ISSN 1479-2621
Plant Genetic Resources: Characterization and Utilization 8(2); 162–170
doi:10.1017/S1479262110000122

Identification and evaluation of vegetable type pigeonpea (*Cajanus cajan* (L.) Millsp.) in the world germplasm collection at ICRISAT genebank

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Received 15 February 2010; Accepted 16 April 2010 – First published online 10 May 2010

Abstract

Pigeonpea (*Cajanus cajan* (L.) Millsp.) seed harvested while it is immature is a nutritious vegetable and forms a substitute for green pea [*Pisum sativum* (L.)]. Using the characterization data of more than 12,000 accessions conserved at ICRISAT genebank, Patancheru, India, 105 accessions were selected for important traits of vegetable pigeonpea (mature pod length >6 cm, seeds per pod >5 and 100-seed weight >15 g) and evaluated for these traits during 2007–08. From the initial evaluation, 51 accessions were identified as vegetable type and further evaluated for traits of vegetable pigeonpea during 2008–09 to identify most promising accessions. ICP 13831 produced longest immature pods (10.3 cm), ICP 13828 had maximum number of seeds per pod (5.9) and ICP 12746 produced larger seeds (44.8 g/100 seeds). Highest percentage of total soluble sugars (9.7%) was recorded in immature seeds of ICP 13413. ICP 15143 followed by ICP 15186 recorded more dry pods per plant and seed yield per plant. Performance of ICP 12184, ICP 13413, ICP 14085 and ICP 15169 was better than that of the best control for pod length, seeds per pod, soluble sugars and protein content. Cluster analysis based on scores of first five principal components resulted in three clusters that differed significantly for days to 50% flowering, days to 75% maturity, shelling percentage and soluble sugars. Important traits of vegetable pigeonpea such as immature pod length, seeds per pod, seed soluble sugars and protein content had shown strong positive correlation. Caribbean and Eastern Africa were found as the best source regions for vegetable pigeonpea. Evaluation of selected accessions at potential locations in different countries was suggested to identify vegetable pigeonpeas suitable for different regions and for use in crop improvement programs.

Keywords: accession; collection; variation; vegetable

Pigeonpea (*Cajanus cajan* (L.) Millsp.), originated in India, is the sixth most important legume crop. It is an excellent source of proteins, minerals and vitamins, and has multiple uses like food, feed, fuel, fencing, roofing, basket making and as soil enricher and soil binder. It also has wide applications in traditional medicine (van der Maesen, 2006). Pigeonpea has wide adaptability to diverse climates and grown as a field and/or backyard crop in about 82 countries (Nene and Sheila, 1990). FAO statistics are available only for 21 countries, and pigeonpea as a field crop was grown on 4.63 million ha with a production of 3.42 million ton during 2007. India has the largest area under pigeonpea (3.50 million ha) followed by Myanmar (0.57 million ha), Kenya

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(0.19 million ha), Malawi (0.12 million ha), Uganda (0.09 million ha), Tanzania (0.07 million ha), Nepal (0.02 million ha) and Dominican Republic (0.02 million ha) (FAO, 2007).

Pigeonpea seed picked while it is immature is a nutritious vegetable (24–30 d after flowering) and forms a substitute for green pea [*Pisum sativum* (L.)] (ICRISAT, 1989). Immature pigeonpea seeds are consumed as vegetable in many Caribbean and Latin American countries, India, Indonesia, Myanmar, Nepal and Philippines in Asia and Kenya, Malawi, Tanzania and Zambia in Africa (Kannaiyan *et al*., 1983; Faris *et al*., 1987; Pandita and Dahiya, 1988; Sugui *et al*., 2000; van der Maesen, 2006). Soft green seeds of pigeonpea are also mixed in meat dishes (Sugui *et al*., 2000). In the Indian subcontinent, pigeonpea is mainly used as a pulse in the form of 'dhal' (seeds soaked, dried, hulled and split seeds). However, in some parts of the India, particularly in Gujarat state, immature seeds are used as vegetable.

The success of any crop improvement program depends on the availability of genetic variability. The genebank at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, conserves 13,632 pigeonpea germplasm accessions, including 555 accessions of wild relatives from 74 countries. Lack of awareness on nutritional importance and multipurpose uses of the crop are the main reasons for under utilization of pigeonpea (Mathews and Saxena, 2005). Lack of such information on germplasm conserved in genebanks is the major drawback for low utilization of pigeonpea germplasm collections. Therefore, the present study was undertaken to identify and evaluate pigeonpea germplasm with traits of vegetable type to enhance its utilization by researchers in crop improvement and direct utilization by the farmers.

