The Pharma Innovation Journal 2021; 10(11): 716-722

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 716-722

www.thepharmajournal.com
Received: 03-08-2021
Accepted: 09-09-2021

Kanushree Nandedkar
Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Ritu R Saxena
Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

GP Dixit
Project Coordinator, AICRP on Chickpea, ICAR-IIPR, Kanpur, Uttar Pradesh, India

Suman Rawte
Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Ravi R Saxena
Department of Agricultural Statistics, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Corresponding Author:
Kanushree Nandedkar
Department of Genetics and Plant Breeding, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

DUS based Agro-morphological characterization and classification of desi chickpea (*Cicer arietinum* L.)

Kanushree Nandedkar, Ritu R Saxena, GP Dixit, Suman Rawte and Ravi R Saxena

Abstract
Modern plant breeding and agricultural systems have narrowed the base for the genetic diversity of cultivated chickpea and to explore new sources of variation that might be used in plant breeding programmes. The current investigation was carried out to morphologically characterize and classify desi chickpea genotypes on the basis of DUS descriptors suggested by PPV& FRA, GOI, 2007. Among 20 DUS traits observed; 5 traits were monomorphic, 9 traits were dimorphic, 4 traits were trimorphic and rest 2 traits were found to be polymorphic among all chickpea genotypes revealing the presence of a significant amount of genetic variability with the potential to assign various morphological profiles for varietal identification and characterization.

Keywords: Characterization, DUS, Morphological, Shannon-weaver index, Diversity

Introduction
The cultivated chickpea is one of the most important pulse crops of India. In India, area of chickpea cultivation is recorded to be 11.89 M ha with production and productivity of 11.38 million tons and 956 kg/ ha in 2018 (Source: FAOSTAT, 2018). In Chhattisgarh, chickpea was grown in about 2.93 lakh ha which constitutes about 2.77% of the total area cultivated for chickpea. The state produced about 2.23 lakh tons of chickpea which amounts to about 1.82% of the total production (Source: Success report 2018-19, Farmer portal). Chickpea is tremendously diverse with respect to growth habit and morphology. Large genetic variations also exist for contents of protein and micronutrients in chickpea presenting a viable opportunity for genetic biofortification. Therefore, there is an expeditious need to characterise genotypes and determine varietal purity. In any crop improvement programme, the identification and characterization of new cultivars is crucial for their efficient utilisation and germplasm conservation. Traditionally, morphological trait characterization has been used as a foundation for germplasm classification, visual identification, differentiation, and cataloguing. It could reveal their phylogeny, which would be extremely beneficial to a plant breeder in using these germplasm in a frontier area of chickpea research. Morphological characterization studies are carried out by employing morphological markers, which are highly heritable traits. They are cheap, simple, does not necessitate the use of sophisticated laboratory techniques and quick to score. Since, a variety attains acceptance only when farmers get genetically pure seeds of high standards. Characterization of varieties is crucial for IPR (intellectual property rights) protection, as well as quality seed production and certification. The measurement of the descriptor is used to assess diversity, but the environmental effect on these traits renders this measure relatively insensitive, particularly where differences are small. Therefore, it is important to define morphological descriptors for different genotypes of chickpea and to analyze their consistency over the years using various genetic tools (Singh *et al.*, 2018) [22].
Plant morphological characteristics have long been acknowledged as the unquestionable descriptors for DUS testing and varietal classification of crop varieties (Joshi *et al.*, 2018) [13]. Thus, every morphological characteristic that is linked to and contributes significantly to increased seed yield would be beneficial in increasing yield. According to aforesaid facts, this investigation was carried out to characterize 98 chickpea genotypes on the basis of qualitative DUS descriptors which facilitate to identify and distinguish genotypes, further it would be used in chickpea improvement program.

Materials and Methods

The experiment material comprised of a set of 98 chickpea genotypes including varieties, yield donors and donors for biotic and abiotic stress resistance, obtained from IIPR, Kanpur (Table 1). The experiment was carried out at Genetics and Plant Breeding Farm, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G) during Rabi season of 2020-21. All the genotypes were grown and evaluated in augmented design with each entry in a single row of 4.0 m length; inter and intra-row space was 45 x 10 cm. The recommended agronomical and plant protection practices were followed for the successful raising of the crop. The observations were recorded on 5 randomly selected plants for agro-morphological and seed traits at different crop growth stages as per the guidelines for the conduct of DUS test of chickpea (*Cicer arietinum* L.) by the PPV&FRA, 2007, GOI for characterization and classification of chickpea genotypes. Also the phenotypic frequencies of these traits were used to estimate diversity using Shannon-Weaver Diversity Index. The index (H) was calculated as presented by Negassa, 1985.

