Received: 15 May 2021 | Revised: 07 Jun 2021 | Accepted: 08 Jun 2021

Electronic Journal of Plant Breeding

Research Article

Genetic variability for vegetable traits in pigeonpea (*Cajanus cajan* L.) Millsp.)

A. Fousiya[1], P. Jayamani[1]*, D. Uma[2] and A. Thanga Hemavathy[1]

[1]Department of Pulses, CPBG, TNAU, Coimbatore, Tamil Nadu, India
[2]Department of Biochemistry, CPMB & B, TNAU, Coimbatore, Tamil Nadu, India
***E-Mail:** jayamani1108@gmail.com

Abstract
A study was conducted to determine the genetic variability among sixty four vegetable pigeonpea genotypes for ten quantitative and quality traits. Highly significant differences existed among the genotypes for all the ten characters studied. Phenotypic coefficients of variation (PCV) were found higher than the genotypic coefficient of variation (GCV) for all the traits. High PCV and GCV was observed for total soluble sugars (28.73, 27.94 %) and hundred fresh bean weight (26.54, 25.87 %), respectively. PCV and GCV values were moderate for the traits *viz*., fresh pod length, fresh pod width, the number of beans per pod, bean length, bean width, protein content and fibre content. High heritability was observed for fresh pod length, fresh pod width, the number of beans per pod, hundred fresh bean weight and total soluble sugars. High heritability coupled with high genetic advance as per cent of mean was observed for fresh pod length, fresh pod width, hundred fresh bean weight and total soluble sugars indicating the additive gene effect. The genotypes *viz*., CVPP-20-002, CVPP-20-023, CVPP-20-017, CVPP-20-031, CVPP-20-032 and CVPP-20-061 showed a good performance for quantitative and nutritional traits and were superior over the check varieties. The promising genotypes identified for different vegetable traits could be used in the breeding programme to develop vegetable/dual purpose varieties in pigeonpea.

Key words
Pigeonpea, vegetable traits, nutritional analysis, genetic variability, dual purpose pigeonpea

INTRODUCTION

Pigeonpea (*Cajanus cajan*(L.) Millsp) is the major pulse crop of India after chickpea. It belongs to family, 'Leguminaceae' and the genus '*Cajanus*' belongs to the subtribe '*Cajanae*' under 'Phaseolae' with subfamily 'Papilionaceae' (Aiyer and Reddy, 1947) and is also known as '*Arhar*' or '*Tur'*, generally. Pigeonpea is cultivated mainly as *Kharif* crop and is versatile in its uses. It is largely consumed in the form of dry split seed as 'dal' by majority of Indian vegetarian population. It is also taken as fresh green pods in many Caribbean and Latin American countries and to some extent in India, Kenya, Tanzania and Zambia. The green pods of pigeonpea are of great demand as vegetable in certain parts of India, mainly in Karnataka and Gujarat. The supplementation of cereals with protein rich legumes is considered as one of the best solutions to protein-calorie malnutrition in the developing world (Chitra *et al*., 1996). Vegetable type pigeonpea is richest source of protein (26-28 per cent), greatly supplementing the vegetarian diet and is also rich in iron, iodine and sulphur containing amino acids *viz*., methionine and cystine. Pigeonpea young beans contain more minerals, ten times more fat, five times more vitamin A and three times more vitamin C than in field peas (Saxena *et al*., 2010). The young beans contain lower quantities of trypsin and amylase- inhibitors and flatulence-causing sugars. The young beans cook quickly and the protein and starch digestibility are higher than in mature seed (Singh *et al*., 1984).

The huge collection of different crop species, landraces and varieties distributed throughout the world, which comprises valuable germplasm collection, and are the result of continuous natural and human selections in cultivated crops since the beginning of agriculture. The evolution of pigeonpea through natural and human selection in diverse elevation zones has resulted in a wide variety of locally adapted landraces. The information regarding the genetic variability present in a population and estimates of heritability are the prerequisites for framing an effective breeding programme for improvement of any crop. Therefore, it is necessary to collect, conserve and to study the genetic diversity among various crops in the form of germplasm for establishing the wide genetic base for the posterity.

