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Phenological, Morphological and Yield based Characterization of Chickpea (*Cicer arietinum* L.) Germplasm Lines

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ABSTRACT

Background: The characterization of chickpea genetic resources is a vital step to explore genetic variability in breeding programs. In the present study, we characterized 90 germplasm lines of desi chickpea collected across the Indian chickpea growing region. The identified trait-specific germplasm lines will be used as a valuable genetic resource for the chickpea improvement programme.

Methods: An experiment was conducted in augmented design to characterize germplasm lines of chickpea for 13 qualitative and 17 quantitative agro-morphological traits under Bundelkhand agro-climatic conditions.

Result: Ample variation was observed for qualitative and quantitative traits. The study revealed that the presences of high variability in qualitative and quantitative traits are useful in the identification of plant genotype for a specific trait, genetic purity analysis, germplasm conservation and also possible use of potential genotype in the breeding program.

Key words: *Cicer arietinum* L., Germplasm, Morphological, Phenological, Variability.

INTRODUCTION

Globally, chickpea (*Cicer arietinum* L.) is the second most important pulse crop after beans. It belongs to subfamily *Papilionoideae*, tribe *Cicereae* and family *Leguminosae*. Southwest Asia and Mediterranean region are supposed to primary whereas, Ethiopia is considered secondary center of diversity (Vavilov, 1926). Nutritionally, chickpea seed is enriched with protein (20-26%), carbohydrate (62%), fat (4%), essential amino acids, vitamins A, B and C, minerals, soluble and insoluble fiber (Bodake *et al*. 2014). Chickpea crops have the ability to fix atmospheric nitrogen in the root nodules through an enzymatic process of rhizobium bacteria which supports a sustainable farming system (Alyemeni *et al.* 2016). The global production of chickpea was 17.23 M tons from 17.85 M ha with 1473.5 kg/ha productivity during 2018 (FAO, 2018). In India, chickpea is cultivated on 9.67 million ha with an annual production and productivity of 10.09 million tons and 1043 kg ha^{-1}, respectively (AICRP, Annual Progress Report 2018-19). In India, major chickpea growing states are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Andhra Pradesh and Karnataka. The productivity of chickpea is low with greater variation due to several biotic and abiotic stresses under different farming environments. The major biotic constraints affecting chickpea cultivation are fusarium wilt, dry root rot, botrytis gray mold, pod borer whereas, drought, heat, salinity and chilling are the major abiotic stresses which severely affect chickpea productivity.

The identification of potential genotypes based on morphological characters is a pre-requisite for any crop improvement program for development of new cultivars and improvement in the existing cultivars (Choudhury *et al*. 2014). Hence, the collection and conservation of germplasm is essential to preserve genetic diversity and provides opportunities for breeders to utilize in their breeding programs. In India, 14,651 accessions of chickpea along with some introductions from other chickpea growing countries are conserved at NBPGR, New Delhi (Archak *et al*. 2016). It is of paramount importance to characterize germplasm collections before utilizing them in a breeding program for the development of improved cultivars. Therefore, characterization of germplasm is important for identifying genotypes with distinct desirable morphological traits which can be utilized in the breeding program (Aktar-Uz-Zaman *et al.* 2020). Despite, availability of several standardized protocols, the cultivar purity and selection or rejection accordingly carried out purely on plant morphology under field conditions. Chickpea plants have several stable morphological features as well as qualitative characters that can be utilized to assess the variability among accessions. The present study was planned to assess the phenological and morphological variability among the ninety chickpea germplasm lines and to identifying best performing genotypes based on yield and component traits to be utilized in future breeding programs.

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MATERIALS AND METHODS

The experiment was conducted at Banda University of Agriculture and Technology, Banda, Uttar Pradesh, India (24°53′ and 25°55′N, 80°07′ and 81°34′E with 123m ASL) during 2018-19. Experimental material comprised of 90 diverse chickpea genotypes which include high-yielding advanced breeding lines and released varieties. The experiment was planted in an augmented block design (Federer 1956) with 2R x 2m x 30cm plot using four checks (JG 14, JG 16, JAKI 9218 and Radhey). A total of 10 test genotypes were planted in each block along with four randomly repeated checks to control local error.

The data was recorded on 13 phenological and 17 quantitative traits as per chickpea DUS descriptors (PPV and FR authority, GOI, New Delhi 2007). Method of taking observation, appropriate stage and measuring scale of traits are presented in Table 1.

The average values of quantitative traits were analyzed as per the statistical procedure (Johnson *et al*. 1955), along with repeated checks to estimate adjusted mean, standard deviation and coefficient of variation with the help of statistical software SPAD (Rathore *et al*. 2004).