Result and Discussion

Stem: Anthocyanin colouration being an important trait observed before flowering of plants was recorded for two categories i.e. presence and absence of anthocyanin colouration in stem in all the 98 genotypes, out of which 41 genotypes were found showing presence of anthocyanin pigmentation and remaining 57 genotypes showed absence of anthocyanin colouration. Based on Stem: Height at initiation of first flower, the genotypes were found to fall under two categories. First category being medium stem height with 8-15 nodes at initiation of first flower, have only 3 genotypes whereas the second category being high stem height with >15 nodes at initiation of first flower have 95 genotypes. On the basis of Time of flowering i.e. 50% of the plants with at least one open flower, genotypes were grouped into two groups. 86 genotypes were early with 40-60 days to 50% flowering and 12 genotypes was medium type with 61-80 days to 50% flowering.

At 50% flowering stage the plants were observed for distinguishable morphological characters namely Plant: Growth habit, Plant: colour of foliage, Leaflet: Size, Leaf: Pattern, Flower: number per peduncle, Flower: colour and Flower: Stripes on standard, contributing for identification and distinguishing the genotypes under observation. Based on variations in Plant: Growth habit the genotypes were classified into two groups. 21 genotypes were erect type and 77 genotypes were classified as semi-erect type. Plant: colour of foliage which is an important distinguishing feature in plant characterization showed wide variation and grouped all the 98 genotypes into three categories i.e. light green, medium green and dark green. 20 genotypes showed light green foliage colour, 31 genotypes showed medium green foliage colour and 47 genotypes were found to have dark green foliage colour. Variations were observed with respect to Leaflet: Size (i.e. length of leaflet from middle of the plant and middle of the leaf) and based on that, 40 genotypes were recorded with small leaflet size of <10mm, 57 genotypes were recorded with medium leaflet size of 10-15mm and only 1 genotype was found to have large leaflet size of >15mm. No variation was found among the genotypes for Leaf: Pattern and all the genotypes had pinnate type of leaf pattern. Variations were also observed in trait Flower: number per peduncle as out of 98 genotypes, 95 genotypes were found to have single flower per peduncle and 3 genotypes were observed with twin flower per peduncle. One of the most essential and easily detectable distinguishing visual features is flower colour. It is commonly utilised as a marker gene in genetic studies and breeding (Kumawat *et al.*, 2020) [15]. No variation was found among the genotypes for Flower: colour and all the genotypes had pink flowers. The genotypes were also examined for Flower: Stripes on standard and it was recorded thatall98 genotypes showed presence of stripes on standard petal of flower.

The study of Peduncle: Length at pod development stage revealed that current experimental genotypes can be categorized into two group's i.e. medium and long peduncle genotypes. 72 genotypes exhibited medium peduncle length of 5-10 mm whereas 26 genotypes exhibited long peduncle with length of >10 mm.

At fully developed green pod stage the genotypes were observed for Plant: Height and the observations recorded grouped the genotypes into two groups such that, out of 98 genotypes, 53 genotypes were grouped as short with <45 cm plant height and remaining 45 genotypes were found to have medium plant height of 45-65 cm range.

At harvest maturity stage, observations were recorded on Pod: Size (length) and Pod: Number of seeds for all the genotypes. The Pod: Size was recorded by measuring the length of number of individual pods per genotype using electronic Vernier Caliper's and based on the mean values of pods measured per genotype, 3 major groups were observed i.e. small, medium and large sized pods. 25 genotypes were recorded with small size pods (<15mm), 72 genotypes were found to have medium size pods (15-20mm) and only 1 genotypes was recorded with large size pods (>20 mm). Variations were also found in Number of seeds per pod, 86 genotypes showed one seed per pod and remaining 12 genotypes found to have more than one seed per pod.

All the seed related traits *viz.* Seed: colour, Seed: Size, Seed: Shape, Seed: Testa texture, Seed: Ribbing and Seed: Type were observed about 30 days after harvest. Among these seed traits, Seed: colour and Seed: Size are proposed to be used for grouping chickpea varieties (Anon, 2007) [3] and also these two traits are most preferred traits by consumer and important marketing traits (Solanki *et al.*, 2019) [23]. Based on variations observed in Seed: colour, the genotypes were classified into five colour groups which are green, yellow, brown, dark brown and grey. Among these five colour groups, Brown colour seeds were predominant and recorded in 85 genotypes, whereas 4 genotypes were found to have dark brown seeds, 6 genotypes exhibited Yellow colour seeds, Green seeds were found in 2 genotypes and only 1 genotype had Grey seeds. The Seed: Size in genotypes was recorded based on the 100 seed weight of each genotype at 10% moisture content. Out of 98 genotypes, 57 genotypes exhibited very small size seeds with <20g 100 seed weight, 28 genotypes exhibited small size seeds with 20-25g 100 seed weight, 11 genotypes were found with medium size seeds with 100 seed weight of 26-35g, whereas only 1 genotypes was found to have large size seeds with 36-45g 100 seed weight.This large seeded line would be screen out as export purpose and also used in chickpea hybridization programme (Kumawat *et al.*,2020) [15]. Variations observed for Seed: Shape revealed that the Angular type was predominant and exhibited by 97 genotypes and only 1 genotype had Owl's head seed shape. Based on wide variations observed in Seed: Testa texture three major groups were formed. Rough texture was observed in 81 genotypes,

