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Morphometric Characterization of Genotypes Based on Seed and Seedling Traits in Chickpea (*Cicer arietinum* L.)

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A B S T R A C T

All the 159 genotypes were characterized and grouped into different classes on the basis of observations recorded for different qualitative and quantitative traits as per the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability on chickpea (*Cicer arietinum* L.) The varietal characterization, varietal identification and genetic purity assessment is utmost important for field functionaries, Certification Officers, Seed Production Officers and Seed Growers for maintaining quality of the seed. These were helpful in genetic purity and DUS testing in seed certification process. The results of the present study clearly indicated that the genotypes of chickpea can be distinguished and identified by plant and seed morphological characters. These differences in morphological traits were useful in identification of individual chickpea genotypes.

Introduction

Chickpea (*Cicer arietinum* L.) popularly known as Gram, Bengal gram, Chhola and Garbanzo bean is one of the first seed legumes domesticated by humans in ancient times (Vander, 1987). Chickpea is self-pollinated, annual, autogamous legume with chromosome number (2n=2x=16). The estimated genome size of chickpea is ~740 Mb (Arumuganathan and Earle, 1991). The *Cicer* genus belongs to family leguminosae, subfamily papilionaceae and tribe *Cicereae alef*. The *Cicer* genus currently comprises 44 species, out of which 35 are perennial species and nine are annual including cultivated *C. arietinum*. The wild annual progenitor of chickpea has been identified as *C. reticulatum* L. (Ladizinsky and Adler, 1976) and the perennial progenitor is proposed as *C. anatolicum* (Tayyar and Waines, 1996). Temperate regions of Southeastern Turkey and adjoining Syria is considered as the place of origin of chickpea. The chickpea has been divided in to two groups: Two distinct types of cultivated chickpea are known based on seed shape, size, and colour: the Desi

variety, characterized mainly by pink flowers and the angular type. *Kabuli* type, with white flowers and owl-head-shaped, beige, large seeds with a low percentage of fibre, primarily grown in Mediterranean countries; and brown, small seeds with a high percentage of fibre, principally grown in South Asia and Africa.

Chickpea grains provide about 18-24 per cent protein, 4-10 per cent fat, 52-71 per cent carbohydrate, 10-23 per cent fibre, minerals and vitamins (Yadav and Shrivastava, 2002). It plays a crucial role in supplying protein source (19-24%), among essential amino acids, lysine, methionine, threonine, valine, isoleucine and leucine are major components of seed protein. It contains considerable number of vitamins such as B1, B2, ascorbic acid (vitamin C) and niacin. The daily per capita availability of 14 g chickpea is a source of approximately two to three per cent (56 kcal) energy and 4.7 per cent protein to Indian population, besides being an important source of calcium and iron (10-12%). Thus, chickpea plays an important role in human nutrition also (Ali and Kumar, 2005). Hence it is also called as poor man's meat (Barman, 2012). Chickpea improves soil quality by enhancing its physical, chemical, and biological properties and storing atmospheric nitrogen in its root nodules.

Emphasis on characterization, varietal identification and genetic purity assessment of chickpea cultivars is very important to the field functionaries, certification officers, seed production officers and seed growers for regulating the quality of the seed. A number of released varieties in chickpea have a narrow genetic base thus making varietal identification a difficult task for quality control. As the number of cultivars expand, the relevance for cultivar purity increases as a measure of seed quality. Uniform standards for crop purity and germination are available for various crops in the Indian Minimum Seed Certification Standards (IMSCS). However, standardized procedures are not available to seed analysts for determining cultivar purity. As a general rule, no cultivar can be identified or rejected purely by examining only seed or morphological characters in the field. Therefore, for keeping the purity of cultivars, stable visual diagnostic characters of seed, seedling and plant morphology are most essential for cultivar identification. Since, India is a signatory for the World Trade Organization and "The Protection of Plant Varieties and Farmer's Rights (PPV & FR) Act, 2001" came into existence, varietal characterization and identification become more significant in the present scenario and it is attracting the attention of breeders, seed industry, seed production and seed certification agencies, seed testing laboratories (STL's) and farmers.

