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Genetic Diversity Analysis, Characterization and Evaluation of Elite Chickpea (*Cicer arietinum* L.) Genotypes

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A B S T R A C T

The 60 elite chickpea genotypes were morphologically characterized and classified as per the guidelines for the conduct of DUS test of chickpea (*Cicerarietinum* L.)by the PPV&FRA, 2007, GOI. Among 13 DUS traits observed; seven traits were found tri-morphic, four traits di-morphic and two traitspolymorphic among 60 chickpea genotypes indicated the existence of remarkable amount of genetic variability that have great potential to assign distinctive morphological profiles which could be used for varietal identification and characterization. The Non-hierarchical Euclidean cluster analysis using 11 quantitative traits revealed the maximum inter-cluster distances between cluster III & VII (7.84) and cluster III & IV (6.84). The genotypes *viz*., JG-35, JG-315, RSG-931, Vishal, CSJ-741, Vikas, GNG-1958,PG-5, PDG-4, ICCV-6, ICCV-10, JG-11 andICCV-2 were found most diverse among 60 chickpea genotypes which could be used as parents in hybridization programme for more heterotic response and generation of better segregants in chickpea breeding.

Introduction

Chickpea (*Cicer arietinum* L.), commonly known as gram or Bengal gram, is the third most important pulse crop after common bean-*Phaseolus vulgaris* L. and field pea- *Pisum sativum* L. (Aggarwal *et al.*, 2015).Chickpea seed is a good source of carbohydrates and proteins, which collectively constitute 80% of the total dry seed weight (Aggarwal *et al.*, 2013). It also contains on an average of 22% protein, 63% carbohydrates, 4.5% fat, 8% crude fiber and 2.7% ash (Wood and Grusak, 2007) as well as minerals(calcium, magnesium, zinc, potassium, iron and phosphorus) and vitamins especially thiamine and niacin (Jukanti*et al.*, 2012). Moreover, its pod shells and seed coats are used as fodder

(Tahir and Karim, 2011). The assessment of genetic diversity is important not only for crop improvements but also efficient management and conservation of germplasm resources. Varietal descriptions provided by the concerned plant breeders are generally inadequate to characterize a variety.

Therefore, there is a great need to characterize the genotypes and to identify the varietal purity. Identification and characterization of new cultivars are also essential for their efficient utilization and germplasm conservation in any crop improvement programme.

Since, a variety attains acceptance only when farmers get genetically pure seeds of high standards. Characterization of varieties is great significance for the protection of IPR (intellectual property right) as well as quality seed production and certification. It's simple, cheap and do not require any sophisticated laboratory techniques.

However, the generation of data is liable to influenced by a complex G X E interaction, which can be overcome by developing and publishing DUS descriptors, skillful and experienced breeder through awareness about trait diversity. Genetic diversity is the basic requirement of any breeding programme aimed at genetic amelioration of yield (Shafique *et al.,* 2016).It isa pre-requisite in effective hybridization programme for the selection of parents intended to more heterotic responses and potential source of better segregants in subsequent generations for various characters (Dwevedi and Lal, 2009).

Modern plant breeding and agricultural systems have narrowed the base for the genetic diversity of cultivated chickpea. Therefore, it is time to explore new sources of variation that might be used in plant breeding programmes.

Materials and Methods

The experimental material comprised of 60 elite chickpea genotypes (Table1) from chickpea germplasm maintained at Pulses Section, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar (Haryana, India). These genotypes were evaluated in Randomized Block Design (RBD) with three replications during *Rabi* 2014-15following the recommended agronomical package of practices. The observations were recorded on13 DUS traits for morphological characterization and classification of chickpea genotypes as per the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability (DUS) on chickpea (*Cicer arietinum* L.) approved by the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) in 2007, Government of India (Table 2) as well as 11 quantitative traits (days to 50% flowering, days to maturity, number of secondary branches per plant, number of pods per plant, plant height (cm), number of seeds per pod, 100 seed weight (g), seed yield per plant (g), standard germination (%), seedling length (cm) and seed vigour index-I) to assess the genetic divergence by Non-hierarchical Euclidean cluster analysis (Spark, 1973) based on Ward's minimum variance method using INDOSTAT software.

