VARIABILITY AND PATH ANALYSIS IN BUSH TYPE VEGETABLE COWPEA (*Vigna unguiculata* (L.) Walp.)

By

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2001

DECLARATION

I hereby declare that this thesis entitled " **Variability and path analysis in bush type vegetable cowpea (*Vigna unguiculata* (L.) Walp.)**" is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "**Variability and path analysis in bush type vegetable cowpea (*Vigna unguiculata* (L.) Walp.)**" is a record of research work done independently by **Mr. Ajith. P. M.** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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TO MY LOVING

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INTRODUCTION

1. INTRODUCTION

Cowpea *Vigna unguiculata* (L.) Walp. is a versatile crop grown for pulse, vegetable and fodder purpose. In varieties grown for vegetable purpose, tender pods are fleshy and succulent. Green pods are highly nutritious and 100 gram contains protein 4.3 g, carbohydrates 8 g, minerals 0.9 g, fibre 2.0 g, calcium 80 mg, phosphorus 74 mg and iron 2.5 mg besides many vitamins in appreciable quantities (Aykroyd, 1963). Cowpea grains contain the amino acid methionine in quantities higher than in any other legume.

Cowpea has been cultivated since very ancient time in the Mediterranean region by the Greeks, Romans and Spaniards. It has been raised as a vegetable crop in southern Asia and the Far East for its immature pods. It is most widely cultivated in India, Indonesia, Philippines and Srilanka. Vegetable cowpea is grown throughout India and has its most extensive cultivation in Kerala. Varieties grown are mostly twining types which require staking. Erecting stakes and training plants on them is a laborious and demanding cultural operation which can be done away with, if bush type varieties are grown.

Several local and improved bush type vegetable cowpea varieties are available. An understanding of variability in green pod yield and yield contributing characters among such varieties is essential for crop improvement efforts.

Keeping in view the above mentioned aspects, the present investigation was undertaken with the following objectives.

i. To study the genetic variability for different traits by estimating phenotypic and genotypic coefficient of variation.

ii. To estimate the heritability and genetic advance for different characters.

iii. To study the association between yield and its components by estimating correlation coefficients and

iv. To understand the direct and indirect effects of yield contributing characters by path coefficient analysis.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The present study aimed at variability and path coefficient analysis in bush type vegetable cowpea. Crop improvement work is rather scanty in bush type vegetable cowpea. Hence relevant literature on crop improvement in cowpea in general is reviewed under different headings.

2.1 Genetic variability, heritability and genetic advance

Genetic variability for yield and yield contributing traits in the base population is essential for successful crop improvement (Allard, 1960). Greater the variability, more the chances for selection of better genotypes. The genetic parameters like coefficient of variation, heritability and genetic advance provide an exact picture of variability in a population.

Lakshmi and Goud (1977) observed wide variability for many characters studied in 12 genotypes of cowpea. Characters with high genotypic coefficient of variation and high heritability included plant height, pods per plant and pod length. High heritability was seen for seeds per pod also. High genetic advance was observed for pod length and plant height while low genetic advance plus moderate heritability was recorded for pods per plant.

Angadi *et al.* (1978) in a study with 50 genotypes of cowpea observed high variability for all characters considered including pod yield. Genotypic coefficient of

variation ranged from 30.48 for seeds per pod to 81.58 for number of pods per plant. High genotypic coefficient of variation was observed for number of pod clusters per plant and 100-seed weight while moderate to low values were recorded for seeds per pod. Heritability ranged from 68.35 per cent for number of branches to 98.92 per cent for 100-seed weight. Pod number, pod clusters per plant, seed yield, pod yield and 100-seed weight showed high heritability coupled with high genetic advance while a high value of heritability and low genetic advance were exhibited by number of branches and seeds per pod.

Ramachandran *et al.* (1980) noticed high variability for number of days to first harvest, internode length, weight of 10 pods, seed number per pod, pod number per plant and pod yield per plot. The highest genotypic coefficient of variation was for yield per plot which was followed by pod number per plant and internode length. Estimated heritability was the highest for number of days to flowering. The highest genetic advance was found for seed number per pod.

Pandita *et al.* (1982) studied six traits in 40 genotypes of cowpea and recorded high variability for all the characters including days to first flowering, plant height and pod yield per plant with the exception of number of pods per cluster. The highest phenotypic and genotypic coefficients of variation were observed for pod yield per plant which also recorded high value of heritability and high genetic advance as percentage of mean.

Vaid and Singh (1983) reported that branch number and pod yield per plant gave high values of genotypic and phenotypic coefficients of variation, heritability and expected genetic advance.

Yap (1983) found the existence of substantial genetic variability among cowpea cultivars of Malaysia. High heritability was recorded for pod length while pod yield and seed protein content showed low heritability.

In a study on genetic variability of 40 genotypes of cowpea, Dharmalingam and Kadambavanasundaram (1984) obtained high heritability values for the characters pod length, 100-seed weight and harvest index.

Chikkadyavaiah (1985) in a study of yield per plant and 11 related characters in 207 indigenous and 117 exotic genotypes recorded the greatest variability for plant spread in Kharif season and for plant height in the summer. Heritability and genetic advance were high for plant height in both the seasons.

Apte *et al.* (1987) noticed high heritability for 100-seed weight, seeds per pod and days to maturity in a study with 50 cowpea genotypes. Percentage genetic gain was greatest for 100-seed weight followed by plant height, branches per plant and seeds per pod.

In a study on seed yield per plant and eight related traits from 49 cowpea cultivars of diverse origin by Patil and Baviskar (1987), the highest variability occurred for seed yield per plant followed by pods per plant, pod clusters per plant and days to maturity. The genotypic and phenotypic coefficients of variation were the highest for pod clusters

per plant followed by pods per plant, seed yield per plant and 100-seed weight. Heritability estimate was the highest for 100 seed weight (90.94 %) followed by days to maturity and pod length.

Ye and Zhang (1987), in a study of 12 characters in 24 vegetable cowpea genotypes recorded high heritability estimates for pod length, flowering date and length of flowering period. They also noticed that the heritability values for pod yield components were generally higher than for pod yield itself.

In a study of 35 genotypes of cowpea conducted by Sharma *et al.* (1988), the maximum genotypic coefficient of variation was found for dry matter yield followed by plant height, green forage yield, pods per plant, seed weight and green pod yield. Heritability values ranged from 46.9 per cent for green pod yield to 98.0 per cent for days to 50 per cent maturity.

Kandasamy *et al.* (1989) studied the performance of 10 cowpea cultivars in six different environments and reported wide variability for days to 50 per cent flowering, days to maturity, pods per plant, pod clusters per plant, pod length, seeds per pod, 100-grain weight and seed yield per plant. The maximum range of variation was observed for number of pods per plant, clusters per plant and seed yield per plant. High phenotypic and genotypic coefficients of variation were recorded for pods per plant, clusters per plant and seed yield per plant. High heritability coupled with high genetic advance was noticed for pods per plant, clusters per plant, 100-seed weight and seed yield per plant.

The genetic variability study by Thiyagarajan (1989) in cowpea revealed moderate variability for plant height, number of clusters per plant, number of pods per plant and yield per plant. Days to 50 per cent flowering, days to maturity, plant height, pod length, number of seeds per pod and 100-grain weight were the characters which recorded high heritability estimates. Both the estimates of heritability and genetic advance were high for plant height, number of seeds per pod and 100-grain weight.

Thiyagarajan *et al.* (1989), in a study of variability in 36 Nigerian cowpea genotypes from IITA (International Institute of Tropical Agriculture, Nigeria) reported that plant height and seed yield per plant recorded high values for heritability and genotypic coefficient of variation. High estimates of heritability and genetic advance as percentage of mean were observed for plant height, clusters per plant, pods per plant, seeds per pod and seed yield per plant.

In a genetic variability study with 25 fodder cowpea types, Roquib and Patnaik (1990) reported high estimates of heritability for plant height, seed number per plant, pods per primary branch, pod length, pod breadth, days to 50 per cent flowering, days to maturity and seed yield per plant. All the above characters excepting pod breadth had high estimates of genetic advance at five per cent selection intensity

Thiyagarajan *et al.* (1990) reported high heritability for the characters, *viz.*, primary branches per plant, clusters per plant, pods per plant, seeds per pod and seed yield per plant in cowpea.

Siddique and Gupta (1991) worked out estimates of variability in cowpea and reported high variability for days to first flowering, plant height, pods per plant, pod length, 100-seed weight, seeds per pod and seed yield. High phenotypic and genotypic coefficients of variation were recorded for pods per plant, plant height, 100-seed weight and seed yield. High heritability estimates were reported for pods per plant, plant height, seed yield, 100-seed weight, days to first flowering, pod length and seeds per pod. High genetic gain was reported for days to first flowering, plant height and seed yield.

Savithramma (1992) reported high genotypic coefficients of variation for seed weight per plant and 100-seed weight. Plant height, pod length and 100-seed weight showed high heritability values. High genetic advance was recorded for plant height, seed weight per plant and 100-seed weight.

Evaluating 15 genotypes of cowpea under eight environments, Damarany (1994) reported high heritability values for weight of seeds per plant (94.4 %), number of pods per plant (85.9 %) and 100-seed weight (83.3 %).

Sawant (1994) studied seed yield and 11 component traits in cowpea and reported high phenotypic and genotypic coefficients of variation for plant height, pods per plant, inflorescences per plant and 100-seed weight. High heritability was observed for plant height, seed yield per plant, pods per plant, 100-seed weight, inflorescences per plant, branches per plant and pod length.

Sobha (1994) reported significant differences for several characters among 31 genotypes of bush type vegetable cowpea. Pod weight, pod yield and pods per plant

recorded high genotypic coefficient of variation. High heritability and genetic advance were observed for pod weight, pod yield per plant, days to harvest, pod length and pod girth.

Wide variation for plant height, pods per plant, pod length, pod width, seeds per pod and grain yield in cowpea were observed by Mathur (1995). The highest genotypic coefficient of variation was recorded for grain yield per plant. All the traits studied showed high heritability estimates. High genetic gain was reported for pods per plant and grain yield per plant.

Rewale *et al.* (1995) reported high estimates of heritability and genetic gain for 100-seed weight, plant height and harvest index in their study with 70 diverse genotypes of cowpea.

Variability in cowpea was studied by Backiyarani and Nadarajan (1996) and they reported high genotypic and phenotypic coefficients of variation for leaf area index, number of pods per plant, number of clusters per plant and 100-seed weight. High heritability coupled with high genetic advance was shown by 100-seed weight, harvest index, leaf area index and single plant yield.

Sreekumar *et al.* (1996) in a study with 18 vegetable cowpea genotypes reported high genotypic and phenotypic coefficients of variation, heritability and genetic advance for pod length and number of seeds per pod. Number of days to flowering and number of days to first harvest recorded high heritability with low genetic advance. High environmental influence was noticed for number of green pods.

A study of five yield related traits with seven cowpea genotypes by Rajaravindran and Das (1997) revealed very low genotypic coefficients of variation for all the characters except for green pod yield. Days to maturity recorded the lowest genotypic and phenotypic coefficients of variation. Heritability was highest for pod length followed by days to 50 per cent flowering, days to maturity and green pod yield while it was the lowest for number of pods per plant. Genetic advance was high for green pod yield and number of pods per plant.

Ram and Singh (1997) studied variability among 34 cowpea genotypes and reported high heritability estimates for pod length, peduncle length, green pod yield per plant, seeds per pod, days to 50 per cent flowering, days to maturity, plant height, branches per plant and 100-seed weight. High heritability combined with high genetic advance was observed for pod length and green pod yield per plant.

Wang Yan Feng *et al.* (1997), in a study of ten important agronomic characters of 1192 accessions of yard long bean reported high genetic variability for all the characters studied including pod length, pod weight, pod shape, pod colour and seed coat colour.

In a study with 30 different genotypes of yard long bean, Resmi (1998) observed significant differences among the genotypes for all the 24 characters studied. The highest phenotypic coefficient of variation was recorded for pod yield per plant (30.56) followed by number of pods per kilogram (26.54) and number of inflorescences per plant (25.16). The highest genotypic coefficient of variation was recorded for pod yield per plant (29.5) followed by number of pods per kilogram (26.5). Heritability was the highest for number

of pods per kilogram (98.0 %) and 100-seed weight (98.0 %) followed by pod weight (96.0 %) and pod length (95.0 %). High heritability along with high genetic advance was reported for pod yield per plant, number of pods per kilogram, number of inflorescences per plant and weight of pods.

Vardhan and Savithramma (1998 a) in a study with 102 accessions of cowpea found high variability for all the characters studied except for dry pod yield. High values of genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance were observed for plant height, number of primary branches, number of secondary branches, seed yield per plant and green pod yield.

Vardhan and Savithramma (1998) evaluated 29 accessions of cowpea and reported high phenotypic and genotypic coefficients of variation, high heritability and high genetic advance for green pod yield, pods per plant, plant height and number of secondary branches.

Dwivedi *et al.* (1999) evaluated 345 accessions of cowpea and noticed a wide range of variability in number of branches, days to flowering, days to maturity, clusters per plant, peduncle length, pods per cluster, pods per plant, seeds per pod, pod weight per plant, seed weight per plant and 100-seed weight.

In a study on variability in cowpea, Hazra *et al.* (1999) reported high phenotypic and genotypic coefficients of variation along with high heritability and genetic advance for plant height, pod weight, pod length, and pod yield per plant.

Rangaiah and Mahadevu (1999) observed wide range of variability and high estimates of genotypic coefficient of variation for plant height, number of branches per plant, number of seeds per plant, pod weight and total seed weight per plant. All these characters showed high heritability as well along with high genetic advance.

