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Characterization of Morphological Traits and Diversity Assessment of *Desi* Chickpea (*Cicer arietinum* L.) Lines

Sunny Thakur[1*], Garima Mishra[2], Surbhi Pachori[1] and Anita Babbar[3]
[1]Ph.D. Scholar, Department of Plant Breeding & Genetics, JNKVV, Jabalpur, (Madhya Pradesh), India.
[2]Ph.D. Scholar, Department of Plant Breeding & Genetics, RVSKVV, Gwalior, (Madhya Pradesh), India.
[3]Principal Scientist, Department of Plant Breeding & Genetics, JNKVV, Jabalpur, (Madhya Pradesh), India.

(Corresponding author: Sunny Thakur)*
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ABSTRACT: The experiment was conducted in the *rabi* season of 2019-20 with the objective of morphological characterization and diversity estimation of 55 desi chickpea lines. Visual assessment of 19 phenotypic traits listed in DUS guidelines was performed. Seven traits were monomorphic, six were dimorphic, four were trimorphic and one (seed size) was polymorphic. Stem height at the initiation of the first flower, plant growth habit, and plant height showed considerable variation. Shannon's diversity indices were estimated using Microsoft excel. The index ranged from 0 to 1.420, with a mean value of 0.428. The highest value was obtained for seed size(g). Based on the current results, genotypes ICCV 181603, ICCV 191606, JG24 may be used as parents to develop tall, semi-erect and bold seeded varieties suitable for mechanical harvesting. These findings showcase wide morphological variation among the lines and their potential utilization in varietal identification, germplasm characterization and crop improvement.

Keywords: Chickpea, DUS, Morphological Characterization, Shannon's Diversity Index, Diversity.

INTRODUCTION

Chickpea (*Cicer arietinum* L.) also known as Bengal gram or Garbanzo bean has approximately 20-25% protein, making it an important pulse crop of global importance, especially in developing nations such as India, Pakistan, and other Asian and African countries facing a dire problem of nutritional security. India accounts for more than 65% of the global production of *desi* type chickpea. Therefore, it influences the global yield trends (FAOSTAT, 2020). However, the production is comparatively stagnant. These limits on the yield potential can be attributed to the various biotic and abiotic factors. Breeders need to include diverse germplasm lines in the breeding programmes to break the yield plateau and attain sustainable gains. There is an imperative requirement for the systematic characterization and evaluation of *Cicer* species to utilize target traits (Singh *et al*., 2021). Morphological traits are used for visual identification and classification of the germplasm. Morphological studies are the basis of the early simple and inexpensive morphological marker-based polymorphism analysis to assess diversity. Phylogenetic relationships among various lines could be unveiled using morphological characterization to limit recurring parents and benefit breeders in developing improved varieties with a broader genetic base. A proper perception of the relationships of chickpea genotypes is valuable to plan efficient strategies and crop breeding programs (Admas *et al.,* 2021). Nevertheless, the environmental influence on the descriptors hampers their utilization if the traits are not highly heritable (Singh *et al*., 2018). There are 14,651 chickpea accessions present at NBPGR, New Delhi. However, the amount of germplasm available for utilization by breeders for crop improvement is limited. Lack of germplasm characterization is one reason for this underuse. Morphological characterization also plays a crucial role in the varietal identification as the universally acknowledged descriptors for DUS (distinctness, uniformity, and stability) testing and varietal characterization (Joshi *et al*., 2018). Therefore, the present study describes the morphological characterization of 55 desi chickpea lines based on DUS descriptors to ease their identification and utilization in crop improvement programmes.

MATERIALS AND METHODS

A total of 55 desi chickpea lines were assessed on the Breeder Seed Production Unit at College of Agriculture, Jabalpur, during the rabi 2019-2020. The AICRP on chickpea, Jabalpur and ICRISAT, Hyderabad provided the germplasm. Genotypes were planted in 3 replications in a Randomized Complete Block Design (RCBD) in plots having 4 rows of 4-

meter length and inter and intra row spacing was 30 × 10 cm. Agronomical and plant protection practices were followed as per the recommended package of practices.