In any breeding programme, the selection of parents is of greater importance so as to get maximum heterosis and a wide spectrum of variability in the segregating generations. Assessments of genetic variability for vegetable traits are useful to predict the extent of improvement possible for the development of vegetable pigeonpea. Depending on the stage of harvest and cultivar, the level of protein, sugars, crude fiber, and starch may also vary considerably. Vegetable pigeonpea has the potential to increase income, food security, and nutrition among small holder households. So far piegonpea varieties suitable for vegetable/dual purpose have not been released for Tamil Nadu. Hence, there is an urgent need to identify cultivars with high vegetable yield, along with the high nutritional value. The objective of this study was to estimate the genetic variability for vegetable traits in pigeonpea genotypes.

MATERIALS AND METHODS

Traditionally, long duration pigeonpea (>200 days) suitable for vegetable purposes are grown in the larger area mainly intercropped with turmeric at Thondamuthur block of Coimbatore district. The young pods of vegetable pigeonpea are being collected and marketed by the farmers. For the present study, open pollinated seeds maintained by the farmers were collected from three different farmers of Thondamuthur block and raised during *Kharif,* 2019 at Department of Pulses, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. A total of seventy plants were selected based on vegetable traits and harvested individually. The selected plants were raised along with the check varieties viz., BSR 1 , BRG 1, BRG 3 during *Kharif*, 2020 in randomized block design (RBD) with two replications. Each plant was sown in a single row of 4 m length with a spacing of 90 × 30 cm. The uniform progeny rows were selected for taking observations. Three plants were randomly selected in each replication and nine vegetable traits *viz*., fresh pod length (cm), fresh pod width (cm), the number of beans per pod, bean length (cm), bean width (cm), hundred fresh bean weight (g), protein content (% in wet basis) (Oliver Lowry, 1951), the total soluble sugars (%) (Ludwig Thomas and Goldberg Hyman, 1956) and fibre content (%) (Maynard, 1970) were recorded. The above observations were taken when the young fresh beans turns from dark green to light green colour.

Mean values recorded for the quantitative traits were analysed (ANOVA) following standard statistical techniques. The genotypic and phenotypic coefficients of variation were calculated as per the formula suggested by Burton (1952). GCV and PCV values were categorized as low (0-10%), moderate (11-20%) and high (> 20%) as indicated by Sivasubramaniam and Menon (1973). Heritability (broad sense) was calculated as per Hanson *et al*. (1956). The heritability percentage was categorized as low (0-30%), moderate (30 -60 %) and high (>60%) as given by Johnson *et al.* (1955) and genetic advance as per Johnson *et al*. (1955) were also worked out. Genetic advance as per cent of mean was categorized as low (0-10%), moderate (11 – 20%) and high (>20%) as suggested by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The extent of genetic variability in base population is the fundamental stone for the success of any breeding programme. The genotypic evaluation process is useful for preliminary characterization and discrimination of genotypes to understand the level of genetic variability that exist in the gene pool (Atilla *et al*., 2010).The present study was carried out to study the genetic variability in vegetable/dual purpose pigeonpea. The genotypes exhibited a wide range of genetic variability for all nine vegetable traits which were studied among sixty four genotypes including three check varieties.