Smooth texture in 2 genotypes and Tuberculated texture was found in remaining 15 genotypes. No variation was found in Seed: Ribbing and all the genotypes showed presence of seed ribbing. Also no variation was observed in Seed: Type as all the 98 genotypes were Desi type.

Similarly, genotypes identification based on distinguishable morphological characters were carried out and reported by Janghel *et al.*,2020 [12], Kumawat *et al*., 2020 [15], Aktar-Uz-Zaman *et al*., 2020 [2], Adem and Tesso, 2019 [1], Awol & Bulti, 2019 [6], Solanki *et al.*, 2019 [23], Gediya *et al*., 2018 [10], Awol & Bulti, 2018 [5], Joshi *et al*., 2018 [13], Singh *et al*., 2018 [22], Saha, 2017 [20], Joshi and Aggarwal, 2016 [14], Archak *et al.*, 2016 [4], Bayahi and Rezgui, 2015 [7], Bodake *et al*., 2014 [8], Zaccardelli *et al.*, 2013 [26], Heidarv and *et al*., 2011 [11], Sarao *et al*., 2009 [21], Lalitha, 2007 [16], Upadhyaya *et al*., 2002 [25].

Shannon-weaver diversity indices

The Shannon-weaver diversity index estimated for all the 20 morphological traits among 98 chickpea genotypes ranged from 0 to 1.041 with a mean value of 0.399. The highest diversity index was exhibited by Plant: colour of foliage (1.041) followed by Seed: Size (0.965) whereas the lowest diversity index (0) or the traits exhibiting no diversity were Leaf: Pattern, Flower: colour, Flower: Stripes on standard, Seed: Ribbing, Seed: Type. Similar estimation of diversity using Shannon-weaver index was performed by Nandedkar *et al*., 2020 [17] and Rawte and Saxena, 2018 [19].

Results indicated that these genotypes have a significant amount of genetic variability, and also has the potential to assign distinctive morphological profiles from a combination of morphological DUS traits, which could be used for varietal identification and characterization, as well as the selection of diverse parents in hybridization programs for more heterotic response and generation of better segregants in chickpea breeding. Morphological characteristics that are linked to enhanced seed production or contribute significantly to yield could be effective in increasing seed output. Thus, systematic characterization allows for more efficient utilization of the material under consideration in the chickpea improvement program, and these lines are preferred to selection.

