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Research Article

Morphological characterization of early duration pigeonpea genotypes

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Abstract
The DUS test is an important tool for cataloguing the genotypes and utilization of variants in the crop improvement programme. In the present investigation, a total of 55 early duration pigeonpea genotypes were categorized by descriptors and cluster analysis for 21 agro morphological traits. Wide variations were observed in the characters *viz.,* flower colour, a pattern of streaks, pod colour, seed colour, seed shape and size and no much variation was observed for the remaining traits. The traits *viz.,* earliness and prominent type of pod constriction were identified in all the genotypes. The genotypes were partitioned into six clusters. Cluster I encompass 32 genotypes; cluster II consists of seven genotypes; four genotypes each were placed in clusters III and V; clusters IV and VI comprised of five and three genotypes, respectively. In the present study, the DUS descriptors and the variation observed in the early duration pigeonpea genotypes will form the basis for designing the pigeonpea improvement programme.

Keywords: DUS, descriptors, early duration pigeonpea, genotypes, cluster.

INTRODUCTION

Pigeonpea *Cajanus cajan* (L.) Millsp. is the principal legume crop occupying the second most significant position among the pulse crops in India. India pioneers in pigeonpea production with 43.16 lakh tonnes cultivated under 47.24 lakh ha with the mean yield of 914 kg/ha in 2020-21 (*www.indiastat.com*). In Tamil Nadu, 0.50 lakh metric tonnes of pigeonpea are produced from 0.47 lakh ha with the productivity of 1049 kg/ha (*www.indiastat.com*). The crop is acclimatized to a wide range of ecological conditions which can withstand drought. It contains high levels of protein with 57.3 to 58.7 per cent carbohydrate, 1.2 to 8.1 per cent crude fibre and 0.6 to 3.8 per cent of lipids (Patel *et al*., 2018). The “Protection of Plant Varieties and Farmers Act” (PPV&FRA) in 2001 was legislated by the Government of India for providing protection to plant varieties based on distinctiveness, uniformity and stability (DUS) tests apart from novelty. The uniqueness of a particular variety can be determined by DUS testing and it will be utilized for varietal identification, registration and protection. The traits identified during characterization can also be used for categorizing similar genotypes into different clusters. A dendogram is the representation of relationships of similar genotypes. In this context, an attempt was made to distinguish 50 pigeonpea germplasm based on different morphological traits and to identify the persisting variability.

MATERIALS AND METHODS

The experimental material used in the present research comprises of 55 early duration pigeonpea genotypes (110 – 135 days duration) obtained from Dr. Ramiah gene bank and Department of Pulses, Tamil Nadu Agricultural University, Coimbatore which was listed in **Table 1**. The experiment was raised in an augmented block design