Materials and Methods

The field experiment was carried out at All India Co-ordinated Research Programme on Chickpea, Regional Agricultural Research Station, Vijayapura during *Rabi* 2021-2022 to study the morphometric characterization of chickpea genotypes. The experimental site was located at latitude of 16˚ 77' North, longitude of 75˚ 74' East and an altitude of 516.29 meters above mean sea level in Northern Dry Zone of Karnataka (Zone 3).

A field experiment was laid out in an augmented design. The experiment consisted of 150 germplasms involving nine local checks. Different genotypes were evaluated in five blocks using augmented design with an entry in a single row of 4.0 m length which contains 30 entries with 9 checks repeating in every block. Inter and intra-row space was 45×10 cm, respectively. The recommended agronomical and plant protection practices were followed for the successful raising of the crop.

Observations were recorded on eighteen morphological traits based on the DUS guide line of chickpea for each character in each replication at different crop growth stages. Out of 18, 12 were characterized under plant level and 06 traits were characterized under seed level.

Results and Discussion

The primary step in describing and classifying the material under investigation is morphological characterization. Characteristics are used to evaluate the requirements for distinctness, homogeneity and stability. Understanding morphological features, aids in the identification, selection and transfer of favourable genes, as well as the design of new populations. The present study was conducted to classify 159 chickpea lines using morphological characteristics based on DUS guideline. Because of the wide variation in morphological features, an attempt was made to classify the chickpea genotypes and identify those using descriptors. The 159 genotypes may well be distinguished from each other based on morphological differences.

The analysis of variance for all the 9 quantitative characters under study is presented in Table 1. The analysis of variance revealed that mean square due to

genotypes was highly significant for all the 9 characters. It is indicating the presence of sufficient amount of variability in the experimental material used. Table 2 indicates the maximum, minimum, mean, standard deviation, standard error and coefficient of variation for the all 9 characters.

Characterization chickpea genotypes based on the plant morphological characteristics; the 159 genotypes were divided into different groups. Based on the plant height at 50 per cent flowering mean height was 17.96 cm, Among the 159 genotypes, heights of insertion of first flowers were high (>15 nodes) in 122 genotypes, medium (8-15 nodes) in 36 genotypes and low (<8 nodes) in one genotype.

Flower colour is reliable morphological marker and can usually be distinguished the two main types of chickpea, *Desi* and *Kabuli* types by their flower colour. The flower colour was observed as pink in all the *Desi* types (125 genotypes), white in all the *Kabuli* types (34 genotypes) (Plate 1). Time 50 percentage of flowering varied among all the genotypes, based on this 49 genotypes were extra early flowering (<40 days), 51 genotypes were early flowering (40-60 days) and 59 genotypes were medium flowering (61-80 days). Based on the growth habit genotypes were categorized to three groups *viz.,* erect (31), semi-erect (82) and spreading (46) (Plate 2). Leaf characters like foliage colour and leaflet size were observed to be quite useful in the classification of chickpea genotypes (Plate 3). According to the variation of the leaf size genotypes were divided to three groups, four were large (>15 mm), 95 were medium (10-15 mm) and 60 were small (<10 mm). On the basis of foliage colour, the 159 genotypes of chickpea were classified into three groups.

The 33 genotypes were light green, 50 genotypes were medium green and 70 genotypes were dark green. Wide variation in the plant height was observed based on that genotypes were categorized to three groups *viz.,* tall in 17 genotypes (>60 cm), medium in 102 (45-60 cm) and small in 60 genotypes (<45) height. Based on the pod size genotypes were characterized into three groups *viz.,* large with >20 mm (24), medium within 15-20 mm (97) and small with <15 mm (38). Based on days to maturity genotypes were classified into two groups *viz.,* early (131) and medium (28). Number of primary branches per plant ranged between 2 to 4.4 with a mean of 2.92. Secondary branches varied significantly among the 159 genotypes where it was ranged between 4 to 11.8 with a mean of 7.34 branches. While based on the number of seeds per pod two groups were made *viz.,* pods with one seeded in 123 genotypes and more than one seed in 36 genotypes.