Materials and methods

ICRISAT's pigeonpea germplasm characterization database of over 12,000 accessions was used to select vegetable type accessions. A total of 105 accessions having dry pod length >6 cm, seeds per pod >5 and 100-seed weight >15 g were selected (Faris *et al*., 1987). Selected accessions are from 15 countries and ICRISAT with a maximum of 31% of total accessions from Zaire, followed by Ethiopia (29%), Cape Verde (17%), Grenada (13%) and Kenya (8%). All other countries including ICRISAT contributed <5% of total collection from respective countries at ICRISAT genebank. Only 5 out of 9200 accessions (0.05%) from India and 12 out of 1620 accessions (0.7%) from ICRISAT met the criteria of vegetable pigeonpea. Selected accessions and three control cultivars ICP 7035 and ICP 7119 (indeterminate flowering) and ICP 11543 (ICPL 87) (determinate flowering) were evaluated in vertisols at ICRISAT, Patancheru, India (18°N, 79°E, 545 m a.s.l. and 600 km away from sea). Each accession was planted in three rows of 4-m length with a spacing of 75 cm between rows and 50 cm between plants. The trial was laid out in alpha design with two replications during 2007–08 rainy season. The crop received a basal dose of DAP at 100 kg/ha and life-saving irrigations. The crop was protected from weeds, pests and diseases. Three representative plants were selected from the middle row for each accession for recording observations on nine agronomic traits [days to 50% flowering, days to 75% maturity, immature pod length (cm) and width (mm), seeds per pod, shelling percentage (%), 100-seed weight (g), dry pods per plant and dry seed yield per plant (g) (IBPGR and ICRISAT, 1993)]. Accessions were also evaluated for two nutritional traits: protein content (%) and total soluble sugars (%) of immature seeds, at the Central Analytical Services Laboratory, ICRISAT, Patancheru, India. Immature pods were picked when they were at physiological maturity, i.e. when they are fully grown but just before they lose their green colour. At this stage, the green seed is more nutritious than the dry seed because it has more protein and sugars than the dry mature seeds (Faris *et al*., 1987).

From the initial evaluation, accessions performing better than the best control for traits of vegetable pigeonpea were selected. Accessions selected for vegetable traits in the initial evaluation were from Kenya (15), Malawi (12), Tanzania (6), India (3), Zaire (3), Grenada (2), Venezuela (2), Zambia (1) and ICRISAT (7). Selected accessions along with three control cultivars were evaluated during 2008–09 rainy season at ICRISAT, Patancheru, India, in an alpha design with three replications to assess the range of variation and identify most promising vegetable type accessions. All cultivation practices were similar to those of initial evaluation. Observations on nine agronomic and two nutritional traits were recorded. Data were analyzed using Residual Maximum Likelihood (REML) method considering accessions as random (random model) in GenStat 12 (Patterson and Thompson, 1971). Balanced Linear Unbiased predictors (BLUPs) were calculated for each accession and each trait (Schonfeld and Werner, 1986). Means over replications were calculated for all traits under study. Principal component analysis (PCA) was carried out using the standardized data of 11 traits. Cluster analysis according to Ward (1963) was performed using scores of first five PCs. The range, means and variances were estimated for all traits in each cluster. The means for different traits in each cluster were compared using Newman (1939)–Keuls (1952) procedure. The homogeneity of variances was tested by Levene's (1960) test. Shannon–Weaver (1949) diversity index was estimated for all traits and clusters to asses the phenotypic diversity. Phenotypic correlations were estimated among all traits under study and identified significant correlations among the traits of vegetable pigeonpea (Snedecor and Cochran, 1980). Heritability in broad sense was estimated to know the heritability for vegetable traits of pigeonpea.

Results

REML analysis

Variance component due to genotypes indicated highly significant differences between accessions for all traits during the year 2007–08 and 2008–09 (Table 1). Variances pooled over two seasons indicated highly significant genotypic differences for all traits, except soluble sugars in immature seeds. Variance component due to genotype × environment interactions was highly significant for days to 50% flowering, days to 75% maturity, shelling percentage, 100-seed weight, seed protein content and dry seed yield per plant suggesting the differential response of genotypes in two seasons.