Table 1. List of pigeonpea genotypes used

S. No.	Genotype	Source	S. No.	Genotype	Source
1.	CRG 9407	TNAU, Coimbatore	29.	PUSA 992	IARI, New Delhi
2.	CRG 5	TNAU, Coimbatore	30.	IPAE 19-04	IIPR, Kanpur
3.	CRG 16- 04	TNAU, Coimbatore	31.	PAU 881	PAU, Ludhiana
4.	CRG 16- 01	TNAU, Coimbatore	32.	PA 662	GBPAU & T, Pantnagar
5.	ICPL 88001	ICRISAT, Hyderabad	33.	PA 663	GBPAU & T, Pantnagar
6.	ICPL 86020	ICRISAT, Hyderabad	34.	IPAE 15-08	IIPR, Kanpur
7.	ICPL 84031	ICRISAT, Hyderabad	35.	CRG 16-12	TNAU, Coimbatore
8.	ICPL 91045	ICRISAT, Hyderabad	36.	Pusa Arhar 21-1	IARI, New Delhi
9.	ICPL 88027	ICRISAT, Hyderabad	37.	PA 291	GBPAU & T, Pantnagar
10.	ICPL 11255	ICRISAT, Hyderabad	38.	PA 662	GBPAU & T, Pantnagar
11.	ICPR 2447	ICRISAT, Hyderabad	39.	PA 669	GBPAU & T, Pantnagar
12.	ICP 245535	ICRISAT, Hyderabad	40.	AL 2250	PAU, Ludhiana
13.	ICP 245517	ICRISAT, Hyderabad	41.	IPAE 15-03	IIPR, Kanpur
14.	ICP 245527	ICRISAT, Hyderabad	42.	RVKT 333	ICRISAT, Hyderabad
15.	ICP 245541	ICRISAT, Hyderabad	43.	WRG 65	RARS, Warangal
16.	ICP 12527	ICRISAT, Hyderabad	44.	PAH 10	GBPAU & T, Pantnagar
17.	ICP 10697	ICRISAT, Hyderabad	45.	BRG 4	UAS, Bangalore
18.	IC 525466	ICRISAT, Hyderabad	46.	BSMR 203	MAU, Maharashtra
19.	IC 9066	ICRISAT, Hyderabad	47.	BSMR 175	MAU, Maharashtra
20.	AL 601	PAU, Ludhiana	48.	BSMR 164	MAU, Maharashtra
21.	VBN 1	NPRC, Vamban	49.	BSMR 79	MAU, Maharashtra
22.	PA 128	GBPAU & T, Pantnagar	50.	BSMR 736	MAU, Maharashtra
23.	AH 17-13	ICRISAT, Hyderabad	51.	CO (RG) 7	TNAU, Coimbatore
24.	AL 2207	PAU, Ludhiana	52.	VLA 1	ICRISAT, Hyderabad
25.	PUSA 2020-2	IARI, New Delhi	53.	UPAS 120	GBPAU & T, Pantnagar
26.	PA 650	GBPAU & T, Pantnagar	54.	APK 1	RRS, Aruppukottai
27.	AH 17-28	ICRISAT, Hyderabad	55.	VBN 3	NPRC, Vamban
28.	NAM 88	ICRISAT, Hyderabad			

(ABD) II with four blocks during *Rabi,* 2021-22 and genotypes were raised in a single row with 4 m length and a spacing of 60 x 20 cm.

Twenty-one agro morphological traits *viz.,* anthocyanin colour of hypocotyl, branching pattern, time of flowering, plant growth habit, stem colour, leaf shape, pubescence on the lower surface of the leaf, plant height, flower colour of the base of the standard petal, flower pattern of streaks on the standard petal, the colour of the pod, pod pubescence, pod waxiness, pod surface stickiness, pod constriction, pod length, the number of seeds per pod, seed colour pattern, seed shape and size of seed (100 seed weight) were recorded. The genotypes were evaluated for each trait in five randomly selected plants based on the note number given according to the National Test guidelines for DUS characters in pigeonpea.

Anthocyanin colouration of hypocotyl was recorded during the seedling stage. The traits *viz.,* branching pattern, time of flowering, growth habit, stem colour, leaf shape, leaf pubescence, flower colour and pattern of streaks in flower were observed during the flowering stage. The pod features *viz.,* colour, pubescence, waxiness, stickiness, constriction and size were observed during the pod development stage. The colour of the seed, plant height, seed colour pattern, seed shape and 100 seed weight were recorded at harvest. Using qualitative characters, hierarchical clustering was performed by calculating Euclidean distance and the cluster diagram was constructed by NJ (Neighbour Joining) dendogram using GGT 2.0 Software (Kujane *et al.,* 2019).

RESULTS AND DISCUSSION

The genotypes were characterized and their absolute and relative frequencies were computed and the results were depicted in **Table 2**.

Anthocyanin colouration was present in 47 genotypes (85.55 %) and absent in eight genotypes (14.45 %) which indicates the anthocyanin colouration of hypocotyl can be seen in most of the pigeonpea germplasm accessions studied. Muniswamy *et al.* (2014) and Metkar and Gawande (2014) reported that the presence of anthocyanin colouration is more prominent in pigeonpea. This trait will be useful in breeding programmes for differentiation of genotypes and also in maintenance breeding. All the genotypes taken for the study fall under the early duration

Table 2. Classification of the early duration pigeonpea genotypes based on DUS characters