Data for the 19 descriptor traits were recorded on 10 randomly selected plants for each character in each replication as per the DUS guideline of chickpea. The phenotypic frequencies calculated were further used to estimate Shannon's Diversity Index (H) according to Negassa (1985) to assess the present diversity.

$$H = -\sum [pi \times \log pi]$$

Where, pi is the portion of the total number of entries belonging to the i^{th} class.

RESULTS AND DISCUSSION

A. Morphological characterization

Based on the variation of morphological traits, an attempt was made to characterize the 55 genotypes based on the characteristics described in the DUS guidelines (PPV & FRA, 2018). Stem anthocyanin pigmentation was observed in all 55 genotypes. Similarly, traits such as pinnate leaf pattern, pink flower colour, stripes on standard, long peduncle length, and ribbing on seed surface were observed in all the genotypes present understudy. It is evident that directional selection for yield has narrowed the genetic base (Tiwari *et al.*, 2021). Forty-five genotypes had medium initiation of first flower, *i.e.*, nodes (8-15 nodes), while 10 genotypes showed high initiation of first flower (>15 nodes). Plant height was used to categorize the genotypes into 3 classes. Two genotypes were short heighted (<45 cm), 40 were medium (45-65 cm), and 13 genotypes were tall (>65 cm). Notable variation was present in the intensity of foliage colour as 12 genotypes had medium green foliage, and the remaining 43 had dark green colour. As for the leaflet size, genotypes were kept in three categories: small, medium and large. Three genotypes recorded small leaflet size (<10 mm); 37 genotypes were medium (10-15 mm), and 15 had large leaflets (15<mm). Not much variation was observed in the genotypes for the number of flowers per peduncle. Only one genotype had twin flowers per peduncle rest all the 54 genotypes observed a single flower per peduncle. Three categories of pods size are available, *viz*., small, medium and large. Four genotypes had small (<15 mm), 16 had medium (<15-20 mm), and 35 had large pod size (>20 mm). Variation was present for the number of seeds per pod, 21 genotypes had one seed per pod, and the remaining 34 had more than one seed per pod.

Table 1: List of Morphological Descriptors according to DUS guideline.

Sr. No.	Descriptors	States	Stage of observation
1.	Stem anthocyanin coloration	Absent and present	Before flowering
2.	Stem height at initiation of first flower	Low (<8 nodes), medium (8-15 nodes) and high (>15 nodes)	First flowering
3.	Plant: growth habit	Semi erect (20-40° from vertical), semi spreading (40-60° from vertical) and spreading (60-80° from vertical)	50 % flowering
4.	Plant: colour of foliage	Light green, medium green and dark green	50 % flowering
5.	Leaflet size (mm)	Small (<10mm), medium (10-15mm) and large (>15mm)	50 % flowering
6.	Leaf pattern	Simple, compound and pinnate	50 % flowering
7.	Flower: number per peduncle	Single and twin	50 % flowering
8.	Flower: colour	White, pink and blue	50 % flowering
9.	Flower: stripes on standard	Absent and present	50 % flowering
10.	Peduncle length (mm)	Short (<5mm), medium (5-10mm) and long (>10mm)	Pod development
11.	Plant: height	Short (<45 cm), medium (45-65 cm) and tall (>65 cm)	Fully developed green pods
12.	Pod: size (length)	Small (< 15 mm), medium (15-20 mm) and large (>20 mm)	Harvest maturity
13.	Number of seeds per pod	One and more than one	Harvest maturity
14.	Seed colour	Yellow, brown and dark brown	30 days after harvest
15.	Seed shape	Pea shaped, owl's head and angular	30 days after harvest
16.	Seed testa texture	Smooth, rough and tuberculated	30 days after harvest
17.	Seed ribbing	Absent and present	30 days after harvest
18.	Seed size(g)	Very small (<15 g), small (15-18 g), medium (19-24 g), large (25-30 g) and very large (>30 g)	30 days after harvest
19.	Seed type	Desi and kabuli	30 days after harvest