Morphological characterization

Anthocyanin pigmentation on stem is one of most important morphological markers in chickpea germplasm and discriminated into two groups based on their presence or absence. The pigmentation was present in all the *Desi* types (45 genotypes) and absent in the *Kabuli* types of chickpea (15 genotypes). Chickpea cultivars were classified into three groups based on plant growth habit *viz*., erect, semi-erect and spreading (Table 3). The *Desi* types exhibited all types of growth habit,

whereas, *Kabuli* types semi-erect and spreading types of growth habit (Plate- 1). Both the traits were found distinct, uniform and stable in chickpea cultivars that could be used in varietal identifications as well as characterization of chickpea germplasm for their conservation.

The chickpea genotypes were classified into four groups based on foliage colour, *viz*., Light green, Medium green, Dark green and Greenish purple (Table 4).Only first three types of foliage colour were observed in 60 chickpea genotypes. Based on leaflet size, the chickpea genotypes were classified into three categories *viz*., small (<10mm), medium (10-15mm) and large (>15mm). The *Desi* types constituted small to large types, while, medium to large in the *Kabuli* types (Table 5). Both the leaf traits(foliage colour and leaflet size) were quite useful in the characterization of chickpea germplasm but more affected by environmental factors due to the polygenic control and more GX E interactions.

On the basis of number of flowers per peduncle, all the chickpea genotypes were classified into two groups. The *Kabuli* types had single flower per peduncle and in the *Desi* types only two genotypes (RSG-931 and CSJ-741) showed twin number of flowers per peduncle and remaining others had single flower per peduncle (Plate- 2).On the basis of flower colour, the chickpea genotypes were classified into three groups *viz*., pink, white and blue colour. The flower colour observed as pink in all the 45 *Desi* genotypes and white in all the 15 *Kabuli* genotypes (Plate- 3). Flower colour is reliable morphological marker and distinguishing the chickpea genotypes into two main types. The *Kabuli* types always exhibited white flower colour which could be typically used for varietal identification. The chickpea genotypes were classified into two categories on the basis of absence or presence of stripes on flower. All the *Desi* types had stripes on flower (45 genotypes), whereas, the *Kabuli* types were without stripes (15 genotypes). On the basis of peduncle length, the chickpea genotypes were classified into three main categories presented in Table 6 *viz*., short (<5mm), medium (5-10mm) and long (>10mm). Most of the genotypes were having medium peduncle length. The flower characteristics are most important morphological marker to distinguish the two types of chickpea.

On the basis of pod size, the 60 chickpea genotypes were classified into three categories *viz*., small (<15 mm), medium (15-20 mm) and large (>20 mm). The *Desi* types had small to large type, while, the *Kabuli* type showed medium to large in pod size. Most of the genotypes showed medium to large pod size (Table 7). Chickpea pod size was found to variable due to polygenic control and, genotypic and environmental interactions.

Chickpea cultivars were classified into different groups based on seed colour, seed size, seed testa texture and seed type. On the basis of seed colour, all the 60 genotypes were categorized into seven groups presented in Table 8. Based on seed shape, the 60 chickpea genotypes were classified into three groups (Angular, owl's & pea shapes). The seed shape was observed as angular in 38 genotypes, owl's shape in 22 genotypes and none was found in pea shaped (Plate- 4). On the basis of seed testa texture, the chickpea genotypes were classified into three groups *viz*., rough, smooth and tuberculated. Most of the genotypes showed rough seed testa texture except two *Kabuli* types (BG-1053 and IPCK 10-151) which exhibited smooth texture and no genotype was found in tuberculated texture (Plate- 5).Among 60 chickpea genotypes studied, 45 genotypes were classified as the *Desi* types and 15 genotypes as the *Kabuli* types based on the seed type (Plate- 6).With respect to seed characteristics, results are

consistent with the results obtained earlier in chickpea.

