

Original Research Article

Exploring the Chickpea genotypes through morphological characterization for improved breeding

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 suggested by PPV & FRA, GOI, 2007. Out of the 20 DUS traits examined, it was found that 5 traits displayed monomorphic pattern, 8 traits exhibited dimorphic pattern, 6 traits showed trimorphic pattern, and the remaining 1 trait demonstrated polymorphic pattern among all the chickpea genotypes. 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 breeding purposes and the potential for developing 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. 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 4.8m² 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.

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

SI 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(> 15mm)	
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 (<20g)/ Small (20-25g)/ Medium (26-35g)/ Large (36-45g)/ Very large (>45g)	
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 figure 1. The pictorial representation of all morphological characters was visualized in figure 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 (40-60days) 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 (< 10mm) was recorded in 2 genotypes, medium leaflet size (10-15 mm) was recorded in 27 genotypes and large leaflet size (> 15mm) 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 (<5mm), 24 genotypes were recorded with medium peduncle length (5-10mm) and remaining 4 genotypes were recorded with large peduncle length (>10mm). 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 (45-65cm) 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 tests 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.

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] 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.

4. CONCLUSION

Out of the 20 DUS traits examined, it was found that 5 traits displayed monomorphic pattern, 8 traits exhibited dimorphic pattern, 6 traits showed trimorphic pattern, and the remaining 1 trait demonstrated polymorphic pattern among all the chickpea genotypes. The findings of the investigation demonstrated that a 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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Table 2: Morphological characterization of advance desi chickpea genotypes based on DUS descriptors

SI 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	JG 36	Present	Medium	Medium	Semi-erect	Medium	Medium
28	JG 24	Present	High	Medium	Semi-erect	Medium	Large
29	RVG-204	Present	High	Medium	Semi-erect	Dark	Medium
30	ICCV 211207	Present	High	Medium	Semi-erect	Dark	Medium
31	ICCV 211202	Absent	Medium	Medium	Erect	Medium	Medium
32	ICCV 211204	Present	Medium	Medium	Erect	Medium	Medium
33	ICCV 211201	Present	Medium	Early	Erect	Light	Medium

34	ICCV 211208	Present	High	Medium	Erect	Medium	Large
35	JG 12	Present	Medium	Medium	Semi-erect	Medium	Medium
36	ICCV 211203	Present	Medium	Medium	Erect	Medium	Medium
37	ICCV 211210	Present	High	Medium	Semi-erect	Medium	Large
38	ICCV 211209	Present	High	Medium	Erect	Light	Medium
39	ICCV 211206	Present	Medium	Medium	Erect	Dark	Medium
40	ICCV 211205	Present	Medium	Medium	Semi-erect	Medium	Large

Table 2: Conti...

SI 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
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	JG 36	Pinnate	Single	Pink	Present	Medium	Medium	Medium
28	JG 24	Pinnate	Single	Pink	Present	Medium	Tall	Large
29	RVG-204	Pinnate	Single	Pink	Present	Medium	Medium	Medium
30	ICCV 211207	Pinnate	Single	Pink	Present	Medium	Tall	Medium
31	ICCV 211202	Pinnate	Single	Pink	Absent	Medium	Medium	Medium
32	ICCV 211204	Pinnate	Single	Pink	Present	Medium	Tall	Large
33	ICCV 211201	Pinnate	Single	Pink	Present	Small	Medium	Small
34	ICCV 211208	Pinnate	Single	Pink	Present	Medium	Tall	Large
35	JG 12	Pinnate	Single	Pink	Present	Medium	Tall	Medium
36	ICCV 211203	Pinnate	Single	Pink	Present	Large	Medium	Large
37	ICCV 211210	Pinnate	Single	Pink	Present	Small	Medium	Medium
38	ICCV 211209	Pinnate	Single	Pink	Present	Medium	Medium	Medium
39	ICCV 211206	Pinnate	Single	Pink	Present	Medium	Tall	Medium
40	ICCV 211205	Pinnate	Single	Pink	Present	Large	Medium	Large

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	JG 36	double	brown	very small	Angular	smooth	present	Desi
28	JG 24	single	brown	medium	Angular	smooth	present	Desi
29	RVG-204	single	dark brown	medium	Angular	smooth	present	Desi
30	ICCV 211207	single	brown	medium	Angular	smooth	present	Desi
31	ICCV 211202	single	dark brown	small	Angular	smooth	present	Desi
32	ICCV 211204	double	yellow	small	Angular	smooth	present	Desi
33	ICCV 211201	single	brown	medium	Angular	smooth	present	Desi
34	ICCV 211208	single	brown	medium	Angular	smooth	present	Desi
35	JG 12	single	yellow	small	Angular	rough	present	Desi
36	ICCV 211203	single	brown	small	Angular	smooth	present	Desi
37	ICCV 211210	double	brown	medium	Angular	smooth	present	Desi
38	ICCV 211209	single	yellow	small	Angular	smooth	present	Desi
39	ICCV 211206	single	brown	medium	Angular	smooth	present	Desi
40	ICCV 211205	single	dark brown	medium	Angular	smooth	present	Desi