Rangaiah *et al.* (1999) reported high estimates of phenotypic coefficient of variation along with high to moderate heritability as well as genetic advance for number of clusters per plant, number of pods per plant, number of seeds per plant and pod weight.

In a study with genotypes of cowpea on eight characters, Sharma (1999) observed high genotypic coefficient of variation, high heritability and high genetic advance for plant height. Genotypic coefficient was highest (40.96 %) for plant height followed by harvest index (34.91 %), days to 50 per cent flowering (28.51 %) and days to 50 per cent pod formation (25.09 %). The characters studied showed high heritability estimates. Plant height had the highest genetic advance (86.49 %) followed by days to 50 per cent pod maturity (34.73 %), days to 50 per cent flowering (34.12 %) and days to 50 per cent pod formation (33.63 %).

Anbuselvam *et al.* (2000) in a study with 50 diverse genotypes of cowpea, reported high phenotypic and genotypic coefficients of variation for seed yield per plant, number of branches per plant, plant height, number of pods per plant and 100-seed weight. High heritability was recorded for plant height, length of pod and days to 50 per cent flowering, while moderate heritability was observed for number of branches per plant, number of seeds per pod, 100-seed weight and seed yield per plant. Low

heritability was observed for number of clusters per plant and number of pods per plant. Genetic advance was high for plant height and low for other characters. Highest genetic advance as percentage of mean was found for plant height followed by number of branches per plant, 100-seed weight and days to 50 per cent flowering. Number of branches per plant, 100-seed weight and seed yield per plant showed moderate heritability along with moderate genetic advance.

Kalaiyarasi and Palanisamy (2000 a) reported that seed yield per plant and number of pods per plant had high estimates of genotypic coefficients of variation followed by 100-seed weight, number of seeds per pod and plant height. High heritability coupled with high genetic advance was observed for seed yield per plant, number of pods per plant, 100-seed weight and number of seeds per pod.

In a variability study on cowpea by Kalaiyarasi and Palanisamy (2000), moderate phenotypic and genotypic coefficients of variation were reported for plant height, pod length and seed yield per plant. High heritability along with high genetic advance was observed for plant height, number of branches per plant, pod length and seed yield per plant.

Kumar and Sangwan (2000) conducted variability studies in cowpea using 72 diverse genotypes for nine yield related traits and found moderate to high heritability coupled with high genetic advance as percentage of mean for plant height, pod length, 100-seed weight, grain yield per plant, number of branches per plant and number of pods per plant.

In a variability study conducted by Pournami (2000), significant differences were observed among the 15 vegetable cowpea genotypes for many characters. Maximum genotypic coefficient of variation was observed for number of pods per plant (26.55) followed by yield of vegetable pods per plant (24.94). Heritability was the highest for number of pods per plant (96.12 %) followed by yield of vegetable pods per plant (95.12 %). High estimates of heritability coupled with high genetic advance were recorded for number of pods per plant, pod yield per plant, and pod weight.

Tyagi *et al.* (2000), in a study with 24 genotypes of cowpea found moderate phenotypic coefficient of variation for number of seeds per pod, pod length, number of pods per plant and 100-seed weight while it was high for plant height, days to 50 per cent flowering, seed weight per pod, seed yield per plant and days to maturity. Genotypic coefficient of variation had the same pattern as for phenotypic coefficient of variation for all the above mentioned characters except for number of seeds per pod. All the characters exhibited high heritability. High values of heritability, genotypic coefficient of variation and genetic advance were observed for days to 50 per cent flowering, plant height, seed yield per plant and days to maturity. High heritability, moderate genotypic coefficient of variation and moderate genetic advance were observed for pod length, number of pods per plant, seed weight per pod and 100-seed weight. Number of seeds per pod showed high heritability along with low values for both genotypic coefficient of variation and genetic advance.

Vidya (2000) in a study with 50 cultivars of yard long bean observed high variability for all the 12 characters considered. The maximum value of genotypic coefficient of variation was recorded for yield of vegetable pods per plant (27.53) followed by number of pods per inflorescence (24.92) and number of pods per plant (24.83). The highest phenotypic coefficient of variation was observed for yield of vegetable pods per plant (28.95) followed by number of pods per plant (26.39) and number of pods per inflorescence (25.60). The heritability estimates recorded for all the characters were high with a maximum estimate (95.85 %) for length of main stem followed by pod weight (94.77 %), number of pods per inflorescence (94.70 %), pod length (91.76 %) and number of inflorescences per plant (90.78 %). Expected genetic gain as percentage of mean was high for yield of vegetable pods per plant (53.93) followed by number of pods per inflorescence (49.81), number of pods per plant (48.13) and length of main stem (38.68). High heritability coupled with high genetic advance was observed for number of pods per inflorescence, yield of vegetable pods per plant, number of pods per plant, pod weight, length of main stem and number of inflorescences per plant.

2.2. Correlation studies

Yield is determined by several component characters. The relationship of yield with other traits is of great importance while formulating any selection programme for crop improvement. Research work done in cowpea to bring out the relationship of

different traits with pod yield and among the yield contributing factors is briefly reviewed.

Chauhan and Joshi (1980) found negative correlation between 100-seed weight and pod number per plant in a study with 36 genotypes of cowpea.

Positive and significant correlation of pod yield with primary branches per plant was found by Jana *et al.* (1982). Also, primary branches per plant was negatively correlated with pod length.

Patil and Bhapkar (1987) in a study with 49 genotypes of cowpea reported negative correlation between pods per plant and seeds per pod.

Sharma *et al.* (1988) reported that green pod yield was highly and positively correlated with pods per plant, days to first flowering, seeds per pod and plant height in cowpea.

High positive correlation was found between green pod yield and primary branches per plant, pods per cluster, clusters per plant, 100-seed weight and seeds per pod by Tewari and Gautam (1989) in a study on 20 diverse cowpea varieties.

Apte *et al.* (1991) found significant positive correlation of days to 50 per cent flowering with number of branches, pod number, pod length and seeds per pod. Plant height showed significant positive correlation with pod number and seeds per pod and a negative correlation with number of branches. Number of branches exhibited significant positive correlation with pod number and seeds per pod. Pod number had positive

correlation with seeds per pod while pod length was positively correlated with seeds per pod.

Misra *et al.* (1994) found that green pod yield per plant was positively correlated with leaf area, pod length and pod weight.

High and positive correlation between pod yield and days to harvest, pod length, pod girth, pod weight, seeds per pod and 100-seed weight was reported by Sobha (1994).

Tamilselvam and Das (1994) in a study on cowpea reported positive association of pod length with seeds per pod and 100-seed weight. Clusters of pods per plant showed a negative association with pod length and 100-seed weight. Pods per plant was negatively correlated with pod length.

Kar *et al.* (1995) reported that pod yield was strongly associated with seeds per pod.

Mathur (1995) reported that pods per plant showed high negative correlation with seeds per pod and positive correlation with plant height, pod length and pod width. Pod length had high positive correlation with seeds per pod and negative correlation with plant height. Pod width had negative correlation with seeds per pod.

Naidu *et al.* (1996) found that number of clusters per plant was positively correlated with number of pods per plant.

Yield of green pods was found to be positively correlated with number of fruiting points per plant, number of pods per plant, pod length and number of seeds per pod in a study by Sreekumar *et al.* (1996) with 18 vegetable cowpea genotypes.

The genotypic and phenotypic correlation of green pod yield with several characters was studied by Chattopadhyay *et al.* (1997). They reported that pod length, green pod weight, seeds per pod and 100-seed weight exhibited significant positive genotypic correlations with green pod yield. Days to flowering registered high and negative association with green pod yield both at genotypic and phenotypic level. Pod number showed significant negative relationship with green pod weight and pod length.

A study by Resmi (1998) with 30 genotypes of vegetable cowpea revealed high positive association of green pod yield with pod weight, pod length and number of pods per plant.

Vardhan and Savithramma (1998 a) found a significant positive association of green pod yield per plant with pod length, pod width and fresh pods per plant. They recommended selection of genotypes bearing larger, wider and higher number of pods per plant for green pod yield improvement in cowpea.

Vardhan and Savithramma (1998) reported very high positive association of green pod yield with pods per plant.

Positive genotypic correlation of pod yield per plant with number of seeds per pod, number of pods per plant, length of harvesting period, number of pods per inflorescence, pod weight and pod length was reported by Pournami (2000).

Vidya (2000) studied 50 genotypes of yard long bean and found that at the genotypic level number of pods per plant had the highest positive correlation with pod yield per plant (0.7654) followed by number of pods per inflorescence (0.6504), pod

weight (0.4942), length of harvesting period (0.3398), pod girth (0.2855), pod length (0.2740) and number of primary branches (0.2590). Number of pods per plant, number of pods per inflorescence, pod weight and length of harvesting period were suggested as the characters to be given weightage while selecting for pod yield improvement in cowpea.

2.3 Path analysis

Path coefficient is a standardised partial regression coefficient which measures the direct influence of one variable upon another and permits the separation of correlation coefficients into components of direct and indirect effects (Dwey and Lu, 1959). The information obtained from path analysis helps in indirect selection for genetic improvement of yield.

Chauhan and Joshi (1980) showed that the negatively correlated traits, *viz.*, pod number per plant and 100-seed weight were the most important components of yield.

Jana *et al.* (1983) reported that pod number per plant had the highest direct effect on pod yield per plant.

Ye and Zhang (1987) indicated that number of pods per inflorescence had the greatest direct effect on pod yield.

High negative direct effect on yield was obtained through days to flowering and pod length by Tewari and Gautam (1989).

Misra *et al.* (1994) found that pod length had the greatest direct effect on pod yield followed by leaf area and pod diameter while direct but negative effects were observed for number of leaves per plant and average pod weight.

Sobha (1994) reported that pod weight exerted the maximum positive direct effect on green pod yield followed by pod girth and 100-seed weight in bush type vegetable cowpea.

In a path analysis by Kar *et al.* (1995) in vegetable cowpea, pod length and fibre content were found to be the main determinants of pod yield.

Path analysis of green pod yield by Chattopadhyay (1997) indicated that green pod weight, dry pod weight, pod number and seeds per pod were the most important components of yield because of their high positive direct effects. Days to flowering registered highly negative direct effect indicating early flowering would lead to high yield. Green pod weight, dry pod weight, pod number, seeds per pod and days to flowering were suggested as the important components demanding attention in yield improvement efforts.

Resmi (1998) reported that number of pods per plant exerted the maximum positive direct effect on pod yield followed by pod weight in vegetable cowpea. Pod length exerted positive indirect effect on pod yield through pod weight and number of pods per kilogram, while pod weight exerted indirect effect through number of pods per kilogram. Number of pods per kilogram had negative direct effect on pod yield.

Vardhan and Savithramma (1998) reported that green pods per plant, pod length, pod width and number of primary branches were the major traits contributing to green pod yield per plant.

Pournami (2000) reported that days to first flowering exerted the maximum direct effect on pod yield followed by number of pods per plant. Days to first harvest, length of harvesting period and number of inflorescences per plant exerted negative direct effect on pod yield.

Vidya (2000) conducted path analysis in vegetable cowpea and found that maximum direct effect on yield was shown by number of pods per plant (0.7613) followed by pod weight (0.5884) and number of pods per inflorescence (0.1105). Number of pods per inflorescence had high indirect effect via number of pods per plant (0.6706). It was suggested that number of pods per plant and pod weight be given importance while formulating selection programmes for yield improvement in vegetable cowpea.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study aimed at evaluating a collection of bush type vegetable cowpea varieties for yield and component characters was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during 2000-2001. The details of the field experiment conducted and the statistical analysis carried out are provided hereunder.

3.1 Materials

The materials comprised of 20 diverse genotypes of bush type vegetable cowpea which included 14 local cultivars and six improved varieties, *viz.*, Arka Suman, Arka Garima, Pusa Komal, CO-2, Vamban-2 and Kanakamani. The varieties are denoted by accession numbers Vu 1 to Vu 20. The morphological features of the varieties are given in Table-1. Plates 1 and 2 show the variation in pod characters of the varieties.