Genetic Diversity analysis

The Non-hierarchical Euclidean cluster analysis grouped 60 chickpea genotypes into seven distinct clusters. Clustering pattern revealed that cluster VI was the largest group (13 genotypes) and cluster VII (4 genotypes)was smallest (Fig. 1). The maximum intra-cluster distances were shown by cluster III (3.71) and cluster VI (3.54), while, minimum by cluster VII (2.92) and cluster V (2.39) in Table 9. The maximum inter-cluster distance were displayed between cluster III & VII (7.84) followed by cluster III & IV (6.84), while, minimum by cluster II & V (3.57), followed by clusters IV & V (3.81) in Table 9.

The cluster means of chickpea genotypes for 11 quantitative traits revealed considerable differences among all the clusters (Table 10). It was evident that cluster VII had the highest mean value for number of seeds per pod (1.53), germination *per cent* (85.33), seedling length (30.44) and seed vigour index-I (2664.40), whereas, lowest for morpho-phenological traits *viz*., days to 50% flowering (77.08) and days to maturity (126.00). Cluster IV showed the maximum mean value for number of secondary branches per plant (8.11), number of pods per plant (71.52) and seed yield per plant (19.87). The above comparison indicated that traits of cluster IV and VII had the highest mean value for most of the yield contributing traits. Hence, the genotypes included in the cluster IV (GNG-1958, PG-5, PDG-4, BG-3028, & IPCK 2010-92) and cluster VII (ICCV-6, ICCV-10, JG-11 & ICCV-2) were more divergent than the other clusters. Among the 13 morphological DUS traits observed; seven were tri-morphic *viz*., plant growth habit, leaflet size, flower colour, peduncle length, pod size, seed shape and seed testa texture, four traits di-morphic*viz*., anthocyanin pigmentation on stem, number of flowers per peduncle, stripes on flower and seed type, and two traits polymorphic *viz*., foliage colour and seed colour among the 60 elite chickpea genotypes indicated the existence of remarkable amount of genetic variability in these genotypes that have great potential to assign distinctive morphological profiles from combination of morphological DUS traits which could be used for varietal identification and characterization as well as selection of diverse parents in hybridization programme for more heterotic response and generation of better segregants in chickpea breeding. The anthocyanin pigmentation on stem, flower characteristics as well as seed characteristics were able to distinguish chickpea genotypes distinctively, found uniformly, consistently and least affected by environmental factors which could be used for assigning a distinctive morphological profile for germplasm characterization in chickpea. Similar results were described by Archak*et al.,* 2016 for 12 qualitative traits in chickpea *viz*., early plant vigor, plant growth habit, plant pigmentation, number of leaflets per leaf, leaflet size, plant pubescence, flower color, biomass, pod shape, seed color, seed shape and seed surface.

Non-hierarchical Euclidean cluster analysis using Ward's minimum variance method grouped 60 chickpea genotypes into non-overlapping seven distinct clusters indicated the presence of substantial amount of genetic diversity among these genotypes. The genotypes of higher intra- and inter-cluster distances have more genetic divergence than the genotypes of minimum intra- and inter-cluster distances. Therefore, the genotypes of cluster III & VII and cluster III & IV could be used as parents in chickpea hybridization programme for obtaining high heterotic response and high frequency of desirable recombinants in the segregating generations.