S. No	Qualitative characters	Descriptors	Note	Absolute frequency	Relative frequency (%)	Germplasm
1.	Plant anthocyanin colouration of hypocotyl	Absent	1	08	14.45	ICPR 2447, NAM 88, BRG 4, BSMR 736, VLA1, UPAS 120, APK 1, VBN 3.
		Present	9	47	85.55	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, CO(RG)7.
2.	Plant branching pattern	Erect (<30°)	3	24	43.63	CRG 9407, CRG 5, CRG 16- 04, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICP 245535, AL 601, VBN 1, PA 128, PUSA 2020-2, NAM 88, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, Pusa Arhar 21-1, PA 291, APK 1, VBN 3.
		Semi-spreading (30°-60°)	5	31	56.37	CRG 16- 01, ICPR 2447, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AH 17-13, AL 2207, PA 650, AH 17-28, IPAE 19-04, IPAE 15-08, CRG 16-12, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BRG 4, BSMR 203, BSMR 175, BSMR 164, BSMR 79, BSMR 736, Co(RG)7, VLA1, UPAS 120.
		Spreading (>60°)	7	0	0.00	NIL
3.	Time of flowering (50% of the plants with at least one open flower)	Very early (< 60 days)	1	0	0.00	NIL
		Early (61-90 days)	3	55	100	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
		Medium (90-130 days)	5	0	0.0	NIL
		Late(131-160days)	7	0	0.00	NIL
		Very late (>160 days)	9	0	0.00	NIL
4.	Plant growth habit	Determinate	1	03	05.45	ICPL 86020, ICPL 11255, APK 1.
		Indeterminate	3	52	94.55	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 84031, ICPL 91045, ICPL 88027, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, VBN 3.

5.	Stem colour	Green	1	26	47.27	CRG 9407, CRG 16- 04, ICPL 86020, ICPL 84031, , ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245541, AL 601, PA 128, AH 17-13, PUSA 2020-2, AH 17-28, NAM 88, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 291, AL 2250, IPAE 15-03, BSMR 79, BSMR 736, CO(RG)7.
		Purple	2	29	52.73	CRG 5, CRG 16- 01, ICPL 88001, ICPL 91045 ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, VBN 1, AL 2207, PA 650, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 662, PA 669, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BRG 4, VLA1, UPAS 120, APK 1, VBN 3.
6.	Leaf shape	Oblong	1	50	90.91	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, PAH 10, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, CO(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
		Obovate	3	04	07.27	ICPL 86020, WRG 65, BSMR 203, BSMR 175.
		Narrowly oblong	5	01	01.82	PUSA 992.
7.	Leaf pubescence on lower surface of the leaf	Absent	1	04	07.27	ICPL 11255, ICPR 2447, ICP 245527, UPAS 120.
		Present	9	51	92.73	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICP 245535, ICP 245517, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, APK 1, VBN 3.
8.	Flower colour of base of petal (standard)	Light yellow	1	20	36.36	CRG 5, CRG 16- 01, ICPL 88001, ICPL 84031, ICPL 88027, ICPL 11255, ICPR 2447, PA 128, NAM 88, PUSA 992, PA 662, CRG 16-12, Pusa Arhar 21-1, AL 2250, BSMR 203, BSMR 79, PA 662, BRG 4, BSMR 736, VLA1.
		Yellow	2	31	56.36	CRG 9407, CRG 16- 04, ICPL 86020, ICPL 91045, ICP 245517,ICP 245535, ICP 245527, ICP 245541, ICP 12527, IC 525466, IC 9066, AL 601, VBN 1, AH 17-13, AL 2207, PUSA 2020-2, PA 650, PAU 881, PA 663, IPAE 15-08, PA 291, PA 669, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 175, BSMR 164, Co(RG)7, UPAS 120, VBN 3.
		Orange yellow	3	01	01.82	IPAE 19-04.
		Purple	4	0	0.00	NIL
		Red	5	03	05.46	ICP 10697, AH 17-28, APK 1.
9.	Flower pattern of streaks on petal (standard)	Absent	1	06	10.91	CRG 9407, NAM 88, IPAE 15-03, RVKT 333, BSMR 79, BSMR 736.
		Sparse	3	13	23.64	CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 84031, ICPL 88027, ICP 245517, ICP 245541, VBN 1, PA 128, PUSA 992, AL 2250, PAH 10, VBN 3.
		Medium	5	32	58.18	CRG 5, ICPL 86020, ICPL 91045, ICPR 2447, ICP 245535, ICP 245527, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, PUSA 2020-2, PA 650, AH 17-28, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, WRG 65, BSMR 203, BSMR 175, BRG 4, Co(RG)7, VLA1, UPAS 120, APK 1.
		Dense	7	04	07.27	ICPL 11255, AL 2207, PA 669, AH 17-13, BSMR 164.
		Mosaic	9	0	0.00	NIL