A wide variability was observed for all the traits. The fresh pod length ranged from 4.65 (BSR 1) to 8.90 cm (CVPP-20-061) with a mean value of 6.74 cm. Upadhyaya *et al.* (2010) reported the fresh pod length ranged from 4.82 (ICP 13828) to 10.31 cm (ICP 13831) with a mean value of 5.74 cm in vegetable pigeonpea. The fresh pod width ranged from 0.39 (CVPP-20-007) to 1.10 cm (BRG 1) with a mean value of 0.64 cm (**Table 1**). The number of beans per pod ranged from 4.00 (CVPP-20-039), (CVPP-20-059) to 7.00 (CVPP-20-061) with a mean value of 5.40. Ojwang *et al*. (2016) reported the average number of beans per pod ranged from 4.8 (LRG 229) to 7.0 (LRG 267) at crop season and from 4.7 (LRG 052) to 6.0 (LRG 235) at ratoon season in pigeonpea. The bean length ranged from 0.34 (CVPP-20-007) to 0.98 cm (CVPP-20-032) with a mean value of 0.58 cm. The bean width ranged from 0.30 (CVPP-20-007) to 0.88 cm (CVPP-20-032) with a mean value of 0.53 cm. The hundred fresh bean weight recorded the mean value of 21.15 g and it ranged from 13.98 (CVPP-20-003) to 28.99 g (CVPP-20-032). In general, vegetable pigeonpea varieties (BRG1 and BRG 3) were sown during the month of May by the farmers in Krishnagiri district. Hence, the increased bean weight (Up to 40 g/100 bean weight) was observed in the market drawn