Seed colour variation was observed, genotypes were categorized into two categories. Thirty-four genotypes displayed brown seeds, and the remaining 21 had dark brown seed colour. Seed size has a high heritability. Following seed size (based on 100 seed weight), genotypes were classified into five groups. Two genotypes were very small (<15 g), 6 were small (15-18 g), 16 medium (19-24 g), 19 large (25-30 g), and 12 had very large seed sizes (>30 g). Genotypes were found to vary for seed shape; on this basis, genotypes were placed in two groups. Thirty-five genotypes had intermediate (irregular) seed shapes, and 20 genotypes were angular types. Genotypes were placed in two groups were based on seed testa texture. Smooth texture was noted for 43 genotypes, and the remaining 12 had rough seed surface. Similar findings were reported by Upadhyaya *et al.* (2003); Shrivastava *et al.* (2012); Bayahi and Rezgui (2015). All the 55 chickpea genotypes were of desi type.

Morphological characterization helps to classify the germplasm and its efficient utilization in the breeding program. NDUS (Novelty, Distinctness, Uniformity and Stability) are important for the release of variety. Morphology of genotypes have been a major component of varietal identification (Gediya *et al*., 2018). Characterization helps to identify and transfer desirable traits to genotypes. The morphological descriptors showed overlapping expression to various degrees and in diverse combinations. Still, they turned out to be of great service as they could be used to establish the identity of all the genotypes.

Similar morphological characterization was reported by Archak *et al.* (2016); Awol *et al.* (2018); Gediya *et al.* (2018); Adem and Tesso (2019); Gnyandev *et al.* (2019); Solanki *et al.* (2019); Janghel *et al.* (2020); Aktar-Uz-Zaman *et al*. (2020); Kumawat *et al.* (2020); Chaudhary *et al.* (2021).

B. Shannon's diversity indices

Diverse parents are the prime requirement of any hybridization program. The Shannon's diversity indices estimated for 19 morphological traits (Table 2) ranged from 0 to 1.420 with a mean value of 0.428. The highest value of diversity index 1.420 was obtained for seed size(g) whereas, the lowest value of diversity index of 0 was obtained for stem: anthocyanin colouration, leaf: pattern, flower: colour, flower: stripes on standard, peduncle: length, seed ribbing, and seed: type as genotypes exhibited no variability for these traits. Similar results were obtained in the studies conducted by Bouri *et al.* (2021); Ashinie *et al.* (2020); Rawte *et al.* (2018). The values of diversity indices unveiled the presence of high diversity in the morphological characters studied, particularly for the seed size. Therefore, can be utilized for improvements of these traits.

Table 2: Frequency distribution and Shannon-weaver diversity index for various morphological traits of chickpea genotypes.

Characters	Score	Genotype frequency	Percentage Contribution (%)	Shannon's Diversity Index
Stem anthocyanin coloration				
Absent	1	-	-	0.000
Present	9	55	100	
Stem height at initiation of first flower				
Low (<8 nodes)	3	-	0	0.474
Medium (8-15 nodes)	5	45	81.8	
High (>15 nodes)	7	10	18.2	
Plant: Growth habit				
Semi erect (20-40° from vertical)	5	27	49.1	0.693
Semi spreading (40-60° from vertical)	6	28	50.9	
Spreading (60-80° from vertical)	7	-	0	
Plant: Colour of foliage				
Light Green	1	-	0	0.524
Medium green	2	12	21.8	
Dark green	3	43	78.2	
Greenish purple	4	-	0	
Leaflet size (mm)				
Small (<10mm)	3	3	5.4	0.779
Medium (10-15mm)	5	37	67.2	
Large (>15mm)	7	15	27.4	
Leaf pattern				
Simple	1	-	0	0.000
Compound	2	-	0	
Pinnate	3	55	100	
Flower: Number per peduncle				
Single	1	54	98.1	0.090
Twin	3	1	1.9	
Flower: colour				
White	1	-	0	0.000
Pink	2	55	100	
Blue	3	-	0	
Flower: Stripes on standard				
Absent	1	-	0	0.000
Present	9	55	100	
Peduncle Length (mm)				
Short (<5mm)	3	-	0	0.000
Medium (5-10mm)	5	-	0	
Long (>10mm)	7	55	100	
Plant: Height				
Short (<45 cm)	3	2	3.6	0.693
Medium (45-65 cm)	5	40	72.8	
Tall (>65 cm)	7	13	23.6	
Pod: size (length)				
Small (< 15 mm)	3	4	7.2	0.837
Medium (15-20 mm)	5	16	29.3	