RESULTS AND DISCUSSION

The variability in breeding material is essential to develop elite high-yielding cultivars which are reflected with cultivar adaptation for better performance at farmer fields. Thus, characterization for yield and contributing traits is an essential step to distinguish genotypes. The germplasm lines are characterized with agro-morphological traits, biochemical

Table 1: Phenological and quantitative descriptors used for morphological assessment.

Descriptors	Observation stage	Measurement scale
Qualitative descriptors		
Growth habit	50% flowering	3-Erect (0-150 from vertical), 5-Semi-erect 16-600 from vertical), 7-Spreading (61-800 from vertical)
Stem pigmentation	Before flowering	1-Absent, 9–Present
Leaf colour	50% flowering	1-Light green, 2-Medium green, 3-Dark green, 4-Greenish purple
Leaflet size	50% flowering	3-Small (<10mm), 5-Medium (10-15mm), 7-Large (>15mm)
Flower colour	50% flowering	1-White, 2-Pink, 3–Blue
Stripe on standard	50% flowering	1-Absent, 9–Present
Peduncle length	Pod development	3-Short (<5mm), 5-Medium (5-10mm), 7-Long (>10mm)
Seed colour	Post-harvest	1-Beige (Kabuli), 2-Creamy beige, 3-Green, 4-Yellow, 5-Orange, 6-Brown, 7-Dark brown, 8-Grey, 9–Black
Seed shape	Post-harvest	1-Pea-shaped, 2-Owl's head, 3–Angular
Seed type	Post-harvest	1-Desi, 3–Kabuli
Seed size	Post-harvest	1-Very small (<20g), 3-Small (20-25g), 5-Medium (26-35g), 7-Large (36-45g), 9-Very large (>45g)
Testa texture	Post-harvest	1-Rough, 2-Smooth, 3–Tuberculated
Seed ribbing	Post-harvest	1-Absent, 9–Present
Quantitative descriptors		
Days to germination	At germination	10 to 20 days after sowing
Early plant vigour	Seedling stage	scale one to nine (1-9)
Days to flower initiation	Flowering	Appearance of first flower from sowing
Days 50% flowering	Flowering	50% plant flowering from sowing
Days to first pod appearance	Podding	Appearance of first pod from sowing
Days to completion of flowering	Fully flowering	Maximum plant flowered from sowing
Days to maturity	At maturity	Physiological maturity from sowing
Plant height (cm)	At maturity	Height from base of cotyledonary node up to top of main axis
Height of first pod(cm)	At maturity	Height from base of cotyledonary node up to first pod
Internode distance(cm)	At maturity	Measured distance b/w two pods
Primary branches	At maturity	Counting branches arising from main stem
Secondary branches	At maturity	Counting branches arising from primary branches
No. of pod per plant	At maturity	Average number of pods per plants
No. of seeds per pods	At maturity	Average of number of seeds per pod
100 seed weight	Post-harvest	Weight of100 seed at 10% seed moisture
Harvest index (%)	Post-harvest	Ratio of economical yield and biological yield
Seed yield per plot	Post-harvest	Grain yield (gm/plot)

Source: PPV and FR authority, GOI (2007).

markers and molecular markers to measure genetic variability (Smykal *et al.* 2008). Characterization based on consistent morphological descriptors is a very vital tool to identify superior genotypes with desirable traits.

The frequency distribution of thirteen qualitative traits with per cent proportion of genotypes is presented in Table 2. Based on growth habit, twelve genotypes (13%) were found erect, forty-three (47%) semi-erect and thirty-five (38%) were found spreading type growth habit (Fig 1). The erect architecture of chickpea plant concerning the height of first pod is a desirable trait for mechanical harvesting of chickpea crop (Vishnu *et al*. 2020). Seventy-four genotypes (82%) showed stem pigmentation and 14 genotypes (15%) were non-pigmented (Fig 2). The intensity of green colour was

Table 2: Frequency distribution of 13 qualitative descriptors assessed germplasm lines.