Table 1. Mean performance of vegetable traits in pigeonpea

S. No.	Genotypes	Fresh pod length (cm)	Fresh pod width (cm)	Number of beans per pod	Bean length (cm)	Bean bread-th (cm)	Hundred fresh bean weight(g)	Protein content (% in wet basis)	Total soluble sugars (%)	Fibre content (%)
1	CVPP-20-001	6.73	0.62	5.00	0.43	0.33	14.58	28.25	3.45	8.56
2	CVPP-20-002	7.61	0.42	6.00	0.40	0.39	22.97	28.12	5.34	8.90
3	CVPP-20-003	6.21	0.53	5.55	0.38	0.33	13.98	27.67	4.23	8.41
4	CVPP-20-004	5.91	0.63	4.50	0.58	0.43	17.67	26.92	4.28	9.23
5	CVPP-20-005	5.80	0.47	4.50	0.45	0.39	24.65	28.90	5.10	8.90
6	CVPP-20-006	6.51	0.48	5.00	0.45	0.39	20.78	28.21	3.90	8.79
7	CVPP-20-007	7.52	0.39	6.00	0.34	0.30	18.79	27.45	3.97	8.69
8	CVPP-20-008	5.77	0.54	6.00	0.52	0.49	14.21	27.96	5.23	9.08
9	CVPP-20-009	6.34	0.59	6.00	0.47	0.39	15.62	27.81	4.89	9.05
10	CVPP-20-010	6.54	0.72	6.00	0.57	0.44	17.53	26.94	4.37	8.99
11	CVPP-20-011	6.47	0.51	5.50	0.50	0.34	16.93	27.54	4.29	8.76
12	CVPP-20-012	5.38	0.60	5.00	0.53	0.49	18.89	28.12	3.99	8.56
13	CVPP-20-013	6.83	0.63	6.00	0.48	0.38	16.78	28.01	3.44	8.46
14	CVPP-20-014	6.33	0.62	6.00	0.62	0.54	22.56	27.65	4.15	8.88
15	CVPP-20-015	5.94	0.46	4.50	0.44	0.37	23.76	27.99	3.90	8.56
16	CVPP-20-016	7.32	0.48	6.00	0.45	0.38	19.65	26.90	4.25	8.49
17	CVPP-20-017	8.24	0.45	6.00	0.39	0.37	27.88	27.89	3.87	8.90
18	CVPP-20-018	7.00	0.54	6.50	0.46	0.44	16.66	27.51	3.96	8.76
19	CVPP-20-019	7.13	0.52	6.00	0.47	0.42	18.95	28.34	4.52	8.65
20	CVPP-20-020	7.40	0.67	6.00	0.56	0.48	20.05	27.09	4.90	8.43
21	CVPP-20-021	6.19	0.57	5.00	0.42	0.40	22.00	27.65	5.23	7.98
22	CVPP-20-022	5.69	0.57	5.00	0.42	0.33	24.57	27.59	4.80	7.88
23	CVPP-20-023	5.94	0.63	5.00	0.60	0.57	21.55	28.90	4.56	9.10
24	CVPP-20-024	6.91	0.48	5.50	0.42	0.41	23.97	28.54	3.97	8.97
25	CVPP-20-025	6.48	0.62	5.50	0.52	0.50	22.34	28.03	4.78	8.99
26	CVPP-20-026	6.37	0.64	5.50	0.60	0.58	20.00	27.65	4.32	8.56
27	CVPP-20-027	6.45	0.65	6.00	0.63	0.55	16.54	26.98	5.12	8.76
28	CVPP-20-028	7.51	0.79	6.00	0.62	0.56	15.68	26.97	3.99	8.34
29	CVPP-20-029	6.93	0.76	5.50	0.66	0.60	19.98	27.01	4.28	8.76
30	CVPP-20-030	8.43	0.67	5.00	0.57	0.55	23.04	27.04	3.95	8.90
31	CVPP-20-031	7.82	0.56	6.00	0.53	0.49	26.05	27.54	4.67	8.65
32	CVPP-20-032	5.94	1.02	5.50	0.98	0.88	28.99	27.68	4.90	8.55
33	CVPP-20-033	6.71	0.92	5.50	0.82	0.80	23.55	28.02	3.89	8.28
34	CVPP-20-034	8.38	0.86	6.00	0.67	0.64	22.09	28.22	5.20	8.09
35	CVPP-20-035	7.52	1.02	6.00	0.96	0.83	17.88	27.65	4.37	9.23
36	CVPP-20-036	6.96	0.92	5.50	0.84	0.79	17.45	27.94	4.90	9.22
37	CVPP-20-037	7.42	0.67	5.50	0.63	0.59	16.90	26.93	4.78	8.79
38	CVPP-20-038	7.15	0.75	5.00	0.75	0.73	14.78	27.82	5.22	8.75
39	CVPP-20-039	6.45	0.54	4.00	0.54	0.49	21.67	27.05	4.95	8.08
40	CVPP-20-040	6.25	0.56	4.50	0.56	0.55	22.56	28.06	4.39	9.05
41	CVPP-20-041	6.49	0.72	5.50	0.65	0.63	21.76	27.11	3.90	8.00
42	CVPP-20-042	6.43	0.73	5.00	0.69	0.66	24.05	27.90	5.21	8.00
43	CVPP-20-043	7.33	0.49	5.00	0.36	0.34	23.99	26.92	4.57	8.28
44	CVPP-20-044	7.35	0.65	5.00	0.56	0.54	21.55	26.97	4.96	8.99
45	CVPP-20-045	7.36	0.67	6.00	0.62	0.60	17.89	27.80	3.98	8.10
46	CVPP-20-046	7.65	0.66	5.50	0.62	0.60	16.45	28.01	4.00	8.05
47	CVPP-20-047	6.86	0.54	4.50	0.52	0.51	15.87	28.05	5.12	8.67
48	CVPP-20-048	6.74	0.63	4.50	0.62	0.59	16.99	27.25	4.95	9.04
49	CVPP-20-049	6.68	0.75	4.50	0.72	0.69	21.00	27.05	4.93	8.96
50	CVPP-20-050	5.77	0.54	4.50	0.47	0.44	24.05	28.09	5.20	9.22
51	CVPP-20-051	6.38	0.56	5.00	0.55	0.53	20.44	28.22	5.00	8.06
52	CVPP-20-052	6.34	0.65	5.00	0.61	0.60	23.54	26.20	4.97	8.77
53	CVPP-20-053	6.63	0.64	5.50	0.56	0.54	21.47	27.80	4.50	8.00
54	CVPP-20-054	6.73	0.56	5.50	0.56	0.55	19.86	26.54	4.65	8.90
55	CVPP-20-055	7.71	0.71	6.00	0.63	0.60	19.50	27.09	4.39	8.88
56	CVPP-20-056	7.55	0.56	6.00	0.55	0.52	17.05	27.89	4.09	7.98
57	CVPP-20-057	7.61	0.76	5.00	0.74	0.72	21.09	28.02	5.02	8.95
58	CVPP-20-058	5.90	0.65	5.50	0.56	0.44	23.05	27.66	4.87	8.25
59	CVPP-20-059	5.90	0.85	4.00	0.80	0.78	24.76	27.09	4.99	8.14
60	CVPP-20-060	6.25	0.55	4.50	0.43	0.42	23.55	27.01	4.92	8.22
61	CVPP-20-061	8.90	0.90	7.00	0.82	0.80	21.00	27.21	4.97	9.38
62	BSR 1	4.65	0.85	5.50	0.63	0.61	20.89	26.94	5.03	8.04
63	BRG 1	6.40	1.10	6.00	0.73	0.67	26.04	27.56	5.00	8.44
64	BRG 3	5.58	0.65	6.00	0.75	0.74	22.05	28.04	5.21	9.01
	Mean	6.74	0.64	5.40	0.58	0.53	21.15	27.62	4.57	8.63
	Range	4.65-8.90	0.39-1.10	4.00-7.00	0.34-0.98	0.30-0.88	13.98-28.99	26.20-28.90	3.44-5.34	7.88-9.38
	S.E	0.10	0.02	0.08	0.02	0.02	0.42	0.07	0.06	0.05
	CD (5%)	0.20	0.03	0.16	0.03	0.03	0.84	0.14	0.12	0.10

