PERFORMANCE ANALYSIS OF CLOVE BEAN *Ipomoea muricata* (L.) JACQ. GENOTYPES

By

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THESIS

Submitted in partial fulfilment of the requirement for the degree of

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DECLARATION

I, hereby declare that this thesis entitled "**Performance analysis of clove bean *Ipomoea muricata* (L.) Jacq. genotypes**" is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara
Dt 14. 8. 2008.

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CERTIFICATE

Certified that this thesis entitled **"Performance analysis of clove bean *Ipomoea muricata* (L.) Jacq. genotypes"** is a bonafide record of research work done independently by **Ms. Malsawmkimi** under my guidance and supervision and that it has not formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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Malsawmkimi

Dedicated to

My Loving

FAMILY &

MY ADVISOR

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Introduction

1. INTRODUCTION

India is bestowed with diverse agro climatic conditions ideally suited for growing a number of vegetable crops. It is the second largest vegetable producer in the world contributing to about 14.4 per cent of world vegetable production. But the burgeoning population presents a greater need for further intensification of vegetable cultivation. Food security as well as nutritional security have become the most important issues of the developing countries. As per the Global Hunger Index (GHD), India stands at 94th position, out of 118 countries listed and falls under "alarming" category. It is estimated that by the year 2020 the population of the world will increase to 8 billion while that of India to 1.2 billion. Around 80 per cent of the world population (6 billion) will be in the developing world, of which 2 billion will be undernourished. The diversified and highly nutritive vegetables are of great importance in alleviating hunger and malnutrition.

Since no horizontal expansion in land area is possible to build up production, more and more underexploited crops have to be located to fit into the prevailing cropping systems of India, so as to increase the present production level to reach the recommended nutritional requirement. It is pertinent to mention that man has not added any new vegetable crop, developed through directed domestication and improvement. It is necessary, therefore that systematic attempts should be made to evaluate such underexploited crops for their nutritional /medicinal properties. Once an ideal new crop is located, efforts should be made to popularize the potential of an economically viable one.

Undoubtedly, there is need to broaden the range of vegetable crops utilized by man. An untapped potential exists in the large group of underutilized and under exploited plants. Commercialization of underexploited vegetables will help in solving the problem to a certain extent. *Ipomoea muricata* (L.) Jacq. (2n = 30) is one such underexploited vegetable belonging to the family convolvulaceae . It is a native of Tropical America, distributed in warmer part of south and south east Asia including Japan, China, Myanmar, Sri Lanka and Nepal. It is christened so, because of the resemblance of its thickened pedicel to cloves of the spice tree 'clove'.

Ipomoea muricata (L.) Jacq. is a slender climbing twiner, whose young seeds, fruits and thickened pedicels are eaten as a vegetable in China and Sri Lanka. This is cultivated in India as a minor vegetable for its edible fruit and pedicel or as an ornamental plant for its nocturnal flower. In china, the leaves are used in treating stomach aches and the seeds for treating trauma (Gunn, 1972).

The milky juice is extracted, refined and used as a hair tonic by Indian women, as well as to coagulate rubber sap. In the Philippine islands the plants are used as a remedy against snake bite (Chandler *et al.*, 1977).

The synonyms of this species are ***Calonyction muricatum*** **(L.) G.Don,** ***Ipomoea muricata*** **(L.) Jacq.,** ***Convolvulus muricatus*** **L.** and ***Ipomoea petiolaris*** **(kunth) G. Don.**

This is commonly referred to as clove bean (English), Michai (Hindi, Bengali), Garayo (Gujarati), Kattutali & Mukkattikkay (Tamil), Gariya (Marathi), and Nithya vazhuthana (Malayalam).

In spite of its importance, high yielding and superior quality varieties are lacking which in fact necessitates a need based crop improvement programme. For assessing superiority of genotypes, a sound knowledge of the nature and magnitude of variation in the available material and genetic parameters like genetic advance, heritability, genetic divergence and association of different traits among themselves and with yield becomes imperative before embarking upon any major selection procedure. Hence the present study was undertaken with the following objectives.

1. Genetic cataloguing of the germplasm based on the descriptor of *Ipomoea muricata* (L.) Jacq.

2. Estimating the phenotypic and genotypic coefficients of variation and assessing the genetic parameters, viz. heritability, genetic advance and genetic gain.

3. Estimating the direct and indirect effects of yield attributes on yield using path coefficient analysis.

4. Clustering the different accessions so as to quantify the genetic divergence among themselves.

5. Identifying elite *Ipomoea muricata* (L.) Jacq. genotypes on the basis of selection indices.

Review of Literature

2. REVIEW OF LITERATURE

Despite its wide genetic variability, nutritional and economic importance, very little attention has been paid to this crop. Crop improvement works appear very scanty in clove bean. However relevant literature available on crop improvement in related species and legumes in general is reviewed here under.

2.1 BOTANY

Roxburgh (1832) reported *Ipomoea muricata* (L.) Jacq. can be distinguished from *Ipomoea grandifolia* by its axillary peduncles which are half the length of the petioles and pale bluish large flowers with widened tube which are hairy inside.

Hooker (1885) observed that *Ipomoea muricata* (L.) Jacq. was having muricate stem; cordate to ovate leaves which are acute and glabrous, entire; flower sepals elliptic to lanceolate; corolla rose to purple in colour, tube linear and seeds glabrous.

Kirtikar and Basu (1975) studied the botany of *Ipomoea muricata* (L.) Jacq. and revealed that it is a large twiner; stem often muricate; leaves 7.5 to 15cm by 6.3 to 12.5cm, broadly ovate, acuminate, glabrous, entire, base deeply cordate with rounded lobes; petioles 7.5 to 15 centimeter long; peduncles 1 to 5 flowered, variable in length; bract caducous; pedicel usually much thickened upward in fruit; sepals 1.3 to 1.6 centimeter long, elliptic oblong, aristate, subequal in length, the 3 outer much broader than the 2 inner; corolla 5 to 7.5 centimeter long , rose purple; tube 2.5 to 5cm long, hairy within; anthers not twisted; capsule 1.3 to 1.7 cm in diameter, globose, apiculate; seeds 1cm long, smooth polished and black.

Saldanha and Nicolson (1976) reported that Ipomoea *muricata* (L.) Jacq. was glabrescent, slender twiner; with muricate stem. Leaf entire, broadly ovate, shortly acuminate, cordate, 6 to 10 x 5 to 8cm.Cyme few to many flowered;

Peduncle 7 to 15cm long; bract short. Corolla salverform, violet, 5 to 7 cm long, pubescent outside; tube widened above; limb subentire. Capsule ellipsoid, smooth to 0.8 cm across, shortly beaked.

The plant was described as an annual herbaceous vine that trails or twines to several feet. The vines were smooth and armed with numerous spines or warts of 3-4mm length. When crushed, the plant exudates a milky, viscous juice. The leaves were smooth, 7to 8 cm long, 6-15 cm wide with 5 to 6 lateral nerves on each side of the midrib, egg shaped or orbicular in form, heart shaped at base and attached to the leaf stalk between its lobes. The leaf tip tapers to a short point with the midrib sometimes extending beyond like a tiny tooth, simple or rarely lobed. The inflorescence appear in the leaf axil in bundles of one to three, stalks are usually shorter than those of the subtending leaves. The calyx was five lobed with linear segments. The corolla was bell shaped and pale purple (Chandler *et al.*, 1977)

Oommachan (1977) studied the botany of *Ipomoea muricata* (L.) Jacq. and reported that it was a slender climbing twiner. Stem muricate with soft prickles. Leaves cordate, acuminate, glabrous, long petioled. Flowers pale pink or purplish, sometimes 1 to 5 racemiform on a peduncle or more cymose; bract caducous; pedicels thick. Sepals subequal in length. Corolla hairy within. Stamens included. Capsule globose, apiculate. Seeds smooth polished, black.

Baker and Rendle (1979) mentioned that corolla is red or lilac in colour, about 3 inches long; tube about 2½ inches long, passing gradually into the funnel shaped-limb; expanded limb about 2 inches in diameter; capsule is globose, upto 1 inch in diameter; seeds 4, smooth and brown.