Means

Mean values for different traits indicated that only one accession ICP 13828 flowered earlier (121 d) than the medium duration control (ICP 7119) having indeterminate flowering habit, and none of the accessions flowered earlier than another control ICP 11543, showing determinate flowering habit and flowered in 69 d. Only seven accessions flowered earlier than the control ICP 7035, which is a popular long duration vegetable type variety released in India, China, Fiji and Philippines, and flowered in 132 d. The control ICP 11543 has the longest period of flowering (82 d) followed by ICP 12184 (80 d). Forty one accessions continued flowering for more than 60 d indicating their suitability as vegetable pigeonpea. Shortest flowering duration was in ICP 15186 (42 d). The two control cultivars ICP 7035 and ICP 7119 showing indeterminate flowering pattern showed shorter flowering duration of 49 and 48 d, respectively. Only ICP 13828 and ICP 15156 matured earlier than that of best control having indeterminate flowering habit (ICP 7119).

Twenty-six accessions produced longer pods than that of best control ICP 7035 (8.0 ± 0.4 cm). Supporting the initial selection of accessions for the present study, all accessions produced pods more than 6.0 cm long. Longest pods were produced in ICP 13831 (10.3 cm). High frequency of accessions from Grenada (100%), Malawi (83%) and Tanzania (83%) produced longer pods than that of best control indicating these countries as a source for pigeonpea with longer pods. Pod width is also a desirable trait of vegetable pigeonpea. Six accessions (ICP 15195, ICP 15222, ICP 13831, ICP 12746, ICP 13102 and ICP 14366) produced pods with width more than or similar to that of best control ICP 7035 (12.8 mm ± 0.6). Twenty-seven accessions produced pods with more seeds than that of the best control ICP 7035 (5 ± 0.2), and ICP 13828 produced maximum number of seeds per pod (5.9). Five accessions and two controls did not meet the selection criteria of more than five seeds per pod. Thirteen accessions from Kenya (total 15 accessions) followed by 9 out of 12 accessions from Malawi and 3 out of 6 accessions from Tanzania produced pods with a

Table 1. Estimates of genotypic variance (δ^2_g) and genotype × environment (δ^2_{ge}) interaction in vegetable pigeonpea germplasm evaluated in 2007 and 2008 at ICRISAT, Patancheru, India

	Genotypic variance (δ^2_g)				
Character	2007	2008	Pooled	Variance due to genotype × environment (δ^2_{ge})	Heritability (h^2)
Days to 50% flowering	682.56**	379.85**	585.98**	23.54**	98.4
Days to 75% maturity	871.46**	635.55**	776.28**	38.28**	97.4
Pod length (cm)	1.26**	0.95**	1.14**	0.07 NS	85.4
Pod width (mm)	2.89**	1.96**	2.57**	0.12 NS	82.8
Seeds per pod (no.)	0.14**	0.15**	0.11**	0.03 NS	62.3
Shelling percentage (%)	93.80**	25.98**	42.95**	27.96**	74.3
100-seed weight (g)	20.80**	14.57**	12.30**	6.13**	73.1
Seed soluble sugar (%)	0.50*	1.08*	0.26 NS	0.43 NS	60.2
Seed protein (%)	1.25**	0.46**	0.67**	0.34**	68.7
Dry pods per plant (no.)	11,809.00**	1456.1**	11,280.00**	<0.001 NS	83.4
Dry seed yield per plant (g)	2514.00**	140.20**	925.0*	1002.0**	79.0

*Significant at 0.05 level of probability.
**Significant at 0.01 level of probability.

width that was more than that of the best control. None of the accessions was better than those of the best control (ICP 7119) for shelling percentage. However, ICP 7988 (49%) and ICP 12031 (45.7%) were found promising for shelling percentage.

Large immature seeds are the consumer preferred trait of vegetable pigeonpea. Eight accessions in the order of seed size ICP 12746, ICP 13107, ICP 7988, ICP 15222, ICP 13450, ICP 12058, ICP 13599 and ICP 8000 produced seeds larger than the seeds produced by best control ICP 7035 (31.2 ± 2.0 g/100 seeds), and ICP 12746 produced largest seeds (44.8 g). Two accessions each from India, Kenya and ICRISAT, and one accession each from Malawi and Tanzania produced larger seeds than that of best control. Sweetness of the pigeonpea seed is a preferred trait for vegetable purpose (Yadavendra and Patel, 1983). In the present study, higher total soluble sugars were recorded in immature seeds of ICP 13413 (9.7%), ICP 12184 (9.3%), ICP 13069 (9.1%), ICP 14085 (9.0%), ICP 15169 (8.8%), ICP 8514 (8.7%), ICP 13387 (8.7%), ICP 13442 (8.7%) and ICP 13598 (8.7%) than that of best control ICP 7035 (7.9 ± 0.7%). Seventeen accessions produced seed protein content higher (>22%) than that of best control ICP 7119 (21.6 ± 0.4%). ICP 13438 had a maximum 22.7% protein.