Table.1 List of 60 elite chickpea genotypes used for morphological DUS characterization and genetic diversity analysis

SN	Genotypes	Developed by	SN	Genotypes	Developed by
1.	BG 372	IARI, New Delhi	31.	RSG 963	RARI, Durgapura
2.	C 235	PAU, Ludhiana	32.	WR 315	Maintained at CCS HAU
3.	CSG 8962	CSSRI, Karnal	33.	DKG 876	CSK HPK, Dhaulakuan
4.	DCP 92-3	IIPR, Kanpur	34.	E 100Ym	CCSHAU, Hisar
5.	GNG 663	ARS, RAU, Sriganganagar	35.	H 00-256	CCSHAU, Hisar
6.	GNG 1581	ARS, RAU, Sriganganagar	36.	H 04-99	CCSHAU, Hisar
7.	GNG 1958	ARS, RAU, Sriganganagar	37.	H 07-157	CCSHAU, Hisar
8.	GNG 1999	ARS, RAU, Sriganganagar	38.	H 08-18	CCSHAU, Hisar
9.	Gaurav	CCSHAU, Hisar	39.	H 09-96	CCSHAU, Hisar
10.	H-208	CCSHAU, Hisar	40.	H 10-57	CCSHAU, Hisar
11.	HC-1	CCSHAU, Hisar	41.	Rajas	MPKV, Rahuri
12.	HC-3	CCSHAU, Hisar	42.	Vishal	MPKV, Rahuri
13.	HC-5	CCSHAU, Hisar	43.	Vikas	MPKV, Rahuri
14.	Hima	Maintained at CCS HAU	44.	GNG 2146	ARS, RAU, Sriganganagar
15.	ICC 4958	ICRISAT, Hyderabad	45.	CSJ 741	RARI, Durgapura
16.	ICCV 6	IIPR, Kanpur	46.	BG 1053	IARI, New Delhi
17.	ICCV 10	ICRISAT, Hyderabad	47.	BG 3028	IARI, New Delhi
18.	JG 11	JNKVV, Jabalpur	48.	GNG 1969	ARS, RAU, Sriganganagar
19.	JG 35	JNKVV, Jabalpur	49.	HK 1	CCSHAU, Hisar
20.	JG 315	JNKVV, Jabalpur	50.	HK 2	CCSHAU, Hisar
21.	Katila	Maintained at CCS HAU	51.	HK 4	CCSHAU, Hisar
22.	NARC 9006	Maintained at CCS HAU	52.	ICCV 2	ICRISAT, Hyderabad
23.	Pusa 547	IARI, New Delhi	53.	JGK 1	JNKVV, Jabalpur
24.	PBG 5	PAU, Ludhiana	54.	JGK 27	JNKVV, Jabalpur
25.	PDG 4	PAU, Ludhiana	55.	L 550 (K)	PAU, Ludhiana
26.	PDG 84-16	PAU, Ludhiana	56.	Virat	MPKV, Rahuri
27.	PG 5	MPKV, Rahuri	57.	GNG 2237	ARS, RAU, Sriganganagar
28.	PG 517	MPKV, Rahuri	58.	HK 07-234	CCSHAU, Hisar
29.	RSG 888	RARI, Durgapura	59.	IPCK 2010-92	IIPR, Kanpur
30.	RSG 931	RARI, Durgapura	60.	IPCK 10-151	IIPR, Kanpur

Table.2 Guidelines for DUS test by PPV&FRA, 2007 for 13 morphological DUS traits on chickpea

SN	Characteristics	States	Observation stage
1.	Anthocyanin pigmentation on stem	Absent/ Present.	Before flowering
2.	Plant growth habit	Erect (0-15º from vertical)/ Semi-erect (16-60º from vertical)/ Spreading (61-80º from vertical).	At 50% flowering
3.	Foliage colour	Light green/ Medium green/ Dark green/ Greenish purple.	
4.	Leaflet size (Length)	Small (<10 mm)/ Medium (10-15 mm)/ Large (>15 mm).	
5.	Number of flowers/ peduncle	Single/ Twin.	
6.	Flower colour	White/ Pink/ Blue.	
7.	Stripes on flower	Absent/ Present.	
8.	Peduncle length	Short (<5 mm)/ Medium (5-10 mm)/ Long (>10 mm).	Pod development
9.	Pod size	Small (<15 mm) / Medium (15-20 mm) / Large (>20 mm).	Harvest maturity
10.	Seed colour	Beige (*Kabuli*)/ Creamy beige/ Green/ yellow/ Orange brown/ Dark brown/ Grey black.	30 days after harvest
11.	Seed shape	Pea-shaped/ Owl's head/ Angular.	
12.	Seed testa texture	Rough/ Smooth/ Tuberculated.	
13.	Seed type	*Desi*/ *Kabuli*.	