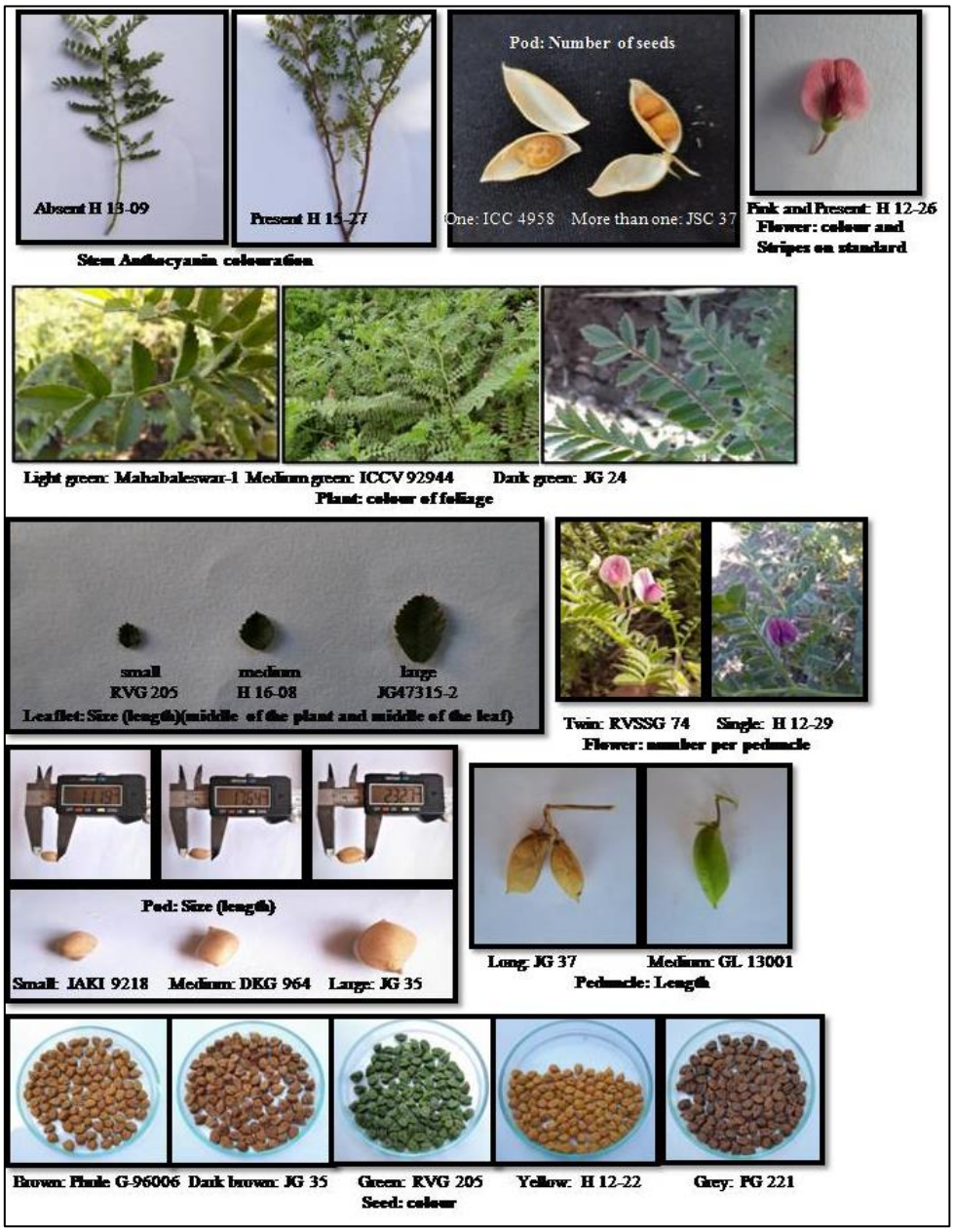

Fig 1a: Pictorial representation of agro-morphological traits in chickpea

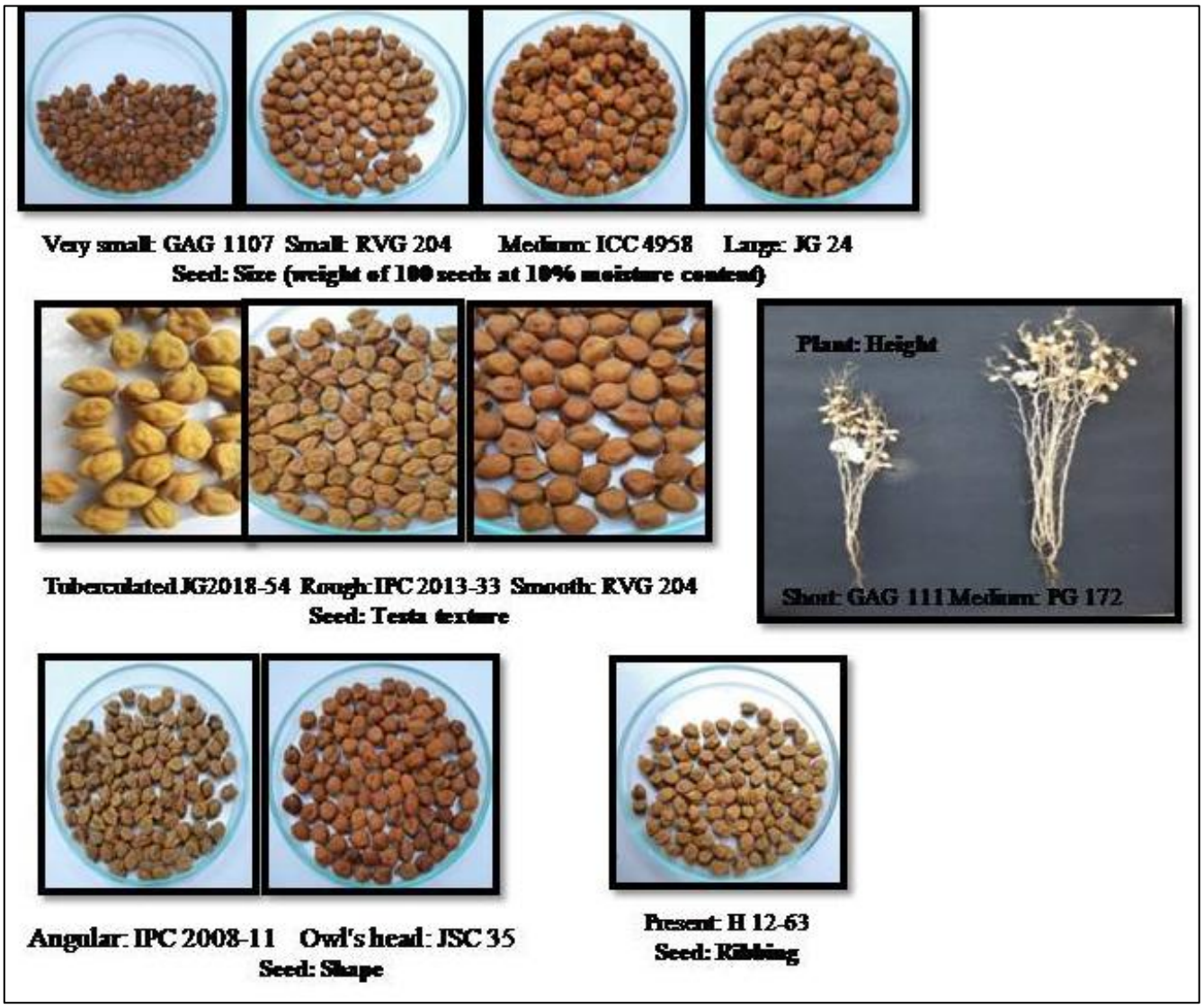

Fig 1b: Pictorial representation of agro-morphological traits in chickpea

Table 1: Agromorphological characterization of desi chickpea based on DUS descriptors

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
NBeG 776	Yield	Present	H	E	ER	MG	M	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Medium	Angular	R	Present	Desi
JSC 35	FW	Present	H	E	SE	MG	S	Pinnate	Single	Pink	Present	M	M	M	One	Dark Brown	Small	Owl's head	R	Present	Desi
RVSSG 75	Yield	Present	H	E	SE	MG	S	Pinnate	Single	Pink	Present	L	SH	M	One	Brown	Medium	Angular	T	Present	Desi
ICC 4958	Drought	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Medium	Angular	R	Present	Desi
RVG 204	MH	Present	H	E	ER	DG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Small	Angular	S	Present	Desi
RVG 205	Variety	Absent	H	M	SE	LG	S	Pinnate	Single	Pink	Present	M	M	M	One	Green	Very small	Angular	R	Present	Desi
JG 16	Variety	Absent	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	S	>1	Brown	Very small	Angular	R	Present	Desi
JSC 37	DRR	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	>1	Brown	Small	Angular	R	Present	Desi
RVSSG 74	Yield	Present	H	E	ER	MG	M	Pinnate	Twin	Pink	Present	L	M	M	One	Brown	Small	Angular	T	Present	Desi
CSJ 303	Yield	Absent	H	E	ER	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
CSJ 313	Yield	Present	H	E	ER	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
AKG 70	Yield	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Medium	Angular	R	Present	Desi