Large (>20 mm)	7	35	63.5	
Number of seeds per pod				
One	1	21	38.2	0.664
>1	3	34	61.8	
Seed colour				
Yellow	4	2	3.6	0.794
Brown	6	33	60.0	
Dark brown	7	20	36.4	
Seed shape				
Owl's head	2	-	0	0.655
Intermediate (irregular)	2.5	35	63.6	
Angular	3	20	36.4	
Seed testa texture				
Smooth	1	43	78.0	0.524
Rough	2	12	22.0	
Tuberculated	3	-		
Seed Ribbing				
Absent	1	-	0	0.000
Present	9	55	100	
Seed size(g)				
Very Small (<15 g)	1	2	3.7	1.420
Small (15-18 g)	3	6	10.9	
Medium (19-24 g)	5	16	29.0	
Large (25-30 g)	7	19	34.6	
Very large (>30 g)	9	12	21.8	
Seed type				
Desi	1	55	100	0.000
Kabuli	3	-	0	

Table 3: Morphological Characterization of *Desi* Chickpea genotypes with Scoring based on DUS descriptors.

Sr. No.	Genotypes	Stem Height	Growth Habit	Foliage Colour	Leaflet Size	Flower per Peduncle	Plant Height	Pod Size	Number of seeds per pod	Seed colour	Seed Shape	Seed Texture	Seed Size
1.	ICCV 181606	7	6	3	5	1	5	7	3	6	3	1	5
2.	ICCV 181610	5	6	3	5	1	5	5	3	6	3	1	5
3.	ICCV 181108	5	6	3	5	1	5	7	3	6	2.5	1	5
4.	PA 030 [1063 (192)]	5	6	3	5	1	5	3	3	6	2.5	1	5
5.	JG 74 × JG 14	5	6	3	5	1	5	7	3	6	3	2	5
6.	JG 74 × JG (315)-14	5	6	3	5	1	5	7	3	6	3	2	5
7.	JG 12 × JG 16-3	5	5	3	5	1	5	7	3	7	3	1	5
8.	ICCV 181667	7	5	2	5	1	5	7	3	6	2.5	1	5
9.	ICCV 181664	7	5	2	7	1	5	7	1	6	3	1	5
10.	JG 9605 × JG 1307	5	6	2	5	1	5	5	3	6	2.5	2	1
11.	ICCV 181603	5	5	3	7	1	7	5	3	6	2.5	1	9
12.	ICCV 181602	5	5	2	7	1	5	7	3	7	2.5	2	7
13.	ICCV 181612	5	5	3	7	1	5	7	3	6	3	1	7
14.	ICC 251741	5	6	3	5	1	5	5	3	7	3	1	5
15.	ICCV 181668	5	6	3	5	1	7	7	3	7	2.5	1	7
16.	PA 058 1033(8)	5	5	3	5	1	5	7	3	7	2.5	1	5
17.	ICCV 181101	7	5	3	7	1	7	7	1	6	2.5	1	7
18.	ICCV 181106	7	6	3	5	1	7	7	1	7	2.5	1	9
19.	ICC 15118	5	6	3	5	1	3	7	1	7	2.5	2	9
20.	ICCP 173656	5	6	3	5	1	5	3	1	6	3	1	7
21.	JG 12 × JG 16-1	5	6	3	5	3	3	7	3	6	2.5	2	7
22.	JG 63 × ICC 1205	5	5	3	5	1	5	5	1	7	3	1	3
23.	JG 12 × JG 14	5	6	2	3	1	5	5	3	7	3	2	1
24.	JG 2016-1614	5	6	3	5	1	5	5	3	6	2.5	1	3
25.	JG 2017-48	5	6	3	5	1	5	5	3	6	3	2	3
26.	JG 74 × JG 11551	5	6	3	5	1	5	7	3	7	2.5	2	3
27.	JG 2017-50	5	6	3	5	1	5	7	3	7	3	1	7
28.	ICCV 15107	5	6	3	5	1	5	5	1	7	2.5	1	9
29.	JG 2017-49	5	5	2	7	1	5	3	3	6	2.5	1	7
30.	JG 63 × ICC 14407	7	6	3	5	1	5	5	3	7	3	1	3
31.	JAKI 9218 × JG14	5	6	3	7	1	5	7	3	7	3	2	5
32.	BDNG × NARSING PUR	5	6	3	5	1	5	5	3	7	3	2	7
33.	JG 11 X JG 14	5	6	3	5	1	5	5	1	7	2.5	1	7
34.	Phule G 0914-	5	6	3	5	1	5	7	1	6	2.5	2	5