3.2 Methods

3.2.1 Layout and conduct of the experiment

The crop was raised in a field experiment in randomised block design with three replications during November 1999 to February 2000. The experimental field was divided into 3 blocks of twenty plots each and the treatments were allotted to each block

Table 1. Morphological features of the 20 genotypes of vegetable cowpea

Acc No.	Genotypes	Source	Growth habit	Pod attachment to peduncle	Pod shape	Pod colour	Seed shape	Seed coat colour
Vu 1	Arka Suman	IIHR, Bangalore	Semi erect	Pendent	Straight	Light green	Oval	Light brown
Vu 2	Pusa Komal	IARI, New Delhi	Erect	Sub erect	Straight	Light green	Oval	Cream coloured with brown marking
Vu 3	CO-2	TNAU, Coimbatore	Erect	Pendent	Slightly curved	Light green	Kidney shaped	Brown with cream coloured markings
Vu 4	Vamban-2	National Pulses Research Centre, Vamban	Semi erect	Sub erect	Curved	Light green	Oval	Cream coloured
Vu 5	Kanakamani	KAU, TCR. Dt.	Semi erect	Pendent	Slightly curved	Dark green	Oval	Reddish brown
Vu 6	Arka Garima	IIHR, Bangalore	Semi erect	Pendent	Slightly curved	Light green	Kidney shaped	Reddish brown
Vu 7	Local	Kothamangalam,EKM. Dt.	Semi erect	Pendent	Straight	Dark green	Oval	Reddish brown
Vu 8	Local	Kalliyoor, TVM. Dt.	Erect	Erect	Straight	Light green	Kidney shaped	Brown
Vu 9	Local	Koliyakodu, TVM.Dt.	Erect	Pendent	Curved	Light green	Oval	Reddish brown
Vu 10	Local	Kothamangalam, EKM.Dt.	Semi erect	Pendent	Straight	Dark green	Rhomboid	Reddish brown
Vu 11	Local	Thodupuzha, EKM.Dt.	Semi erect	Pendent	Straight	Dark green	Rhomboid	Grey
Vu 12	Local	Kuruppanthara, KTM.Dt.	Semi erect	Pendent	Slightly curved	Dark green	Oval	Reddish brown
Vu 13	Local	Kakkoor, EKM.Dt.	Semi erect	Sub erect	Slightly curved	Light green	Oval	Light brown
Vu 14	Local	Brahmamangalam, KTM. Dt.	Semi erect	Pendent	Straight	Reddish brown	Rhomboid	Light brown
Vu 15	Local	Vaikom, KTM.Dt.	Semi erect	Pendent	Curved	Dark green	Oval	Light brown
Vu 16	Local	Kumaranalloor, KTM. Dt.	Erect	Pendent	Slightly curved	Dark green	Rhomboid	Dark brown
Vu 17	Local	Koothattukulam, EKM. Dt.	Semi erect	Pendent	Slightly curved	Dark green	Kidney shaped	Black
Vu 18	Local	Koliyoor, TVM. Dt.	Semi erect	Pendent	Slightly curved	Light green	Oval	Light brown
Vu 19	Local	Cherthala, ALPY. Dt.	Semi erect	Sub erect	Slightly curved	Light green	Oval	Light brown
Vu 20	Local	Chungam, KTM. Dt.	Semi erect	Pendent	Curved	Dark green	Oval	Light brown

IIHR: Indian Institute of Horticultural Research. IARI : Indian Agricultural Research Institute. TNAU : Tamil Nadu Agricultural University
KAU : Kerala Agricultural University. TCR. Dt.:Thrissur District , EKM. Dt.:Ernakulam District, KTM. Dt.:Kottayam District,
TVM. Dt.: Thiruvananthapuram District, ALPY. Dt.:Alapuzha District

at random. The plot size was 3.6 x 3.6 m. Spacing was 0.6 m between rows and 0.4 m between plants within a row. The crop was managed as per the "Package of Practices recommendations" of Kerala Agricultural University (Kerala Agricultural University, 1996). Plate 3 shows a general view of the experimental field.

3.2.2 Biometric Observations

The observations on the following characters were recorded.

a. Days to 50 per cent flowering : Number of days taken from sowing to the day at which 50 per cent of the plants in each plot attained flowering.

For the following characters, observations were recorded from five randomly selected plants in each plot. The data for statistical analysis were obtained from the mean values worked out thereafter.

b. Number of days to first harvest : Number of days from sowing to the day of first harvest.

c. Length of harvest period (days) : Number of days from the first harvest to the last harvest.

d. Duration (days) : Number of days from sowing to the last harvest.

e. Length of main stem (cm) : Length of main stem from the ground level to its tip was recorded.

f. Number of primary branches : Primary branches were counted at the full maturity of the plant.

Plate 1. Variation in pod characters 1

Plate 2. Variation in pod characters 2

Plate 3. General view of the experimental field

Plate.1

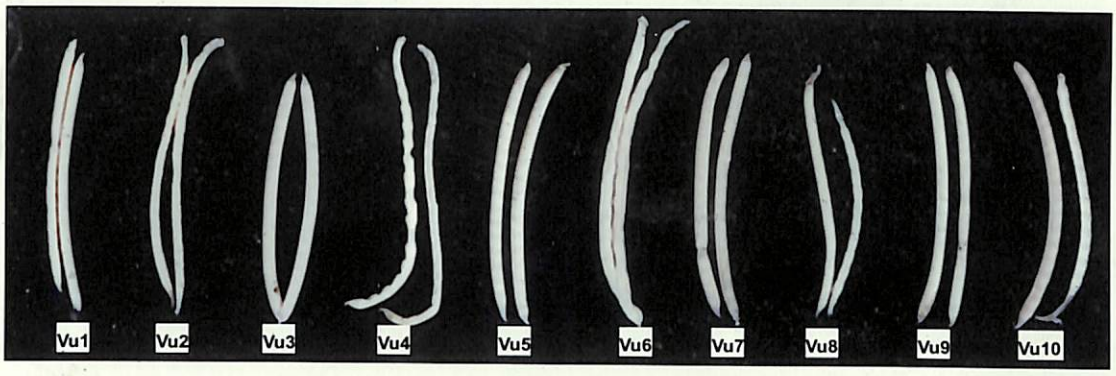


Plate.2

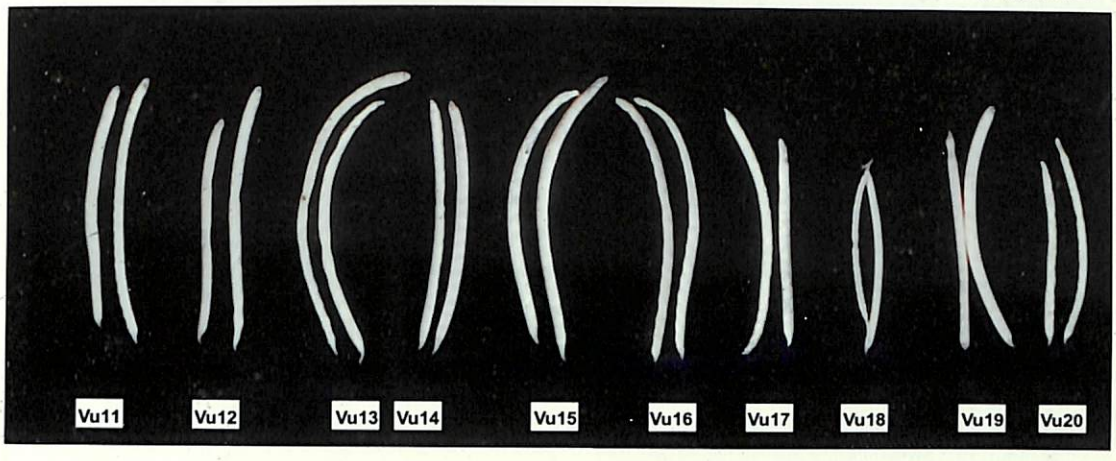


Plate.3

g. Number of pod clusters per plant : The number of pod clusters on each observational plant was recorded.

h. Number of pods per plant : Total number of pods harvested from each observational plant were separately counted and the average worked out.

i. Yield of green pods per plant (g) (Yield per plant) : Weight of pods from observational plants at each harvest was taken using a top loading balance and added to get the total and the average worked out.

j. Number of pods per cluster : The total number of pods in ten randomly chosen clusters in the observational plants were counted and the average worked out.

Pod characters *viz.*, pod length (cm), pod girth (mm), pod weight (g) and number of seeds per pod were recorded from ten randomly selected pods at vegetable maturity stage from each plot and mean value for each character was worked out.

k. Incidence of pests and diseases : The crop was periodically examined for the incidence of pests and diseases.

3.2.3 Statistical analysis.

The data collected were subjected to the following statistical analyses.

Analysis of variance (ANOVA) and analysis of covariance (ANCOVA) for RBD (Panse and Sukhatme, 1967) in respect of the various characters was done.

The mean values for all the varieties for each of the characters were worked out and compared using critical differences.

3.2.3.1 Variance and covariance

The variance and covariance components were calculated as:

For the character Xi,

$$\text{Environmental variance, } \sigma^2 e_i = \text{MSE}$$

$$\text{Genotypic variance, } \sigma^2 g_i = \frac{\text{MST} - \text{MSE}}{r}$$

$$\text{Phenotypic variance, } \sigma^2 p_i = \sigma^2 g_i + \sigma^2 e_i$$

where MST and MSE are the mean sum of squares for treatment and error respectively from ANOVA and r is the number of replications and $\bar{x}_i$ is the overall mean of the i^{th} trait calculated from all varieties. For two characters Xi and Xj, the covariances were worked out from the ANCOVA as:

$$\text{Environmental covariance, } \sigma e_{ij} = \text{MSPE}$$

$$\text{Genotypic covariance, } \sigma g_{ij} = \frac{\text{MSPT} - \text{MSPE}}{r}$$

$$\text{Phenotypic covariance, } \sigma p_{ij} = \sigma g_{ij} + \sigma e_{ij}$$

where MSPT and MSPE are the mean sum of products for treatment and error respectively between i^{th} and j^{th} characters.

3.2.3.2 Coefficient of variation

The variability in the genotypes for different characters was expressed using the coefficient of variation which is a unit free measurement.

$$\text{Phenotypic coefficient of variation, PCV} = \frac{\sigma p_i}{x_i} \times 100$$

$$\text{Genotypic coefficient of variation, GCV} = \frac{\sigma g_i}{x_i} \times 100$$

$$\text{Environmental coefficient of variation, ECV} = \frac{\sigma e_i}{x_i} \times 100$$

where σp_i, σg_i and σe_i are the phenotypic, genotypic and environmental standard deviations respectively.

3.2.3.3 Heritability (H^2)

Heritability in broad sense was calculated as a percentage based on the formula given by Jain (1982).

$$H^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

where $\sigma^2 g$ and $\sigma^2 p$ are the genotypic and phenotypic variance of the trait.

Heritability per cent was categorised as suggested by Robinson et al. (1949) *viz.*, low (0-30), moderate (30-60) and high (above 60).

3.2.3.4 Genetic advance under selection

Genetic advance as a percentage of mean was estimated as :

$$\text{Genetic advance, GA} = \frac{kH^2\sigma p}{x} \times 100$$

where k is the standardised selection differential (k = 2.06) at five per cent selection intensity (Miller *et al.*, 1958) and x is the mean of the character over all varieties.

3.2.3.5 Correlation analysis

The correlation coefficients (phenotypic, genotypic and environmental) between two characters denoted as i and j were worked out as

$$\text{Genotypic correlation } (r_{gij}) = \frac{\sigma g_{ij}}{\sigma g_i \times \sigma g_j}$$

$$\text{Phenotypic correlation } (r_{pij}) = \frac{\sigma p_{ij}}{\sigma p_i \times \sigma p_j}$$

$$\text{Environmental correlation } (r_{eij}) = \frac{\sigma e_{ij}}{\sigma e_i \times \sigma e_j}$$

where σg_{ij}, σp_{ij} and σe_{ij} are the genotypic, phenotypic and environmental co-variances between the characters i and j. σg_i, σp_i and σe_i are the genotypic, phenotypic and environmental standard deviations for the character i and σg_j, σp_j and σe_j are the genotypic, phenotypic and environmental standard deviations for the character j.

3.2.3.6 Path coefficient analysis

The direct and indirect effects of component characters on yield were estimated through path analysis technique (Wright, 1954).

RESULTS

4. RESULTS

The performance of 20 genotypes were evaluated for various morphological and yield traits. Since serious incidence of any pest or disease did not occur in the experimental field, scoring for pest and disease was not needed. The data were statistically analysed and the results are presented in this chapter.

4.1 Analysis of variance

The analysis of variance (Table 2) revealed significant differences among the varieties for all the characters studied.

4.2. Mean performance of the varieties.

The mean values of each of the 20 cultivars for the 14 characters studied are presented in Table 3. Days to 50 per cent flowering ranged from 44.33 to 54.00. Vu 6 was the earliest and Vu 17 was the latest to come to 50 per cent flowering. Vu 12 and Vu 18 were statistically on par with Vu 6, and Vu 5 was on par with Vu 17 for days to 50 per cent flowering. Vu1, Vu 2, Vu 8 and Vu 18 took only 58 days for first harvest. Cultivars Vu 3, Vu 5, Vu 6, Vu 7, Vu 9, Vu 10, Vu 11, Vu 12, Vu 15, Vu 19 and Vu 20 were statistically on par with them. Maximum number of days to first harvest, was taken by Vu 14 (68.33 days) and V u4, Vu 13, Vu 16 and Vu 17 were statistically on par with it.