10.	Pod colour	Green	1	03	05.46	CRG 9407, BSMR 79, BSMR 736.
		Green with brown streak	2	04	07.27	ICP 10697, AH 17-28, PA 291, PAH 10.
		Green with purple streak	3	47	85.45	CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, BSMR 203, BSMR 175, BSMR 164, NAM 88, BRG 4, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
		Purple	4	0	0.00	NIL
		Dark purple	5	01	01.82	PUSA 2020-2.
11.	Pod pubescence	Absent	1	0	0.00	NIL
		Present	9	55	100	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
12.	Pod waxiness	Absent	1	55	100	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
		Present	9	0	0.00	NIL
13.	Pod surface stickiness	Absent	1	40	72.73	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245541, PA 128, AH 17-13, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 175, NAM 88, BRG 4.
		Present	9	15	27.27	ICPL 86020, ICP 245517, ICP 245527, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, AL 2207, BSMR 203, BSMR 164, BSMR 79, BSMR 736, APK 1.
14.	Pod constriction	Slight	3	0	0.00	NIL
		Prominent	7	55	100	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
15.	Pod length	<4 cm	3	03	05.46	VBN 1, PA 669, RVKT 333.
		Cm	5	50	90.91	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245541, ICP 12527, ICP 10697, IC 525466, IC 9066, AL 601, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, AL 2250, IPAE 15-03, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, NAM 88, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
		>5 cm	7	02	03.63	ICP 245527, IPAE 15-08.

16.	Number of seeds per pod	2	3	0	0.00	NIL
		3	5	17	30.91	CRG 9407, CRG 5, ICPL 84031, ICPL 88027, ICP 10697, AL 601, VBN 1, PA 128, AL 2207, PUSA 2020-2, NAM 88, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, RVKT 333.
		4	7	38	69.09	CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 91045, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, IC 525466, IC 9066, AH 17-13, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, IPAE 15-03, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, BRG 4, BSMR 736, Co(RG)7, VLA1, UPAS 120, APK 1, VBN 3.
17.	Plant height	Short (<100cm)	3	44	80.00	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, IC 525466, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, RVKT 333, NAM 88, VLA1, UPAS 120, APK 1.
		Medium (100-150)	5	11	20.00	ICP 10697, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, BRG 4, BSMR 736, Co(RG)7, VBN 3.
		Tall(>150cm)	7	0	0.00	NIL
18.	Seed colour	Cream	1	05	09.09	CRG 9407, ICPL 84031, IC 9066, BSMR 79.
		Brown	2	44	80.00	CRG 5, CRG 16- 04, CRG 16- 01, ICPL 88001, ICPL 86020, ICPL 91045, ICPL 88027, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 12527, IC 525466, AL 601, VBN 1, AH 17-13, AL 2207, PUSA 2020-2, PA 650, AH 17-28, PUSA 992, IPAE 19-04, PAU 881, PA 662, PA 663, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, PA 669, AL 2250, IPAE 15-03, WRG 65, PAH 10, BSMR 203, BSMR 164, NAM 88, BRG 4, BSMR 736, Co(RG)7, UPAS 120, APK 1, VBN 3.
		Dark brown	3	04	07.28	ICP 10697, ICPL 11255, PA 128, VLA1.
		Grey	4	02	03.63	RVKT 333, BSMR 175.
		Purple	5	00	0.00	NIL
19.	Seed colour pattern	Uniform	1	38	69.09	CRG 9407, CRG 5, CRG 16- 04, CRG 16- 01, ICPL 86020, ICPL 84031, ICPL 91045, ICP 245517, ICP 245527, ICP 245541, ICP 12527, ICP 10697, IC 9066, AL 601, VBN 1, PA 128, AH 17-13, PUSA 2020-2, PA 650, AH 17-28, IPAE 19-04, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, AL 2250, IPAE 15-03, RVKT 333, WRG 65, PAH 10, BSMR 203, BSMR 175, BSMR 164, BSMR 79, BSMR 736, Co(RG)7, UPAS 120, VBN 3.
		Mottled	2	17	30.91	ICPL 88001, ICPL 88027, ICPL 11255, ICPR 2447, ICP 245535, IC 525466, PA 662, AL 2207, NAM 88, PUSA 992, PAU 881, PA 663, PA 662, PA 669, BRG 4, VLA1, APK 1.
20.	Seed shape	Oval	1	37	67.27	CRG 9407, CRG 16- 04, CRG 16- 01, ICPL 86020, ICPL 84031, ICPL 91045, ICPL 88027, ICPR 2447, ICP 245535, ICP 245517, ICP 245527, ICP 245541, ICP 10697, IC 9066, AL 601, VBN 1, AL 2207,PA 128, PUSA 2020-2, PA 650, IPAE 19-04, PUSA 992, PA 662, IPAE 15-08, CRG 16-12, Pusa Arhar 21-1, PA 291, PA 662, AL 2250, IPAE 15-03, WRG 65, PAH 10, BSMR 203, Co(RG)7, UPAS 120, VBN 3.
		Globular	2	17	30.91	CRG 5, ICPL 88001, ICPL 11255, ICP 12527, AH 17-13, IC 525466, NAM 88, P AH 17-28, AU 881, PA 669, RVKT 333, BRG 4, BSMR 175, BSMR 164, BSMR 79, BSMR 736, APK 1.
		Elongate	3	01	01.82	PA 663.

