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Studies on genetic variability and divergence in yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc.) genotypes screened under polyhouse conditions

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Abstract

The current investigation was carried out on "Morphological and molecular characterization of yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc.) genotypes screened under polyhouse conditions". The analysis of variance showed that there were very significant ($p = 0.01$ and $p = 0.05$) genotypic variations for growth, yield and biochemical parameters in yardlong bean. The range, mean, phenotypic variance, genotypic variance, genotypic coefficient of variation, phenotypic coefficient of variation, broad-sense heritability, genetic advance and genetic advance over percent of mean were calculated. The genotypes showed considerable amount of variability for all the traits. The high estimates of heritability coupled with high genetic advance over percent of mean were noticed for the traits *viz.*, plant height at final harvest, number of primary branches at final harvest, number of flowers per cluster, number of clusters per plant, pod length, pod weight, number of pods per cluster, number of pods per plant, yield (kg/ plant), yield per hectare, crude protein, ascorbic acid and TSS which shows that additive gene action has a significant influence on the traits and selection will be effective in improving these traits. By applying Tocher's approach, 40 genotypes were divided into 9 clusters, the maximum divergence was observed between clusters III and IX for traits like yield, pod length, number of pods per plant, number of primary branches at final harvest and pod weight contributed maximum towards total divergence, the genetically diverse genotype of these clusters aids in the creation of larger recombinants, and would be an aid in the genetic improvement of yardlong bean genotypes.

Keywords: Genetic variability, heritability, genotypic coefficient of variation, phenotypic coefficient of variation, genetic advance, genetic advance over percent of mean, divergence and mahalanobis D^2

Introduction

An economically important crop, the yardlong bean (*Vigna unguiculata* ssp. *sesquipedalis* (L.) Verdc. $2n=22$) is grown commercially for its green pods which are consumed both as cooked and raw (Hammer, 1984) [8].

It is highly self pollinating, flowers are either purple or white and the leaves have a light sheen. Typically, flowers are bigger than cowpeas. Black, brown and a variety of mottled colours and has all possible seed colours. Young pods are consumed as vegetables and the pods are used in a manner similar to that of conventional field beans (Saidaiyah *et al.*, 1985) [20].

The crop which originated in central West Africa, is now widely grown in a number of South East Asian nations, including Taiwan, the Philippines, Indonesia, Thailand, India, Pakistan, Bangladesh and South China (Rambabu *et al.*, 2016) [16].

In India, there are roughly 18,560–20,160 acres under cultivation per year (Toppo *et al.*, 2018) [26]. It is grown as an intercrop, mixed crop and a sole crop in the south-western districts of Karnataka, including Belagavi, Kodagu, Uttara Kannada, Udupi, Dakshina Kannada, Hassan, Chikkamagaluru, and some areas of Bengaluru. The crop is referred to as an under utilised leguminous crop because it is neither farmed economically on a big scale nor traded widely.

Yardlong bean is a considerable source of nourishment, especially vitamin A and C, which provide 17 percent and 31 percent, respectively and 100 g of beans have 47 calories (USDA, 2005) [27]. This legume is also known as poor man's meat containing high nutritive value with good amount of digestible protein both in fresh pods and leaves (23.52-26.27%) (Ano and Ubochi, 2008) [1]. The pods are also rich in calcium (72 mg), phosphorus (59 mg), iron (2.5 mg), carotene (564 mg), thiamine (0.07 mg), riboflavin (0.09 mg) and vitamin C (24 mg/100

g) of edible pods. It is also rich source of micronutrients like iron (102.6-120.0 mg/100 g), zinc (32.58-36.66 mg/100 g), manganese (2.92-3.34 mg/100 g), cobalt (0.33-0.57 mg/100 g) and selenium (5 µg/100 g) are also found in yardlong bean (Benchasri *et al.*, 2017) [3]. It can be used as a medicine to reduce cholesterol levels in the blood (Rubatzky and Yamaguchi, 1997) [19].