PDKV Kanchan	Variety	Absent	H	E	ER	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	T	Present	Desi
JAKI 9218	Variety	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Small	Angular	R	Present	Desi
AKG 46	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	T	Present	Desi
H 15-25	Yield	Absent	H	M	SE	LG	M	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	R	Present	Desi
H 15-04	Yield	Absent	H	E	ER	LG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Yellow	Very small	Angular	R	Present	Desi
GNG 2285	Yield	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	L	SH	S	One	Brown	Small	Angular	R	Present	Desi
H 15-13	Yield	Absent	H	M	ER	MG	S	Pinnate	Single	Pink	Present	M	M	S	One	Brown	Very small	Angular	R	Present	Desi
H 12-29	Yield	Absent	H	M	ER	MG	S	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
H 08-18	Yield	Absent	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	R	Present	Desi
H 12-63	MH	Absent	H	E	ER	MG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 14-01	Yield	Absent	H	M	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 13-01	Yield	Absent	H	M	ER	MG	S	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
H 14-22	Yield	Absent	H	E	ER	MG	S	Pinnate	Single	Pink	Present	M	M	S	One	Brown	Very small	Angular	R	Present	Desi
H 13-09	Yield	Absent	H	E	ER	MG	S	Pinnate	Single	Pink	Present	M	M	S	One	Brown	Very small	Angular	R	Present	Desi
HC-1	Variety	Absent	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Yellow	Very small	Angular	R	Present	Desi
H 12-22	Yield	Absent	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	M	>1	Yellow	Very small	Angular	R	Present	Desi