type as 50 per cent flowering was observed between 61 and 90 days (www.plantauthority.gov.in). Early genotypes are more advantageous than late-maturing due to the early types are most suitable for cultivation in all seasons and also escape from terminal stress.

In the case of branching pattern, 24 genotypes (43.63 %) had erect plant type and 34 genotypes (56.37 %) were found to be semi-spreading type. Geofroy *et al.* (2020), Manyasa *et al.* (2008), Muniswamy *et al.* (2014), Metkar and Gawande (2014), Ranjani and Jayamani (2021), Upadhyaya *et al.* (2007) and Yohane *et al.* (2020) reported similar results in case of semi-spreading type in pigeonpea. The branching pattern is the most significant parameter for varietal identification and characterization studies (Sahu *et al*., 2018) in pigeonpea. With reference to plant growth habits, the genotypes ICPL 86020, ICPL 11255 and APK 1 showed determinate plant type and other genotypes were found to be indeterminate type. Similar results were reported earlier by Ranjani and Jayamani (2021) and Upadhyaya *et al.* (2007) that an indeterminate type of growth habit was prominent in pigeonpea.

The green colour stem was observed in 26 genotypes (47.27 %), whereas 29 genotypes (52.73 %) exhibited purple colour (**Fig. 1**). Metkar and Gawande (2014) reported similar results that high proportion of purple stem was observed than green stem in pigeonpea. Ranjani and Jayamani (2021) reported contrast results that green stem was noticed in all the pigeonpea genotypes. Based on plant height, 44 genotypes (80.00 %) were categorized as short (less than 100 cm) and 11 genotypes (20.00 %) with a medium height between 100 and 150 cm.

Regarding leaf shape, 50 genotypes (90.91 %) showed oblong leaf shape, four (7.27 %) exhibited an obovate leaf and PUSA 992 (1.82 %) had a narrowly oblong type (**Fig.2**). Ranjani and Jayamani (2021) reported the oblong type of leaf as prominent in pigeonpea. Leaf characteristics are useful for the identification of varieties and categorizing genotypes into different groups. Leaf pubescence on the lower surface was prominent in 51 genotypes (92.73 %) and absent in four genotypes (7.27 %).

In the view of the flower pattern of streaks on the standard petal, streaks were absent on six genotypes (10.91%), 13 genotypes (23.64 %) fall under sparse, 32 (58.18 %) under medium and four (7.27 %) genotypes in dense category (**Fig. 3**). Based on flower colour, 20 genotypes (36.36 %) were light yellow, 31(56.36 %) showed yellow, PA 650 (01.82 %) had orange-yellow and three (05.46 %) were red coloured (**Fig. 4**). Chaudhary *et al.* (2021), Rupika and Bapu (2014) and Yohane *et al.* (2020) also reported yellow flower colour as prominent in pigeonpea.