Table 2. Analysis of variance of 14 characters in 20 vegetable cowpea genotypes

Sl. No.	Character	Mean square		
		Replication	Genotypes	Error
	Degrees of freedom	2	19	38
1.	Days to 50 per cent flowering	0.12	19.11**	0.92
2.	Number of days to first harvest	52.65	26.15*	11.39
3.	Length of harvest period (days)	0.87	16.18**	4.88
4.	Duration (days)	0.22	31.41**	1.88
5.	Length of main stem (cm)	8.23	4564.71**	2.94
6.	Number of primary branches	0.22	2.98**	0.08
7.	Number of pod clusters per plant	3.69	12.18**	0.57
8.	Number of pods per cluster	0.15	0.43**	0.04
9.	Number of pods per plant	21.63	45.93**	5.03
10.	Pod length (cm)	6.51	28.75**	0.46
11.	Pod girth (mm)	4.04	22.24**	1.58
12.	Pod weight (g)	0.50	5.44**	0.29
13.	Number of seeds per pod	3.14	24.14**	1.42
14.	Yield of green pods per plant (g)	33.25	1013.75**	164.30

**Significant at 1 % level.
*Significant at 5 % level

Table 3. Mean values for 14 biometric characters in 20 vegetable cowpea genotypes

Cultivar	Days to 50 % flowering	Days to first harvest	Length of harvest period	Duration (days)	Length of main stem (cm)	No. of primary branches	No. of pod clusters /plant	No. of pods /cluster	No. of pods/ plant	Pod length (cm)	Pod girth (mm)	Pod weight (g)	No.of seeds /pod	Yield of green pods/plant
Vu 1	47.67	58.00	40.33	105.00	19.27	3.20	15.0	2.93	36.47	20.1	24.20	6.75	17.60	206.37
Vu 2	50.00	58.00	39.33	100.33	26.73	4.00	9.00	3.20	29.00	18.8	23.00	5.50	12.50	190.13
Vu 3	46.67	60.33	34.67	100.67	67.67	4.00	9.99	2.20	28.00	17.97	23.20	5.45	16.00	195.07
Vu 4	50.33	65.00	35.33	107.33	15.93	4.20	11.00	3.20	31.00	20.33	20.20	5.92	18.87	207.33
Vu 5	52.67	60.33	39.67	107.67	23.93	3.60	16.20	2.40	35.53	17.80	24.00	6.67	19.27	200.60
Vu 6	44.33	60.33	36.67	104.00	24.80	2.20	10.73	2.33	30.33	21.50	33.57	9.50	15.00	215.73
Vu 7	47.33	60.33	41.00	108.33	111.47	4.93	10.00	2.60	32.27	18.80	21.90	6.25	15.53	196.77
Vu 8	48.67	58.00	49.00	105.67	33.33	3.20	9.20	2.80	29.07	18.13	22.40	5.50	14.20	190.43
Vu 9	46.67	62.67	37.33	107.33	22.00	4.07	9.20	2.00	18.73	17.07	23.80	4.75	18.07	130.00
Vu 10	50.33	60.33	34.00	102.33	121.8	2.47	13.00	2.20	28.13	17.27	22.20	5.25	17.20	171.70
Vu 11	47.00	60.33	37.00	104.33	65.33	2.87	8.40	2.33	26.47	17.90	21.00	5.50	19.40	182.20
Vu 12	45.67	60.33	39.33	106.67	33.47	4.47	11.00	2.27	31.33	19.47	23.80	5.50	18.13	181.67
Vu 13	46.67	64.33	40.00	110.00	37.07	2.60	9.00	1.93	26.60	10.00	21.50	4.75	9.70	202.5
Vu 14	51.00	68.33	40.33	111.33	105.67	2.40	9.00	2.80	27.27	18.40	20.80	4.50	14.00	179.00
Vu 15	47.33	60.33	36.67	107.33	90.00	2.27	11.20	2.40	34.00	21.10	24.00	5.25	16.80	202.30
Vu 16	47.00	64.33	40.33	110.00	25.67	4.13	10.40	2.47	30.60	20.60	23.40	5.75	14.67	190.67
Vu 17	54.00	66.67	41.00	109.67	63.80	3.07	10.80	2.07	28.67	20.40	22.00	4.50	13.80	172.77
Vu 18	44.67	58.00	39.33	103.33	115.67	5.40	11.00	2.13	33.33	23.60	24.00	9.17	19.30	203.10
Vu 19	48.33	60.33	36.67	103.33	32.67	1.93	9.00	2.27	27.40	11.70	21.70	4.83	10.40	192.40
Vu 20	47.00	62.67	40.33	110.00	121.53	2.33	10.40	2.07	32.67	19.90	23.60	5.67	15.20	183.76
SE	0.55	1.95	1.28	0.79	0.99	0.16	0.43	0.12	1.29	0.39	0.73	0.31	0.69	7.4
CD (0.05)	1.59	5.58	3.65	2.27	2.83	0.47	1.24	0.35	3.71	1.12	2.08	0.88	1.97	21.19
Mean	48.17	61.45	38.92	106.23	57.89	3.37	10.68	2.43	29.84	18.54	23.21	5.84	15.78	189.72

Length of harvest period was maximum for Vu 8 (49.00 days). Vu 1, Vu 7, Vu 13, Vu 14, Vu 16, Vu 17 and Vu 20 also had similarly prolonged harvest period. Vu 10 had the shortest harvest period (34.00 days). Varieties Vu 3, Vu 6, Vu 9, Vu 11, Vu 15 and Vu 19 too had compact harvest period. Vu 2 recorded the shortest duration of 100.33 days and Vu 3 and Vu 10 were statistically on par with it. Vu 14 had the longest duration of 111.33 days. Vu 13, Vu 16, Vu17 and Vu 20 were statistically on par with Vu 14 for duration.

The vegetative characters *viz.*, length of main stem and number of primary branches showed wide variation among the cultivars. Minimum main stem length of 15.93 cm. was recorded by Vu 4 and no other cultivar was statistically on par with it. Maximum main stem length of 121.80 cm was recorded by Vu 10. Vu 18 had the largest number of primary branches (5.40) and only Vu 7 was on par with it. Vu 19 had the lowest number of primary branches (1.93). The other cultivars with lesser number of primary branches were Vu 6, Vu 14, Vu 15 and Vu 20.

The variety Vu 5 recorded the maximum number of pod clusters per plant (16.20) and Vu 1 was statistically on par with it. Vu 11 had the minimum number of pod clusters per plant (8.40). Vu 2, Vu 8, Vu 9, Vu 13, Vu 14, and Vu 19 were statistically on par with Vu 11 for the character.

Regarding number of pods per cluster, the maximum value of 3.20 was recorded by Vu 2 and Vu 4. Plate 4 shows Vu 2 (Pusa Komal). Only Vu 1 was statistically on par with them for number of pods per cluster. The minimum value for number of pods per

cluster (1.93) was shown by Vu 13. Maximum number of pods per plant was recorded by Vu 1 (36.47). Pod count per plant was similarly high for Vu 5, Vu 15 and Vu 18. The minimum number of pods per plant was recorded by Vu 9 (18.73).

Pod characters *viz.*, pod length, pod girth, pod weight and number of seeds per pod differed significantly among the varieties. Pod length ranged from 10.00 cm (Vu 13) to 23.60 cm (Vu 18). Plate 5 shows Vu 18 (Koliyoor Local), which showed the maximum pod length. None of the varieties was statistically on par with Vu 18 for the character. There was remarkable variation in pod girth. It ranged from 20.20 mm (Vu 4) to 33.57 mm (Vu 6). It is noteworthy that none of the other varieties possess high pod girth comparable to that of Vu 6. Apart from Vu 4, low pod girth was recorded by varieties such as Vu 7, Vu 10, Vu 11, Vu 13, Vu 14, Vu 17 and Vu 19. The highest pod weight was recorded for Vu 6 (9.50 g) and Vu 18 was statistically on par with it. Pod weight was minimum for Vu 14 and Vu 17 (4.50 g) and cultivars Vu 9, Vu 10, Vu 13, Vu 15, Vu 17 and Vu 19 also had similarly low pod weight. Number of seeds per pod was maximum for Vu 11 (19.40) and Vu 1, Vu 4, Vu 5, Vu 9, Vu 12 and Vu 18 were on par with it. Vu 13 recorded the minimum number of seeds per pod (9.70) with Vu 19 statistically on par with it. .

The yield of green pods per plant ranged from 130.00 g (Vu 9) to 215.73 g (Vu 6). Significantly higher green pod yield in comparison to other varieties was recorded by the top yielder Vu 6. Plate 6 shows Vu 6 (Arka Garima).

Plate 4. Pusa Komal with large number of pods per cluster

Plate 5. Koliyoor Local which showed the maximum pod length

Plate 6. Arka Garima – the highest green pod yielder

Plate 4

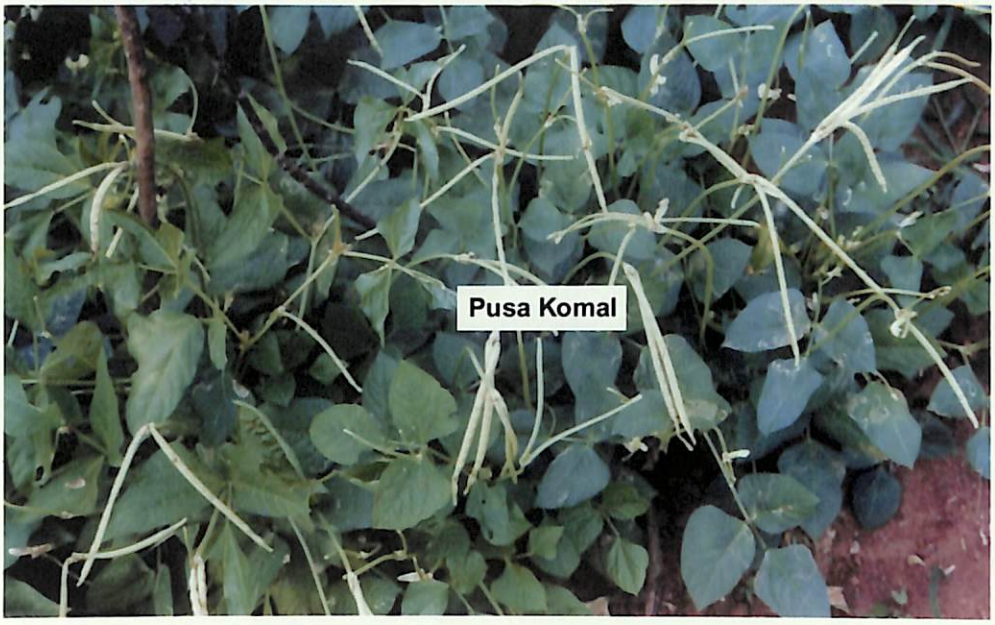
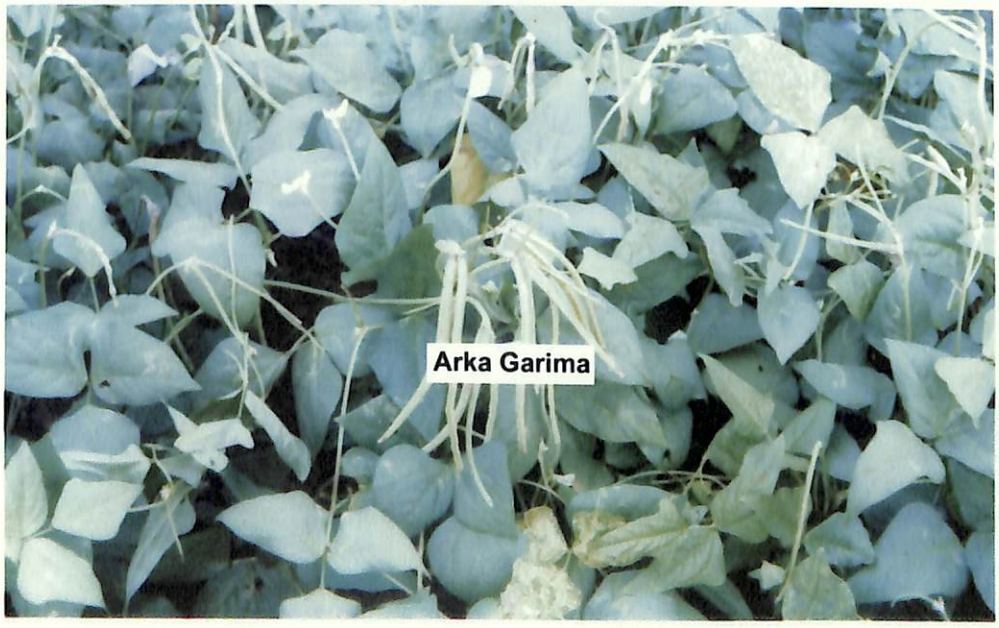


Plate 5

Plate 6



4.3 Variability Studies

The phenotypic, genotypic and environmental variance and coefficients of variation for the 14 characters are presented in Table 4. Fig. 1 shows the phenotypic and genotypic coefficients of variation for the 14 characters.

Length of the main stem showed the maximum value for GCV (67.36) followed by number of primary branches (29.17), pod weight (22.43), number of pod clusters per plant (18.41), number of seeds per pod (17.43), pod length (16.56), number of pods per cluster (14.71), number of pods per plant (12.37), pod girth (11.30) and yield of green pods per plant (8.87). GCV was the least for duration (2.95).

The highest PCV was observed for length of main stem (67.43) followed by number of primary branches (30.38), pod weight (24.22), number of pod clusters per plant (19.72) and number of seeds per pod (19.00).

The difference between phenotypic and genotypic coefficients of variation was least for length of main stem (0.06 %) succeeded by duration (0.27 %) and was relatively high for number of days to first harvest (2.96 %) and length of harvest period (2.59 %).