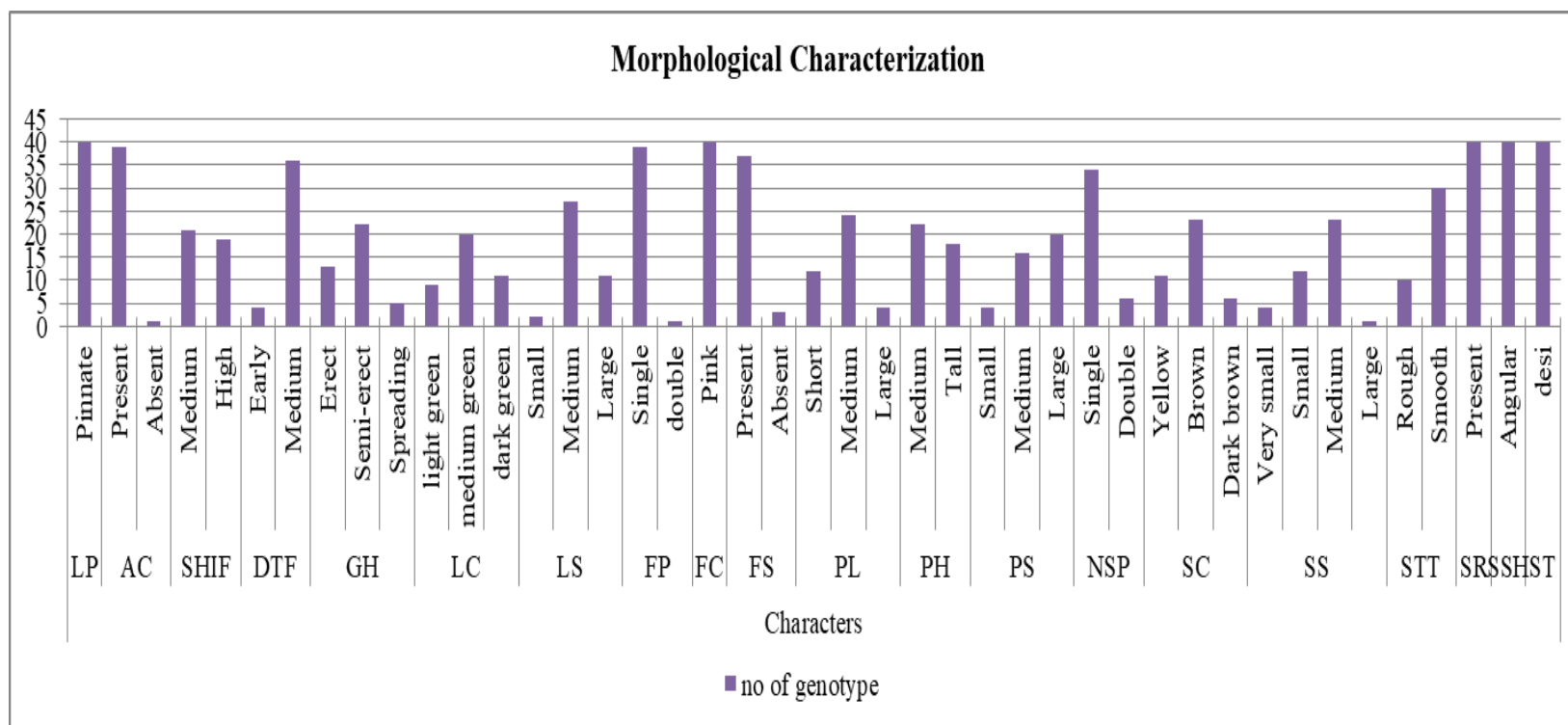


Fig. 1. Diversity representation of morphological and seed attributes in advanced breeding lines of chickpea