A wide range of genetic variability is available in the yardlong bean providing good scope for improvement in yield and associated traits of yardlong bean through selection. Performance of the genotypes differs with region, season and other growing conditions. As a result, a prominent genotype performing well in one region may fail to perform well in other regions of different climatic conditions. The criteria for selection of suitable high yielding genotype for the region requires collection and evaluation of available yardlong bean genotypes. Ultimately, the yield and production of high quality pod depends upon the selection of suitable genotypes for a particular region.

Materials and Methods

The current investigation was carried out between April 2022 and July 2022 in naturally ventilated polyhouse of the Department of Vegetable Science, Kittur Rani Channamma College of Horticulture, Arabhavi, Belagavi District (Karnataka) during Late *Rabi*, 2022.

The research was carried out using 40 genotypes of yardlong bean using randomized complete block design (RCBD) with two replications. Yardlong bean seeds were sowed at the spacing of 1.0m × 0.6m. Ten plants are present in each treatment. Five tagged plants were selected randomly from each treatment to record observations for different traits *viz.*, plant height at final harvest, number of primary branches at final harvest, number of flowers per cluster, number of clusters per plant, pod length, pod weight, number of pods per cluster, number of pods per plant, yield (kg/ plant), yield per hectare, crude protein, ascorbic acid and TSS.

Genotypic coefficient of variation and phenotypic coefficient of variation were estimated according to Burton and Devane (1953) [4] based on estimate of genotypic variance and phenotypic variance. The broad sense heritability (h^2) was estimated by following the procedure suggested by Falconer, 1981 [1]. The genetic advance was calculated by following the standard procedure given by Robinson *et al.*, 1949 [18]. The genetic advance over percent of mean for each trait was predicted by the formula given by Johnson *et al.*, (1955) [10]. D^2 statistics from Mahalanobis (1936) [12] was employed to evaluate the genetic divergence. The genotypes were clustered using Tocher's approach as reported by Rao (1952) [17] utilising all D^2 values. Singh and Chaudhary (1977) [22] formula was used to compute the intra- and inter-cluster distances.

Results and Discussion

The analysis of variance revealed that there were highly significant differences among genotypes for various quantitative traits observed at one and five percent level of significance. The mean sum of squares for 40 genotypes of yardlong bean are shown in table 1.

Variation shown by the genotypes for all the traits shows wide range of variability present in the genotypes. A wide range of variability existing for different quantitative traits has also been reported in yardlong bean by Sivakumar (2012) [24], Litty

(2015) [11], Rambabu *et al.* (2016) [16] and Asoontha and Abraham (2017) [2]. The GCV gives fundamental data for assessing and analyzing the genetic variability ranges for quantitative traits, while the PCV evaluates the frequency of total variation (Table 2).

Among various traits studied, greater PCV and GCV values were found in the current study for number of primary branches at final harvest, number of clusters per plant, pod length, pod weight, number of pods per cluster, number of pods per plant, yield (kg/ plant), yield per hectare, ascorbic acid and TSS. It suggests that there is significant variation that can be further increased by selection. These results are in line with the findings of Jithesh (2009) [9] in yardlong bean and Sivakumar and Celine (2014) [23] in yardlong bean for number of pods per plant; Jithesh (2009) [9] in yardlong bean, Pravin *et al.* (2013) [15] in cowpea, Vavilapalli *et al.* (2013) [28] in bush cowpea for pod length; Jithesh (2009) [9] in yardlong bean and Thouseem *et al.* (2018) [25] in cowpea for yield (kg/ plant); Sivakumar (2012) [24] in vegetable cowpea and Pravin *et al.* (2013) [15] in cowpea for number of primary branches at final harvest and pod weight; Jithesh (2009) [9] in yardlong bean for pod weight.

The moderate PCV and GCV results were reported for plant height at final harvest, number of flowers per cluster and crude protein. These findings are in line with the research findings of Jithesh (2009) [9] for protein strength in yard long bean; Sivakumar (2012) [24] for protein constituent in bush cowpea.