Joseph *et al.* (1982) reported that clove bean is a large climbing plant with muricate stem. Its leaves are broadly ovate, entire and glabrous; the base is deeply cordate. The pedicel is thickened upwards bearing the fruit which is a capsule. The seeds are polished black.

Concalves (1987) reported *Ipomoea muricata* (L.) Jacq. as glabrous annual. Stem wide climbing, muricate. Leaf laminate ovate or circular, 7-16 x 6-14 cm, acuminate at the apex, cordate at the base, membranous; petiole 4 to 12 cm long, smooth or muricate. Inflorescence one to few flowered dischasial or monochasial cyme; peduncle 3 to 10 cm long, muricate; pedicels 1 to 2 cm long, smooth, much thickened in the fruit; bracts minute. Sepals subequal, ovate oblong; outer sepals 6 to 7mm long. Corolla opening at night, pale bluish purple, 5 to 7.5 cm long; tube narrow and cylindrical, 3 to 6 cm long; limb funnel –shaped or salver shaped. Capsule ovoid, 1.8 to 2 cm. Seeds ovoid, 9-10 x 5 mm., flattened, black, glabrous.

According to Wu and Raven (1995) Ipomoea *muricata* (L.) Jacq. was a herbaceous annual, twining. The axial parts are often tuberculate, glabrous or nearly so with milky sap, with 2-10 m vine length. Petiole 4-12 cm in length, leaf blade cordate, 7 to 10 x 6.5 to 15 cm, base acuminate. Inflorescence 1 to few flowered, peduncle 3 to 6 cm, bracts oblong, pedicel 1 to 2 cm, thicker apically, much thickened in fruit. Flower nocturnal, sepals oblong to ovate, equal, fleshy, glabrous distinctly enlarged in fruit and eventually reflexed. Outer 2 sepals 6 to 8 cm, apex attenuate. Corolla pale purple, salver form, 7 to 7.5cm, tube 3 to 6cm, flaring apically, limb funnelform to rotate, 3 to 5 cm in diameter, shallowly 5 lobed. Stamens slightly exerted or not. Filament inserted in apical part of corolla tube, base cordate, pistil slightly exerted or not, ovary glabrous. Stigma 2 lobed, capsule ovoid, 1.8 to 2 cm, mucronate. Seeds black, trigonous 9 to 10 mm, glabrous.

Dwivedi (2003) reported *Ipomoea muricata* (L.) Jacq. as a smooth, climbing vine. The stems are rough, with small tuberculous outgrowths or prickles. The leaves are smooth, soft, heart shaped, 5 to 10 centimeters long and tapering abruptly into a narrow point at the tip. The flowers are large, 5 to 6 centimeters long, pale purple and borne singly or in small stalked cluster resembling the morning glory. The fruit is round and 10-15 millimeters in diameter. The seeds are polished, black and smooth.

2.2 USES

Dalziel (1937) reported that in the Philippines the seeds were used as a vulnery and were considered a very efficacious antidotal remedy for poisoning and the plant sap was used as an insecticide.

Mensier (1957) studied seeds of *Ipomoea muricata* (L.) Jacq and the results showed that the oil content in seeds was 9.00%, with an iodine value of 110, saponification value of 202.00, refractive index of 1.4529 nD^30 and density of 0.9160 30^C. It contained stearic acid 11-23 %, palmitic acid 7-14%, behenic acid 1-5 %, oleic acid 20-59 %, linoleic acid 15-38 % and linolenic acid 1-15 %.

Gunn (1972) reported that the young seeds, fruits, and thickened pedicels of *Ipomoea muricata* (L.) Jacq. were eaten as vegetable in China and Sri Lanka, and the species was cultivated in India for its edible pedicels or as ornamental for its nocturnal flowers.

The milky juice of *Ipomoea muricata* (L.) Jacq. was extracted, refined, and used as a hair tonic by Indian women, the juice was used to coagulate rubber sap, in China. In the Philippines the plants were used as ornamental or as a remedy against snake bite. (Chandler *et al.*, 1977).

Oommachan (1977) reported that the thickened pedicels of *Ipomoea muricata* (L.) Jacq. were much eaten as a vegetable, especially in South India.

Joseph *et al.* (1982) reported that clove bean has got many medicinal properties. Among the tribal of Chota Nagpur, especially the mundas, the powdered seeds of clove bean are a known to remedy to cure fever. The juice of the plants is sprayed to kill bugs in and around the house.

Ambasta *et al.* (1986) reported that the swollen pedicels were edible, seeds were cathartic and the fixed oil contained high concentration of behenic acid (3.75%).

Ysrael (1999) reported that *Ipomoea muricata* (L.) Jacq. (Locally known as Tonkon) has been used for generations by the Dominicans in Philippines for medicinal purposes. The seeds, stems and leaves were said to be effective in treating several types of skin ailments such as chronic and gangrenous wounds, cuts and blisters due to burns. The seeds were found to have both analgesic and antiseptic properties. Chemists identified indolizidine alkaloids in the seeds, to which the analgesic properties have been attributed. Antimicrobial and antifungal compounds were also identified. Different formulations of the crude drug have been made, namely, an ointment for the treatment of skin ailments, glycerol preparation for the treatment of pharyngitis and an otic preparation for the treatment of otitis externa.

Dwivedi (2003) reported that from the seeds of *Ipomoea muricata* (L.) Jacq. different formulations of crude drugs have been made, namely, an ointment for the treatment of skin ailments, glycerol preparation for the treatment of pharyngitis and an otic preparation for the treatment of otitis externa. The juice of this plant was employed to destroy bedbugs, and the seeds were said to be identical in their medicinal properties with those of the official plant. Analgesic, antiseptic, antimicrobial and antifungal compounds were also identified.

Hillario (2002) studied antibiotic properties of *Ipomoea muricata* (L.) Jacq. and revealed that the ointment preparation was effective against dermatitis, open wounds and boils. A glycoside muricatin ($C_{28}H_{52}0_{11}$), isolated from the seeds, appeared to consist of 4-0-L-rhamnopyranocyl-L-rhamnopyranose moety attached glyco-sidically to (+)-11 hydroxyhexadecanoic acid. It was cardiac depressant, spasmolytic to the smooth musculature of gut, lower the blood pressure of the anesthetized dog and had no action on the respiration, skeleton muscle and blood vessel of the frog.

Toll and Hurlbut (2003) reported ingestion of *Ipomoea muricata* (L.) Jacq. might cause hallucination and cholinergic effects such as diaphoresis, salivation, lacrimation and diarrhoea.

2.3 DISTRIBUTION

Kirtikar and Basu (1975) reported that *Ipomoea muricata* (L.) Jacq. was distributed in central Nepal at 900 to 1400m, also in Pakistan , India, Bhutan, China, Japan, Tropical Africa, The southern United States, Mexico, Colombia, Brazil and The West Indies

Oommachan (1977) reported that *Ipomoea muricata* (L.) Jacq. was distributed widely in India, Ceylon and Japan.

Hooker (1985) mentioned that *Ipomoea muricata* (L.) Jacq. was distributed in upper gangetic plains, Himalaya from Kangra to Sikkim up to 5000 feet., Bengal, Deccan hills and upper Burma, Ceylon, China and Japan.

2.4 VARIABILITY

The extent of variability is of paramount importance in the improvement of any crop. Knowledge of available variability within the species enables the breeder to determine the method of crop improvement. Selection of superior types will be effective only when major part of the variability of the trait is genetic.

In lablab bean, Joshi (1971) reported a wide range of phenotypic variability in yield and yield components. Pandey and Dubey (1972) assessed the extent of variability in lablab bean where they observed significant differences among the accessions for number of seeds pod^{-1}, 100 seed weight, protein content and yield. Arunachalam (1979) observed a high genotypic coefficient of variation (gcv) in characters like yield plant^{-1}, pod number and plant height in lablab bean.