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



Pinnate

Leaf Pattern



Present

Anthocyanin
Coloration



Erect

Semi Erect

Spreading

Growth Habit



Dark Green

Medium Dark

Light

Color of foliage



Large

Medium

Small

Leaflet Size

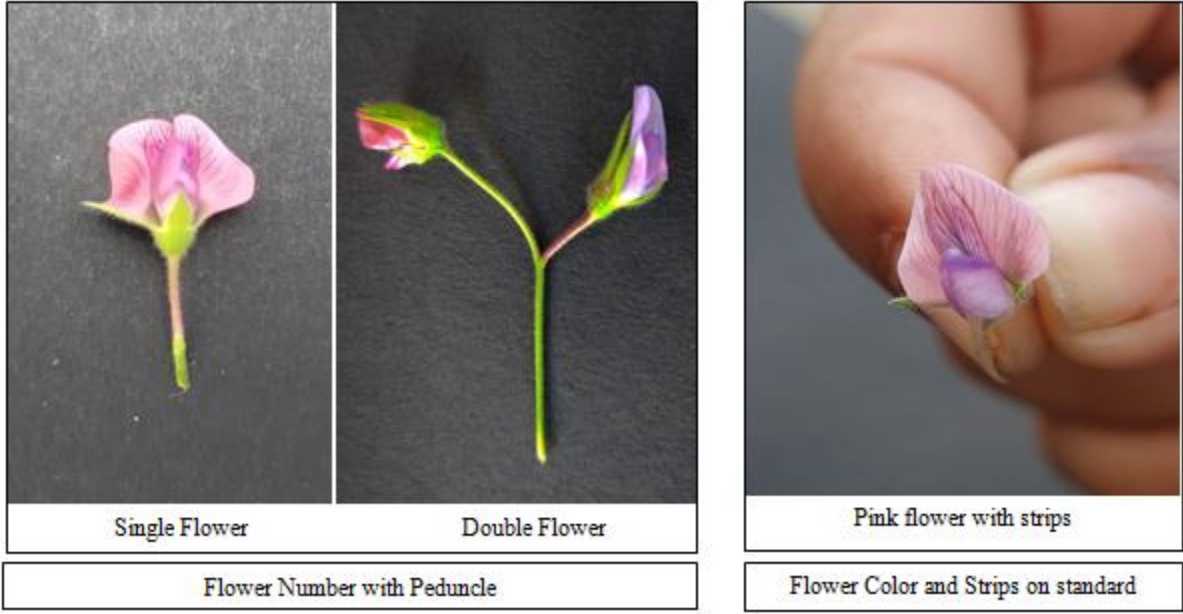


Fig. 2a: Pictorial representation of Morphological traits in Chick pea

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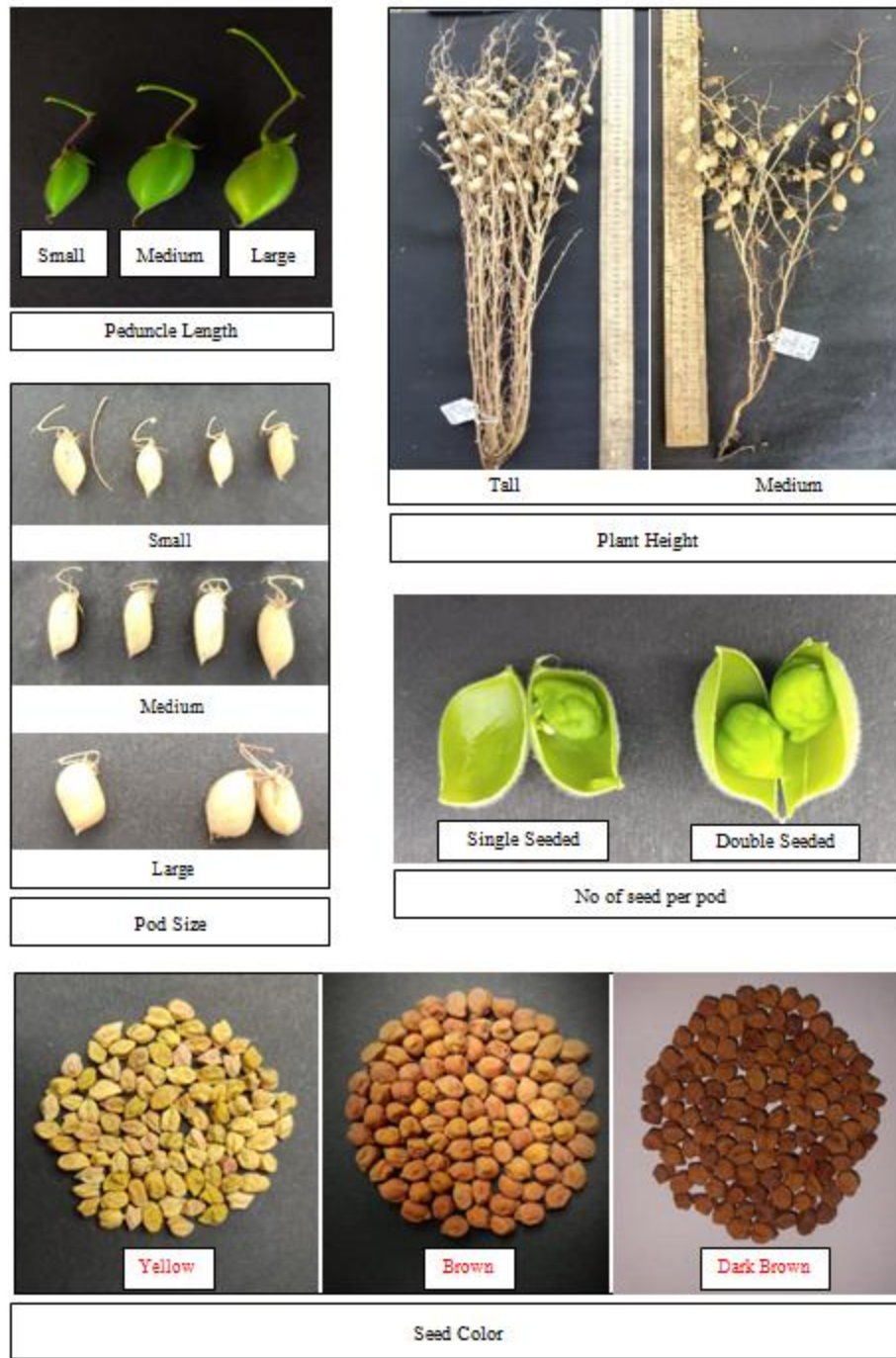