Table.3 Classification of 60 chickpea genotypes on the basis of plant growth habit

Erect (6)	**GNG-1958, Gaurav, HC-5, DKG-876, H 09-96, GNG-2146.**
Semi-erect (40)	BG-372, C-235, CSG-8962, DCP 92-3, GNG-663, GNG-1581, GNG-1999, H-208, HC-3, ICCV-10, JG-11, JG-35, JG-315, NARC-9006, Pusa-547, PBG-5, PDG-4, PG-5, RSG-888, RSG-931,RSG-963, E-100Ym, H 00-256, H 04-99, H 07-157, H 10-57, Rajas, Vishal, Vikas, CSJ-741, BG-1053, BG-3028, GNG-1969, HK-1, HK-2, HK-4, ICCV-2, JGK-27, Virat, GNG-2237.
Spreading (14)	HC-1, Hima, ICC-4958, ICCV-6, Katila, PDG 84-16, PG-517, WR-315, H 08-18, JGK-1, L-550, HK 07-234, IPCK 2010-92, IPCK 10-151.

Table.4 Classifications of 60 chickpea genotypes on the basis of foliage colour

Light green (6)	**BG-372, GNG-663, Gaurav, PDG 84-16, CSJ-741, BG-3028.**
Medium green (19)	DCP 92-3, HC-3, Hima, ICC-4958, JG-315, RSG-963, WR-315, E-100Ym, H 00-256, H 04-99, H 10-57, Rajas, Vishal, GNG-1969, HK-2, ICCV-2, JGK-27, L-550, IPCK-2010-92.
Dark green (35)	C-235, CSG-8962, GNG-1581, GNG-1958, GNG-1999, H-208, HC-1, HC-5, ICCV-6, ICCV-10, JG-11, JG-35, Katila, NARC-9006, Pusa-547, PBG-5, PDG-4, PG-5, PG-517, RSG-888, RSG-931, DKG-876, H 07-157, H 08-18, H 09-96, Vikas, GNG-2146, BG-1053, HK-1, HK-4, JGK-1, Virat, GNG-2257, HK 07-234, IPCK 10-151.

Table.5 Classifications of 60 chickpea genotypes on the basis of leaflet size

Small (22)	**DCP 92-3, GNG-663, H-208, HC-1, BG-372, C-235, CSG-8962, GNG-1581, GNG-1999, Gaurav, HC-5, Hima, ICCV-10, JG-315, PDG-4, PDG 84-16, RSG-888, WR-315, H 07-157, H 09-96, H 10-57, Vikas.**
Medium (33)	ICCV-6, PG-517, RSG-931, DKG-876, E-100Ym, Rajas, HC-3, Katila, Pusa-547, PG-5, H 00-256, H 08-18, GNG-2146, CSJ-741, BG-1053, GNG-1969, HK-4, ICC-4958, JG-11, NARC-9006, PBG-5, RSG-963, H 04-99, Vishal, BG-3028, HK-1, Virat, GNG-1958, HK-2, ICCV-2, JGK-1, JGK-27, IPCK 10-151.
Large (5)	JG-35, L-550, HK 07-234, IPCK 2010-92, GNG-2237.

Table.6 Classification of 60 chickpea genotypes on the basis of peduncle length

Short (2)	**PDG-4, PG-5.**
Medium (38)	BG-372, C-235, CSG-8962, H-208, GNG-1958, GNG-1999, Gaurav, H 09-96, DCP 92-3, GNG-663, GNG-1581, HC-1, HC-5, Hima, ICCV-6, ICCV-10, JG-315, NARC-9006, Pusa-547, RSG-888, RSG-931, RSG-963, DKG-876, E-100Ym, H 04-99, H 07-157, H 10-57, Vikas, IPCK 10-151, HC-3, PBG-5, PDG 84-16, PG-517, H 00-256, Vishal, GNG-2146, CSJ-741, BG-1053.
Long (20)	ICC-4958, JG-35, WR-315, H 08-18, Rajas, L-550, Virat, JGK-1, JGK-27, JG-11, BG-3028, GNG-1969, HK-1, HK-4, ICCV-2, HK-2, GNG-2237, Katila, HK 07-234, IPCK 2010-92.