Singh *et al.* (1979) observed a high genotypic coefficient of variation for all the characters except number of seeds pod^{-1} indicating the predominance of additive gene effects in lablab bean. Basawana *et al.* (1980) studied the variability in *Lablab purpureus* and found high gcv for pod weight, width and thickness, yield plant^{-1}, number of flowers inflorescence^{-1} and number of pods cluster^{-1}. Characters like number of days to flowering, pod size, number of pods plant^{-1} and number of flower cluster^{-1} showed a high and significant variation in lablab bean (Pandita *et al.*, 1980).

Jalajakumari (1981) reported highly significant genetic variability for all the characters studied in seventeen cowpea varieties. In lablab bean, Rao (1981) has conducted the genetic analysis of quantitative characters and reported large genotypic coefficient of variation in pod yield plant^{-1}, inflorescence plant^{-1}and plant height.

In genetic variability studies conducted in cow pea under dry farming conditions Pandita *et al.* (1982) found significant differences for all the 40 traits except number of pods per cluster. Wide variation existed for yield per plant, days to flowering and plant height. Pod yield per plant had the highest genotypic and phenotypic coefficient of variation.

High genotypic coefficient of variation was observed for all the characters like pod yield plant^{-1}, number of pods plant^{-1} and breadth of pod in sixteen genotypes of lablab bean (Das *et al.*, 1987).

Siddique and Gupta (1991) reported high variability for days to first flowering, plant height, pods per plant, pod length, 100 seed weight, and seeds per pod and seed yield in cow pea. High variability, among different genotypes for days to flowering, number of pods per cluster, pod length, and number of seeds per pod in cow pea was reported by Rejatha (1992).

Aghora *et al.* (1994) studied 19 diverse vegetable cow pea lines and found that wide variability existed among the genotypes with respect to the protein content Sobha (1994) studied genetic variability in 32 genotypes of bush type vegetable cowpea and found that pod weight and pod yield had high genotypic coefficient of variation

Patil and Shinde (1995) evaluated 89 genotypes of green gram and reported large amount of variability for all the characters except days to flowering and number of seeds per pod as indicated by the estimates of genetic coefficient of variability and phenotypic coefficient of variability.

Uddin and Newaz (1997) conducted the genetic variability and correlation studies in fifteen lablab bean genotypes including two exotic types. Results showed high variability in green pod yield and number of green pods plant^{-1}. A moderately high gcv was observed for individual pod weight, number of flowers cluster^{-1} and number of inflorescence.

In a study with 30 different genotypes of yard long bean Resmi (1998) observed significant differences among the genotypes for vine length, number of primary branches, days to flowering, days to harvest, pod length, pod girth, pod weight, seeds per pod, inflorescence per plant, pod per inflorescence, pod per plant, pod yield per plant, 100 seed weight, fibre content of pods and protein content of pods. Maximum phenotypic coefficient of variation was recorded for pod yield per plant followed by number of inflorescence per plant. High genotypic coefficient of variation was recorded for pod yield per plant followed by number of pods in one kilogram of cowpea.

Significant variability was noticed for days to 50 per cant flowering, plant height, number of primary branches per plant, pod length, number of pods per plant, number of seeds per pod, 100 seed weight, and yield per plant in cow pea (Sobha and Vahab, 1998).

While working with 102 accessions of cowpea, Vadhan and Savithramma (1998) obtained high values of genotypic and phenotypic coefficients of variation for plant height, number of primary branches, seed yield per plant and pod yield per plant.

In cowpea, Hazra *et al.* (1999) reported high phenotypic and genotypic coefficients of variation for plant height, pod weight, pod length and pod yield per plant.

Rangaiah and Mahadevu (1999) in cowpea 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.

Variability studies in fourty four accessions of lablab bean revealed that genetic coefficient of variation was high for the characters like weight of pod, number of pods plant^{-1}, thickness of pod, pod length and yield plot^{-1} (Biju, 2000).

Considerable variation in composition was seen among cultivars of lablab bean while analysing for nutritional factors (Chetia *et al.*, 2000). On dry matter basis, the percentage of crude protein varied from 22.06 to 28.34, crude fat 1.62 to 2.22, crude fibre 6.02 to 10.63.

Results of genetic variability studies in sweet potato (*Ipomoea batatas*) by Hossain *et al.* (2000) revealed high phenotypic and genotypic coefficient of variation for vine length, number of storage roots per plant, individual root weight, storage root and fresh yield per plant.

Pournami (2000) conducted variability studies in cowpea and observed significant differences among the 51 genotypes for days to first flowering, inflorescence per plant, pods per inflorescence, pods per plant and pod length. Maximum genotypic coefficient of variation was observed for number of pods per plant followed by yield per plant.

Vidya (2000), in a study with 50 cultivar of yard long bean, reported significant differences among the varieties for length of main stem, number of primary branches, days to first flowering, length of harvesting period, number of inflorescences per plant, number of pods per inflorescence, number of pods per plant, pod length, pod girth, pod weight, and seed per pod. High phenotypic and genotypic coefficient of variation was obtained for length of main stem, number of primary branches, weight of pod, pod length and seeds per pod.

Sankari *et al.* (2001) studied fifteen genotypes of sweet potato and found that the gcv was high for length and girth of vine and yield of roots per vine.

Vineetakumari *et al.* (2003) conducted variability studies with 50 cowpea genotypes and observed high genotypic and phenotypic coefficient of variation for days to flowering, days to maturity, number of clusters per plant, number of pods per plant, 100 seed weight and seed yield per plant.

Anshebo *et al.* (2004) studied genetic variability in sweet potato (*Ipomoea batatas*) genotypes and reported that the phenotypic coefficient of variation was higher than the genotypic coefficient of variation indicating the influence of environment on the expression of these traits.

A study conducted from 1995 to 1998 to screen fifteen strains of *Lablab purpureus* in rainfed conditions in Punjab by Singh *et al.* (2004) revealed that there existed much variabiity for days to flower initiation, pod length, pod width and green pod yield per plant which ranged from 67.4 to 108.9 days, 5.0 to 11.6 cm, 1.7 to 2.7 cm and 0.376 to 2.596 kg respectively.

Mahalakshmi *et al.* (2005) evaluated fifty seven groundnut genotypes and reported significant differences for the characters like days to flower initiation, plant height, yield per plant, total number of pods, and maturity index. In general, the genotypic and phenotypic coefficient of variation was high for all the characters except for plant height, maturity index and shelling percentage.

Mohan and Aghora (2006) studied 97 pole types of lablab bean out of which maximum pod length was recorded by IIHR 0486 (18.3 cm) and pod width by IIHR 049 (4.0 cm). Average pod weight was highest in IIHR 0413 (18.0g) and pod width in IIHR 049 (4.0 cm).

Working with 7 diverse genotypes of peas Ranjan *et al.* (2006) reported that there was significant variability for the characters like days to flowering, plant height, days to maturity, pods per plant, seeds per pod, seed yield per plant and 100 seed weight.

Sharma *et al.* (2007) studied genetic variability in 20 diverse pea genotypes and observed that phenotypic and genotypic coefficients of variation were of high magnitude for plant height and moderate for pods per plant and pod yield per plant.

Kumar *et al.* (2008) studied genetic variability in 23 genotypes of lentil and found that the Pcv was generally higher than the Gcv for all the characters but in many cases, the two values differed only slightly. The lowest values were shown by days to maturity, number of seeds per pod and protein content and the highest values were shown by harvest index followed by grain yield per plant.

2.5 HERITABILITY AND GENETIC ADVANCE

Singh *et al.* (1979) studied 48 strains of lablab bean and reported high heritability value for all characters. Among these, days to flower and yield plant^{-1} showed very high heritability while number of seeds pod^{-1} showed the lowest. Basawana *et al.* (1980) reported high heritability and genetic advance for yield plant^{-1}, pod weight, pod width and number of flowers inflorescence^{-1} in lablab bean.

Working on eleven cow pea varieties Jana *et al.* (1983) obtained high heritability and genetic advance for characters 1000 grain weight and days to flowering.