The *Desi* type is characterized by pinkish flower, small plant stature small leaflets with growth habit of spreading and semi erect and usually one to two seeds per pod. The *Kabuli* type have long plant stature, white flowers, bigger leaflets and usually one or two seeds per pod. The results of the study correlate with the investigation conducted by Upadhayay *et al.,* (2002); Yadav and Shrivastava (2002); Lalitha (2007).

With respect to seed characteristics, results are consistent with the results obtained earlier in chickpea and other leguminous crops. Germplasm with large variation in seed colour is providing good breeding material for varietal development program, which is recognized by high market price and high profitability to farmers. Chickpea cultivars classified into different groups based on seed colour, seed size, seed shape, seed testa texture, seed ribbing and seed type. On the basis of seed colour, all the 159 genotypes were categorised into nine groups. 47 were brown, twenty were dark brown, 14 were yellow, one was green, 19 were beige, sixteen were creamy beige, five were black, three were grey, 30 were orange (Plate 4). On the basis of seed testa texture, the chickpea genotypes were classified into three group's *viz.,* rough, smooth and tuberculated (Plate 5). The seed testa texture was smooth in 21 genotypes, tuberculated in 31 genotypes and rough in 107 genotypes. Based on seed size seeds were classified to five groups *viz.,* mostly seed size was medium (26-35 gm) in 64 genotypes, very small (<20 gm) in 46 genotypes, small (20-25 gm) in 32, eight genotypes were large (36-40 gm) and one was very large (>41 gm). According to the seed shape 93 genotypes were angular, 53 genotypes were angular and seven genotypes were pea shaped (Plate 6). Based on the seed ribbing most seeds observed presence of the seed ribbing (140), while remaining 19 were absent (Plate 7). Among 159 chickpea genotypes studied, 125 genotypes were classified as the *Desi* types and 34 genotypes as the *Kabuli* types based on the seed type (Plate 8).

The *Desi* types are characterized by small, irregularly shaped seeds of various colours (light brown, dark brown, yellow pink, green, black or variegated colours) having thick and rough seed coat. The *Kabuli* type have large owl's head shape, beige and creamy beige colour, larger seed with smooth and rough seed coat.

Table.1 Analysis of variance of quantitative traits in chickpea genotypes

Source	Df	DFF	DM	PHFF	LS	PB	SB	PHM	PS	SPP	TW
Block (eliminating Treatments)	4	1.28 ns	2.53 ns	3.27 ns	0.05 ns	0.02 ns	0.35 ns	38.14 ns	0.1 ns	0.09 ns	1.88 ns
Treatment (ignoring Blocks)	158	195.86**	94.96**	14.64**	0.07**	0.32**	3.18**	72.59**	0.13**	0.2**	81.21**
Treatment: Check	8	121.84**	16.4**	14.06**	0.23**	0.15**	6.68**	199.41**	0.24**	0.52**	468.9**
Treatment: Test	149	193.42**	99.06**	14.46**	0.05**	0.3**	2.56**	63.48**	0.12**	0.18**	54.77**
Treatment: Test vs. Check	1	1152.89**	112.99**	45.27**	0.76**	5.86**	67.16**	415.64**	0.22 ns	0.11 ns	918.5**
Treatment: Test and Test vs. Check	150	92.87**	61.46**	13.47**	0.06**	0.32**	2.65**	61.52**	0.11**	0.18**	46.33**
Error	32	1.29	2.3	2.02	0.02	0.02	0.61	26.86	0.05	0.06	0.82

