desi |
| 3 | JG 2020-1614 | single | yellow | medium | Angular | rough | present | Desi |
| 4 | JG 12 x JG 16-1 | single | brown | medium | Angular | rough | present | Desi |
| 5 | JG 2020-12-16-13 | single | brown | medium | Angular | smooth | present | Desi |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 6 | ICCV 191618 | single | dark brown | medium | Angular | smooth | present | Desi |
| 7 | ICCV 191608 | single | brown | medium | Angular | smooth | present | Desi |
| 8 | ICCV 181667 | single | yellow | small | Angular | smooth | present | Desi |
| 9 | JG 12 x ICC4958 | single | yellow | small | Angular | smooth | present | Desi |
| 10 | JG 23 x ICC 251741 | single | brown | medium | Angular | rough | present | Desi |
| 11 | ICCV181109 | single | brown | medium | Angular | smooth | present | Desi |
| 12 | ICCV191609 | single | brown | medium | Angular | smooth | present | Desi |
| 13 | JG 2018-51 | single | yellow | very small | Angular | smooth | present | Desi |
| 14 | ICC181612 | single | yellow | small | Angular | rough | present | Desi |
| 15 | JG 2021-96029 | single | yellow | small | Angular | rough | present | Desi |
| 16 | JG 2020-15118 | single | dark brown | Large | Angular | rough | present | Desi |
| 17 | ICCV191606 | single | brown | medium | Angular | smooth | present | Desi |
| 18 | ICCV191616 | single | dark brown | medium | Angular | smooth | present | Desi |
| 19 | JG 2020-634958 | double | brown | small | Angular | rough | present | Desi |
| 20 | JG 2017-49 | single | brown | medium | Angular | rough | present | Desi |
| 21 | JG 2020-1614 | double | brown | small | Angular | smooth | present | Desi |
| 22 | JG 11 x JG 14 | double | brown | medium | Angular | rough | present | Desi |
| 23 | JG 12 x JG 14 | single | yellow | very small | Angular | smooth | present | Desi |
| 24 | ICC181106 | single | brown | medium | Angular | smooth | present | Desi |
| 25 | PG 205 | single | brown | small | Angular | smooth | present | Desi |
| 26 | ICCV181602 | single | brown | medium | Angular | smooth | present | Desi |
| 27 | RVG-204 | single | dark brown | medium | Angular | smooth | present | Desi |
| 28 | ICCV 211207 | single | brown | medium | Angular | smooth | present | Desi |
| 29 | ICCV 211202 | single | dark brown | small | Angular | smooth | present | Desi |
| 30 | ICCV 211204 | double | yellow | small | Angular | smooth | present | Desi |
| 31 | ICCV 211201 | single | brown | medium | Angular | smooth | present | Desi |
| 32 | ICCV 211208 | single | brown | medium | Angular | smooth | present | Desi |
| 33 | ICCV 211203 | single | brown | small | Angular | smooth | present | Desi |
| 34 | ICCV 211210 | double | brown | medium | Angular | smooth | present | Desi |
| 35 | ICCV 211209 | single | yellow | small | Angular | smooth | present | Desi |
| 36 | ICCV 211206 | single | brown | medium | Angular | smooth | present | Desi |
| 37 | ICCV 211205 | single | dark brown | medium | Angular | smooth | present | Desi |
| 38 | JG 12 (c) | single | yellow | small | Angular | rough | present | Desi |
| 39 | JG 24 (c) | single | brown | medium | Angular | smooth | present | Desi |
| 40 | JG 36 (c) | double | brown | very small | Angular | smooth | present | Desi |

## 4. CONCLUSION

Among the 20 DUS traits evaluated in the chickpea genotypes, it was observed that 5 traits exhibited a monomorphic pattern, 8 traits displayed a dimorphic pattern, 6 traits showed a trimorphic pattern, and 1 trait demonstrated a polymorphic pattern. The findings of the investigation revealed that comprehensive morphological analysis holds immense practical significance for plant breeders in the selection of genotypes, both in the field and at the seed level. Morphological traits that exhibit a strong correlation with higher seed yield or make a substantial contribution to overall yield are of particular importance in the improvement of seed productivity. Therefore, the process of morphological characterization plays a vital role in developing distinct profiles for these breeding lines, facilitating their accurate identification, thorough characterization, and rigorous evaluation within the chickpea breeding program. As a result, the systematic and meticulous characterization approach enables a more efficient and optimized utilization of the available genetic material, thereby maximizing the potential for success in the chickpea improvement program. Consequently, these well-characterized lines become the preferred choices for selection, ensuring a targeted and effective breeding process.

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## COMPETING INTERSETS

Authors have declared that no competing interests exist.

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