	6-6												
35.	ICCV 191601	5	5	3	5	1	7	7	1	6	2.5	1	9
36.	ICCV 191602	5	5	2	5	1	5	7	3	6	2.5	1	7
37.	ICCV 191603	7	5	3	5	1	7	5	1	6	2.5	1	7
38.	ICCV 191604	5	5	2	7	1	7	5	3	7	2.5	1	7
39.	ICCV 191605	5	5	3	5	1	5	7	3	7	3	1	7
40.	ICCV 191606	5	6	3	7	1	5	7	3	7	3	1	7
41.	ICCV 191607	5	5	3	7	1	7	7	3	7	2.5	1	9
42.	ICCV 191608	5	6	3	7	1	7	7	3	6	2.5	1	9
43.	ICCV 191609	7	5	3	7	1	7	7	3	6	3	1	7
44.	ICCV 191610	5	5	2	5	1	5	7	3	6	2.5	1	7
45.	ICCV 191611	5	5	3	7	1	5	7	1	6	2.5	1	7
46.	ICCV 191612	7	5	2	3	1	5	7	1	6	2.5	1	5
47.	ICCV 191613	5	5	3	7	1	7	7	1	6	2.5	1	9
48.	ICCV 191614	5	5	3	5	1	5	7	1	6	2.5	1	9
49.	ICCV 191615	5	5	3	5	1	5	5	1	6	2.5	1	7
50.	ICCV 191616	5	5	3	5	1	5	5	1	6	2.5	1	5
51.	ICCV 191617	5	5	2	5	1	7	7	1	6	2.5	1	5
52.	ICCV 191618	5	6	3	5	1	5	7	1	6	2.5	1	9
53.	NBeG 47	5	5	3	5	1	5	7	1	6	2.5	1	9
54.	JG 36	5	6	2	3	1	5	3	1	6	3	1	3
55.	JG 24	7	5	3	7	1	7	7	3	7	2.5	1	9

CONCLUSIONS

The results of the morphological characterization based on the DUS guidelines and diversity estimates obtained using Shannon's diversity index (H) aided in the effective classification of the genotypes. Based on this study, a high amount of diversity is present in the germplasm for traits such as seed size, pod size, leaf size, number of seeds per pod and seed shape. Seed size and seed shapes are desirable market and consumer traits. Genotypes with such morphology can be selected as a donor in the crossing programme after establishing the stability and heritability of the traits. Similarly, genotypes with erect and semi-spreading growth habit with having tall plant height and the first fruiting node above 25 cm can be utilized to develop plant types suitable for mechanical harvesting.

FUTURE SCOPE

Estimation of heritability and other genetic parameters for the traits such as plant height and seed size can be performed to deduce the environmental influence on the traits and their further utilization in the crop improvement programmes.

Morphological characterization can be fruitful in creating core collection at gene banks to improve the availability of germplasm to the breeders.

Marker-based identification and DUS characterization of *desi* chickpea germplasm might help maintain the purity of varieties to benefit both farmers and consumers in the long term.

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Conflict of Interest. None.

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