ns P > 0.05;* P <= 0.05;** P <= 0.01

Table.2 Descriptive statistics of quantitative traits in studied

Trait	Min	Max	Mean	Std.Error	Std. Deviation	CV
DFF	30.00	74	51.98	1.08	13.61	2.14
DM	82.00	119.27	100.01	0.75	9.46	1.52
PHFF	7.42	27.45	17.96	0.30	3.76	7.83
LS	5.81	17.00	10.42	0.02	0.25	13.34
PB	2.00	4.40	2.92	0.04	0.53	4.64
SB	4.14	12.04	7.34	0.13	1.62	10.29
PHM	18.64	74.12	50.49	0.62	7.83	10.14
SPP	1.00	2.00	1.22	0.03	0.44	7.71
PS	8.00	23.00	1.69	0.03	0.34	13.56
TW	10.18	50.33	24.22	0.62	7.77	3.6

Note: DFF: Days to fifty per cent flowering (days) **DM:** Days to maturity (days) **PHFF:** Plant height at 50 per cent flowering (cm) **LS:** Leaflet size (mm) **PB:** Primary branches **SB:** Secondary branches **PHM:** Plant height at maturity (cm) **PS:** Pod size (mm) **SPP:** Seeds per pod **TW:** Test weight (gm)

Plate.1 Classification of genotypes based on flower colour

Pink

White

Plate.2 Characterization of genotypes based on the growth habit

(a)

(b)

(c)

Plate.3 Variability in genotypes based on the leaf size (a) and colour of the foliage (b)

(a)

(b)

Plate.4 Characterisation of genotypes based on the colour of the seeds

Plate.5 Variability of genotypes based on the seed testa texture

Rough

Smooth

Tuberculated

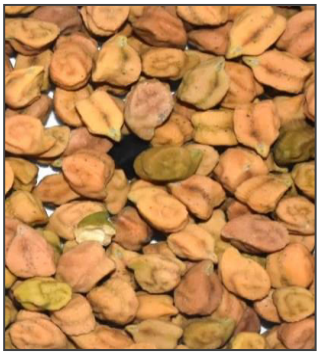

Plate.6 Classification of genotypes based on the shape of the seeds

Angular

Owl's head

Pea

Plate.7 Classification of genotypes based on the seed ribbing

Present

Absent

Plate.8 Characterization based on the seed type

Desi

Kabuli

Characterization of genotypes based on the seed traits helps in the varietal identification and to maintain genetic purity. Similar findings and grouping of genotypes based on seed morphological characters are reported by Yadav and Shrivastava (2002); Upadhyaya (2002); Lalitha (2007); Gediya *et al.,* (2018) and Gnyandev (2019) in chickpea.

These visual traits indicated overlapping of expression in various combinations, yet proved that they are of great utility as identity of all the genotypes could be established individually. Morphological traits of genotypes have been a major segment of varietal identification (Gediya *et al.,* 2018). It is not possible to identify advanced promising lines using any single parameter. Hence, detailed morphological description of plants and seeds should therefore be prepared. Utilization of these features in sequential fashion is useful and convenient to distinguish different genotypes. Similarly, genotypes identification based on distinguishable morphological characters were reported by Kaul *et al.,* (2007); Upadhay *et al.,* (2002); Sarao *et al.,* (2009); Araujo and Vello (2010); Keneni *et al.,* (2011); Shrivastava *et al.,* (2012); Bayahi *et al.,* (2015).

Results of investigation concluded that distinct morphological profile would be most practically valuable to a plant breeder while selecting genotypes in field and

seed level. Morphological character those associated with higher seed yield or which makes a significant contribution to yield would be useful in the improvement of seed yield. Therefore, morphological characterization facilitates to develop distinct profile of these lines and helped in identification, characterization and evaluation of elite *Kabuli* chickpea lines. Hence, systematic characterization leads to a more efficient use of material under consideration in chickpea improvement programme and these lines prefer to selection.

Author Contribution

S. S. Nagavi: Investigation, formal analysis, writing—original draft. S. B. Patil: Validation, methodology, writing—reviewing. M. D. Patil:—Formal analysis, writing—review and editing. A. S. Sajjan: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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