Low GCV and moderate PCV were observed for days to first flowering. The findings were in agreement with Vavilapalli *et al.* (2013) [28] in bush cowpea and Rambabu *et al.* (2016) [16] in yardlong bean for days to first flowering.

The degree of variability present for different traits, it is required to divide the observed variability into phenotypic coefficient of variation and genotypic coefficient of variation. Even so, this does not accurately depict how much of the character is inherited. Therefore, one may rely on a character's heritability since it allows plant breeders to choose how much selection pressure to apply in a given environment and separating the effects of the environment from all other variables.

The higher broad sense of heritability (>60%) estimates were observed for plant height at final harvest, number of primary branches at final harvest, number of flowers per cluster, number of clusters per plant, pod length, pod weight, number of pods per cluster, number of pods per plant, yield (kg/ plant), yield per hectare, crude protein, ascorbic acid and TSS (Table 2).

The high estimates of heritability coupled with high genetic advance over percent of mean were noticed for the traits like plant height at final harvest, number of primary branches at final harvest, number of flowers per cluster, number of clusters per plant, pod length, pod weight, number of pods per cluster, number of pods per plant, yield (kg/ plant), yield per hectare, crude protein, ascorbic acid and TSS. High heritability offers a greater role for additive and additive x additive gene action which can be exploited by applying simple selection. Similar studies were also obtained by Savithiri *et al.* (2018) [21] in yardlong bean for yield (kg/ plant); Mary and Gopalan (2006) [13] in cowpea for plant height at final harvest and number of primary branches at final harvest; Jithesh (2009) [9] in yardlong bean for pod length and crude protein content; Sivakumar (2012) [24] in vegetable

cowpea for crude protein; Vavilapalli *et al.* (2013)^[28] in bush cowpea and Nwosu *et al.* (2013)^[14] in cowpea for number of pods per plant; Savithiri *et al.* (2018)^[21] in yardlong bean and Thouseem *et al.* (2018)^[25] in cowpea for pod length, plant height at final harvest and number of pods per plant. High heritability coupled with moderate genetic advance over

percent of mean was observed for days to first flowering suggests non-additive genetic action and these traits can be enhanced through recombination breeding (particular combination followed by intermating lines). Similar results were also reported by Rambabu *et al.* (2016)^[16] in yardlong bean for days to first flowering.

Table 1: Analysis of variance in yardlong bean genotypes (mean sum of squares) for growth, flowering, yield and quality parameters

Sl. No.	Source of variation/Characters	Replications	Treatments	Error	S.Em±	CD (5%)	CD (1%)
	Degrees of freedom	1	39	39			
A. Growth parameters							
1	Plant height at final harvest (m)	0.17	0.78**	0.04	0.15	0.43	0.57
2	Number of primary branches at final harvest	8.65	3.64**	0.12	0.25	0.70	0.94
B. Flowering parameters							
1	Days to first flowering	123.50	48.54**	13.68	2.62	7.48	10.02
2	Number of flowers per cluster	46.51	4.40**	0.64	0.56	1.61	2.16
3	Number of clusters per plant	25.20	31.21**	2.35	1.08	3.10	4.15
C. Yield parameters							
1	Pod length (cm)	5.82	307.37**	6.98	1.87	5.34	7.16
2	Pod weight (g)	4.85	89.86**	2.95	1.22	3.48	4.65
3	Number of pods per cluster	28.32	5.80**	0.56	0.53	1.52	2.03
4	Number of pods per plant	90.10	153.38**	6.06	1.74	4.98	6.66
5	Yield (kg/plant)	0.16	0.06**	0.003	0.04	0.11	0.15
6	Yield/ha (tonnes)	20.21	47.92**	1.00	0.71	2.02	2.71
D. Quality parameters							
1	Crude protein (g/100 g)	0.02	1.36**	0.04	0.14	0.41	0.55
2	Ascorbic acid (mg/100 g)	1.28	22.67**	0.39	0.44	1.26	1.69
3	TSS (°B)	0.001	2.88**	0.02	0.10	0.27	0.36