4.4 Heritability and genetic advance

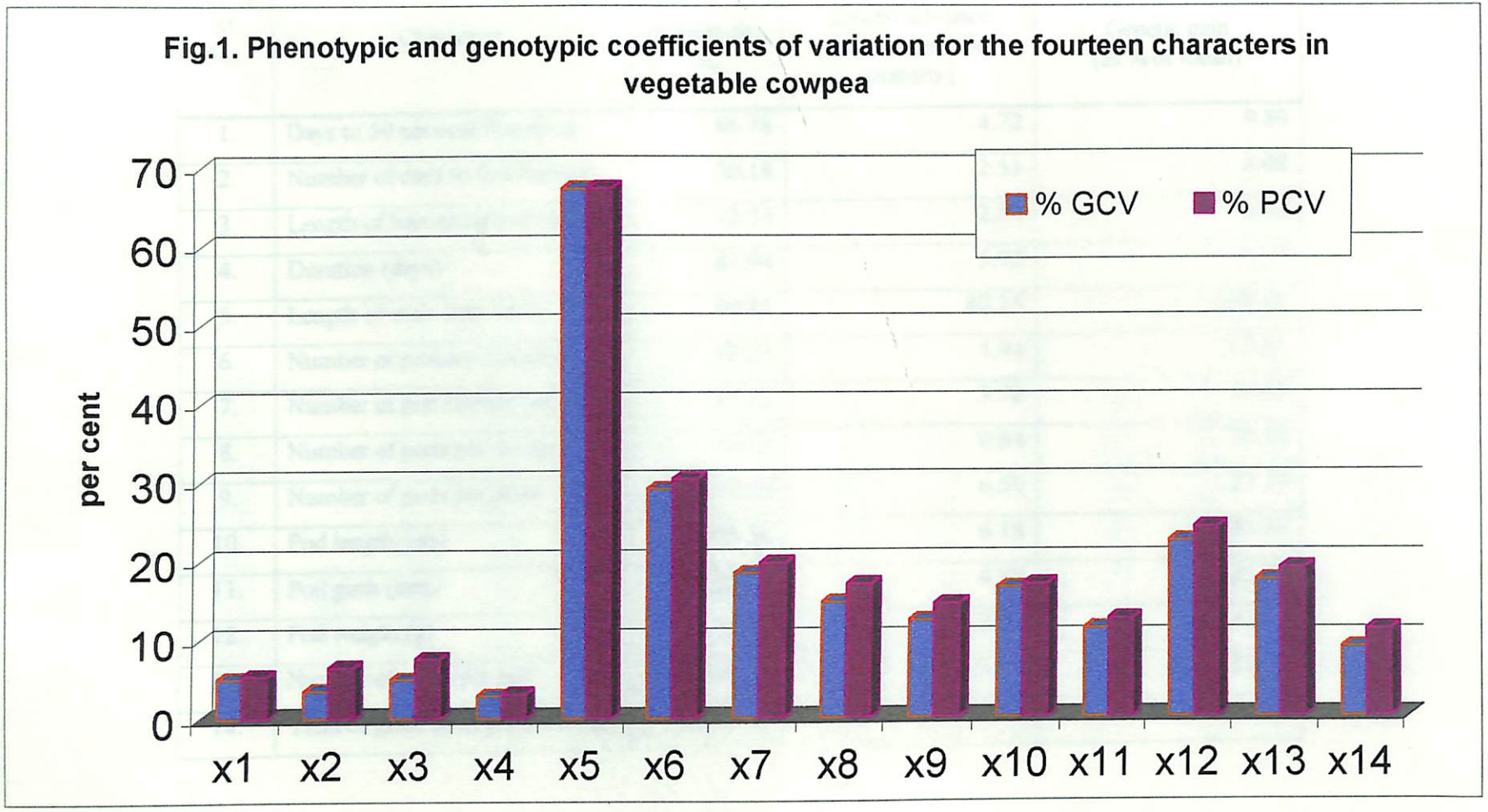
The estimates of heritability and genetic advance are given in Table 5 and Fig. 2. All the characters except number of days to first harvest and length of harvest period showed high heritability. The highest heritability estimate was recorded by length of main stem (99.80 %) followed by pod length (95.39 %), number of primary branches

Table 4. Components of variance for the 14 characters in vegetable cowpea

Sl. No.	Characters	Mean ± SE	σ^2p	σ^2g	σ^2e	GCV %	PCV %
1.	Days to 50 per cent flowering	48.17±0.55	6.98	6.06	0.92	5.11	5.49
2.	Number of days to first harvest	61.45±1.95	16.31	4.92	11.39	3.61	6.57
3.	Length of harvest period (days)	38.57±1.28	8.65	3.77	4.88	5.03	7.63
4.	Duration (days)	106.23±0.79	11.73	9.84	1.88	2.95	3.22
5.	Length of main stem (cm)	57.89±0.99	1523.53	1520.59	2.94	67.36	67.43
6.	Number of primary branches	3.37±0.16	1.05	0.97	0.08	29.17	30.38
7.	Number of pod clusters per plant	10.68±0.43	4.43	3.87	0.57	18.41	19.72
8.	Number of pods per cluster	2.43±0.12	0.17	0.13	0.04	14.71	17.04
9.	Number of pods per plant	29.84±1.29	18.66	13.63	5.03	12.37	14.48
10.	Pod length (cm)	18.54±0.39	9.89	9.43	0.46	16.56	16.96
11.	Pod girth (mm)	23.21±0.73	8.47	6.89	1.58	11.30	12.53
12.	Pod weight (g)	5.84±0.31	2.01	1.72	0.29	22.43	24.22
13.	Number of seeds per pod	15.78±0.69	8.99	7.57	1.42	17.43	19.00
14.	Yield of green pods per plant (g)	189.72±7.40	447.45	283.15	164.30	8.87	11.15

σ^2p - Phenotypic variance σ^2g - Genotypic variance σ^2e - Environmental variance GCV- Genotypic coefficient of variation
PCV- Phenotypic coefficient of variation

Fig.1. Phenotypic and genotypic coefficients of variation for the fourteen characters in vegetable cowpea

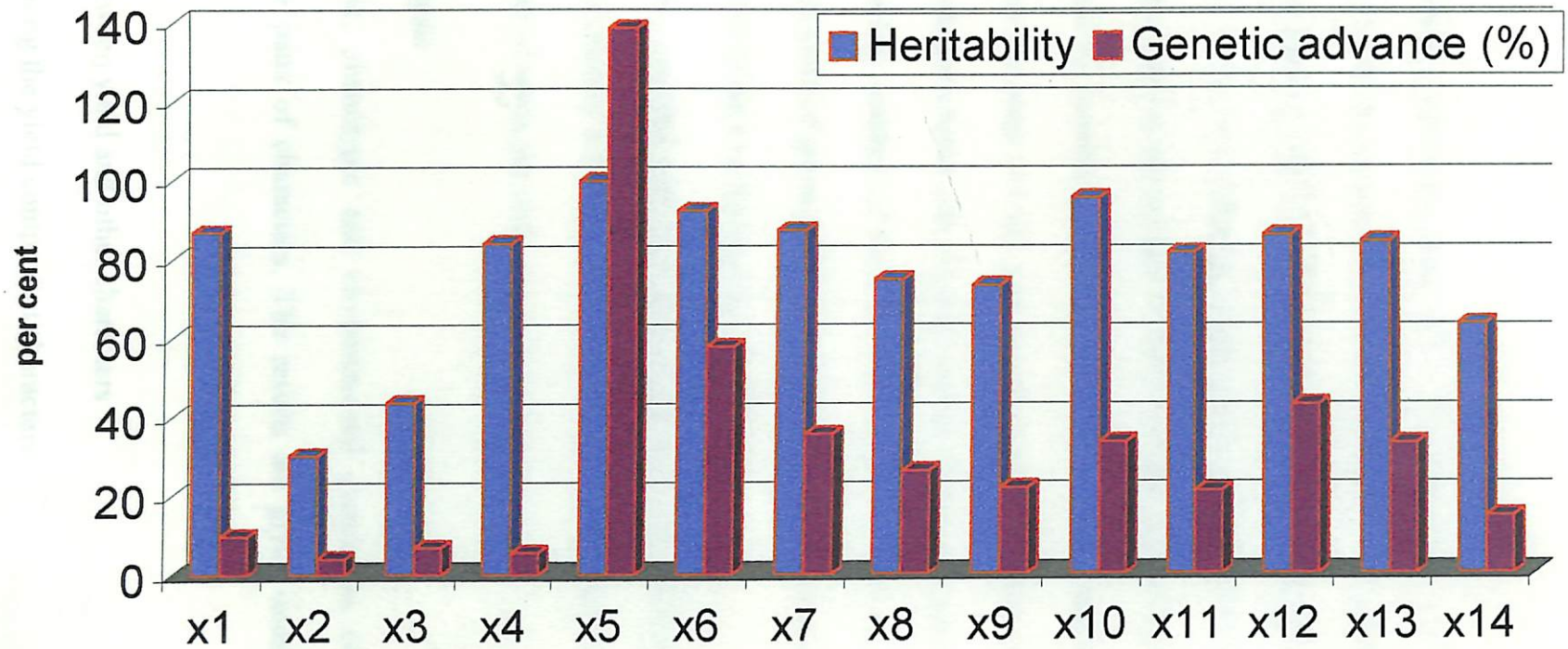


x1- Days to 50 % flowering
x2- Number of days to first harvest
x3- Length of harvest period
x4- Duration
x5- Length of main stem
x6- Number of primary branches
x7- Number of pod clusters per plant
x8- Number of pods per cluster
x9- Number of pods per plant
x10- Pod length
x11- Pod girth
x12- Pod weight
x13- Number of seeds per pod
x14- Yield of green pods per plant

Table 5. Heritability, Genetic advance and Genetic gain for the 14 characters in vegetable cowpea

Sl. No.	Characters	Heritability %	Genetic advance (at 5 % selection intensity)	Genetic gain (as % of mean)
1.	Days to 50 per cent flowering	86.78	4.72	9.80
2.	Number of days to first harvest	30.18	2.51	4.08
3.	Length of harvest period (days)	43.53	2.64	6.84
4.	Duration (days)	83.94	5.92	5.57
5.	Length of main stem (cm)	99.81	80.25	138.62
6.	Number of primary branches	92.21	1.94	57.65
7.	Number of pod clusters per plant	87.23	3.78	35.43
8.	Number of pods per cluster	74.61	0.64	26.18
9.	Number of pods per plant	73.06	6.50	21.79
10.	Pod length (cm)	95.39	6.18	33.33
11.	Pod girth (mm)	81.36	4.88	21.00
12.	Pod weight (g)	85.75	2.50	42.83
13.	Number of seeds per pod	84.17	5.19	32.95
14.	Yield of green pods per plant (g)	63.28	27.57	14.53

Fig.2 Heritability and genetic advance for the fourteen characters in vegetable cowpea



x1- Days to 50 % flowering
x2- Number of days to first harvest
x3- Length of harvest period
x4- Duration
x5- Length of main stem
x6- Number of primary branches
x7- Number of pod clusters per plant
x8- Number of pods per cluster
x9- Number of pods per plant
x10- Pod length
x11- Pod girth
x12- Pod weight
x13- Number of seeds per pod
x14- Yield of green pods per plant

(92.21 %), number of pod clusters per plant (87.23 %), days to 50 per cent flowering (86.78 %), pod weight (85.75 %), number of seeds per pod (84.17 %), duration (83.94 %) and number of pods per plant (73.06 %). The minimum value was recorded by number of days to first harvest (30.18 %) succeeded by length of harvest period (43.53 %).

Expected genetic gain as percentage of mean was the highest for length of main stem (138.62) followed by number of primary branches (57.65), pod weight (42.83), number of pod clusters per plant (35.43), pod length (33.33), number of seeds per pod (32.95), number of pods per cluster (26.18) and number of pods per plant (21.79). Days to 50 per cent flowering, number of days to first harvest, length of harvest period, duration, pod girth and yield of green pods per plant exhibited low values with the least value of 4.08 for number of days to first harvest.

High heritability coupled with high genetic advance was observed for length of main stem, number of primary branches, pod weight, number of pod clusters per plant, pod length and number of seeds per pod.

4.5 Correlation analysis

The genotypic, phenotypic and environmental correlation coefficients were estimated for all the pairs of characters. The results are given under the following subtitles.

a. Correlation between yield and other characters

b. Correlation among the yield component characters

a. Correlation between yield and other characters

The phenotypic, genotypic and environmental correlation coefficients of yield with and other characters are presented in Table 6. Correlation diagram showing genotypic correlation between yield and other characters is also given in Fig. 3.

High positive phenotypic correlation was found for number of pods per plant (0.5108) and pod weight (0.4419). Length of harvest period, number of pod clusters per plant, number of pods per cluster, pod length and pod girth also recorded positive correlation with green pod yield. Days to 50 per cent flowering, number of days to first harvest and duration recorded negative phenotypic correlation with pod yield.

The highest genotypic correlation was found for number of pods per plant (0.8972) followed by pod weight (0.6325), number of pods per cluster (0.4255), number of pod clusters per plant (0.3205) and pod girth (0.3061). Number of days to first harvest showed a negative genotypic correlation of (–0.4087) with green pod yield.

In the case of environmental correlation, the highest value was recorded for days to 50 per cent flowering (0.2150) followed by number of primary branches (0.1417).

b. Correlation among the yield component characters

The phenotypic, genotypic and environmental correlation coefficients among the yield components are given in Table 7, 8 and 9 respectively.