In a study on genetic variability with 40 genotypes of cowpea Dharmalingam and Kadambavanasundaram (1984) obtained high heritability for pod length and 100 seed weight.

Siddique and Gupta (1991) reported high heritability estimates for pods per plant, plant height, 100 seed weight and 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 in cow pea.

In a study with 59 varieties of cow pea Sudhakumari (1993) reported high values of heritability and genetic advance for pod length, number of primary branches per plant and 100 seed weight.

Sawant (1994) studied 11 component traits in cowpea and reported high heritability and genetic advance for plant height, seed yield per plant, pods per plant inflorescence per plant, branches per plant, pod length and 100 seed weight.

In cowpea, plant height, pods per plant, pod length, pod width, seeds per pod and grain yield showed high heritability estimates. (Mathur, 1995). High genetic gain was reported for pods and grain yield per plant.

Rewale *et al.* (1995) studied heritability different characters in 70 diverse cowpea genotypes and found that the estimates of heritability and genetic advance were high for 100 seed weight and plant height.

In sweet potato (*Ipomoea batatas*) Alam *et al.* (1998) observed high genotypic coefficient of variation coupled with high heritability and genetic advance for the traits vine length, number of tubers per plant and individual tuber weight.

High heritability was observed for crude protein and crude fibre content in winged bean, but genetic advance was low (Philip, 1984)

Singh *et al.* (1986) studied 16 genotypes of lablab bean and they observed high heritability with greater genetic advance for pod yield plant^{-1}, number of pods plant^{-1} and breadth of pods. Das (1987) indicated that 100 seed weight and green pod yield plant^{-1} had high heritability of 91.4 per cent and 85.6 per cent respectively.

Study conducted by Newaz (1990) in thirteen genotypes of lablab bean in Bangladesh showed high heritability as well as high genetic advance for pod yield, number of pods plant^{-1}, number of inflorescence cluster^{-1} and pod weight.

Study conducted by Borah and Shadeque (1992) in lablab bean showed high heritability and genetic advance in characters like pod weight, pod breadth and vitamin C content.

Genetic advance and heritability were estimated by Desai *et al.* (1996) in lablab bean which revealed that there was ample scope for improvement in number of branches, seeds pod^{-1}, days to flowering, days to maturity, 100 seed weight and yield.

Working with seven cowpea genotypes Rajaravindran and Das (1997), reported that heritability was the highest for pod length followed by days to 50 per cent flowering, days to maturity, green pod yield while it was the lowest for pod per plant. Genetic advance was high for green pod yield. Genetic advance was high for green pod yield and pods per plant.

In lablab bean Uddin and Newaz (1997) observed high heritability and genetic advance in characters like pod yield, number of pods plant^{-1} and pod weight.

Biju (2000) observed that the highest heritability for weight of pod followed by pod length, shelling percentage and girth of pod in lalab bean.

Nehru and Manjunath (2001) reported high heritability and genetic advance for pods per plant and moderate heritability for plant height, 100 seed weight and yield per plant in cowpea.

Sankari *et al.* (2001) studied fifteen genotypes of sweet potato and reported high heritability coupled with high genetic advance for vine length, vine girth and yield of roots per vine.

Narayanankutty *et al.* (2003) observed high heritability coupled with high genetic advance for fruit yield, pods per plant and weight of pods in cow pea.

Rai *et al.* (2004) reported high heritability and genetic advance for pod yield plant^{-1}, number of pods plant^{-1} and pod weight in French bean.

Ampily (2005) observed high heritability and genetic advance over three seasons for green pod yield plant^{-1}, seed yield plant^{-1}, hundred seed weight and pod length and indicated that the variation in these characters was most likely due to additive genes, hence simple direct selection may be effective to improve these characters.

Deepalakshmi and Ganesamurthy (2007) observed high heritability accompanied with high genetic advance for characters like days to 50 per cent flowering, plant height, leaves per plant and single plant yield thus suggesting that these characters are under additive gene action and gives better scope for selection in sorghum.

In a study of genetic variability with thirty genotypes of cowpea, Eswaran *et al.* (2007) obtained high heritability and genetic advance for plant height at the time of first flowering, plant height at the time of 50 per cent flowering and maturity indicating their dependability for effecting selection.

In clusterbean, Nandhi and Oommen (2007) observed high heritability coupled with high genetic advance for plant height, pod weight and length, number of pods per plant and yield per plant indicating the presence of additive gene action in the expression of these characters.

Tsegaye *et al.* (2007) reported that high heritability and genetic advance were recorded for vine length, leaf area, number of storage root per plant, root weight and fresh yield per plant in sweet potato (*Ipomoea batatas*).

2.6 CORRELATION STUDIES

Yield is a complex character determined by several component characters. Improvement in yield is possible only through selection for the desirable characters. The relationship of yield with other traits is of great importance while formulating any selection programme for crop improvement. Research work done to bring out the relationship of different traits with yield and yield contributing factors in legumes and sweet potato are briefly reviewed.

Studies conducted in 39 genotypes of lablab bean by Basawana *et al.* (1980) revealed a positive correlation between yield and length, width and weight of pod and seeds pod^{-1}. Pandita *et al.* (1980) reported that the length of inflorescence and pod length were positively and highly correlated with yield where as days to flowering was negatively correlated with yield in hyacinth bean.

Sathyanarayana and Gangadharappa (1982) revealed that the green pod yield in lablab bean was significantly and positively correlated with weight, breadth and length of pods and per cent dry weight of green pods but were found to be influenced by the environment.

Naskar *et al.* (1986) conducted correlation studies in 22 sweet potato genotypes. Result showed that the characters like length of vine and internodal length characters were negatively correlated with yield, whereas length of tuber showed maximum positive direct effect on yield.

Ye and Zhang (1987) observed the existence of positive correlation between pod yield, protein yield, dry matter yield and their component in yard long bean. The green pod yield was highly and positively correlated with pods per plant, days to first flowering, seeds per pod and plant height in cow pea (Sharma *et al.*, 1988)

In cowpea, green pod yield per plant was positively correlated with pod length and pod weight in cow pea (Misra *et al* .1994).

In vegetable cowpea, high and positive correlation between pod yield and days to harvest, length, girth, weight of pods, seeds per pod and 100 seed weight was reported by Sobha (1994).

In cowpea, Hussein and Farghali (1995) reported that significant phenotypic correlation between pod length and 100 seed weight and significant genotypic correlation between days to flowering and pod length as well as number of seeds per pod and seed yield.

Kar *et al.* (1995) observed that strong association of pod yield with fibre percentage and seeds per pod in cow pea.

Days to flowering recorded significant genotypic correlation with pod length, number of seeds per pod and seed yield in cowpea. (Naidu *et al*., 1996).

Sreekumar *et al.* (1996) reported significant positive correlation in yard long bean between yield of green pods and number of fruiting points per plant, number of pods per plant, pod length and number of seeds per pod, at phenotypic and genotypic level.

Chattopadhyay *et al.* (1997) reported that pod length, green pod weight, seeds per pod and 100 seed weight exhibited significant positive genotypic correlation with green pod yield. Days to flowering registered high negative association with green pod yield both at genotypic and phenotypic level.

Nandi *et al.* (1997) revealed that pod weight and pod girth were positively and significantly correlated with green pod yield plant^{-1} in dolichos bean.

Uddin and Newaz (1997) conducted correlation studies in lablab bean which showed a positive association of number of flowers in the inflorescence with rate of flower abortion and number of green pods. Green pod yield had strong and significant positive association with pod number, inflorescence plant^{-1} and pod weight.

Correlation studies by Resmi (1998) with 30 genotypes of yard long bean indicated high positive correlation of pod yield with pod weight, pod length and number of pods per plant.

Vardhan and Savithramma (1998) reported that green pod yield per plant in cowpea was significantly and positively correlated with pod length, pod width, pods per plant and biomass of the plant.

Medunzhiyan and Reddy (2000) reported that a significant and positive correlation between tuber yield and vine length as well as number of leaves per plant and he also found a high and positive correlation between vine length and dry matter production in sweet potato.