* Significant @ 5 percent

** Significant @ 1 percent

Table 2: Estimates of mean, range, components of variance, heritability and genetic advance for growth, yield and quality parameters in yardlong bean

Sl. No.	Characters	Mean	Range		GV	PV	Coefficient of Variations (%)		h ² (%)	GA	GAM (%)
			Min.	Max.			PCV	GCV			
2	Number of primary branches at final harvest	5.33	3.50	9.30	1.76	1.88	25.73	24.89	93.56	2.64	49.59
3	Days to first flowering	49.70	35.95	61.35	31.11	17.43	11.22	8.40	56.02	6.44	12.95
4	Number of flowers per cluster	8.99	5.70	13.10	1.88	2.52	17.66	15.27	74.77	2.44	27.20
5	Number of clusters per plant	16.49	9.70	27.20	14.43	16.78	24.84	23.04	86.01	7.26	44.02
6	Pod length (cm)	41.58	22.93	68.87	150.20	157.18	30.15	29.48	95.56	24.68	59.36
7	Pod weight (g)	18.54	9.81	34.96	43.45	46.40	36.74	35.54	93.63	13.14	70.86
8	Number of pods per cluster	7.49	4.45	11.40	2.62	3.18	23.80	21.60	82.31	3.02	40.36
9	Number of pods per plant	38.19	24.90	66.55	73.66	79.72	23.38	22.47	92.40	17.00	44.50
10	Yield (kg/plant)	0.91	0.41	1.47	0.08	0.08	31.18	30.57	96.12	0.56	61.79
11	Yield/ha (tonnes)	12.59	4.46	25.35	23.46	24.46	39.29	38.48	95.89	9.77	77.63
12	Crude protein (g/100 g)	6.29	3.33	8.17	0.66	0.70	13.30	12.91	94.09	1.62	25.79
13	Ascorbic acid (mg/100 g)	15.14	8.70	21.81	11.14	11.53	22.43	22.05	96.64	6.76	44.65
14	TSS (°B)	3.20	1.20	5.90	1.43	1.45	37.63	37.39	98.74	2.45	76.53

GV- Genotypic variance PV- Phenotypic variance PCV- Phenotypic coefficient of variation GCV- Genotypic coefficient of variation h² – Broad sense heritability GA- Genetic advance GAM- Genetic advance over percent of mean

These clusters were developed based on how various characters contributed to the divergence as shown in table 3. Yield (26.79%) contributed maximum to the total genetic diversity among the genotypes followed by pod length (22.31%), number of pods per plant (15.51%), number of primary branches at final harvest (12.82%), pod weight (7.44%), plant height at final harvest (6.92%), number of clusters per plant (3.46%), number of pods per cluster (2.56%), number of flowers per cluster (1.79%) and days to

first flowering (0.38%).

Cluster I was the largest having 29 genotypes each followed by cluster IV (4), and cluster II, III, V, VI, VII, VIII and IX had one genotype each as shown in table 4 and fig. 1. Intra and inter-cluster average D² values are presented in table 5. Among the nine clusters, cluster IV with 4 number of genotypes showed maximum intra-cluster diversity (D² = 85.73) and cluster I with 29 (D² = 78.47) showed minimum intra-cluster diversity.

Table 3: Relative percent contribution of different characters to divergence in genotypes of yardlong bean

Sl. No	Characters	Times ranked first	Contribution (%)
1	Plant height at final harvest (m)	54	6.92
2	Number of primary branches at final harvest	100	12.82
3	Days to first flowering	3	0.38
4	Number of flowers per cluster	14	1.79
5	Number of clusters per plant	27	3.46
6	Pod length (cm)	174	22.31
7	Pod weight (g)	58	7.44
8	Number of pods per cluster	20	2.56
9	Number of pods per plant	121	15.51
10	Yield (kg/plant)	209	26.79

Table 4: Grouping of yardlong bean genotypes into different clusters based on D² value