sample. In the present study, low test weight was reported in check varieties and test genotypes, it may be due to late sowing of the trial in the month of July. The genotypes CVPP-20-005 (28.90%), CVPP-20-023 (28.90 %) and CVPP-20-052 (26.20 %) recorded high and low protein, respectively with a mean value of 27.62 per cent. Hulse (1977) reported seed protein content around 22 per cent in pigeonpea genotypes. Saxena *et al*. (2000) reported the levels of protein in high-protein lines and is from 28.7 to 31.1 per cent. The genotypes CVPP-20-002 (5.34 %) and CVPP-20-061 (9.38 %) recorded high total soluble sugars and fibre content, respectively. The genotypes CVPP-20-013 (3.44 %) and CVPP-20-022 (7.88 %) recorded low total soluble sugars and fibre content, respectively. Saxena *et al*. (2010) reported seed total soluble sugars and fibre content around 5.1 per cent and 8.2 per cent in vegetable pigeonpea genotypes respectively. Singh *et al*. (1977) reported that the vegetable type pigeonpea had higher amount of total soluble sugars and low crude fibre content than *dhal* irrespective of their seed sizes.

Analysis of variance revealed significant differences for all the characters studied, indicating the presence of significant variability among the genotypes *viz*., phenotypic coefficients of variation (PCV), genotypic coefficients of variation (GCV), heritability, genetic advance and genetic advance as per cent of mean for ten characters (**Table 2**). PCV was higher than GCV for all the traits under investigation, indicating the role of environmental variance in the total variance. High GCV and PCV were observed for total soluble sugars (28.73 and 27.94, respectively), hundred fresh bean weight (26.54 and 25.87, respectively), indicating the presence of high amount of variability. Satish Kumar *et al*. (2006) reported high GCV and PCV for hundred fresh bean weight (26.29 and 25.87, respectively) in pigeonpea. The magnitude of moderate PCV and GCV was observed for fresh pod length (15.25 & 14.28, respectively), fresh pod width (13.14 & 12.59, respectively), fresh bean length (12.24 &11.59, respectively). Firoz Mahamad and Sham (2006) reported moderate PCV and GCV for fresh pod length (16.35 & 15.88, respectively), the number of beans per pod (17.25 & 16.28, respectively), in pigeonpea. High heritability was observed in the characters *viz.,* fresh pod length (63.09 %), fresh pod width (63.34 %), the number of beans per pod (79.57 %), hundred fresh bean weight (83.45 %) and the total soluble sugars (64.67 %). Satish Kumar *et al*. (2006) and Firoz Mahamad and Sham (2006) reported high heritability for the number of beans per pod (67.35 %), hundred fresh bean weight (64.23 %). Medium heritability was recorded for bean length (49.57 %), bean breadth (51.23 %), protein content (58.65 %) and fibre content (53.57 %). The high genetic advance as per cent of mean was recorded for characters *viz*., fresh pod length (22.84 %), fresh pod width(29 %), bean length (29.68 %), bean breadth (28.30 %), hundred fresh bean weight (34.09 %) and the total soluble sugars (49.01 %). The low genetic advance as per cent of mean was recorded for characters *viz*., the number of beans per pod (6.66 %), protein content (3.36 %) and fibre content (8.57 %). According to Johnson *et al*. (1955), heritability estimates along with the genetic gain are usually more useful. Fresh pod length (63.09 and 22.84) , fresh pod width (63.34 and 29.68) , hundred fresh bean weight (83.45 and 34.09) , the total soluble sugars (64.67 and 49.01) had high heritability coupled with high genetic advance as per cent over mean, that might be due to the additive gene effects. Hence, selection will be very effective for these characters for the development of vegetable pigeonpea. Pushpavalli *et al*. (2017), Kumar *et al*. (2018) and Satyanarayana *et al*. (2018) reported high heritability coupled with the high genetic advance as per cent over mean for hundred fresh bean weight (62.19 and 20.84, respectively) in pigeonpea. Panse and Sukhatme (1957) reported that the additive gene effects is responsible for the inheritance of those quantitative characters which exhibit high heritability and high genetic advance as per cent mean in broad sense and such characters could be improved by selection. The high heritability and low genetic advance as per cent over mean were observed for the number of seeds per pod (79.57 and 6.66, respectively) suggesting preponderance of non additive gene action in the inheritance of these traits.