H 13-36	Yield	Absent	H	E	SE	MG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 15-03	Yield	Absent	H	E	ER	LG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 12-26	Yield	Absent	H	E	ER	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
H 16-17	Yield	Absent	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 16-12	Yield	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Very small	Angular	R	Present	Desi
H 16-08	Yield	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
H 15-27	Yield	Present	H	E	SE	MG	S	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
ILC 166	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Medium	Angular	R	Present	Desi
Phule G-96006	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
Mahabaleswar-1	Yield	Present	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Small	Angular	T	Present	Desi
ICCV 92944	JG 14	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
JG 24	Variety	Present	H	E	ER	DG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Brown	Large	Angular	T	Present	Desi
ICCV 96854	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Small	Angular	R	Present	Desi
JG 2018-53	Yield	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	T	Present	Desi
JG2017-48	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	T	Present	Desi
JG2018-50	Yield	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	T	Present	Desi
JG47315-2	Yield	Present	H	E	SE	DG	L	Pinnate	Single	Pink	Present	L	SH	M	One	Brown	Very small	Angular	T	Present	Desi
JG2018-54	Yield	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Yellow	Very small	Angular	T	Present	Desi
JG 2016-141611	Yield	Present	H	E	ER	DG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Medium	Angular	R	Present	Desi
JG74315-14	Yield	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	T	Present	Desi
JG 2018-51	Yield	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	T	Present	Desi
Narsinghpur Bold	Yield	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Small	Angular	R	Present	Desi
CSN 8962	Variety	Absent	H	M	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	R	Present	Desi
GLW 64	Yield	Present	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Small	Angular	R	Present	Desi
GL 13042	Yield	Present	H	E	SE	LG	S	Pinnate	Single	Pink	Present	L	SH	S	One	Brown	Small	Angular	R	Present	Desi
GL 1202	Yield	Present	H	M	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
PG 211	Yield	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	M	M	>1	Brown	Small	Angular	R	Present	Desi
PG 222	Yield	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
PG 172	Yield	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Small	Angular	R	Present	Desi
PG 170	Yield	Present	H	E	ER	MG	S	Pinnate	Single	Pink	Present	L	M	S	One	Brown	Very small	Angular	R	Present	Desi
PG 221	Yield	Absent	H	M	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Grey	Small	Angular	R	Present	Desi
PG 158	Yield	Present	H	E	ER	MG	M	Pinnate	Single	Pink	Present	L	M	S	One	Brown	Very small	Angular	R	Present	Desi
GJK 0921	Wilt	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Medium	Angular	R	Present	Desi
GJG 0814	Wilt	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Very small	Angular	R	Present	Desi
GG 4	Variety	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Medium	Angular	R	Present	Desi
GJG 0922	Wilt	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	One	Dark Brown	Medium	Angular	R	Present	Desi
GJG 6	Variety	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Dark Brown	Small	Angular	R	Present	Desi
GAG 1107	Yield	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	S	Present	Desi
GAG 111	Yield	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
GJG 3	Variety	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	SH	M	One	Brown	Small	Angular	R	Present	Desi
GJG 0904	Wilt	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
ICC 4658	Yield	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Medium	Angular	R	Present	Desi
ICC 1710	DRR	Absent	H	M	SE	DG	M	Pinnate	Single	Pink	Present	L	M	S	>1	Brown	Very small	Angular	R	Present	Desi
ICC 5912	Protein	Absent	M	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Brown	Very small	Angular	R	Present	Desi
IPC 2005-24	Wilt	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Yellow	Very small	Angular	R	Present	Desi
ICC 2277	DRR	Absent	H	E	SE	LG	M	Pinnate	Single	Pink	Present	M	M	S	>1	Brown	Very small	Angular	R	Present	Desi
ICC 11764	DRR+BGM	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Brown	Very small	Angular	R	Present	Desi
Phule G 06102	DRR	Present	M	E	SE	DG	S	Pinnate	Single	Pink	Present	M	M	S	One	Brown	Medium	Angular	R	Present	Desi
IPC 2005-64	Wilt	Absent	H	E	SE	LG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
JG 37	Wilt	Present	H	E	SE	DG	M	Pinnate	Twin	Pink	Present	L	M	M	One	Brown	Small	Angular	T	Present	Desi
GL 13001	Variety	Present	H	M	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
Rajendra Chana-1	Variety	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
IPC 2005-28	DRR	Absent	H	E	ER	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
JG 3-14-16	DRR	Absent	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Very small	Angular	R	Present	Desi
CSJ 556	DRR	Absent	H	E	SE	LG	S	Pinnate	Single	Pink	Present	M	SH	S	One	Brown	Very small	Angular	R	Present	Desi
IPC 2012-98	Wilt	Absent	H	E	SE	LG	S	Pinnate	Twin	Pink	Present	L	SH	M	One	Brown	Very small	Angular	R	Present	Desi
IPC 2008-103	Wilt	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Green	Very small	Angular	R	Present	Desi
IPC 2008-11	Wilt	Present	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
IPC 2012-49	Wilt	Absent	H	M	SE	MG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
KGD 99-4	Yield	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Brown	Small	Angular	R	Present	Desi
IPC 2013-33	Wilt	Absent	H	E	ER	MG	S	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
IPC 2007-28	Wilt	Absent	H	E	SE	LG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Brown	Very small	Angular	R	Present	Desi
IPC 2010-134	Yield	Absent	H	E	SE	LG	M	Pinnate	Single	Pink	Present	L	M	M	One	Brown	Small	Angular	R	Present	Desi
GNG 2226	Wilt	Absent	H	E	SE	LG	S	Pinnate	Single	Pink	Present	L	M	S	One	Brown	Very small	Angular	R	Present	Desi
JG 35	Wilt	Present	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	SH	L	One	Dark Brown	Small	Angular	T	Present	Desi
GNG 2264	Yield	Absent	H	E	SE	MG	M	Pinnate	Single	Pink	Present	M	SH	M	One	Yellow	Very small	Angular	R	Present	Desi
MABC 66-266	Wilt	Present	H	E	SE	DG	S	Pinnate	Single	Pink	Present	M	M	S	One	Brown	Small	Angular	R	Present	Desi
DKG 964	AB+CR+FW	Absent	H	E	SE	DG	M	Pinnate	Single	Pink	Present	M	M	M	One	Brown	Very small	Angular	R	Present	Desi
IPC 2006-88 X ILWC 179	Yield	Absent	M	E	SE	LG	M	Pinnate	Single	Pink	Present	L	SH	M	One	Brown	Very small	Angular	R	Present	Desi
IPC 2008-69	Wilt	Absent	H	E	SE	LG	M	Pinnate	Single	Pink	Present	L	M	M	>1	Brown	Very small	Angular	R	Present	Desi