Descriptor	Scale	No. of entries	% entries
Growth habit	3=Erect (0-15° from vertical)	12	13
	5=Semi-erect (16-60° from vertical)	43	47
	7=Spreading (61-80° from vertical)	35	38
Stem pigmentation	1=Absent	14	15
	9=Present	74	82
Leaf colour	1=Light green	6	6
	2=Medium green	26	28
	3=Dark green	58	64
	4=Greenish purple	0	0
Leaflet size	3=Small (<10mm)	18	20.
	5=Medium (10-15mm)	52	57
	7=Large (>15mm)	20	22
Flower colour	1=White	5	5
	2=Pink	85	94
	3=Blue	0	0
Stripe on standard	1=Absent	5	5
	9=Present	85	94
Peduncle length	3=Short (<5mm)	34	37
	5=Medium (5-10mm)	38	42
	7=Long (>10mm)	18	20
Seed colour	1=Beige (kabuli)	4	4
	2=Creamy beige	1	1
	3=Green	1	1
	4=Yellow	28	31
	5=Orange	1	1
	6=Brown	46	51
	7=Dark brown	9	10
	8=Grey	0	0
	9=Black	0	0
Seed shape	1=Pea-shaped	8	8
	2=Owl's head	54	60
	3=Angular	28	31
Seed type	1=Desi	86	95
	3=Kabuli	4	4
Seed size	1=Very small (<20g)	55	61
	3=Small (20-25g)	17	18
	5=Medium (26-35g)	16	17
	7=Large (36-45g)	2	2
	9=Very large (>45g)	0	0
Testa texture	1=Rough,	67	74
	2=Smooth,	2	2
	3=Tuberculated	21	23
Seed ribbing	1=Absent	6	6
	9=Present	84	93

observed as dark green in 58 genotypes (64%), whereas 26 and 6 genotypes exhibited medium green (28%) and light green colour (6%), respectively (Fig 3). No leaf pigmentation was observed in any of the genotypes.

Out of 90 genotypes, 52 (57%) genotypes possessed medium leaflets, 20 (22%) genotypes have large leaflets and 18 (20%) genotypes have small leaflets (Fig 4). Contrary to our finding, Aktar-Uz-Zaman *et al.* (2020) scored all small-sized leaflets in his study material. Majority of genotypes exhibited pink colour (85 genotypes; 94%) while five (5%) genotypes (L-552, IPK-16-103, PUSA 1053, ICVT-181312 and ICVT-181310) had white colour (Fig 5). Though, blue coloured flower was not present in the studied genotypes. The five genotypes (5%) having white colour flower were without a stripe on standard while rest 85 genotypes (94%) had stripe on standard of flower (Fig 5). Thirty-four genotypes (37%) were found to have small peduncle length whereas 38 (42%) and 18 (20%) genotypes had medium and long peduncle length (Fig 6). Eight categories of seed colour were observed among the genotypes: four genotypes (4%) (L-552, PUSA-1053, ICVT-181312 and ICVT-181310) were characterized as beige (Kabuli), 28 genotypes (31%) seed yellow colour, 46 genotypes (51%) seed brown colour, 9 genotypes (10%) seed dark brown colour. Each seed colour creamy beige, green and orange found in single genotype.

The variation in seed shape was characterized as owl's, angular and pea-shaped (Fig 7). Eight genotypes (8%) (L-552, ICVT-181312, ICVT-181310, GNG-1107, DC-2012-13, KGD 2017-1, ICVT-181103 and ICVT-181118) were identified pea-shaped seed, 54 genotypes (60%) owl's head shape and 28 genotypes (31%) with angular shape seed. Most of the genotypes 86 (95%) were observed desi type of seed and only 4 genotypes (4%) (L-552, ICVT-181312, ICVT-181310 and PUSA-1053) were found kabuli type. Considering seed size, 55 genotypes (61%) were characterized as very small, 17 genotypes (18%) small, 16 genotypes (17%) medium -sized whereas, only 2 genotypes (2%) (ICVT-181312 and ICVT-181310) had large seed size. The very large-sized seed genotype was not found in the studied genotypes. Seed rough testa texture was found in 67 genotypes (74%), smooth texture was observed in only two genotypes (2%) (PUSA-1053 and ICVT-181118) and tuberculated testa texture was observed in 21 genotypes (23%) (Fig 8).

The genotypes were also categorized into two groups based on the presence/ absence of ribbing on the seed surface. Most of the genotypes 84 (93%) were found seed ribbing and the rest had not to seed ribbing. Similarly, the identification of morphological traits in 58 genotypes of chickpea was reported by Gediya *et al.* (2018). Sixty elite

Fig 1: Plant Growth habit.

Fig 2: Pigmented and non-pigmented stem.

Fig 3: Light and dark green colour of leaf.

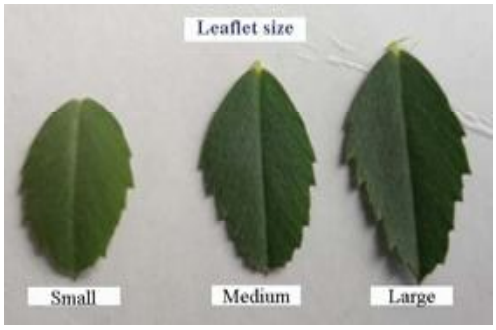

Fig 4: Small, medium and large leaflet size.