Table.7 Classification of 60 chickpea genotypes on the basis of pod size

Small (6)	**Hima, BG-372, GNG-1999, H-208, WR-315, GNG-663.**
Medium (30)	RSG-963, H 10-57, HC-5, H 00-256, C-235, GNG-1958, PDG 84-16, HC-1, CSJ-741, H 09-96, RSG-888, DCP 92-3, Katila, CSG-8962, RSG-931, H 07-157, PDG-4, GNG-1581, H 08-18, ICCV-6, Vikas, JG-315, E-100Ym, Gaurav, HC-3, DKG-876, ICC-4958, PG-517, JG-11, Vishal.
Large (24)	Rajas, H 04-99, GNG-2146, NARC-9006, Pusa-547, PBG-5, ICCV-10, HK-1, IPCK 10-151, IPCK 2010-92, PG-5, GNG-1969, L-550, Virat, JG-35, ICCV-2, HK 07-234, JGK-27, HK-4, BG-1053, JGK-1, GNG-2237, HK-2, BG-3028.

Table.8 Classification of chickpea genotypes on the basis of seed colour

Creamy (4)	**GNG-1969, JGK-1, Virat, IPCK 10-151.**
Creamy white (11)	BG-1053, BG-3028, HK-1, HK-2, HK-4, ICCV-2, JGK-27, L-550, GNG-2237, HK 07-234, IPCK 2010-92.
Green (1)	Hima.
Light reddish brown (13)	C-235, CSG-8962, Gaurav, DCP 92-3, GNG-663, GNG-1581, GNG-1958, JG-315, Katila, NARC-9006, PDG-4, RSG-888, GNG-2146.
Reddish brown (12)	BG-372, ICC-4958, ICCV-10, JG-35, PDG 84-16, PG-5, PG-517, E-100Ym, H 04-99, Rajas, Vishal, CSJ-741.
Light yellowish brown (8)	H 10-57, GNG-1999, RSG-963, WR-315, DKG-876, H 09-96, Vikas, PBG-5.
Yellowish brown (11)	H-208, HC-1, HC-3, HC-5, ICCV-6, JG-11, Pusa-547, RSG-931, H 00-256, H 07-157, H 08-18.

Table.9 Intra (diagonal) and Inter-cluster (above diagonal) distances for 60 chickpea genotypes

	Cluster I	**Cluster II**	**Cluster III**	**Cluster IV**	**Cluster V**	**Cluster VI**	**Cluster VII**
Cluster I	**3.09**	4.27	5.59	4.84	3.72	5.58	5.71
Cluster II		**3.26**	4.35	5.74	3.57	5.00	5.83
Cluster III			**3.71**	6.84	4.78	**6.14**	**7.84**
Cluster IV				**3.03**	3.81	4.86	5.72
Cluster V					**2.39**	4.10	5.04
Cluster VI						**3.54**	4.72
Cluster VII							**2.92**