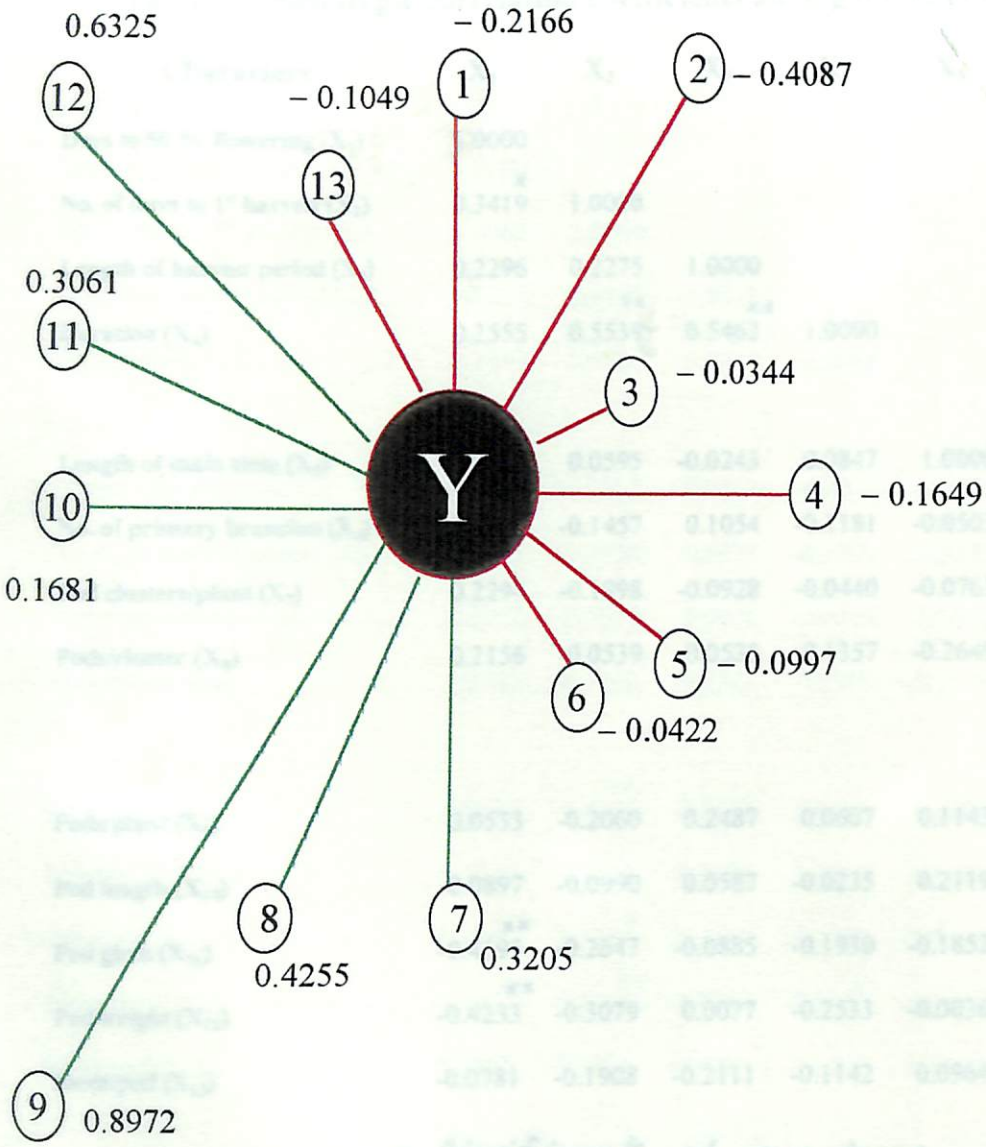
1. Days to 50 per cent flowering

Days to 50 per cent flowering recorded high negative phenotypic correlation with pod weight (–0.4233) and pod girth (–0.4195) while a positive correlation was observed

Table 6. Phenotypic, genotypic and environmental correlation coefficients between green pod yield per plant and other characters

Sl. N0	Characters	Correlation coefficient		
		Phenotypic	Genotypic	Environmental
1.	Days to 50 per cent flowering	–0.1131	–0.2166	0.2150
2.	Number of days to first harvest	–0.1641	–0.4087	0.0286
3.	Length of harvest period (days)	0.0302	0.0344	0.0268
4.	Duration (days)	–0.1137	–0.1649	0.0266
5.	Length of main stem (cm)	–0.0824	–0.0997	–0.1178
6.	Number of primary branches	–0.0083	–0.0422	0.1417
7.	Number of pod clusters per plant	0.2051	0.3205	–0.1527
8.	Number of pods per cluster	0.2224	0.4255	–0.2292
9.	Number of pods per plant	0.5108	0.8972	–0.3157
10.	Pod length (cm)	0.1415	0.1681	0.0835
11.	Pod girth (mm)	0.2410	0.3061	0.0817
12.	Pod weight (g)	0.4419	0.6325	–0.1047
13.	Number of seeds per pod	–0.0614.	–0.1049	0.0631

Fig.3. Genotypic correlation of yield with other characters



1. Days to 50 per cent flowering
2. Number of days to first harvest
3. Length of harvest period (days)
4. Duration (days)
5. Length of main stem (cm)
6. Number of primary branches
7. Number of pod clusters per plant
8. Number of pods per cluster
9. Number of pods per plant
10. Pod length (cm)
11. Pod girth (mm)
12. Pod weight (g)
13. Number of seeds per pod

Positive correlation

Negative correlation

Y: Green pod yield

Table 7. Phenotypic correlation coefficients among the yield component characters

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Days to 50 % flowering (X_1)	1.0000												
No. of days to 1st harvest (X_2)	0.3419*	1.0000											
Length of harvest period (X_3)	0.2296	0.2275	1.0000										
Duration (X_4)	0.2555	0.5539**	0.5462**	1.0000									
Length of main stem (X_5)	-0.0272	0.0595	-0.0243	0.0847	1.0000								
No. of primary branches (X_6)	-0.1751	-0.1457	0.1054	-0.1181	-0.0503	1.0000							
Pod clusters/plant (X_7)	0.2294	-0.1998	-0.0928	-0.0440	-0.0763	0.0667	1.0000						
Pods/cluster (X_8)	0.2156	-0.0539	0.0539	-0.1357	-0.2649	0.1486	0.0981	1.0000					
Pods/plant (X_9)	0.0533	-0.2060	0.2487	0.0607	0.1143	0.0920	0.5783**	0.2654	1.0000				
Pod length (X_{10})	-0.0897	-0.0990	0.0587	-0.0235	0.2119	0.3693*	0.2607	0.2211	0.4094*	1.0000			
Pod girth (X_{11})	-0.4195**	-0.2647	-0.0885	-0.1930	-0.1852	-0.1311	0.1908	-0.1756	0.1703	0.3399*	1.0000		
Pod weight (X_{12})	-0.4233**	-0.3079	0.0077	-0.2533	-0.0036	0.2542	0.2904	0.0224	0.4139*	0.5177**	0.6657**	1.0000	
Seeds/pod (X_{13})	-0.0781	-0.1908	-0.2111	-0.1142	0.0964	0.3806*	0.4281**	0.0066	0.2005	0.5776**	0.0665	0.3156	1.0000

* Significant at 5% level

** Significant at 1% level

Table. 8 Genotypic correlation coefficients among the yield component characters

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Days to 50% flowering (X_1)	1.0000												
No. of days to 1st harvest (X_2)	0.4860**	1.0000											
Length of harvest period (X_3)	0.0556	-0.0792	1.0000										
Duration (X_4)	0.1910	0.9688**	0.5529**	1.0000									
Length of main stem (X_5)	-0.0268	0.0934	0.0289	0.0918	1.0000								
No. of primary branches (X_6)	-0.1763	-0.2954	0.2473	-0.1099	-0.0577	1.0000							
Pod clusters/plant (X_7)	0.3137	-0.2851	0.0468	-0.0044	-0.0858	0.0553	1.0000						
Pods/cluster (X_8)	0.3332*	-0.2000	0.1744	-0.1493	-0.3115	0.1766	0.0677	1.0000					
Pods/plant (X_9)	0.0130	-0.4724**	0.2719	0.0161	0.1309	0.1387	0.7170**	0.3275*	1.0000				
Pod length (X_{10})	-0.1019	-0.1661	0.1085	-0.0349	0.2180	0.4028*	0.2889	0.8714**	0.5192**	1.0000			
Pod girth (X_{11})	-0.4895**	-0.3653*	-0.1159	-0.2307	-0.2064	-0.1358	0.2310	-0.1547	0.1988	0.3801*	1.0000		
Pod weight (X_{12})	-0.5013**	-0.6466**	-0.4077	-0.3320*	-0.0012	0.2942	0.3567*	0.0519	0.5256**	0.5609**	0.7452**	1.0000	
Seeds/pod (X_{13})	-0.1000	-0.3064	-0.3092	-0.1253	0.1066	0.4704**	0.5157**	0.0818	0.3022	0.6157**	0.0816	0.3922*	1.0000

* Significant at 5% level
** Significant at 1% level

Table 9. Environmental correlation coefficients among the yield component characters

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
Days to 50% flowering (X_1)	1.0000												
No. of days to 1st harvest (X_2)	0.3066	1.0000											
Length of harvest period (X_3)	0.7150**	0.4080*	1.0000										
Duration (X_4)	0.6348**	0.1980	0.7038**	1.0000									
Length of main stem (X_5)	-0.1456	0.2233	-0.1592	0.0378	1.0000								
No. of primary branches (X_6)	-0.1717	0.0434	-0.2441	-0.1907	0.4127**	1.0000							
Pod clusters/plant (X_7)	-0.3355*	-0.1791	-0.4530**	-0.2810	0.2428	0.1716	1.0000						
Pods/cluster (X_8)	-0.2865	0.0973	-0.1202	-0.0871	0.1758	0.0153	0.2415	1.0000					
Pods/plant (X_9)	0.2275	0.0365	0.2445	0.2313	0.1108	-0.1511	0.0321	0.0901	1.0000				
Pod length (X_{10})	0.0390	-0.0551	-0.0691	0.0899	-0.0773	-0.1417	-0.0367	-0.0728	-0.2153	1.0000			
Pod girth (X_{11})	-0.0519	-0.2320	-0.0603	-0.0136	0.0449	-0.1119	-0.0249	-0.2528	0.0762	0.0544	1.0000		
Pod weight (X_{12})	0.0663	0.0667	0.1299	0.1871	-0.1530	-0.0706	-0.1343	-0.1005	-0.0104	0.1282	0.2655	1.0000	
Seeds/pod (X_{13})	0.0508	-0.1093	-0.0801	-0.0552	-0.0714	-0.3045	-0.0968	-0.2903	-0.1763	0.3036	-0.0060	-0.1168	1.0000

* Significant at 5% level

** Significant at 1% level

with number of days to first harvest (0.3419). At the genotypic level, positive correlation was observed with number of days to first harvest (0.4860) and negative correlation with pod weight (–0.5013). High positive environmental correlation was evident with length of harvest period (0.7150) followed by duration (0.6348).

2. Number of days to first harvest.

High positive phenotypic correlation was recorded between number of days to first harvest and duration (0.5539) and negative correlation with pod weight (–0.3079). A very high positive genotypic correlation was recorded with duration (0.9688) followed by days to 50 per cent flowering (0.4860). Positive environmental correlation was observed with length of harvest period (0.4080).

3. Length of harvest period

Length of harvest period registered high positive phenotypic correlation (0.5462) and high positive genotypic correlation (0.5529) with duration. Very high positive environmental correlation was recorded with days to 50 per cent flowering (0.7150) followed by duration (0.7038).

4. Duration.

Duration recorded high positive phenotypic correlation with number of days to first harvest (0.5539) followed by length of harvest period (0.5462). High genotypic correlation (0.9688) was observed with number of days to first harvest followed by length of harvest period (0.5529). Duration showed a high positive environmental correlation with length of harvest period (0.7038) and days to 50 per cent flowering (0.6348).

5. Length of main stem.

Phenotypic correlation was negative with number of pods per cluster (–0.2649). Negative genotypic correlation (–0.3115) was seen with number of pods per cluster. Environmental correlation was positive with number of primary branches (0.4127).

6. Number of primary branches

Positive phenotypic correlation was observed with number of seeds per pod (0.3806) followed by pod length (0.3693). Positive genotypic correlation (0.4704) was found with number of seeds per pod. Number of primary branches showed a positive environmental correlation with length of main stem (0.4127).

7. Number of pod clusters per plant

At phenotypic level, number of pod clusters per plant showed a high positive correlation with number of pods per plant (0.5783) followed by number of seeds per pod (0.4281). High genotypic correlation (0.7170) was seen with number of pods per plant and number of seeds per pod (0.5157). The environmental correlation of number of pod clusters per plant with length of harvest period was negative (–0.4530).

8. Number of pods per cluster

Number of pods per cluster showed positive phenotypic correlation with number of pods per plant (0.2654) and negative phenotypic correlation with length of main stem (–0.2649). At the genotypic level, positive correlation was observed with days to 50 per cent flowering (0.3332) and number of pods per plant (0.3275) and negative

correlation with length of main stem (–0.3115). Negative environmental correlation was observed with number of seeds per pod (–0.2903) and pod girth (–0.2528).

9. Number of pods per plant

Positive phenotypic correlation was observed with number of pod clusters per plant (0.5783) followed by pod weight (0.4139) and pod length (0.4094). At the genotypic level high positive correlation was found with number of pod clusters per plant (0.7170), pod weight (0.5256) and pod length (0.5192). Positive environmental correlation was observed with length of harvest period (0.2445) and duration (0.2313) while negative correlation was seen with pod length (–0.2153).

10. Pod length

Pod length showed high positive phenotypic correlation with number of seeds per pod (0.5776), pod weight (0.5177) and number of pods per plant (0.4094). At the genotypic level, positive correlation was seen with number of seeds per pod (0.6157) followed by pod weight (0.5609) and number of pods per plant (0.5192). Positive environmental correlation was observed with number of seeds per pod (0.3036) and negative correlation with number of pods per plant (–0.2153).

11. Pod girth

At the phenotypic level, high positive correlation was seen with pod weight (0.6657) and negative correlation with days to 50 per cent flowering (–0.4195). Genotypic correlation was positive with pod weight (0.7452) and negative with days to

50 per cent flowering (–0.4895). Positive environmental correlation with pod weight and negative correlation with number of pods per cluster were evident.

12. Pod weight

Phenotypic correlation was positive with pod girth (0.6657) and pod length (0.5177) and negative with days to 50 per cent flowering (–0.4233). At the genotypic level, high positive correlation was seen with pod girth (0.7452) followed by pod length (0.5609) and number of pods per plant (0.5256) while negative correlation was seen with number of days to first harvest (–0.6466) and days to 50 per cent flowering (–0.5013). Positive environmental correlation was seen with pod girth (0.2655).

13. Number of seeds per pod

At the phenotypic level, high positive correlation was observed with pod length (0.5776) and number of pod clusters per plant (0.4281). At the genotypic level, high positive correlation was seen with pod length (0.6157) and number of pod clusters per plant (0.5157). Positive environmental correlation was observed with pod length (0.3036) and negative correlation with number of pods per cluster (–0.2903).