Fig 5: Pink, blue and white colour with present or absent of stripe on standard.

germplasm lines of chickpea were characterized into distinct groups based on anthocyanin pigmentation, leaflet size, flower colour and other morphological characters by Janghel *et al.* (2020).

Variation among quantitative traits

The analysis of variance revealed significant variability for most of the quantitative traits indicating presence of considerable variation in genotypes. The descriptive statistics are summarized in Table 3. The highest value of CV was observed in secondary branches (44.65%) followed by seed yield per plot (41.54%), pod per plant (38.67%), early plant vigour (36.29%), seed per pod (35.83%), primary branches (33.51%) and 100 seed weight (32.44%). The maturity duration varied from early (109 days) to late maturity (134 days). Grater variability with high CV for days to maturity and seed yield per plant was reported by Archak *et al.* (2016) and Choudhury *et al.* (2014). The sufficient variability for days to 50% flowering, maturity duration, plant height, pods per plant, biological yield per plant and harvest index were recorded by Malik *et al.* (2014) and it was suggested that the promising genotypes can be used as parents in hybridization program (Malik *et al.* 2014). The genotypes ICVT-181113, ICVT-181112 and ICVT-181118 exhibited early flowering initiation in 49 days compared to local check Radhey (85 days) while the genotype K 850 completed flowering in 85 days. Thirty-two genotypes matured earlier, in which genotypes ICVT-181116, ICVT-181114, ICVT-181115, IC-242463, ICVT-181113 and ICVT-181112 matured in 110 days than Radhey (125 days). Genotypes PG-184, KGD-2017-1, ICP-08-103, PDG-4, CSJ-868 and BDNG-2010-1 have long maturity duration upto130 days.

The plant height ranged from 27.20 cm (GNG-1926) to 68.60 cm (ICVT-181110). Thirty genotypes showed the lowest plant height than the best check JAKI-9218 (45.57cm) whereas eleven genotypes reported height more than check

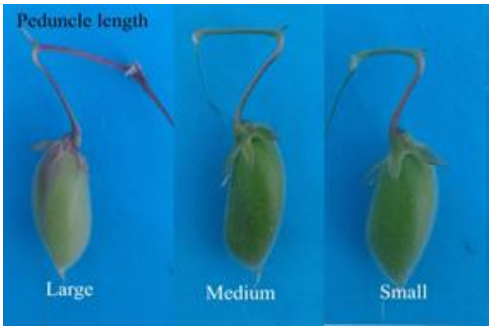

Fig 6: Large, medium and small length of peduncle.

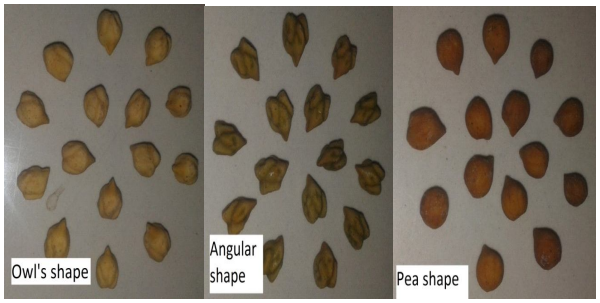

Fig 7: Owl's, angular and pea shape.

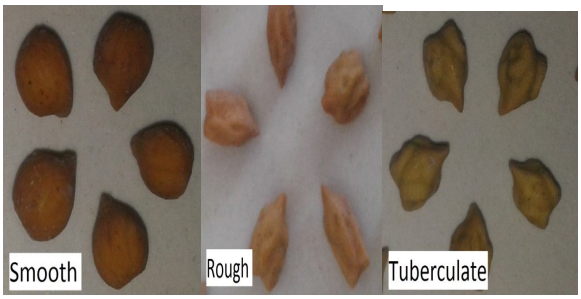

Fig 8: Smooth, rough and tuberculate testa texture.

Table 3: Basic statistics of the quantitative characters of germplasm lines.