In addition to immature pods harvested for selling in local markets, farmers would like to have some dry seeds from their crop for consumption throughout the year. Therefore, accessions were also evaluated for number of dry pods per plant and dry seed yield per plant. Only one accession ICP 15143 produced more dry pods (246) than that of best control ICP 7119 (176.6 ± 16.2). However, ICP 12031, ICP 12035, ICP 13387, ICP 13414, ICP 14366 and ICP 15186 produced more dry pods per plant than that of popular variety ICP 7035 (85.4 ± 16.2). ICP 15143 and ICP 15186 produced more dry seed yield per plant than that of ICP 7035 (59.4 ± 5.7 g).

Principal component analysis

PCA of the standardized data was performed. The first five PCs explained 84.2% variation. The PC 1 alone accounted for 39.01% variation followed by PC 2 with 16.0%, PC 3 with 11.7%, PC 4 with 9.5% and PC 5 with 7.9%. The scores of the first five PCs were used for cluster analysis.

Cluster analysis

A hierarchical cluster analysis conducted on the scores of first five PCs grouped the accessions into three clusters (Fig. 1). Most of the accessions from Kenya (11),

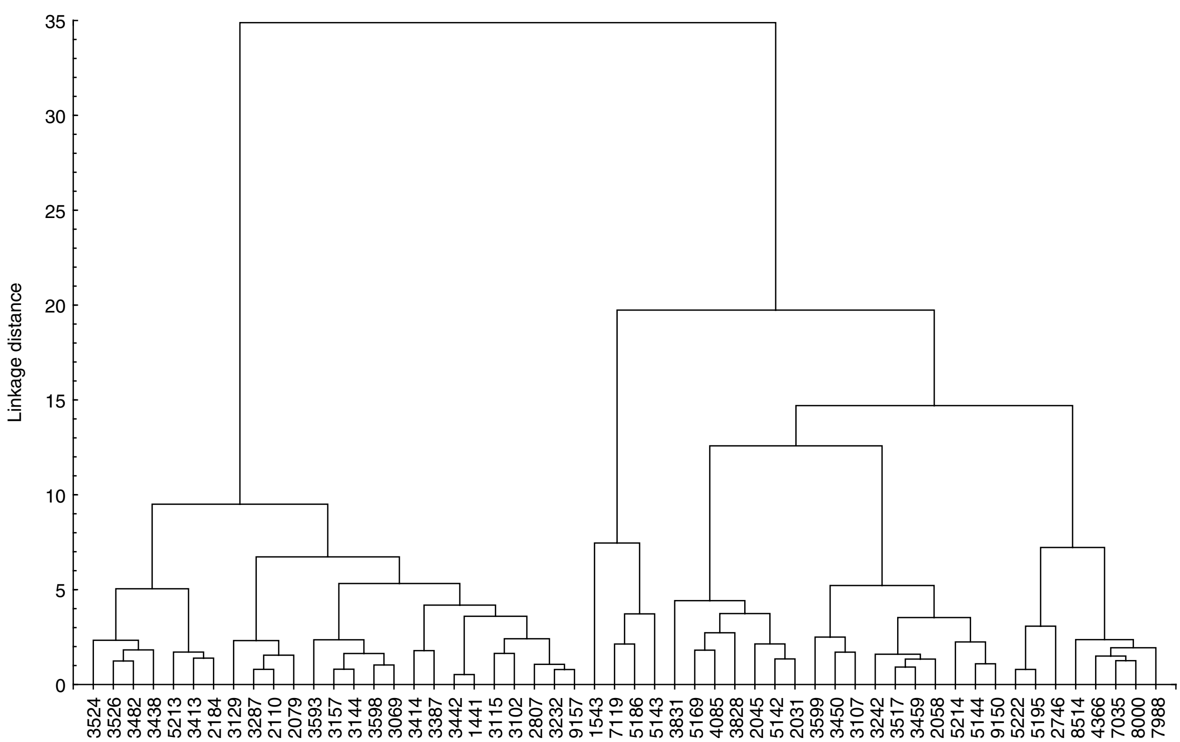

Fig. 1. Dendrogram showing clustering of vegetable pigeonpea accessions (ICP nos) based on first five PCs.