Fig. 1. Variation for stem colour

OBOVATE OBLONG NARROWLY OBLONG

BSMR 79 ICPL 86020 PUSA 992

Fig. 2. Variation for leaf shape

ABSENT SPARSE MEDIUM DENSE

CRG 9407 IPAE 19-04 ICP 12527 AL 2207

Fig. 3. Variation for flower pattern of streaks on standard petal

LIGHT YELLOW YELLOW ORANGE YELLOW RED

CRG 16-01 ICPL 91045 PA 650 ICP 10967

Fig. 4. Variation for flower colour of base of standard petal

Green pods were observed in three genotypes (01.82 %), green pods with brown streaks in four genotypes (07.27 %), green pods with purple streaks in 47 genotypes (85.45 %) and PUSA 2020-2 (01.82 %) had dark purple pods (**Fig. 5**). Pubescence on pods was present in all the genotypes. None of the genotypes exhibited waxy pods. Chaudhary *et al.* (2021) reported similar results in the case of pod pubescence and pod waxinesss in pigeonpea. Pod surface stickiness was recorded in 15 genotypes (27.27 %) whereas it was absent in 40 genotypes (72.73 %). The prominent type of pod constriction was noticed in all the genotypes studied. The pod length was less than 4 cm in three genotypes (05.46 %), between 4 - 5 cm in 50 genotypes (90.91 %) and two genotypes (03.63 %) had a pod length of more than 5 cm. These results were in accordance with Chaudhary *et al.* (2021) and Metkar and Gawande (2014) regarding pod length in pigeonpea.

With regard to the number of seeds per pod, three seeds per pod were observed in 17 genotypes (30.91 %) and 38 genotypes (69.09 %) had four seeds per pod. Cream coloured seeds were observed in five genotypes (9.09 %), brown seeds in 44 genotypes (80.00 %), dark brown in four genotypes (7.28 %) and grey in two genotypes (3.63 %) (**Fig.6**). Seed coat colour in pigeonpea plays the most significant role in consumer preference. Brown seed colour is more preferred by the consumer than greyed purple seed colour. The uniform seed colour pattern was observed in 38 genotypes (69.09 %) whereas 17 (30.91 %) recorded mottled seed colour. Yohane *et al.* (2020) also reported uniform seed colour as more prominent. Oval seed shape was observed in 37 genotypes (67.27 %), globular with 17 genotypes (30.91 %) and PA 663 (1.82 %) had elongated seed shape. Manyasa *et al*. (2008) and Upadhyaya *et al*. (2007) reported oval seed shape in pigeonpea as more prominent. Based on seed size (100 seed weight), 25 genotypes (45.45 %) recorded small seeds, 24 genotypes (43.64 %) with medium, five genotypes (9.09 %) with large seed size and BSMR 164 (1.82 %) had very large seed size.

Sahu *et al.* (2018) observed more variation in the following characters namely branching pattern, growth habit, flower colour, pod colour and seed characters in

Fig. 5. Variation for pod colour

Fig. 6. Variation for seed coat colour

pigeonpea. Among them, oblong leaf shape, presence of waxiness, oval shaped seeds were the most prominent characteristics observed. Chaudhary *et al.* (2021) also observed similar results for oblong leaf shape, green pods with purple streaks and four seeds/pod in pigeonpea.

Cluster analysis of all the genotypes was carried out using GGT 2.0 Software for all the agro morphological traits (**Fig. 7**). The genotypes were partitioned into six clusters. The similarity coefficient ranges from 0.09 to 0.46. Cluster I encompass 32 genotypes and cluster II includes seven genotypes and four genotypes were placed in each cluster III and V, cluster IV constitutes five genotypes, and cluster VI comprises three genotypes. Cluster I is further subdivided into three subgroups with three, twenty-two and seven genotypes respectively.