Wide variability were observed for fresh pod length, fresh

Table 2. Genetic variability of quantitative and quality traits in vegetable pigeonpea

S.No	Characters	PCV (%)	GCV (%)	Heritability (%)	Genetic advance	GA as per cent of mean
1	Fresh pod length	15.25	14.28	63.09	1.54	22.84
2	Fresh pod width	13.14	12.59	63.34	0.19	29.68
3	Number of beans per pod	9.08	8.76	79.57	0.36	6.66
4	Bean length	12.24	11.59	49.57	0.12	20.68
5	Bean breadth	10.94	9.96	51.23	0.15	28.30
6	Hundred fresh bean weight	26.54	25.87	83.45	7.21	34.09
7	Protein content	2.43	1.89	58.65	0.93	3.36
8	Total soluble sugars	28.73	27.94	64.67	2.24	49.01
9	Fibre content	4.56	3.99	53.57	0.74	8.57

pod width , bean length, bean width , hundred fresh bean weight and total soluble sugars . The genotypes *viz*., CVPP-20-002, CVPP-20-023, CVPP-20-017, CVPP-20-031, CVPP-20-032 and CVPP-20-061, were superior over the commercial cultivars with respect to fresh pod length, the number of beans per pod, bean length, bean width, hundred fresh bean weight, protein content, the total soluble sugar and fibre content. The promising genotypes can be used to develop vegetable/dual purpose varieties in pigeonpea.

REFERENCES

Aiyer, H. and Reddy, L. J. 1947. Pigeonpea: Morphology. *J.Sci. Agr.,***5**(7):49-54.

Atilla, J.F., Anderson, R.E., Tatham, R. L. and Black, W. C 2010. Genetic variability and association studies for yield and its attributes in super early pigeonpea [*Cajanus cajan*(L.)Millsp.] genotypes. *Genetica Agraria*, **9**(2): 682- 691. [Cross Ref]

Chitra, A.B., Yadav, V.N. and Singh, S. P. 1996.Correlation and heritability studies in arhar [*Cajanus cajan* (L.) Millsp.].*Indian Agriculturist,* **6**(1): 41-44.

Firoz Mahamad, N. and Sham, N. L. 2006. Effect of nitrogen, phosphorus and sulphur on protein content of arhar [*Cajanus cajan*(L.)]. *Seed Farming,* **2**(5):37-39

Hanson, S., Bhardwaj, B.L. and Bajaj, R. K.1956.Studies on the heritability and inter-relationship of some agronomically important characters in pigeonpea. *Genetica Agraria,* **3**(2): 41-44.