In yard long bean positive genotypic correlation of pod yield per plant with number of seeds per pod, number of pods per plant, length of harvest period, number of pods per inflorescence, pod weight, pod girth and pod length was reported by Pournami (2000).

In vegetable cowpea, pod yield per plant showed high genotypic correlation with number of pods per plant, pod weight, pods per cluster and pod cluster per plant (Ajith, 2001).

Correlation studies by Ushakumari *et al.* (2001) with 50 genotypes of cow pea indicated that yield per plant was significantly and positively associated with vine length, pod length and number of pods per plant.

In cowpea, Kutty *et al.* (2003) observed that number of pods per plant, pod weight and pod length were positively and significantly correlated with yield per plant both at genotypic and phenotypic level. Number of days to first picking showed significant negative correlation with yield per plant.

Pod yield had significant positive association with number of pods, pod length and number of grains per plant at the genotypic level while pod length had significant association at phenotypic level in cowpea. (Neema and Palanisamy, 2003).

Fresh pod yield in cowpea was significantly and positively correlated with number of pods per plant, average pod weight and pod length (Peksen, 2004). There was positive and significant correlation between fresh pod yield, number of branches per plant and pod thickness.

Renukadevi and Subbalakshmi (2006) worked out correlations for eleven characters including seed yield in fifty chickpea genotypes during *Rabi* 2002. Plant height, number of primary branches, number of pods per plant, 100 seed weight, biological yield per plant and harvest index had positive and significant correlation with seed yield.

Deepalakshmi and Ganesamurthy (2007) observed that the seed yield in sorghum was positively and significantly correlated with days to maturity, number of leaves per plant. However, days to flowering, leaf length and leaf breadth recorded positive non significant association with seed yield.

2.7 PATH ANALYSIS

The path coefficient provides an effective means of finding out direct and indirect causes of association and allows a detailed examination of specific forces acting to produce a given correlation and measures the relative importance of each factor.

Pandita *et al.* (1980) reported that suggested that days to flowering, hundred seed weight and pod width have direct effect on yield in dolichos bean.

Murthy (1982) observed that the number of pods per plant was the major contributor to yield followed by pod length, seeds per pod and pod weight in cow pea.

Path coefficient analysis in lablab bean conducted by Sathyanarayana and Gangadharappa (1982) revealed that the weight of pod exerted high direct effect on green pod yield followed by length of inflorescence and days to first flowering. Pods plant^{-1}, bunches plant^{-1} and per cent dry weight of green pods influenced yield indirectly.

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

Biradar *et al.* (1991) found that pod weight had the highest positive direct effect on yield in cowpea followed by plant height and cluster per plant. Pod length, pods per plant and seeds per pod showed negative direct effect on yield.

Path coefficient analysis by Dahiya *et al.* (1992) in 36 genotypes of lablab bean (*Lablab purpureus*) suggested that the increased yield in lablab bean may be brought about by selecting for number of pods plant^{-1}, plant height and pod weight.

Path coefficient analysis by Oseni *et al.* (1992) indicated that days to flowering had the highest direct effect on grain yield followed by 100 seed weight, days to pod filling and pod length in cowpea.

In cowpea, Misra *et al.* (1994) found that pod length had the greatest direct effect on pod yield followed by pod diameter while direct negative effect was observed for average pod weight.

Pod weight showed the maximum positive direct effect on yield followed by pod girth and 100 seed weight in bush type vegetable cowpea (Sobha, 1994).

Kar *et al.* (1995) observed that in vegetable cow pea, pod length and fibre content were found to be the main determinants of pod yield. The 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 (Chattopadhyay *et al.*, 1997).

Nandi *et al.* (1997) derived information on path analysis from 20 local lines of lablab bean (*Lablab purpureus*) grown at Keonjhar, Orissa, in 1994. Pod weight and pod girth were positively and significantly correlated with green pod yield plant^{-1}. The number of pods plant^{-1} was closely associated with green pod yield plant^{-1}.

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 yield.

Path analysis in yard long bean by Vidya (2000) reported that maximum direct effect on yield was shown by number of pods per plant followed by pod weight and the number of pods per inflorescence had high indirect effect via number of pods per plant.

Ajith (2001) reported that pods per plant and pod weight had the highest direct effect on seed yield in vegetable cowpea. The number of pods per plant exerted positive indirect effect via pod weight.

Path coefficient at genotypic level revealed that seed diameter, pod weight, seed weight and pods plant^{-1}, showed maximum positive direct effect on pod yield plant^{-1} indicating that these characters were the main contributors to yield (Biju *et al.,* 2001) in lablab bean.

Kutty *et al.* (2003) indicated that the pods per plant, followed by pod weight had the greatest positive direct effect on yield. The direct effect of pod length and number of days to first picking were low mainly due to high indirect effect via average weight of pods and number of pods per plant.

Path analysis in lablab bean by Tikka *et al.* (2003) indicated that pods plant^{-1}, pod length, branches plant^{-1}, plant height and harvest index were the main yield contributing traits in lablab bean. Positive direct effect and significant association were observed for these traits.

Eight quantitative characters were analysed in twenty eight-dwarf Frenchbean genotypes for path coefficients in relation to pod yield (Nath and Korla, 2004) and found that number of pods plant^{-1}, pod length and harvest index had significant positive association with pod yield.

Path analysis in chickpea by Renukadevi and Subbalakshmi (2006) reported that positive direct effect on seed yield was exhibited by plant height, number of primary branches per plant, number of pods per plant, yield per plant, harvest index and days to maturity.

Sharma *et al.* (2007) found high positive direct effects on yield through plant height, pods per plant and pod length in garden pea.

2.8. GENETIC DIVERGENCE

A knowledge of genetic divergence among the different genotypes is very essential in selection of parents for hybridization programme .According to Singh and Gupta (1968), more the divergent the parents with a reasonable range, the more would be the chance of improving a character in question through hybridization programme.

Jindal (1985) used Mahalanobis D^2statistic to cluster 52 cowpea varieties from India and other countries for ten characters and grouped them in to eight clusters. The clustering did not reflect the geographical origin of the varieties.

Patil and Bhapkar (1987) studied that the genetic divergence among 18 indigenous and 21 exotic genotypes of cowpea and grouped them into 16 clusters using Mahalanobis D^2 statistic.

Sudhakumari and Gopimony (1994) used Mahalanobis D^2 technique to estimate genetic divergence of 59 cowpea varieties and grouped them into eight clusters.

In cowpea, Hazra *et al.* (1996) grouped 45 genotypes into four clusters using Mahalanobis D^2 statistic. Intercluster distance was maximum between cluster I and IV.

Rewale *et al.* (1996) studied that the genetic divergence of 70 genotypes of cowpea and grouped them into 19 clusters using Mahalanobis D^2 statistic. There was no relationship between geographical origin and genetic diversity. Days to initiation of flowering, 50 per cent flowering and maturity, number of inflorescence, pod per plant, pod length, 100 seed weight and seed yield per plant made major contribution to total divergence

Mahalanobis D^2 statistic was used to estimate genetic divergence of ten yield related characters in 50 cowpea genotypes by Santos *et al.* (1997). Length of the main branch, 100 seed weight and pod length were the most important characters to affect divergence.

Viswanathan *et al.* (1998) assessed the genetic divergence in 72 genotypes of cowpea and observed high genetic diversity among them. Information on nine characters from 24 early maturing genotypes of cowpea from different geographical regions were subjected to Mahalanobis D^2 statistic analysis by Tyagi *et al.* (1999) and grouped them into three clusters. Genetic diversity was independent of geographical origin.

Backiyarani *et al.* (2000) used Mahalanobis D^2 statistic analysis to cluster 32 genotypes of cowpea into six clusters of which cluster IV was the largest with 18 genotypes. Geographical diversity was not related to genetic diversity. Single plant yield, harvest index and earliness in flowering together accounted for 80 per cent of the total genetic divergence.

In yard long bean, Vidya (2000) grouped 50 genotypes into four cluster using Mahalanobis D^2 statistic. Cluster I formed the largest cluster with 28 genotypes while cluster IV had only a single cultivar.