Table.10 Cluster means of various quantitative traits of chickpea genotypes

Clusters	**DF**	**DM**	**SB/P**	**Pd/P**	**PH**	**Ss/Pd**	**100SW**	**SY/P**	**SG**	**SL**	**SVI-I**
I	89.94	145.49	7.64	45.52	47.88	1.51	15.11	13.72	83.52	28.95	2419.5
II	88.70	142.76	6.04	37.61	56.13	1.38	17.79	10.57	79.37	29.31	2327.0
III	90.60	150.47	5.80	39.40	55.80	1.23	23.21	10.10	79.00	26.71	2110.8
IV	90.48	148.00	**8.11**	**71.52**	57.82	1.43	23.27	**19.87**	85.07	30.44	2589.8
V	89.21	142.50	6.96	54.33	58.75	1.40	19.73	15.43	82.00	29.23	2396.1
VI	86.07	134.80	6.47	53.00	**60.33**	1.37	**33.17**	12.95	83.13	30.62	2546.1
VII	**77.08**	**126.00**	5.58	53.00	56.58	**1.53**	20.68	14.52	**85.33**	**31.21**	**2664.4**
Mean	88.43	142.87	6.75	48.83	55.57	1.41	20.31	13.61	82.02	29.42	2415.3

DF-Days to 50 *percent* flowering, DM- Days to maturity, SB/P- Number of secondary branches per plant, Pd/P- Number of pods per plant, PH - Plant height (cm), Ss/Pd- Number of seeds per pod, 100SW (g)-100 seed weight (g), SY/P- Seed yield per plant (g), SG (%)- Standard germination (%), SL (cm)- Seedling length (cm), SVI-I- Seed vigour Index-I.

Plate.1 Plant growth habit

Plate.2 Number of flowers per peduncle

Plate.3 Flower colour

Plate.4 Seed shape

Plate.5 Seed texta textures

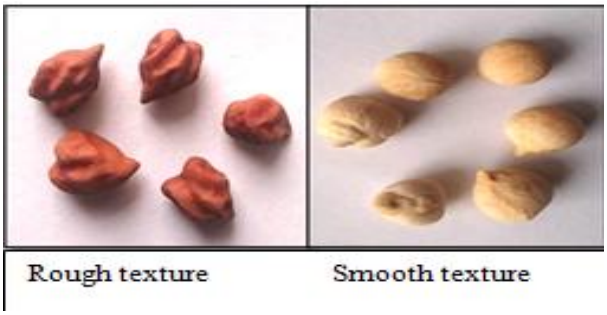
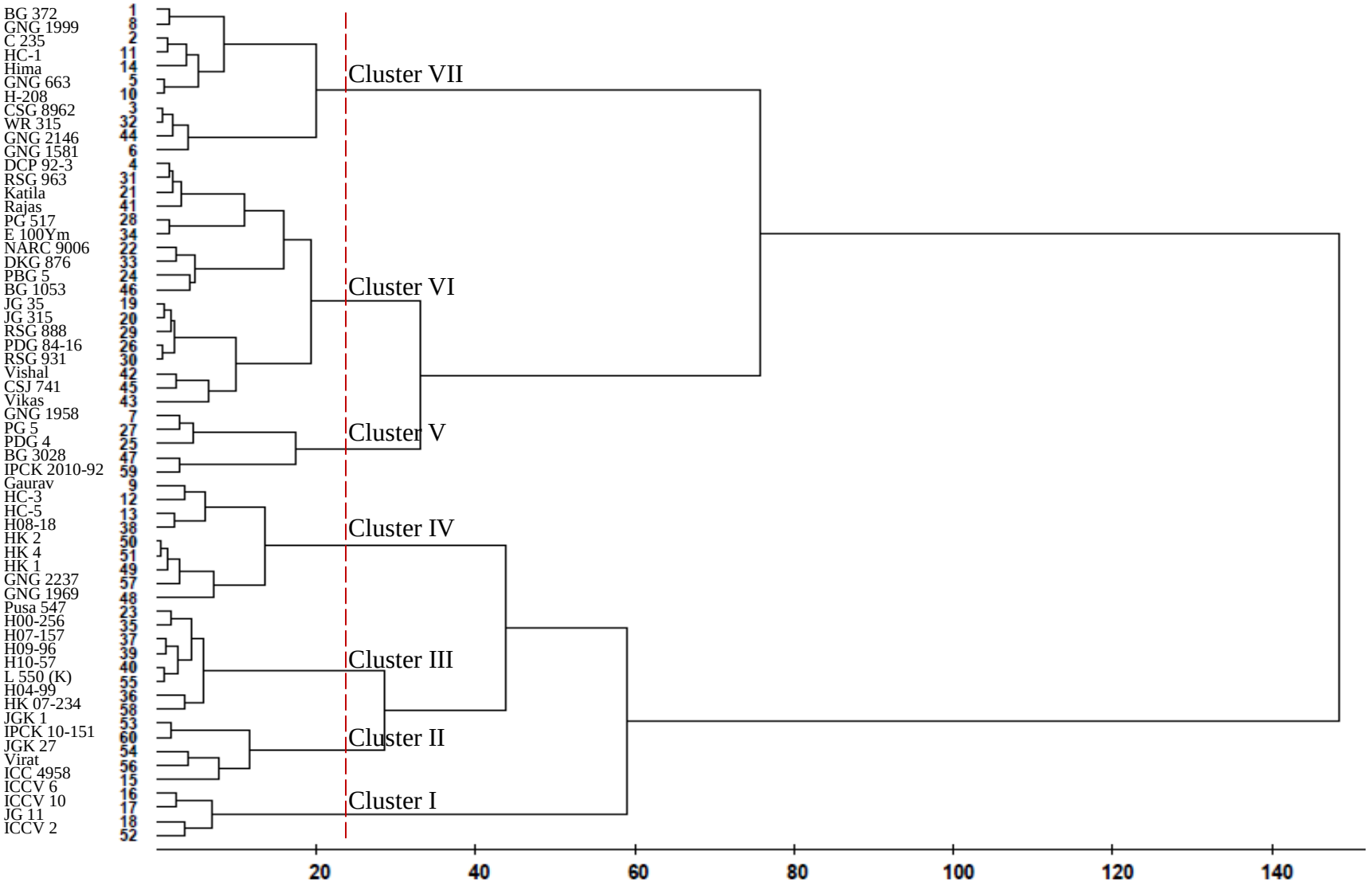