Figure 2b: Pictorial representation of Morphological traits in Chick pea

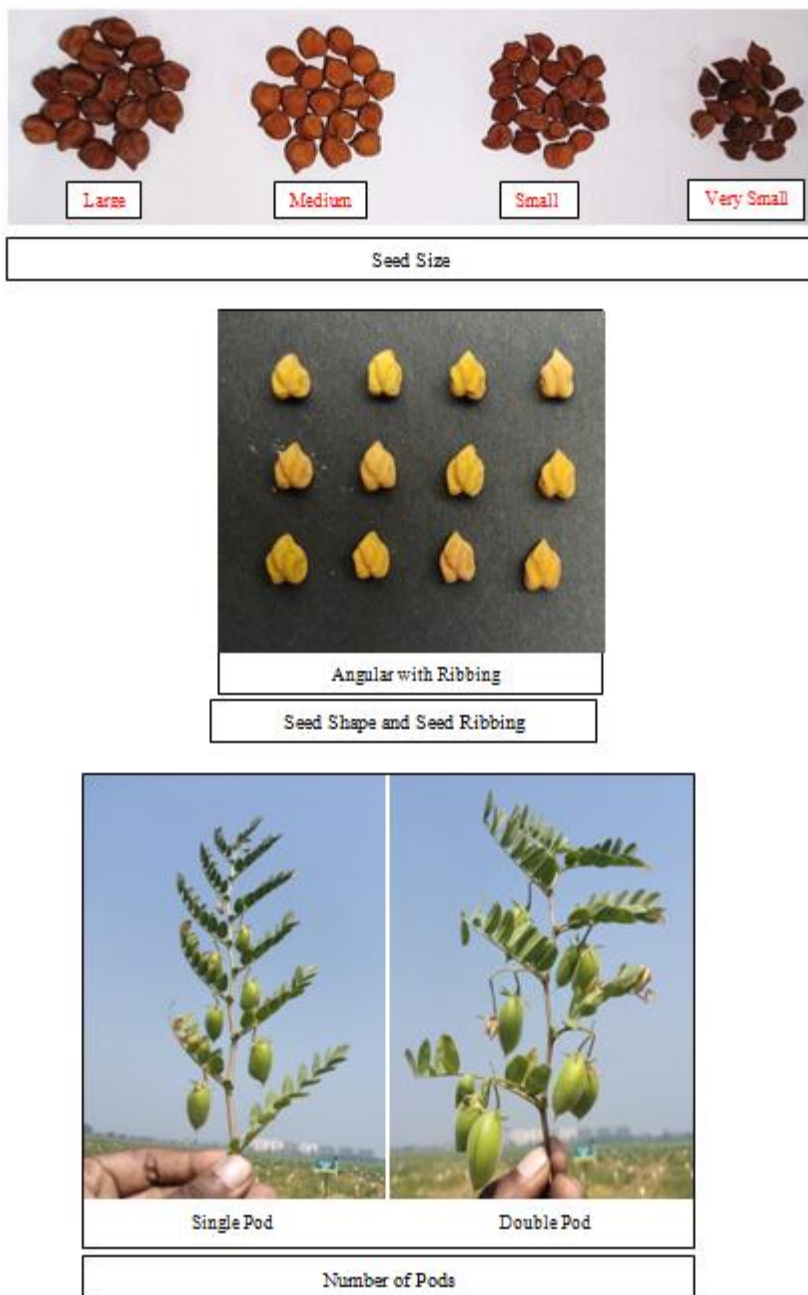


Figure 2c: Pictorial representation of Morphological traits in Chick pea

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