Trait	Mean±SE	Range	C.V
Days to germination	8.88±0.24	4-13	25.5
Early plant vigour	5.67±0.22	1.72-9.97	36.29
Flower initiation	73.46±1.04	49.01-89.76	13.48
Days to 50% flowering	80.91±1.01	52.74-97.99	11.81
Days to 100% flowering	101.39±0.58	91.79-117.04	5.44
Days to first pod appearance	88.35±0.95	62.07-105.82	10.15
Days to maturity	123.61±0.53	109.63-134.38	4.03
Plant height	49.01±0.80	25.39-66.34	15.47
Height of first pod	17.040.50	5.74-32.42	27.91
Internodes distance	1.63±0.04	0.72-3.36	24.31
Primary branches	3.38±0.12	1-7.25	33.51
Secondary branches	5.29±0.25	0.92-10.42	44.65
Pods per plant	24.37±0.99	1.22-57.97	38.67
Seeds per pod	1.34±0.05	0.81-2.31	35.83
Harvest index	51.93±0.65	35.22-71.52	11.94
100 seed weight	19.54±0.67	11.11-40.17	32.44
Grain yield per plot	207.98±9.11	35.39-488.64	41.54

Table 4: Identified promising genotypes for desirable traits.

Trait	Best performing genotype	Description
Early plant vigour	DG-1012-3, ICVT-181107, BG-11-1, GNG-2081	Most vigorous
Days to 50% flowering	ICVT-181112, ICVT-181113, ICVT-181118, IC 244263, ICVT-181114, ICVT-181116, ICVT-181104, ICVT-181110, ICVT-181312, ICVT-181310, BDNG-804, ICVT-181115	Early flowering
Days to first pod appearance	ICVT-181112s	Early podding
Days to maturity	IC-244263, ICVT-181112, ICVT-181113, ICVT-181114, ICVT-181116, ICVT-181115	Early maturity
Harvest index	DG-1012-3	71.42%
Seed index	ICVT-181312	40.89 gm
Pimary branches	GNG-1947	Eight
Pod per plant	JG-16	67
Height of first pod	ICVT-181118	4.4cm
Double poded plant	RG-2015-08, GNG-2372, JG-16, GNG-1969, GNG-2081 and KGD-2013-2	Double poded

Radhey (59.53cm). The minimum and maximum first pod height was observed in ICVT-181118 (4.4 cm) and ICVT-181105 (37.4 cm) while check variety JG-16 was 15.20 cm. The maximum number of pods per plant were recorded in RG-2015-08 (56 pods) compared to Radhey (16 pods) while most of the genotypes were found single-seeded.

Harvest index ranged from 34.12% (CSJ-515) to 71.43% (DG-1012-3) amongst the genotypes and twenty-eight genotypes had the highest harvest index than the best check JG-16 (53.84%). Hundred seed weight varied from 11.11- 40.17gm and maximum was recorded in genotype ICVT-181312 having bold seeds. The seventeen genotypes showed highest seed index than the check JG-14 (14.07gm). The highest seed yield was recorded for the genotype ICVT-181103 (488.64g) while genotype GNG-312 had lowest seed yield (49.01g) and two genotypes (ICVT-181102 and ICVT-181103) exhibited highest seed yield than the best check JG-16 (225g). The highest seed yield per plant was recorded in genotypes IC-269295 (Desai *et al.* 2015). Similarly, a wide range of variance for days to flower initiation, days to 50% flowering, days to maturity, plot yield, number of pods per plant was also reported by Banik *et al.* (2018).

Promising chickpea genotypes

Based on overall performance, superior genotypes were identified for desirable agro-morphological traits (Table 4). Genotypes, ICVT-181107, DG-1012-3, BG-11-1 and GNG-2081 had vigourous growth in early developmental stage compared to JG-16. Twelve genotypes were identified for early flowering (49 days) as compared to early check JG 14. The genotypes ICVT-181112, ICVT-181113, IC-244263, ICVT-181114, ICVT-181116 and ICVT-181115 matured in 110 days and identified as early material under Bundelkhand climate. The ICVT-181118 genotype was identified with minimum pod height (4.4 cm) with semi-spreading nature. The genotypes GNG-2372, RG-2015-08, JG-16, GNG-1969, GNG-2081 and KGD-2013-2 bear paired pod at single peduncle. Choudhury *et al.* (2014) also identified best genotypes from a set of 47 germplasm based on the performance of quantitative traits such as number of pods per plant, seed weight and seed yield per plant.

CONCLUSION

The studied traits showed considerable variation among studied germplasm. The traits days to 50% flowering, days to maturity, number of secondary branches, number of pod per plant and number of seed per pod exhibited sufficient variability that could be used as potential parental lines for crossing program. Six genotypes bear double podded having a high yield compared to single podded genotypes. The genotype ICVT-181118 found to be an early maturing may be used to develop early maturing, high yielding breeding material suitable for drought and heat tolerance under the Bundelkhand region. The genotype ICVT-181103 had a higher yield that could be used as direct selection for high yield and can be tested in a varietal testing program.

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