Narayanankutty *et.al.* (2003) studied genetic divergence in 37 genotypes of vegetable cowpea and grouped them into 11 clusters using Mahalanobis D^2 statistics. The maximum inter cluster distance was observed between cluster VIII and X followed by cluster VI and X and cluster VIII and IX.

In cowpea, Philip (2004) studied genetic divergence in 50 genotypes and grouped them into ten clusters and wide range of genetic divergence was noticed among the genotypes.

In chickpea, Durga *et al.* (2005) grouped 132 genotypes into nine clusters. Cluster I was the largest, comprising of 20 genotypes, followed by cluster V and VII with 15 and 16 genotypes respectively.

Malarvizhi *et al.* (2005) reported the high heritability coupled with high genetic advance for plant height in cowpea.

The genetic divergence was studied in the germplasm of 60 genotypes of black gram by Mahalanobis D^2 analysis. Based on the analysis the 60 genotypes were grouped into 17 clusters. The genotypes included in a cluster were from diverse geographical origin indicating that the geographical diversity need not be necessarily related to genetic diversity (Shanthi *et al.*, 2006).

Pandey (2007) assessed that the genetic divergence in forty four cowpea genotypes and grouped them into nine clusters using Mahalanobis D^2. Cluster strength varied from single genotype (Cluter IV to IX) to 31 genotypes (Cluster I). Clurter II, V, VII had maximum yield per plant, 100 seed weight, pod length and number of seeds per pod. Cluster II had minimum days to maturity while Cluster VII showed maximum days to maturity.

Valarmathi *et al.* (2007) studied genetic divergence in sixty nine cowpea genotypes, which included 60 genotypes from Vigna unguiculata ssp. unguiculata and eight genotypes from Vigna unguiculata ssp. sesquipedalis and all the accessions were grouped into twelve clusters using Mahalanobis D^2. Cluster I was the largest having 47 genotypes.

In Urg bean Chauhan *et al.* (2008) studied the genetic divergence in 210 genotypes and grouped them into nine clusters. The highest number of genotypes appeared in cluster IX which contained 38 entries. The highest intracluster distance was recorded for cluster II while lowest was found in case of cluster IX.

2.9 SELECTION INDEX

To make effective selection for higher yield, it is necessary to determine the selection index.

Rathnaiah (1982) worked out selection indices in lablab bean using characters like number of pods plant^{-1}, plant spread, green pod yield plant^{-1}, number of inflorescences plant^{-1} and length of inflorescence and pod.

Singh *et al.* (1982) reported that green pod yield plant^{-1} showed significant effect on pod weight and 100 seed weight in lablab bean and these characters were ideal for effective selection.

Philip (1984) observed that the characters such as days to final harvest, number of pods plant^{-1} and girth of pods were used for selection index analysis in winged bean

Das *et al.* (1987) found that characters like pod yield plant^{-1}, number of pods plant^{-1} and breadth of pods were effective for selection in lablab bean.

Uddin and Newaz (1997) reported that in lablab bean, characters like number of pods plant^{-1}, inflorescence plant^{-1} and pod weight were effective for improvement of yield.

Borah and Shadeque (1992) suggested that selection index based on length of inflorescence, weight and breadth of pods, pod yield plant^{-1} and pod length resulted in higher yield in 12 local cultivars of lablab bean.

The increased yield in lablab bean was brought about by selecting for number of pods plant^{-1}, plant height and pod weight (Dahiya *et al.,* 1992).

Resmi (1998) worked out the selection indices for yard long bean on the basis of characters which showed high correlation with yield viz., length of vine, number of primary branches, petiole length, days to first flowering, pod length, pod girth, pod weight, pods per inflorescence, pods per kg, Pods per plant and pod yield per plant. Based on analysis the genotype VS-6 attained the maximum selection index value followed by VS-11, VS-19 and VS-3 and the least score were obtained for VS-16, VS-10 and VS-2.

Biju (2000) worked out selection indices in field bean *(Lablab purpureus)* and found that the accession DL-6 was the most superior followed by accessions DL-29, DL-40 and DL-66. Accession DL-6 was the highest yielder with an average yield of 7.1 kg $plot^{-1}$.

Tikka *et al.* (2003) reported that the characters pods $plant^{-1}$, pod length, branches $plant^{-1}$, plant height and harvest index should be considered for selection in order to bring improvement in seed yield in Indian bean Rai *et al.* (2004) observed that maximum direct effect of seed diameter, pod weight and number of pods $plant^{-1}$ towards yield indicated that these characters were very important while making selection for high yielding genotypes in French bean.

3.0 QUALITY ATTRIBUTES

Immature pods of winged bean contained 1.3 to 1.7mg 100^{-1} of iron and 63 to 330 mg100^{-1} of calcium (NAS, 1975)

In winged bean a protein content of 3.2% in immature pods and 8.1% in beans was reported by Norgon *et al.* (1979).

According to Augustin *et al.* (1981) the nutritional composition of faba bean was phosphorus 373.3mg 100^{-1}g; protein 24.8g100^{-1}g, calcium 97.8 mg $100-^{1}$g and iron 6.66mg 100^{-1} g.

John *et al.* (1988) reported that 100g of edible portion contained 1.56 g of protein.

Gopalan *et al.* (1989) reported that the calcium content of field bean was 210 mg 100^{-1}; French bean 50mg 100^{-1} g; the vitamin C content in beans was 27 mg 100^{-1}g, broad beans 12 mg 100^{-1}g, cluster beans 49 mg100^{-1}g, cowpea pods 14 mg 100^{-1}g, field beans 9 mg 100^{-1}g and in French beans 24 mg 100^{-1}g. The iron content of beans was 2.6 mg 100^{-1}g, broad beans 1.4 mg 100^{-1}g, cluster beans 1.08mg 100^{-1}g, cowpea pods 2.5 mg 100^{-1}g, field beans 0.83 mg 100^{-1}g and French beans 0.61 mg 100^{-1}g. The phosphorus content of beans was 160 mg100^{-1}, broad bean 64 mg 100^{-1}g, cluster beans 17 mg100 $^{-1}$g, cowpea pods 59 mg 100^{-1} g, field beans 68 mg 100^{-1} g and French beans 28 mg 100^{-1} g.

As reported by Neeliyara (1998) calcium content of winged bean ranged from 165.4 to 245.4mg 100^{-1} g with a mean value of 201 mg 100^{-1} g and iron 0.56 to 1.41 mg 100^{-1} g. The vitamin C content of the immature pods of winged bean was found to be between 14.3 mg 100^{-1} g and 17.2 mg100^{-1} g with a mean of 15 mg 100^{-1} g. The protein content in winged bean varied from 2.7% to 3.0 %.

According to the reports of NIN (1999) the protein content in various leguminous was bean 0.4g; cluster bean 3.2g; cowpea pods 3.5g, field beans 3.8g and french bean 1.7g/100g and the crude fibre content tables vegetable was beans 0.8g 100^{-1}; broad beans 2.0g100^{-1}; cluster bean 3.2 g 100^{-1}; cowpea pods 2.0 g 100^{-1}, field beans 1.8g100^{-1} and French beans 1.8g100^{-1}.

Materials and Methods

3. MATERIALS AND METHODS

Present investigation on " Performance analysis of clove bean *Ipomoea muricata* (L.) Jacq. genotypes" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara during 2007-2008. The site is located at 10^0 32' N latitude and 76^0 13' E longitude and at an altitude of 22.5m above MSL. The experimental site has a sandy loam soil, which is acidic in reaction (pH 5.3). The area lies in tropical monsoon climatic region, with more than 80 per cent of the rainfall getting distributed through southwest and northeast monsoon showers. Data on temperature, rainfall, relative humidity, number of rainy days and sunshine hours during the entire cropping period were collected from meteorological observatory of College of Horticulture, Vellanikkara (Appendix I).

Season of experimentation

Experiment was conducted during August 2007 to January 2008.