Table 2. Range and means for different traits of vegetable pigeonpea germplasm in different clusters, evaluated at ICRISAT, Patancheru, India

	Range			Mean[1]		
Character	Cluster 1	Cluster 2	Cluster 3	Cluster 1	Cluster 2	Cluster 3
Days to 50% flowering	153–176	69–135	121–165	166.3a	113.7c	143.4b
Days to 75% maturity	215–249	151–195	170–241	237.2a	171.8c	205.7b
Pod length (cm)	6.9–9.9	7.0.–7.7	7.5–10.3	8.66a	7.11b	8.60a
Pod width (mm)	11.1–14.1	8.7–11.0	11.2–16.5	12.17a	10.00b	12.63a
Seeds per pod (no.)	4.9–5.8	4.4–4.9	4.7–5.9	5.37a	4.72b	5.19a
Shelling percentage (%)	33.9–41.0	43.1–53.0	37.0–49.0	37.92c	48.64a	43.65b
100-seed weight (g)	23.7–33.0	26.5–30.8	25.9–44.8	29.46a	28.12b	31.9a
Seed soluble sugars (%)	6.8–9.7	6.8–7.2	6.8–9.0	8.33a	7.02b	7.59c
Seed protein (%)	21.0–22.7	21.2–21.9	20.7–22.5	21.93a	21.46a	21.57a
Dry pods per plant (no.)	42.1–117.7	72.8–246.0	46.7–112.1	71.3b	163.9a	77.8b
Dry seed yield per plant (g)	23.8–53.9	32.6–67.5	28.2–59.4	35.15b	55.33a	42.58b

[1]Differences between means of different clusters were tested by Newman–Keuls test, and same letter indicates non-significant results.

Malawi (9) and Tanzania (3), and one accession each from ICRISAT and Zambia formed first cluster. Two accessions of ICRISAT origin and one accession each from India and Zaire formed second cluster. Five accessions from ICRISAT, four accessions each from India and Kenya, three accessions each from Malawi and Tanzania and two accessions each from Grenada, Venezuela and Zaire formed third cluster. Range of variation was high in cluster 1 for pod length and soluble sugars, cluster 2 for days to 50% flowering, dry pods and seed yield per plant, and cluster 3 for days to 75% maturity, pod width, seeds per pod, shelling percentage, 100-seed weight and seed protein content (Table 2). Cluster means indicated significant differences among clusters for days to 50% flowering and maturity, shelling percentage and soluble sugars. Clusters 1 and 3 with higher mean values for pod length and width, seeds per pod, 100-seed weight, dry pods and seed yield per plant differed significantly from cluster 2.

Phenotypic diversity

Shannon–Weaver diversity index (H') was estimated for different characters and clusters to compare phenotypic diversity among the clusters (Table 3) (Shannon and Weaver, 1949). A low H' value indicates low diversity and unbalanced frequency classes. The H' estimates indicated considerable differences in diversity for all characters. Highest mean diversity over all characters indicates relatively more diverse pigeonpea accessions in cluster 1 than in other clusters. H' values over all the clusters ranged from 0.46 ± 0.08 for pod length to 0.54 ± 0.05 for days to 50% flowering.

Correlations

Phenotypic correlations were estimated among all characters and tested for their significance (Snedecor

Table 3. Shannon–Weaver diversity index (H') for different characters of vegetable pigeonpea germplasm

Character	Cluster 1	Cluster 2	Cluster 3	Mean
Days to 50% flowering	0.602	0.452	0.579	0.54 ± 0.05
Days to 75% maturity	0.574	0.452	0.512	0.51 ± 0.04
Pod length (cm)	0.576	0.301	0.504	0.46 ± 0.08
Pod width (mm)	0.472	0.452	0.471	0.47 ± 0.01
Seeds per pod (no.)	0.567	0.452	0.559	0.52 ± 0.04
Shelling percentage (%)	0.592	0.452	0.545	0.53 ± 0.04
100-seed weight (g)	0.589	0.244	0.529	0.45 ± 0.11
Seed soluble sugars (%)	0.535	0.452	0.512	0.50 ± 0.03
Seed protein (%)	0.545	0.452	0.559	0.52 ± 0.03
Dry pods per plant (no.)	0.545	0.452	0.550	0.52 ± 0.03
Dry seed yield per plant (g)	0.563	0.452	0.559	0.53 ± 0.04
Mean	0.56 ± 0.01	0.42 ± 0.02	0.53 ± 0.01	0.50 ± 0.02

and Cochran, 1980). Magnitude of correlations indicated highly significant positive correlation of days to 50% flowering with days to 75% maturity (0.95), seeds per pod (0.46), total soluble sugars (0.43) and protein (0.35) in immature seeds. As the correlations of days to 50% flowering and of days to 75% maturity are similar with other traits, selection for days to 50% flowering will result in selection for days to 75% maturity.