Clusters	Number of genotypes	Genotype included in the cluster
I	29	EC693334, EC693348, EC693333, Githika, Avka, Sarpan 601, Pallakad Local, VS-37, TCR-117, TCR-85, Malika, TCR-86, TCR-124, TCR-88, VS-56, VS-44, EC693340, TCR-119, Vyjayanthi, EC693337, TCR-112, VS-35, TCR-125, TCR-87, VS-40, Vellayaini Jyothika, Arka Mangala, Kollam Local and Pant Vegetable-20
II	1	TCR-104
III	1	TCR-84
IV	4	TCR-79, TCR-115, TCR-80 and TCR-116
V	1	EC693341
VI	1	VS-53
VII	1	EC693336
VIII	1	Bobbili Local
IX	1	EC693338

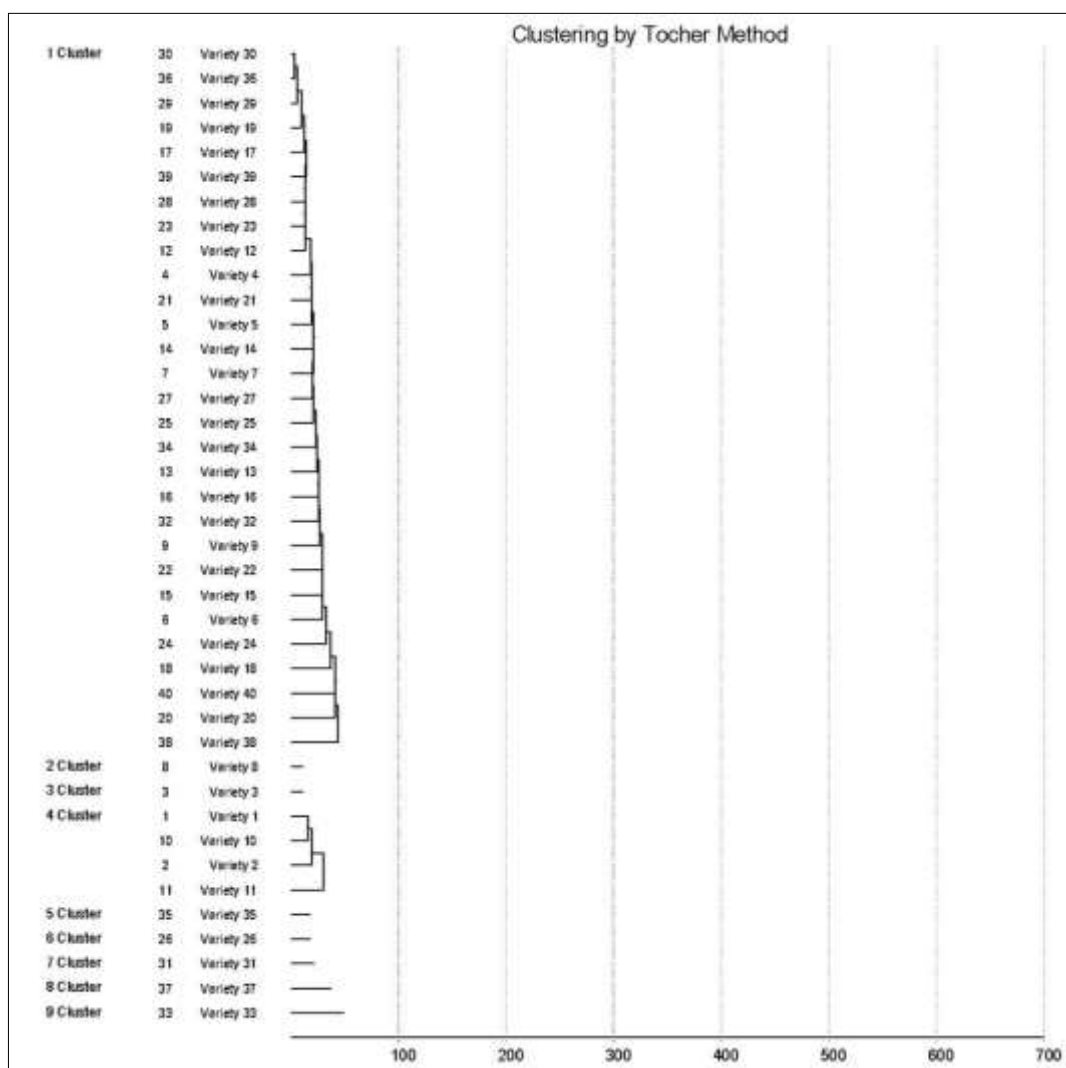


Fig 5: Dendrogram showing the genetic divergence among yardlong bean genotypes using Tocher's method

Table 5: Intra and inter cluster D² and D values in genotypes of yardlong bean

Clusters	I	II	III	IV	V	VI	VII	VIII	IX
I	78.47	149.60	130.39	155.53	167.64	149.43	146.28	200.70	239.26
II		0.00	90.15	70.64	393.37	180.83	391.53	332.89	323.44
III			0.00	132.93	375.86	169.80	313.56	359.27	466.73
IV				85.73	341.82	179.30	388.86	230.20	375.11
V					0.00	183.99	101.02	104.05	175.54
VI						0.00	222.97	160.20	309.90
VII							0.00	287.52	224.81
VIII								0.00	258.57
IX									0.00

Based on the distance between clusters, *i.e.*, inter-cluster distances, the maximum divergence was observed between clusters III and IX (D² = 466.73) followed by clusters II and V (D² = 393.37), clusters II and VII (D² = 391.53), clusters IV and VII (D² = 388.86), clusters III and V (D² = 375.86), clusters IV and IX (D² = 375.11), clusters III and VIII (D² = 359.27), clusters IV and V (D² = 341.82), clusters II and VIII (D² = 332.89), clusters II and IX (D² = 323.44), clusters III and VII (D² = 313.56), clusters VI and IX (D² = 309.90), clusters VII and VIII (D² = 287.52), clusters VIII and IX (D² = 258.57), clusters I and IX (D² = 239.26), clusters IV and VIII (D² = 230.20), clusters VII and IX (D² = 224.81), clusters VI and VII (D² = 222.97), clusters I and VIII (D² = 200.70), clusters V and