The project consisted of the following aspects

3.1. Development of descriptors and genetic characterisation of clove bean *Ipomoea muricata* (*L.*) Jacq.

3.2. Evaluation of genotypes of clove bean Ipomoea *muricata* (*L.*) Jacq.

3.1 Development of descriptors and genetic characterisation of clove bean *Ipomoea muricata* (*L.*) Jacq.

3.1.1. Morphological characterisation

A descriptor was designed for characterization and evaluation of clove bean germplasm as there is no descriptor developed by NBPGR / IPGRI or any other agency working on genetic resources for this underutilized vegetable. Twenty five accessions collected from different parts of Kerala state (Table 1) were genetically characterized based on this descriptor.

3.1.2. Botanical description.

Since the crop is underexploited the botany of the crop was studied in detail and the botanical description of *Ipomoea muricata* (L.) Jacq. has been elucidated.

3.2 Evaluation of variability in clove bean

3.2.1 Experimental materials

The experimental materials consisted of 25 accessions collected from different parts of Kerala and maintained in the Department of Olericulture, College of Horticulture, Vellanikkara.

3.2.2 Experimental methods

The experiment was laid out in a randomized block design with three replications. Five plants were raised separately for each accession at a spacing of 1.5x1.5m under each replication (Plate 1). Pandal was provided for the plants to trail and care was taken to see that the vines of one plant do not overlap with the space provided for the adjacent plants. The crop received timely management and care as per the Package of Practices Recommendations of Kerala Agricultural University (KAU 2007).

3.2.3 Observations

Observations were taken from all the five plants separately for each genotype. The following observations were recorded for all the accessions and average was worked out for further analysis.

Table 1. Passport data of *Ipomoea muricata* (L.) Jacq. accessions:

Sl.No	Collection number	Village	District	State
1	IM-1	Thrissur	Thrissur	Kerala
2	IM-2	Changanacherry	Kottayam	Kerala
3	IM-3	Attapadi	Palakkad	Kerala
4	IM-4	Alappuzha	Alappuzha	Kerala
5	IM-5	Thrissur	Thrissur	Kerala
6	IM-6	Elanad	Thrissur	Kerala
7	IM-7	Pathanamthitta	Pathanamthitta	Kerala
8	IM-8	Kulathur moozhy	Kottayam	Kerala
9	IM-9	Kottayam	Kottayam	Kerala
10	IM-10	Neeratupuram	Kottayam	Kerala
11	IM-11	Kanjirappally	Kottayam	Kerala
12	IM-12	Nadathara	Thrissur	Kerala
13	IM-13	Puthoor	Thrissur	Kerala
14	IM-14	Kottayam	Kottayam	Kerala
15	IM-15	Kottayam	Kottayam	Kerala
16	IM-16	Nilambur	Malappuram	Kerala
17	IM-17	Nilambur	Malappuram	Kerala
18	1M-18	Thrissur	Thrissur	Kerala
19	1M-19	Thrissur	Thrissur	Kerala
20	1M-20	Nilambur	Malappuram	Kerala
21	IM-21	Nilambur	Malappuram	Kerala
22	IM-22	Calicut	Calicut	Kerala
23	IM-23	Palghat	Palghat	Kerala
24	IM-24	Ernakulam	Ernakulam	Kerala
25	IM-25	Quilon	Quilon	Kerala

Plate -1. View of the experimental plot

a) Vine length (cm)

The plants were pulled out when the harvesting was over without any fresh flower production and the length was measured from the collar region to the tip of the main vine and expressed in centimeters.

b) Days to first flower production

The number of days was counted from date of sowing to the date of opening of first flower.

c) Days to first harvest

The number of days from sowing to the date of first harvest of the fruits at vegetable maturity was noted.

d) Length of pedicel (cm)

The length of pedicel of ten fruits from each plant was recorded in centimeters, in centimeters at vegetable maturity and average was worked out.

e) Girth of pedicel (cm)

The girth of pedicel of ten fruits from each plant was recorded in centimeters at vegetable maturity and average was worked out.

f) Weight of pedicel (g)

Weight of the pedicel of ten fruits from each plant was recorded in gram at vegetable maturity and average was worked out.

g) Length of the fruit (cm)

Length of ten fruits from each plant was recorded in centimeters at vegetable maturity and average was worked out.

h) Girth of fruit (cm)

Girth of ten fruits from each plant was recorded in centimeters at vegetable maturity and average was worked out.

i) Weight of fruit (g)

Weight of ten fruits from each plant was recorded in gram at vegetable maturity and average was worked out.

j) Yield per plant (kg)

Weight of fruits harvested periodically at vegetable maturity from each plant was measured separately and the total was worked out and expressed as kilogram.

k) Duration of the crop

The number of days from sowing to final harvest were counted.

l) Number of harvests

The total number of harvests from first to final harvest was noted.

m) Shelf life in open conditions

Shelf life of fruits harvested at vegetable maturity and stored under open condition at room temperature was recorded and average was work out.

n) Reaction to pest and diseases

The incidence of pest / diseases in the main field was observed and recorded periodically.

o) Colour of vine

Colour of vine was observed and recorded.

p) Colour of the flower

Colour of the flowers were observed and recorded.

Chemical properties

q) Ascorbic acid

Ascorbic acid content of the fruit at vegetable maturity was estimated by titration with 2, 6 –dichlorophenol indophenol dye (Sadasivam and Manikantan 1991)

One gram of the fresh sample was extracted in four per cent oxalic acid using a mortar and pestle and made up to 100ml. From this, 5ml of the extract was pipetted, 10ml of four per cent oxalic acid was added and titrated against the dye. Ascorbic acid content of the fresh sample was calculated from the titre value and was expressed in mg 100 g^{-1}.

r) Iron

The iron content was analysed colorimetrically using ferric iron, which gives a blood red colour with Potassium thiocyanate (Raghuramulu *et al.*,2003).

To an aliquot of 6.5 ml diacid solution, one ml of 30 per cent sulphuric acid, one ml of 7 per cent potassium persulphate solution and 1.5 ml of 40 per cent potassium thiocyanate solution was added. The intensity of the red colour was measured within twenty minutes at 540 nm.

A standard graph was prepared using serial dilution of standard iron solution. The iron content of the sample was estimated from the standard graph and expressed in mg 100 g^{-1}.

s) Calcium

The calcium content was estimated using titration method with EDTA as suggested by Page (1972).

Two grams of dried and powdered sample was predigested with 20 ml of 9:4 mixture of nitric acid and perchloric acid and volume was made upto 100 ml. To five ml of diacid extract, 10 ml water, 10 drops of hydroxylamine hydrochloride, 10 ml triethanolamine, 2.5 ml sodium hydroxide and 10 drops of calcone were added. Then it was titrated with 0.02 NEDTA till the appearance of a permanent blue colour. Calcium content was expressed in mg 100 g^{-1} of the sample.

t) Protein

The protein content was estimated using the method of AOAC (1980).

Powdered sample (0.3g) was digested with 6 ml of concentrated H_2SO_4 after adding 0.4 g of $CuSO_4$ and 3.5 g K_2SO_4 in a digestion flask until the colour of the sample was converted to green. After digestion, it was diluted with water and 25 ml of 40 per cent NaOH was pumped. This distillate was collected in 20 per cent boric acid containing mixed indicator and then titrated with 0.2 NHCl. The nitrogen content obtained was multiplied with a factor of 6.25 to get the protein content and was expressed in percentage.

u) Phosphorus

The phosphorus content was analysed colorimetrically as suggested by Jackson (1973); phosphorus gives yellow colour with nitric acid vandate molybdate reagent. To five ml of pre digested aliquot, 5 ml of nitric acid vandate molybdate reagent was added and made upto 50 ml with distilled water. After 10 minutes the OD was read at 420 nm.

A standard graph was prepared using serial dilution of standard phosphorus solution. The phosphorus content of the sample was estimated from the standard graph and expressed in mg 100 g^{-1}.

v) Crude fibre

Crude fibre content was estimated by acid alkali digestion method as suggested by Chopra and Kanwar (1978).