Immature pod length, one of the important traits of vegetable pigeonpea, showed significant positive correlation with seeds per pod (0.58) and seed protein content (0.48). Seeds per pod and total soluble sugar content of green seed showed significant positive correlation (0.41). All important traits except 100-seed weight of vegetable pigeonpea showed strong positive correlation. On the other hand, 100-seed weight had shown significant positive association with pod width (0.49). Therefore, results of present study indicate that the selection for long broad pods may result in the correlated response for other traits of vegetable pigeonpea. Significant positive correlation between days to 50% flowering and seeds per pod (0.46) indicated the association of late maturity and vegetable traits. Significant negative association of days to 50% flowering with dry pods (−0.33) and seed yield per plant (−0.46) also suggest the association of late maturity and traits of vegetable pigeonpea. Upadhyaya *et al.* (2007) reported significantly higher mean values for pod length, seeds per pod and 100-seed weight in late maturity group than early and medium maturity groups. As expected, significant positive association between dry pods and seed yield per plant (0.77) was observed.

Heritability

Heritability in broad sense ranged from 60.2% (seed soluble sugars) to 98.4% (days to 50% flowering) (Table 1). Vegetable pigeonpea traits had shown more than 60% heritability. High heritability for days to 50% flowering and traits of vegetable pigeonpea also suggest the availability of vegetable type pigeonpeas in late maturity group.

Immature pod and seed colours are also important traits of vegetable pigeonpea (Fig. 2). Pandita and Dahiya (1988) reported the preference for green seed by consumers. In the present study, only six accessions produced green colour pods, and four accessions produced light green colour pods. Thirty-five accessions produced mosaic colour pods. Six accessions produced purple pods. However, all accessions with green, light green and mosaic colour pods produced green seed. ICP 13442 with purple pods had green seeds. On the other hand, ICP 8514, ICP 12746 and ICP 15222 produced

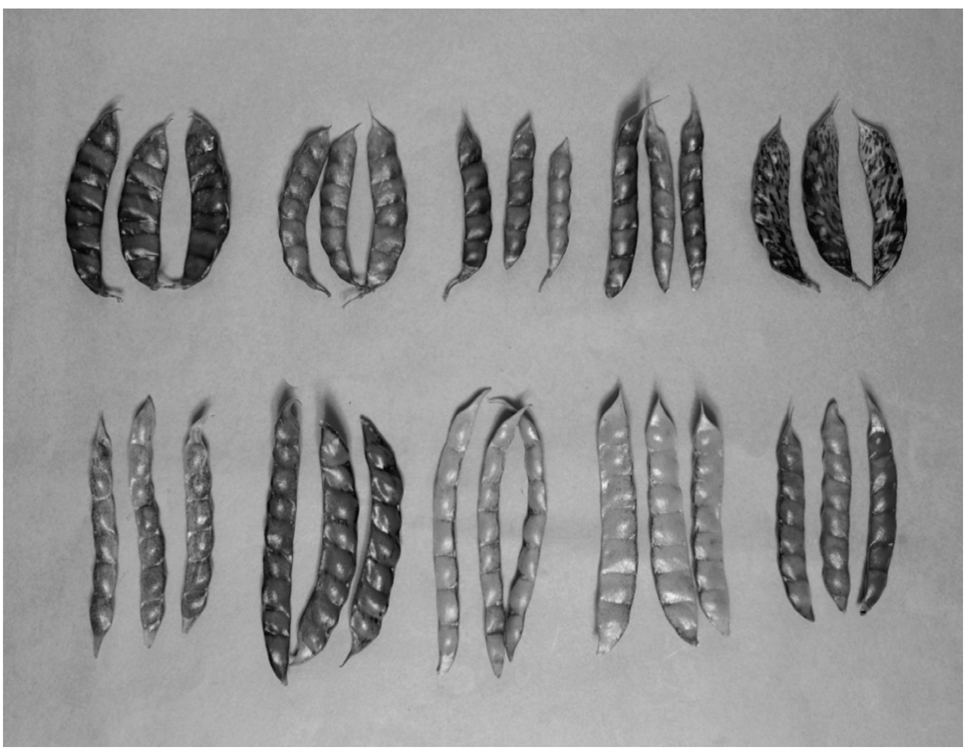

Fig. 2. Diversity for pod traits in vegetable pigeonpea germplasm.