4.6 Path analysis

In path coefficient analysis, the genotypic correlation coefficients among yield and yield contributing characters were partitioned into different components to find the direct and indirect contribution of each character to green pod yield (Table 10). The component characters selected for the analysis were number of days to first harvest,

Table 10. Direct and indirect effects of component characters on yield

Characters	X_1	X_2	X_3	X_4	X_5	Genotypic correlation with yield
Number of days to first harvest (X_1)	**0.2312**	−0.0415	−0.3447	0.0093	−0.2629	−0.4087
Number of pods per cluster (X_2)	−0.0462	**0.2077**	0.2390	0.0039	0.0211	0.4255
Number of pods per plant (X_3)	−0.1092	0.0680	**0.7297**	−0.0050	0.2137	0.8972
Pod girth (X_4)	−0.0845	−0.0321	0.1451	**−0.0253**	0.3029	0.3061
Pod weight (X_5)	−0.1495	0.0108	0.3836	−0.0189	**0.4065**	0.6325

Residue = 0.1019
Underlined figures are direct effects

number of pods per cluster, number of pods per plant, pod girth and pod weight. These characters had high genotypic correlation with yield. Path diagram showing the direct and indirect effects of the component characters on green pod yield is given in Fig.4.

The highest direct effect was shown by number of pods per plant (0.7297) followed by pod weight (0.4065) and number of days to first harvest (0.2312). The lowest direct effect was recorded by pod girth (–0.0253).

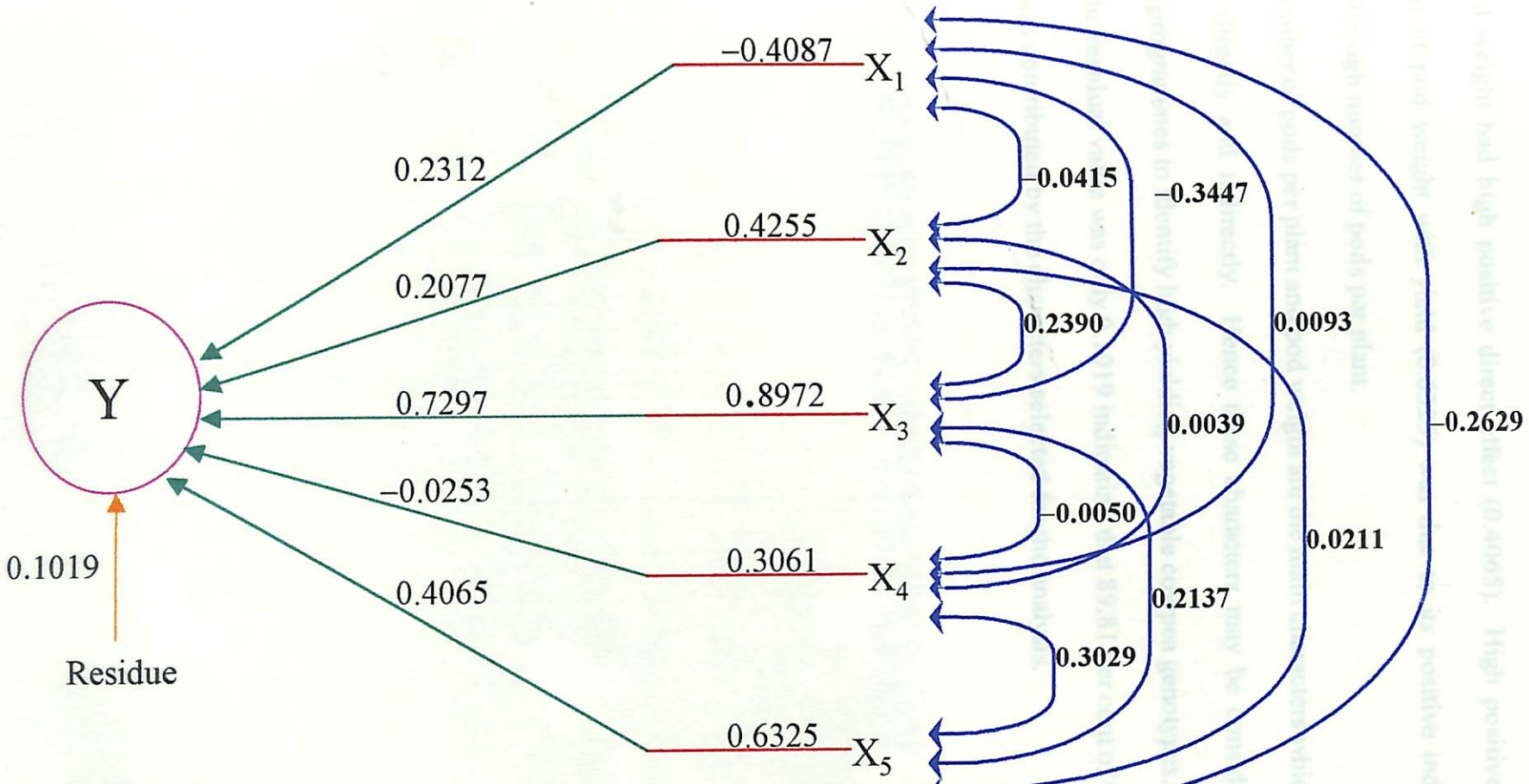
The direct effect of number of days to first harvest was positive (0.2312) but it recorded high negative genotypic correlation with yield due to high negative indirect effect through number of pods per plant (–0.3447) and pod weight (–0.2629).

Pods per cluster showed positive direct effect (0.2077) and its genotypic correlation with yield was high (0.4255) because of its indirect effect (0.2390) through number of pods per plant.

Number of pods per plant had the highest direct effect (0.7297) as well as the highest positive genotypic correlation (0.8972) with yield. It also showed a positive indirect effect (0.2137) via pod weight but the indirect effect through other component characters was negligible. So the correlation recorded here explained the true relationship of number of pods per plant and pod yield.

The direct effect of pod girth was low and negative (–0.0253) but its indirect effect via pod weight was high and positive (0.3029) which nearly accounted for the total genotypic correlation with yield (0.3061).

Fig. 4. Path Diagram showing direct and indirect effects of components on yield



Direct effects shown in green arrows

Genotypic correlation coefficients shown in red steps

Interrelationship shown by curved blue arrows

Y : Green pod yield

X_1-Number of days to first harvest
X_2-Number of pods per cluster
X_3-Number of pods per plant
X_4-Pod girth
X_5-Pod weight

Pod weight had high positive direct effect (0.4065). High positive genotypic correlation of pod weight with yield (0.6325) was due to its positive indirect effect (0.3836) through number of pods per plant.

Number of pods per plant and pod weight are the main characters which influence the yield directly and indirectly. Hence these characters may be considered during selection programmes to identify high yielding vegetable cowpea genotypes.

The residual value was only 0.1019 indicating that 89.81 per cent of the variation in yield was contributed by the characters selected for the analysis.

DISCUSSION

5. DISCUSSION

The present investigation was carried out to study the variability in green pod yield and its contributing factors in 20 genotypes of bush type vegetable cowpea.

Crop improvement largely depends on the magnitude of the genetic variability and the extent to which the desirable traits are heritable. Also the correlation analysis of yield and yield contributing characters and a study of the direct and indirect influence of these characters on yield will be useful in formulating selection programmes.

5.1 Variability studies

The extent of variability existing in a crop provides the basis for effective selection. As the observed variability is the sum of genotypic and environmental effects, knowledge on the nature and magnitude of genetic variation contributing to gain under selection is of utmost importance (Allard, 1960).

There were significant differences among the 20 genotypes of cowpea for all the characters considered in the present study *viz.*, days to 50 per cent flowering, number of days to first harvest, length of harvest period, duration, length of main stem, number of primary branches, number of pod clusters per plant, number of pods per cluster, number of pods per plant, pod length, pod girth, pod weight, number of seeds per pod and yield of green pods per plant. Ramachandran *et al.* (1980), Siddique and Gupta (1991), Sobha (1994), Resmi (1998), Vardhan and Savithramma (1998), Sharma (1999), Pournami

(2000) and Vidya (2000) also observed high variability for several characters in vegetable cowpea including those considered in the present study.

There was remarkable variation in length of main stem ranging from 15.93 cm to 121.80 cm. The excessive growth of main stem attainting enormous length in certain varieties was probably due to the favourable growth conditions provided throughout the experiment. This indicated the tendency of these varieties to trail under exuberant growth conditions. Studies by Pandita *et al.* (1982), Siddique and Gupta (1991), Hazra *et al.* (1996), Resmi (1998), Rangiah and Mahadevu (1999) and Vidya (2000) also revealed high variation for the same character.

Conspicuous variation was noticed for number of primary branches, its range being 1.93 to 5.40. Sobha (1994), Hazra *et al.* (1996) and Vidya (2000) reported wide varietal variation for number of primary branches in cowpea.

Number of pod clusters per plant also showed high variability with mean values ranging from 8.40 to 16.20. This was in accordance with the earlier reports of Radhakrishnan and Jebaraj (1982), Patil and Baviskar (1987), Kandasamy *et al.* (1989) and Dwivedi *et al.* (1999).

Number of pods per plant was another character, which expressed a wide variation ranging from 18.73 to 36.47. This is in agreement with the reports of Ramachandran *et al.* (1980), Radhakrishnan and Jebaraj (1982), Patil and Baviskar (1987), Kandasamy *et al.* (1989), Siddique and Gupta (1991), Hazra *et al.* (1996), Resmi (1998), Dwivedi *et al.* (1999), Pournami (2000) and Vidya (2000).

High variability in pod characters *viz.*, pod length, pod weight and number of seeds per pod was observed in the present investigation. Earlier reports of high variability for pod length (Radhakrishnan and Jebaraj, 1982; Kandasamy *et al.*, 1989; Mathur, 1995; Hazra *et al.*, 1996; Wang Yan Feng *et al.*, 1997; Resmi, 1998; Rangaiah and Mahadevu, 1999; Pournami, 2000; Vidya, 2000), pod weight (Ramachandran *et al.*, 1980; Wang Yan Feng *et al.*, 1997; Resmi, 1998; Rangaiah and Mahadevu, 1999; Pournami, 2000; Vidya, 2000) and number of seeds per pod (Ramachandran *et al.*, 1980; Kandasamy *et al.*, 1989; Mathur, 1995; Hazra *et al.*, 1996; Resmi, 1998; Dwivedi *et al.*, 1999; Rangaiah and Mahadevu, 1999; Vidya, 2000) supports the findings.

Green pod yield per plant showed impressive variation with values ranging from 130.00 g for Vu 9 to 215.73 g for Vu 6. Similarly high variability in pod yield were reported by Ramachandran *et al.* (1980), Pandita *et al.* (1982), Sobha (1994), Hazra *et al.* (1996), Resmi (1998) and Vidya (2000).

Variability is also expressed as the coefficient of variation. In the present study, the PCV ranged from 3.22 for duration to 67.43 for length of main stem. The highest PCV for length of main stem was followed by number of primary branches and pod weight while a low PCV was shown by days to 50 per cent flowering, length of harvest period and number of days to first harvest. High PCV for length of main stem observed in this study is supported by similar findings by Pandita *et al.* (1982) and Siddique and Gupta (1991) and that of pod weight by Hazra *et al.* (1999). Similarly high PCV for number of primary branches was reported by Vardhan and Savithramma (1998). A low

PCV for length of harvest period was observed by Vidya (2000) and for number of days to first harvest by Sobha (1994). This is in conformity with the findings in the present study.

GCV is a better tool to understand useful variability, as it is free from the environmental component affecting variability. GCV ranged from 2.95 for duration to 67.36 for length of main stem. Number of primary branches and pod weight also expressed high values of GCV while low values were shown by days to 50 per cent flowering, number of days to first harvest and length of harvest period.

Corroborative findings of high GCV were reported for length of main stem by Lakshmi and Goud (1977) and Vidya (2000), for number of primary branches by Vardhan and Savithramma (1998) and Sobha (1994) and for pod weight by Sobha (1994), Hazra *et al.* (1999) and Rangaiah and Mahadevu (1999). Low GCV for days to 50 per cent flowering was reported by Kandasamy *et al.* (1989), Sharma (1999) and Anbuselvam *et al.* (2000).

High PCV as well as high GCV were observed for number of primary branches and pod weight. This suggests the scope for improvement of these characters through selection. Sobha (1994) reported high PCV coupled with high GCV for number of primary branches and pod weight. Vardhan and Savithramma (1998) also reported the same for number of primary branches. Hence phenotypic selection will be of advantage in the case of the above two characters.

5.2 Heritability and genetic advance

Heritability provides information on the degree of inheritance of characters from the parents to the progeny. A good knowledge of heritability is a pre-requisite for effective execution of plant breeding programmes, as it is a measure of success in separating genotypes by selection. Heritability in broad sense (V_G/V_P) expresses the extent to which individual's phenotypes are determined by genotypes. Characters possessing high heritability can be improved directly through selection as they are less affected by the environment. The magnitude of heritability indicates the effectiveness of selection based on phenotypic performance (Johnson *et al.*, 1955). Burton (1952) suggested that heritability along with GCV would provide a clear idea about the amount of genetic advance expected through selection.

In the present study, all the characters considered except number of days to first harvest and length of harvest period exhibited high heritability ranging from 99.81 for length of main stem to 63.28 for yield of green pods per plant. Other characters like pod length, number of primary branches, number of pod clusters per plant, days to 50 per cent flowering, pod weight, number of seeds per pod, number of pods per plant and duration also exhibited high heritability.

High heritability for length of main stem in the present study is in agreement with the findings of Chikkadyavaiah (1985) and Vidya (2000).