Hulse, J.H. 1977. Problems of nutritional quality of pigeonpea and chickpea and prospect of research. In: Hulse, J.H., Rachie, K.O. and Billingsley, L.W. Eds., *Nutritional Standards and Methods of Evaluation for Food Legume Breeders*, International Development Research Center, Ottawa, 88-100.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Genotypic and phenotypic correlations in soybeans and their implications in selection .*Agron J.*, **47**(10): 477-483. [Cross Ref]

Kumar, G., Rani, C. S., Sudhakar, C and Kumar, C. S. 2018. Genetic variability and correlation in pigeonpea genotypes. *Electronic Journal of Plant Breeding*, **9**(1): 343-349. [Cross Ref]

Ludwig, Thomas G. and Goldberg, Hyman J. V. 1956. The anthrone method for the determination of carbohydrates in foods and in oral rinsings, *J. D. Res.,* **35**(8):90-93. [Cross Ref]

Maynard, A.J. 1970. Methods in food analysis: physical, chemical and instrumental methods of analysis. *J. Biol Chem*., **176**(3):51-58.

Ojwang, D., Nyankanga, R. and Imungi, J. 2016. Cultivar preference and sensory evaluation of vegetable pigeonpea (*Cajanus cajan*) in Eastern Kenya. *Food Sec.,* **8**(1): 757–767. [Cross Ref]

*Oliver Lowry, H. 1951***.** Protein measurement with the Folin phenol reagent. *J. Biol Chem*., **193**(1):256-275. [Cross Ref]

Panse, V. G and Sukhatme, P. V. 1957. Statistical methods for agricultural research workers. *ICAR, New Delhi*, 381.

Pushpavalli, S. N. C. V. L., Sudhakar, C., Rani, C. S., Rajeswari, R. R and Rani, C. J. 2017.Genetic divergence, correlation and path coefficient analysis for the yield components of pigeonpea genotypes. *Legume Res*., **40**(3): 439- 443.

Satish Kumar. D.G., Faris, U. Singh and Kumar,R.V. 2006. Relationship between seed size and protein content in newly developed high protein lines of pigeonpea. *Plant Foods Hum.Nut.,***36**(10): 335-340. [Cross Ref]

Satyanarayana, N., Sreenivas, G., Jagannadham, J., Amarajyothi, P., Rajasekhar, Y and Swathi, B. 2018. Genetic variability, Correlation and path analysis for seed yield and its components in Redgram [*Cajanus cajan* (L.) Mill sp.]. *Bulletin of Environment, Pharmacology and Life Sciences.,* **7**:53-57.

Saxena, K.B.,Kumar,R.V. and Rao,P.V. 2000.Pigeonpea theory and techniques, In: Gupta, S.K. Ed., Agroloios (India),Jodhpur, 82-112.

Saxena, K. B., Kumar,R.V. and Gowda,C.L.L. 2010.Vegetable pigeonpea-a review. *Journal of Food Legumes,* **23**(2): 91-98.

Singh, L.N., Singh, M.P., Shrivastava, T.K. and Gupta, A.K. 1977. Characteristics and utilization of vegetable types of pigeonpeas *(Cajanus cajan* (L.) Millsp.).*Ind. J. Nutri.Diet.,***14**(2):8-10.

Singh, N.B., Ariyanayagam, R. P., Gupta, S. C. and Rao, A. N. 1984. Relationship of plant height, days to flowering and maturity to grain yield in short duration determinate pigeonpea. *Indian J. Genet. Plant Breed*., **55**(12): 1-5.

Sivasubramaniam, P. and Menon, P.M. 1973. Inheritance of short stature in rice. *Madras Agri J.,* **60**(7):1129-1133.

Upadhyaya, H. D., Reddy, K. N., Gowda, C. L. L. and Sube Singh. 2010. Identification and evaluation of vegetable type pigeonpea (*Cajanus cajan* (L.) Millsp.) in the world germplasm collection at ICRISAT genebank. *Pl. Gen. Res.,* **8**(2): 162–170. [Cross Ref]