Table 4. Performance of promising vegetable pigeonpea germplasm accessions identified for important traits

ICP no.	Days to 50% flowering	Pod length (cm)	Pod width (mm)	Seeds per pod (no.)	Shelling percentage (%)	100-seed weight (g)	Seed soluble sugars (%)	Seed protein (%)	Dry pods per plant (no.)	Dry seed yield per plant (g)
7988	133.7	8.3	12.9	5.1	49.0	35.9	7.4	21.1	100.2	59.4
8000	139.6	8.4	11.8	5.0	45.5	33.6	7.9	20.8	81.7	46.2
11441	163.2	8.8	12.2	5.8	40.5	29.7	8.3	21.0	70.4	35.7
12184	166.3	9.5	12.7	5.6	36.0	26.5	9.3	22.6	65.5	32.4
12746	131.7	8.1	14.3	4.7	48.1	44.8	8.3	20.9	65.6	48.6
12807	171.4	8.8	12.0	5.2	35.5	32.6	8.8	22.5	57.3	36.3
13107	164.5	8.1	12.8	5.6	42.6	36.3	7.5	21.6	47.2	29.3
13413	170.9	9.1	11.3	5.5	41.0	28.7	9.7	22.3	64.0	34.6
13414	169.2	9.1	11.9	5.7	39.4	29.7	8.2	22.1	117.7	53.9
13438	170.1	9.9	12.3	5.4	37.5	29.0	6.8	22.7	86.4	39.4
13442	165.2	8.8	12.8	5.6	38.0	30.2	8.7	21.2	58.6	38.3
13524	176.3	9.9	12.3	5.7	39.0	29.8	7.7	22.7	49.5	26.6
13526	169.4	9.7	11.9	5.1	39.0	27.3	8.1	22.5	65.7	40.1
13599	163.9	8.1	13.2	5.4	45.6	33.8	7.8	20.7	66.8	33.7
13828	121.3	9.9	11.9	5.9	44.4	30.5	7.3	21.8	70.5	44.0
13831	134.1	10.3	14.8	5.4	42.8	32.3	6.8	21.9	82.3	46.6
14085	148.1	9.8	11.4	5.5	38.2	29.0	9.0	22.5	78.7	50.3
15169	139.9	10.0	11.4	5.5	44.9	29.8	8.8	22.1	57.3	38.1
15195	131.3	7.6	16.5	5.1	42.0	32.1	7.4	21.4	77.0	47.7
15222	135.7	7.9	16.3	5.2	43.9	34.8	7.0	21.4	75.7	44.7
Trial mean	151.8	8.5	12.2	5.2	41.4	30.5	7.9	21.7	81.3	40.0
SE+	2.5	0.4	0.6	0.2	2.6	2.0	0.7	0.4	16.2	5.7
CV (%)	2.9	8.2	9.0	9.7	12.6	13.1	18.5	3.7	36.2	26.5

purple pods with mottled green seeds. ICP 8000 and ICP 7035, which was used as a control, produced purple pods with purple seeds.

Discussion

Majority of traditional pigeonpea varieties used as vegetable produce small pods with few small seeds (Pandita and Dahiya, 1988). The consumers of vegetable pigeonpea prefer long green pods having more large sweet seeds. They believe that green colour pods stay attractive even 3–5 d after harvesting and ease in shelling of pods, whereas striped or mosaic colour pods look stale 1–2 d after harvest (Saxena *et al*., 1983; Yadavendra and Patel, 1983; Pandita and Dahiya, 1988; Patel *et al*., 1996). Performance of ICP 12184, ICP 13413, ICP 14085 and ICP 15169 identified in the study was better than that of the best control for important vegetable pigeonpea traits such as pod length, seeds per pod, soluble sugars and protein content, with reasonably good seed size being considered as a promising vegetable trait (Table 4). Two accessions ICP 14085 and ICP 15169 have produced long green pods with green colour seeds. Generally, sugar levels are around 5% in most pigeonpea varieties, but researchers at ICRISAT have found a maximum of 8.8% in ICP 7035 (Faris *et al*., 1987; Rangaswamy *et al*., 2005). In the present study, three accessions ICP 12184, ICP 13413 and ICP 14085 had more than 8.8% total soluble sugars in immature seeds. Mean performance of accessions by geographic region and countries indicated that the accessions from Grenada and Venezuela are of medium-long duration, and recorded high mean values for pod length and width, seeds per pod, and seed protein with considerably high seed weight indicating the landraces from these countries as promising vegetable types. On the other hand, out of a total of 37 accessions from African countries, 15 accessions for pod length, 1 accession for pod width, 25 accessions for seeds per pod, 4 accessions for 100-seed weight and 6 accessions for soluble sugars have performed better than that of the best control.