High heritability for pod length seen in the present investigation is in accordance with the reports from Radhakrishnan and Jebaraj (1982), Dharmalingam and Kadambavanasundaram (1984), Patil and Baviskar (1987), Ye and Zhang (1987), Siddique and Gupta (1991), Savithramma (1992), Sobha (1994), Mathur (1995), Sreekumar (1996), Rajaravindran and Das (1997), Ram and Singh (1997), Hazra *et al.* (1999), Anbuselvam *et al.* (2000), Kalaiyarasi and Palanisamy (2000), Pournami (2000), Kumar and Sangwan (2000) and Vidya (2000).

Studies by Thiyagarajan *et al.* (1990), Vardhan and Savithramma (1998) and Vidya (2000) supports the high heritability estimate for number of primary branches.

Reports of Radhakrishnan and Jebaraj (1982), Kandasamy *et al.* (1989) and Thiyagarajan *et al.* (1990) supports the high heritability values recorded for number of pod clusters per plant in the present study. Thiyagarajan (1989), Rajaravindran and Das (1997), Ram and Singh (1997) and Anbuselvam *et al.* (2000) reported high heritability values for days to 50 per cent flowering. This is in accordance with the present findings. High heritability for pod weight noticed in this study is supported by similar results reported by Sobha (1994), Resmi (1998), Hazra *et al.* (1999), Pournami (2000) and Vidya (2000). High heritability reported for number of seeds per pod by Apte *et al.* (1987), Kandasamy *et al.* (1989), Thiyagarajan *et al.* (1990), Siddique and Gupta (1991), Sobha (1994), Mathur (1995), Sreekumar *et al.* (1996), Ram and Singh (1997) and Vidya (2000) and for number of pods per plant by Radhakrishnan and Jebaraj (1982), Thiyagarajan (1989), Siddique and Gupta (1991), Sobha (1994), Resmi (1998), Vardhan and

Savithramma (1998), Pournami (2000), Kumar and Sangwan (2000) and Vidya (2000) supports the findings in the present study.

Vegetable pod yield also exhibited high heritability, which is in agreement with reports by Siddique and Gupta (1991), Sobha (1994), Sreekumar *et al.* (1996), Resmi (1998), Vardhan and Savithramma (1998), Rajaravindran and Das (1997), Ram and Singh (1997), Pournami (2000) and Vidya (2000).

High estimates of genetic advance was shown by length of main stem and yield of green pods per plant. The high genetic advance of length of main stem is in agreement with the findings of Dumbre *et al.* (1982), Siddique and Gupta (1991) and Vidya (2000). High genetic advance of green pods per plant is in accordance with reports from Kandasamy *et al.* (1989), Sobha (1994), Kalaiyarasi and Palanisamy (2000) and Vidya (2000).

High estimates of genetic advance as percentage of mean were seen for length of main stem, number of primary branches, pod weight, number of pod clusters per plant, pod length, number of seeds per pod, number of pods per cluster and number of pods per plant.

High genetic gain for length of main stem is supported by Sobha (1994), Resmi (1998), Pournami (2000) and Vidya (2000) while that for number of primary branches by Angadi *et al.* (1978), Sobha (1994) and Vidya (2000).

Studies by Sobha (1994), Resmi (1998), Hazra *et al.* (1999), Rangaiah *et al.* (1999), Pournami (2000) and Vidya (2000) supports the high genetic gain for pod weight

while those by Radhakrishnan and Jebaraj (1982) and Rangaiah *et al.* (1999) supports similar findings for number of pod clusters per plant.

Earlier reports of high genetic gain for pod length (Sobha, 1994; Resmi, 1998; Hazra *et al.*, 1999; Pournami, 2000; Kumar and Sangwan, 2000; Vidya, 2000), number of seeds per pod (Ramachandran *et al.*, 1980; Apte *et al.*, 1987; Sobha, 1994) and number of pods per cluster (Sobha, 1994) supports the findings in this investigation.

The high genetic gain for number of pods per plant is in accordance with the findings by Radhakrishnan and Jebaraj (1982), Sobha (1994), Rajaravindran and Das (1997), Resmi (1998), Pournami (2000) and Kumar and Sangwan (2000).

High heritability along with high genetic advance indicates additive gene action for the characters under consideration, which implies the possibility for its genetic improvement through selection (Panse, 1957). In the present study, high heritability coupled with high genetic advance as percentage of mean was observed for length of main stem, number of primary branches, pod weight, number of pod clusters per plant, pod length and number of seeds per pod. These are in conjunction with the reports from Chikkadyavaiah (1985) and Vidya (2000) for length of main stem, Sobha (1994) for number of primary branches, Sobha (1994), Resmi (1998), Pournami (2000) and Vidya (2000) for pod weight, Patil and Baviskar (1987) and Thiyagarajan *et al.* (1989) for pod clusters per plant, Sobha (1994), Ram and Singh (1997) and Kumar and Sangwan (2000) for pod length and Sobha (1994) and Kalaiyarasi and Palanisamy (2000) for number of seeds per pod.

5.3 Correlation studies

Yield is a complex character and is associated with a number of component characters. The relationship of yield with other characters is of great importance while formulating selection programmes for improvement of yield. The genotypic correlation between characters provides a reliable measure of the genotypic association between characters and helps to differentiate the vital associations useful in breeding from non-vital ones (Falconer, 1981)

5.3.1 Correlation between yield and other characters

In the present study, pod yield exhibited high genotypic correlation with number of pods per plant (0.8972), pod weight (0.6325), number of pods per cluster (0.4255), number of pod clusters per plant (0.3205) and pod girth (0.3061) while a negative correlation was expressed with number of days to first harvest (– 0.4087)

The positive genotypic association of pod yield with number of pods per plant observed in the study is in conjunction with results reported by Sharma *et al.* (1988), Tewari and Gautam (1989), Tamilselvam and Das (1994) , Sreekumar *et al.* (1996) and Vardhan and Savithramma (1998).

Earlier reports of high positive correlation of yield with pod weight (Misra *et al.* 1994; Sobha, 1994; Sreekumar *et al.*, 1996; Chattopadhyay *et al.*, 1997; Resmi, 1998; Pournami, 2000; Vidya, 2000), number of pods per cluster (Tewari and Gautam, 1989;

Vidya, 2000), number of pod clusters per plant (Tewari and Gautam, 1989) and pod girth (Misra *et al.* , 1994; Sobha, 1994 ; Vidya 2000) corroborate the present findings. Sobha (1994) obtained a negative correlation of yield with number of days to first harvest as noticed in the present study.

High genotypic as well as phenotypic correlation of yield with number of pods per plant and pod weight evident in the present study is endorsed by the findings of Vidya (2000) for number of pods per plant and Sobha (1994) for pod weight. The above mentioned characters also showed high heritability. Hence it implies that selection for these characters would simultaneously lead to improvement of pod yield as their phenotypic values genuinely reflect the genotypic worth. Number of pods per cluster and number of pod clusters per plant were also found to be worthy of consideration in this context.

It is noteworthy that the environmental correlation coefficients with green pod yield were meagre for all the component characters studied except for number of pods per cluster and number of pods per plant. In general, the magnitude of genotypic correlation coefficients were greater than the corresponding phenotypic correlation coefficients which indicated that the environment had only small effects on the characters considered.

5.3.2 Correlation among the yield component characters

Correlation among yield components gives reliable information for effective selection based on yield components.

Number of days to first harvest had high negative genotypic correlation (–0.6466) with pod weight, which is supported by similar findings by Pournami (2000).

Number of pod clusters per plant expressed highly positive genotypic correlation (0.7170) with number of pods per plant. This is in agreement with the reports by Naidu *et al.* (1996).

Number of pods per plant was also positively correlated at the genotypic level with pod length (0.5192) and pod weight (0.5256). Subbiah (1999) also observed these relationships. Mathur (1995) reported high correlation of pod number per plant with pod length.

Genotypic correlation between pod length and pod weight was evident in the present study. Sobha (1994), Chattopadhyay *et al.* (1997), Pournami (2000) and Vidya (2000) reported positive genotypic correlation of pod length with pod weight.

Positive genotypic association of pod length and number of seeds per pod observed in this study is supported by the reports of Patil and Bhapkar (1987),

Apte *et al.* (1991), Sobha (1994), Tamilselvam and Das (1994), Mathur (1995) and Kalaiyarasi and Palanisamy (2000 b).

The present study suggested high positive genotypic correlation between pod girth and pod weight and is in conformity with several earlier reports (Sobha, 1994; Pournami, 2000; Vidya, 2000).

It should be noted that number of pods per plant and pod weight were highly correlated with each other (0.5256) and both of them were highly correlated with yield. A similar report from Sreekumar *et al.* (1996) supports this. The above two characters had high heritability and genetic advance also. So a selection scheme giving due consideration to these two characters would prove to be highly effective.

5.4 Path analysis

Correlation coefficients reveal only the relation between yield and yield components and not the actual direct and indirect effects of the components on yield. Rate of crop improvement will be rapid if differential emphasis is given to the component characters during selection. The differential emphasis is to be given based on the degree of direct and indirect influence of the component characters on the economic character of interest as revealed by path coefficient analysis. Path analysis splits the genotypic

coefficients into direct and indirect effects of the component characters on yield based on which crop improvement can be done more effectively.

In the present investigation, the highest direct effect on yield was exhibited by number of pods per plant (0.7297) followed by pod weight (0.4065) and number of days to first harvest (0.2312). Number of pods per plant exerted positive indirect effect via pod weight and pod weight exerted positive indirect effect via number of pods per plant.

Number of pods per plant and pod weight had high direct effect along with high genotypic correlation. Pod girth had positive indirect effect via pod weight. Also, number of pods per cluster had positive indirect effect via number of pods per plant. Number of days to first harvest had high negative indirect effect through number of pods per plant and pod weight.

High direct effect of pods per plant is in accordance with earlier findings by Chauhan and Joshi (1980), Jana *et al.* (1983), Chattopadhyay *et al.* (1997), Resmi (1998), Vardhan and Savithramma (1998 a), Pournami (2000) and Vidya (2000).

Studies conducted by Sobha (1994), Chattopadyay *et al.* (1997) Resmi (1998) and Vidya (2000) identified pod weight as one of the major contributors to pod yield as revealed in the present study also.

Hence it suggests that number of pods per plant and pod weight should be given due weightage in selection programmes for improving pod yield in vegetable cowpea.

SUMMARY

6. SUMMARY

The present study entitled "Variability and path analysis in bush type vegetable cowpea (*Vigna unguiculata* (L). Walp.)" was conducted at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani during the period 2000-2001. Twenty bush type vegetable cowpea varieties were collected from different sources. The varieties denoted by accession numbers, Vu 1 to Vu 20 included six improved varieties (Araka Suman, Arka Garima, Pusa Komal, Co-2, Vamban-2 and Kanakamani) and 14 local cultivars. They were evaluated for yield and yield component characters in a field experiment in randomised block design with three replications. Observations were recorded on days to 50 per cent flowering, number of days to first harvest, length of harvest period, duration, length of main stem, number of primary branches, number of pod clusters per plant, number of pods per cluster, number of pods per plant, pod length, pod girth, pod weight, number of seeds per pod and yield of green pods per plant.

Analysis of variance revealed high variability among the genotypes for all the traits studied. The variety Vu 6 (Arka Garima) recorded the highest vegetable pod yield (215.73 g). Vu 9 was the lowest yielder (130.00 g). Vu 1 (Arka Suman) recorded the highest number of pods per plant (36.47). Pod weight was highest for Vu 6 (9.5 g).

High phenotypic coefficient of variation with correspondingly high genotypic coefficient of variation was observed for length of main stem, number of primary branches and pod weight.

All the characters considered except number of days to first harvest and length of harvest period recorded high estimates of heritability ranging from 63.28 to 99.81.

High heritability coupled with high genetic advance was observed for length of main stem, number of primary branches, pod weight, number of pod clusters per plant, pod length and number of seeds per pod.

Pod yield per plant showed high positive genotypic correlation with number of pods per plant, pod weight, number of pods per cluster, number of pod clusters per plant and pod girth. The highest genotypic correlation of yield was with number of pods per plant.

Path analysis revealed number of pods per plant and pod weight as the traits with high direct effect on pod yield. Number of pods per plant exerted positive indirect effect via pod weight and pod weight exerted positive indirect effect via number of pods per plant. The genotypic correlation of these characters with yield was also high. The low residue (0.1019) indicated that the major portion of variation in yield could be accounted by the characters considered in path analysis.

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VARIABILITY AND PATH ANALYSIS IN BUSH TYPE VEGETABLE COWPEA (*Vigna unguiculata* (L.) Walp.)

By

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ABSTRACT OF THE THESIS
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ABSTRACT

The present investigation aimed at evaluation of variability for yield and its association with yield related characters along with their direct and indirect influence on yield was carried out at the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani. Data for the study was generated from a field experiment conducted during the period 2000-2001.

Twenty genotypes of bush type vegetable cowpea which included six improved varieties and 14 local cultivars were evaluated for yield and related characters in a field experiment in randomised block design with three replications.

Analysis of variance revealed high variability among the genotypes for all the characters studied *viz.*, days to 50 per cent flowering, number of days to first harvest, length of harvest period, duration, length of main stem, number of primary branches, number of pod clusters per plant, number of pods per cluster, number of pods per plant, pod length, pod girth, pod weight, number of seeds per pod and yield of green pods per plant. High phenotypic and genotypic coefficients of variation were observed for length of main stem, number of primary branches and pod weight. The variety Vu 6 (Arka Garima) recorded the highest vegetable pod yield and pod weight. Vu 1 (Arka Suman) recorded the highest number of pods per plant. High heritability along with high genetic advance was seen for all the characters considered.

Pod yield per plant showed high positive genotypic correlation with number of pods per plant, pod weight, number of pods per cluster, number of pod clusters per plant and pod girth. Path analysis revealed that number of pods per plant and pod weight were the main yield contributing characters due to their high direct effect on pod yield.