Among the six clusters, cluster I was the largest and cluster VI was the smallest. In cluster III, the genotypes PA 662 and PAU 881 are similarly clustered due to more similar of genotypes. The distance between genotypes is indicated by the horizontal line in the dendrogram. In cluster V, the genotypes RVKT 333 and IPAE 15-03 were found to be more distantly related. However, cluster III and cluster IV

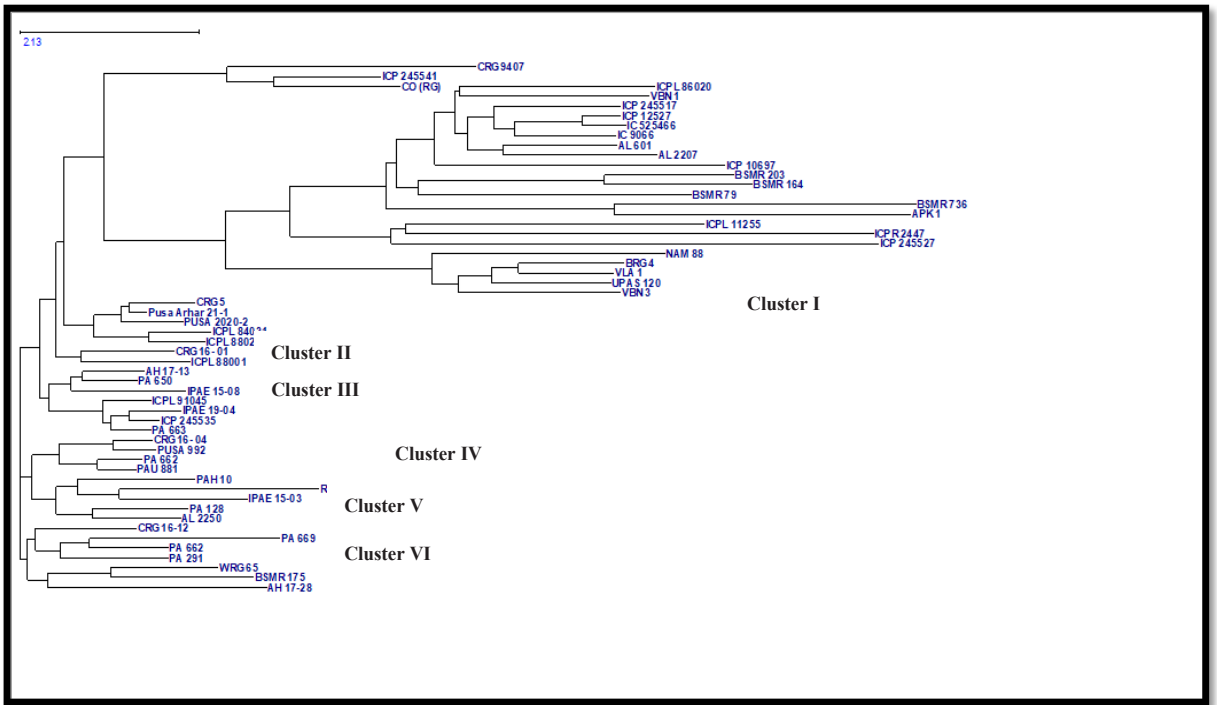

Fig 7. Clustering of 55 genotypes based on qualitative characters

were found to be more closely related as shown in the cluster diagram (**Fig. 7**). The genotypes in cluster I and cluster VI had less similarity and hence these two clusters were distantly placed in the cluster diagram. Adegboyegun *et al.* (2020) divided the pigeonpea genotypes into two clusters. Geofroy *et al.* (2020) obtained five major clusters in their study in pigeonpea. Ranjani and Jayamani (2021) reported four clusters in pigeonpea based on qualitative characters. Sahu *et al.* (2018) categorized the pigeonpea genotypes into two clusters.

Selection of genotypes from diverse groups might result in a higher magnitude of heterosis or the possibility of recovering transgressive segregants for certain traits. It would be possible to establish heterosis by crossing genotypes of cluster I with genotypes of cluster VI. The morphological traits *viz.,* indeterminate type of growth habit, oblong leaf, a green pod with purple streaks, four seeds per pod, brown and oval seeds were predominant in this early duration germplasm. Wide variations were observed for six characters *viz.,* flower colour, a pattern of streaks, pod colour, seed colour, seed shape and size. These traits can also be used in developing trait-specific varieties in pigeonpea.

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