ER = Erect; SE = Semi Erect; H = High; L = Large; M = Medium; SH = Short; E = Early; DG = Dark Green; MG =Medium Green; LG = Light Green; R = Rough; S = Smooth; T = Tuberculated

1= Accessions; 2 = Remark; 3 = Stem: Anthocyanin colouration; 4 = Stem: Height at initiation of first flower; 5 = Time of flowering; 6 = Plant: Growth habit; 7 = Plant: Color of foliage; 8 = Leaflet: Size; 9 = Leaf: Pattern; 10 = Flower: No. per peduncle; 11 = Flower: Colour; 12 = Flower: Stripes on standard; 13 = Peduncle: Length; 14 = Plant: Height; 15 = Pod: Size; 16 = Pod: Number of seeds; 17 = Seed: colour; 18 = Seed: Size (weight of 100 seeds) 19 = Seed: Shape; 20 = Seed: Testa texture; 21 = Seed: Ribbing; 22 = Seed: Type

Table 2: Shannon-weaver diversity index for various morphological traits

Characteristics	Shannon's diversity index
Stem: Anthocyanin colouration	0.680
Stem: Height at initiation of first flower	0.137
Time of flowering (50% of the plants with at least one open flower)	0.372
Plant: Growth habit	0.520
Plant: colour of foliage	1.041
Leaflet: Size (length) (middle of the plant and middle of the leaf)	0.728
Leaf: Pattern	0.000
Flower: number per peduncle	0.137
Flower: colour	0.000
Flower: Stripes on standard	0.000
Peduncle: Length	0.579
Plant: Height	0.690
Pod: Size (length)	0.622
Pod: Number of seeds	0.372
Seed: colour	0.551
Seed: Size (weight of 100 seeds at 10% moisture content)	0.965
Seed: Shape	0.057
Seed: Testa texture	0.524
Seed: Ribbing	0.000
Seed: Type	0.000