VI (D² = 183.99), clusters II and VI (D² = 180.83), clusters IV and VI (D² = 179.30), clusters V and IX (D² = 175.54), clusters III and VI (D² = 169.80), clusters I and V (D² = 167.64), clusters VI and VIII (D² = 160.20), clusters I and IV (D² = 155.53), clusters I and II (D² = 149.60), clusters I and VI (D² = 149.53), clusters I and VII (D² = 146.28), clusters III and IV (D² = 132.93), clusters I and III (D² = 130.39), clusters V and VIII (D² = 104.05), clusters V and VII (D² = 101.02), clusters II and III (D² = 90.15) and cluster II had the least inter-cluster distance (D² = 70.64) with the cluster IV. This indicated close relationship among the genotypes included in the cluster II and cluster IV. Average inter and intra-cluster distances showed that, generally inter-cluster distances were substantially higher than those of intra-cluster distances, suggesting homogeneous and heterogeneous nature of the germplasm lines within and between the clusters respectively. These results were in accordance with the findings of Dalsaniya *et al.* (2009) [5] in cowpea and Devan *et al.* (2021) [6] in yardlong bean.

Conclusion

In conclusion the significant variations were recorded between the genotypes for all the traits under study at one and five percent level of significance. Variation exhibited by the genotypes for all the traits shows wide range of variability in the genotypes.

High GCV and PCV were recorded for most of the traits under study and most of the traits showed high heritability coupled with high genetic advance over percent of mean which shows that these traits are under the influence of additive gene action.

The maximum divergence was observed between clusters III and IX indicated that the genotypes included in these clusters can be used as a parent in hybridization programme to get highly heterotic hybrids from the segregating populations.

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