The accessions identified as vegetable type in the present study include mostly the landraces (43) followed by breeding lines (8). The landraces are time-tested cultivars developed through natural selection coupled with farmer's selection in an ecological region, and named generally by ethnic groups in the region with one or more clearly defined traits. Landraces show high adaptation to varying agroclimatic conditions; resistance to abiotic and biotic stresses and perception of good quality food are the main reasons for liking of landraces by farmers. Results suggest that as per the standard maturity classification developed and being followed at ICRISAT (1978), all landraces except ICP 13828, which is of medium duration, belong to late maturity group. All accessions, except ICP 8514 (semi-determinate) and ICP 8000 (determinate), showed indeterminate flowering pattern (49). Because of perenniality of pigeonpea crop and late maturity coupled with indeterminate flowering habit of most vegetable type accessions identified in the present study, it is possible to extend harvest of immature pods to sell in local markets for longer period. With irrigation facilities, long rainy season or bimodal rainy season as in Kenya, crop will continue to produce pods as long as it remains free of diseases, and the mean temperature remains between about 15 and 30°C (Faris *et al*., 1987).

Pigeonpea landraces are widely adapted compared to green pea, and can be grown in backyards and on field bunds to support the economy of even landless poor. Farmers prefer to grow vegetable pigeonpea for sale of immature pods and seeds and also to harvest mature dry seeds for their consumption. Therefore, vegetable pigeonpea landraces identified will play an important role in the years to come in enhancing the income and nutrition of the poor people in more than 82 countries, where pigeonpea is grown as a field and/or as a backyard crop (Nene and Sheila, 1990). Immature seeds of pigeonpea contain more edible portion (72.0 g/100 g), protein (9.8%), calcium (57 mg/100 g), magnesium (58 mg/100 g), carotene (469 mg/100 g) and ascorbic acid (25 mg/100 g) than the seeds of green pea. The seeds of green pea contain 53 g/100 g of edible portion, 7.2% protein, 20 mg/100 g calcium, 34 mg/100 g magnesium, 83 mg/100 g carotene and 9 mg/100 g ascorbic acid. On the other hand when compared to completely mature dry pigeonpea seeds, immature seeds are easily digestible and contain more protein, soluble sugars, crude fibre and iron (Faris *et al*., 1987).

Many small farmers in Gujarat state of India grow vegetable pigeonpea commercially (Patel *et al*., 1996). Farmers near cities grow pigeonpea under irrigation during March to May with vegetable crops to catch the market when prices are high. A yield of 11 ton/ha of green pods harvested in five pickings has been reported by Patel *et al.* (1996) at Anand, Gujarat, India. ICP 7035 produced a mean vegetable pod yield of 5.23 ton/ha and dry seed yield of 1.69 ton/ha as compared to 4.69 ton/ha mean vegetable pod yield and 1.62 ton/ha dry seed yield for HY 3C (Rangaswamy *et al*., 2005). Jain *et al.* (1981) reported immature pod yield of 5.32 and 4.96 ton/ha from ICP 7035 and ICP 7119, respectively, when evaluated in Zambia. Pandita and Dahiya (1988) reported immature pod yield of 4.6–6.7 ton/ha from ICRISAT-developed early maturing lines (about 90–100 for flowering), which produced relatively smaller pods with less than five small seeds. High harvest of immature pods as well as dry seeds from vegetable pigeonpea is very useful to farmers. When the demand for vegetable pigeonpea is less, farmer will harvest more mature seeds for sale as well as for his consumption.

Multilocation evaluation of selected vegetable pigeonpea accessions at potential locations in India, Philippines, Kenya, Malawi, Caribbean and Venezuela is suggested to identify the most promising accessions for present and future utilization. Organizing field days facilitates the selection of useful accessions by researchers and farmers, thereby enhancing the utilization of this under-utilized multipurpose crop. Utilization of vegetable pigeonpea accessions in crop improvement programmes may trigger the release of vegetable pigeonpea varieties suitable for varying climates. Vegetable type pigeonpea germplasm accessions identified in the present study are conserved in the genebank at ICRISAT, Patancheru, India, and limited quantity seeds of these accessions are available under Standard Material Transfer Agreement (SMTA) for research and development of vegetable pigeonpea varieties.

Acknowledgements

Authors sincerely acknowledge the contribution of all former and present staffs of Genetic Resources Unit, ICRISAT in collection, assembly and conservation of pigeonpea genetic resources. The help of Mr Jacob Mathew, G Ram Reddy and Mr G Dasaratha Rao, Research Technicians, Genetic Resources Unit, in recording observations and documentation of the data for this study is highly appreciated.

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