References

1. Adem A, Tesso B. Phenotypic Characterization and Assessment of Genetic Diversity for Agro-Morphological Traits of Ethiopian Chickpea (*Cicer arietinum* L.) landraces. Black Sea Journal of Agriculture 2019;2(3):146-55.
2. Aktar-Uz-Zaman M, Kamal MM, Alam MA, Islam MR, Zaman SM, Hossaini M. Characterization of Chickpea Germplasm. Agriculturae Conspectus Scientificus, 2020;85(1):19-35.
3. Anonymous. Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability on Chickpea (*Cicer arietinum* L.). Protection of Plant Varieties and Farmers' Rights Authority (PPV & FRA) Government of India. Plant Variety Journal of India 2007;1(1).
4. Archak S, Tyagi RK, Harer PN, Mahase LB, Singh N, Dahiya OP et al. Characterization of chickpea germplasm conserved in the Indian National Gene bank and development of a core set using qualitative and quantitative trait data. The Crop Journal 2016;189:1-8.
5. Awol M, Bulti T. Characterization and Assessment of Genetic Diversity for Agro-Morphological Traits of Ethiopian Chickpea (*Cicer arietinum L.*) Landraces. Uganda Journal of Agricultural Sciences 2018;18(1):1-13.
6. Awol M, Bulti T. Phenotypic characterization and assessment of genetic diversity for agro-morphological traits of Ethiopian chickpea (*Cicer arietinum L.*) landraces. Black Sea Journal of Agriculture 2019;2(3):146-155.
7. Bayahi K, Rezgui S. Agro-morphological characterization and genetic study of new improved lines and cultivars of chickpea (*Cicer arietinum* L.). Journal of Plant Breeding and Genetics 2015;3(3):59-65.
8. Bodake KK, Wagh RS, Deshmukh DV. Morpho-physiological characterization of chickpea (*Cicer arietinum* L.) genotypes. International Journal of Agricultural Sciences 2014;10(2):512-8.
9. Food and Agriculture Organization of the United Nations. FAOSTAT statistical database. [Rome]: FAO 2018.
10. Gediya LN, Patel DA, Kumar D, Vekariya KJ, Nayak JJ. Characterization of chickpea genotypes based on morphological traits. Journal of Pharmacognosy and Phytochemistry 2018;7(4):3008-3015
11. Heidarv L, Reza MA, Mohammad RN, Yadollah F, Behzad S, Khoshnood A. Physiological and morphological characteristics of chickpea accessions under low temperature stress 2011;58(1):126-32.
12. Janghel DK, Kumar K, Sunil R, Chhabra AK. Genetic Diversity Analysis, Characterization and Evaluation of Elite Chickpea (*Cicer arietinum L.*) Genotypes. Int. J. Curr. Microbiol. App. Sci, 2020;9(1):199-209.
13. Joshi MA, Aggarwal D, Sanyal A. Cultivar identification and diversity analysis based on morphological descriptors and image analysis in chickpea (*Cicer arietinum* L.). Legume Research-An International Journal 2018;41(5):647-55.
14. Joshi MA, Aggarwal, Divya. Image Analysis as an emerging tool for varietal identification in Chickpea (*Cicer arietinum L.*) varieties. International Journal of Advanced Technology in Engineering and Science 2016;4(11):2348-7550.
15. Kumawat S, Babbar A, Solanki RS, Biswal M, Banjarey P. Morphological Characterization of Elite Kabuli Chickpea Lines. Int. J. Curr. Microbiol. App. Sc. 9(09):1241-1250.
16. Lalitha A. Varietal Characterization of chickpea (*Cicer arietinum*) varieties. Journal Research ANGRAU. 2007;44(3, 4).
17. Nandedkar K, Sarawgi AK, Parikh M, Saxena RR, Rawte S. Assessment of Diversity based on Agro-morphological and Quality Characterization of Germplasm Accessions of Rice (*Oryza sativa* L.). Int. J. Curr. Microbiol. App. Sci. 2020;9(08):2397- 2408
18. Negassa M. Patterns of phenotypic diversity in an Ethiopian barley collection, and the Arussi-Bale Highland as a center of origin of barley. Hereditas 1985;102:139-150.
19. Rawte S, Saxena RR. Phenotypic Diversity and Correlation analysis for Agro-Morphological Traits in 100 Landraces of Rice (*Oryza sativa* L.) from Chhattisgarh, Int. J. Pure App. Biosci 2018;6(6):345-353.
20. Saha S. Morphological Characterization and Genetic Analysis in Elite Lines of Chickpea (*Cicer arietinum* L.) (Doctoral dissertation, Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur) 2017.
21. Sarao NK, Joshi MA, Sharma RC, Sandhu JS, Kumar J.

Characterization of chickpea based on morphological markers. Journal of Food Legumes 2009;22(4):251-252.
22. Singh S, Sasidharan N, Kalyanrao. Assessment of Genetic Diversity in Chickpea (*Cicer arietinum* L.) Through Morphological Characterization. Plant Archives 2018;18(1):167-172.
23. Solanki RS, Biswal M, Kumawat S, Babbar A. Characterization of indigenous and exotic chickpea lines for qualitative traits. International Journal of Chemical Studies 2019;7(4):1018-1023.
24. Success Report 2018-19 - Farmer Portalfarmer.gov.in › SucessReport2018-19
25. Upadhyaya HD, Ortiz R, Bramel PJ, Singh S. Phenotypic diversity for morphological and agronomic characteristics in chickpea core collection. Euphytica 2002;123(3):333-42.
26. Zaccardelli M, Sonnante G, Lupo F, Piergiovanni AR, Laghetti G, Sparvoli F, Lioi L. Characterization of Italian chickpea (*Cicer arietinum* L.) germplasm by multidisciplinary approach. Genetic resources and crop evolution 2013;60(3):865-877.