Plate.6 Seed types

Fig.1 Dendrogram showing clustering pattern of 60 elite chickpea genotypes for seed yield and its component trait



The genotypes of cluster III, IV and VII (JG-35, JG-315, RSG-888, PDG 84-16, RSG-931, Vishal, CSJ-741, Vikas; GNG-1958,PG-5, PDG-4, BG-3028, IPCK 2010-92; ICCV-6, ICCV-10, JG-11 andICCV-2, respectively) had highest inter-cluster distances as well as higher cluster means for most of the yield component traits indicated that these genotypes were most diverse among 60 elite chickpea genotypes which could be used as parents in hybridization programme of chickpea breeding. The above findings are broadly in agreement with the report of Dwevedi and Lal, 2009; Yadav*et al.,* 2010 and Ojha*et al.,* 2011.

Genetic diversity analysis and morphological DUS characterization among 60 chickpea genotypes were differed significantly for 13 morphological DUS traits and 11 quantitative traits, indicating a large and exploitable amount of genetic variability in these genotypes. The morphological DUS descriptors *viz*., anthocyanin pigmentation on stem, flower characteristics as well as seed characteristics were able to distinguish chickpea genotypes distinctively, uniformly and consistently, and least affected by environmental factors which could be used for assigning a distinctive morphological profile for germplasm characterization in chickpea. Thus, characterization of varieties is in great significance for the identity of a variety, germplasm conservation, protection of IPR rights, maintenance of genetic purity of seed lots and comparisons of breeding lines (Inbreds, purelines and hybrids) for the practical application of plant breeding in the field. Genetic diversity analysis based on Non-hierarchical Euclidean cluster analysis also displayed substantial amount of genetic diversity in the chickpea genotypes *viz*., JG-35, JG-315, RSG-888, PDG 84-16, RSG-931, Vishal, CSJ-741, Vikas, GNG-1958, PG-5, PDG-4, BG-3028, IPCK 2010-92; ICCV-6, ICCV-10, JG-11 and ICCV-2 which could be used in future breeding programme of chickpea for development of elite breeding materials.

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