Two grams of dried and powdered sample was boiled with 200 ml of 1.25 per cent sulphuric acid for thirty minutes. It was filtered through a muslin cloth and washed with boiling water and again boiled with 200 ml of 1.25 per cent sodium hydroxide for thirty minutes. It was filtered through a muslin cloth and washed with sulphuric acid, water and alcohol in sequence. The residue was transferred to a pre weighed ashing dish, dried, cooled and weighed. The residue was then ignited for 30 minutes in a muffle furnace at 600^0C, cooled in a desiccator and reweighed. The fibre content of the sample was calculated from the loss in weight on ignition and expressed in percentage.

3.2.4 Statistical analysis

Data on different characters were subjected to statistical analysis, using Spar-1 package. The analysis of variance technique suggested by Fisher (1954) was employed for the estimation of various genetic parameters. The data thus obtained were processed for analysis of variance, genotypic and phenotypic coefficient of variations, correlation coefficient and path coefficients.

3.2.4.1 Phenotypic and genotypic variance

The variance components were estimated using the formula suggested by Burton (1952).

Phenotypic variance (Vp) = Vg+Ve

Where,

Vg- genotypic variance

Ve- environmental variance

Genotypic variance (Vg) = $(V_T - V_E)/N$

Where,

V_T- mean sum of squares due to treatments

V_E -mean sum of squares due to error

N- Number of replications

Environmental variance (Ve) = V_E

3.2.4.2 Phenotypic and genotypic coefficient of variation

The phenotypic and genotypic coefficient of variation was calculated by the formula suggested by Burton and Devane (1953).

Phenotypic coefficient of variation (pcv) = $(Vp^{1/2} / X) \times 100$

Where,

Vp- Phenotypic variance

X- Mean of characters under study

Genotypic coefficient of variation (gcv) = $(Vg^{1/2} / X) \times 100$

Where,

Vg-Genotypic variance

X- Mean of characters under study

3.2.4.3 Heritability

Heritability in the broad sense was estimated by the formula suggested by Burton and Devane (1953).

$H^2 = (Vg/Vp) \times 100$

Where,

Vg- genotypic variance

Vp-phenotypic variance

The range of heritability was categorized as suggested by Robinson *et al.* (1949) as

0-30 per cent	-	low
31-60 per cent	-	moderate
61 per cent and above	-	high

3.2.4.4 Expected genetic advance

The genetic advance expected for the genotypic variance was calculated using the formula by Lush (1949) and Johnson *et al.* (1955) with value of the constant K as 2.06 as given by Allard (1960).

Expected genetic advance GA= $(Vg/Vp^{1/2}) \times K$

Where

Vg= Genotypic variance

Vp= Phenotypic variance

3.2.4.5 Genetic gain (genetic advance as percentage of mean)

Genetic advance (GA) calculated by the above method was used for estimation of genetic gain.

Genetic gain, GG= (GA/X) x 100

Where,

GA=Genetic advance

X= Mean of characters under study

The genetic gain was classified according to Johonson *et al.* (1955) as follows

1-10 per cent-Low

11-20 per cent-Moderate

21 and above -High

3.2.4.6 Phenotypic and genotypic correlation coefficients

The phenotypic and genotypic correlation coefficients were worked out to study the extent of association between the characters. The phenotypic and genotypic correlation coefficients among the various characters were worked out in all possible combinations according to the formula suggested by Johnson *et al.* (1955).

Phenotypic correlation coefficients between two characters 1 and 2 was calculated by the formula

$(r_{p12}) = COV_{p12} / (V_{p1}.V_{p2})^{1/2}$

Where,

V_{p1} = Phenotypic variance of character 1

V_{p2} = Phenotypic variance of character 2

Genotypic correlation coefficient between two characters 1 and 2 was calculated by the formula

$(r_{g12}) = COV_{g12} / (V_{g1}.V_{g2})^{1/2}$

Where,

V_{g1}= Genotypic variance of character 1

V_{g2}= Genotypic variance of character 2

3.2.4.7 Path coefficient analysis

In path coefficient analysis the correlation among cause and effect are partitioned in to direct and indirect effects of casual factors on effect factor. The principles and techniques suggested by Wright (1921) and Li (1955) for the analysis using the formula given by Dewey and Lu (1959).

3.2.4.8 Genetic divergence

The genetic divergence among 25 accessions were assessed based on different characters as given by Mahalanobis (1936). Clustering of genotypes using Mahalanobis D^2 value was carried out using the computer oriented iterative algorithm method as suggested by Suresh and Unnithan (1996).

3.2.4.9 Selection index

Smith (1936) model was used for formulating the selection index. This is desired to select plants, the merit (H) of which is linearly expressed as:

$$H = a_1G_1 + a_2G_2 + \dots\dots\dots + a_n G_n$$

Where, G_1, G_2.......G_n represents the genotypic values of characters and a_1, a_2...a_n denote the weights to be assigned to each of the character.

Results

4. RESULTS

The studies on "Performance analysis of clove bean *Ipomoea muricata* (L.) Jacq. genotypes" was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara, during 2007 – 2008. The results obtained from the experiments and descriptors developed based on observation of variability in live collections from seed to seed are presented under the following heads.

4.1. Development of descriptors and genetic characterisation of clove bean *Ipomoea muricata (L.)* Jacq.

4.2. Evaluation of genotypes of clove bean *Ipomoea muricata* (*L.*) Jacq.

4.1. Development of descriptors and genetic characterisation of clove bean *Ipomoea muricata* (*L.*) Jacq.

For preliminary characterization and quick discrimination between genotypes, a basic minimal descriptor having uniform expressivity across environments and easy visual scorability would be sufficient for all practical purposes. As there was no descriptor developed for characterization of clove bean, a minimal descriptor was designed. All the characters comprising of vegetative, inflorescence, fruit and seed as described below have been included in the list. These descriptors would allow rapid characterization of clove bean germplasm. For morphological characterization forty characters were considered. Ten of these characters were quantitative while the rest were qualitative in nature. The actual numerical data for the quantitative characters were used for variability studies.

4.1.1 Morphological characterisation

Vegetative characters

1. Twining

Ability of vines to climb to stakes.

0 Non-twining

3 Low

5 Medium

7 High

9 Very high

2. Plant type

Length of the main vine at senescence

5 Short semi spreading (0.75-1.50 m)

7 Medium spreading (1.51-2.50 m)

9 Highly spreading (>2.5 m)

3. Canopy cover

Estimated percentage of ground cover recorded 35-40 days after planting

3 Low (<50%)

5 Medium (50-74%)

7 High (75-90%)

9 Very high (>90%)

4. Vine internode length

Average expression of at least three internodes located in the middle section of the vine

1 Very short (<3 cm)

3 Short (3-5 cm)

5 Intermediate (6-9 cm)

7 Long (10-12 cm)

9 Very long (>12 cm)

5. Internode diameter

1 Very thin (<4 mm)

3 Thin (4-6 mm)

5 Intermediate (7-9 mm)

7 Thick (10-12 mm)

9 Very thick (>12 mm)

6. Predominant vine colour/ pigmentation

Anthocyanin (purple) pigmentation present in the vines besides the green colour may be recorded. The predominant colour should be evaluated considering the whole vine from base to tip.

1 Green

3 Green with few purple spots

4 Green with many purple spots

5 Green with many dark purple spots

6 Mostly purple

7 Mostly dark purple

8 Totally purple

9 Totally dark purple

7. Secondary vine colour

The secondary colour is more easily evaluated using younger vines

0 Absent

1 Green base

2 Green tip

3 Green nodes

4 Purple base

5 Purple tip

6 Purple nodes

7 Other

8. Vine tip pubescence

Degree of hairiness of immature tops recorded at the apex of the vines

0 Absent

3 Sparse

5 Moderate

7 Heavy

9. Stem murication

0 Non tubercled

1 Slightly tubercled

2 Medium tubercled

3 Dense tubercled

10. General outline (shape) of the leaf

Describe from leaves located in the middle section of the vines

1 Rounded

2 Reniform (Kidney-shaped)

3 Cordate (Heart-shaped)

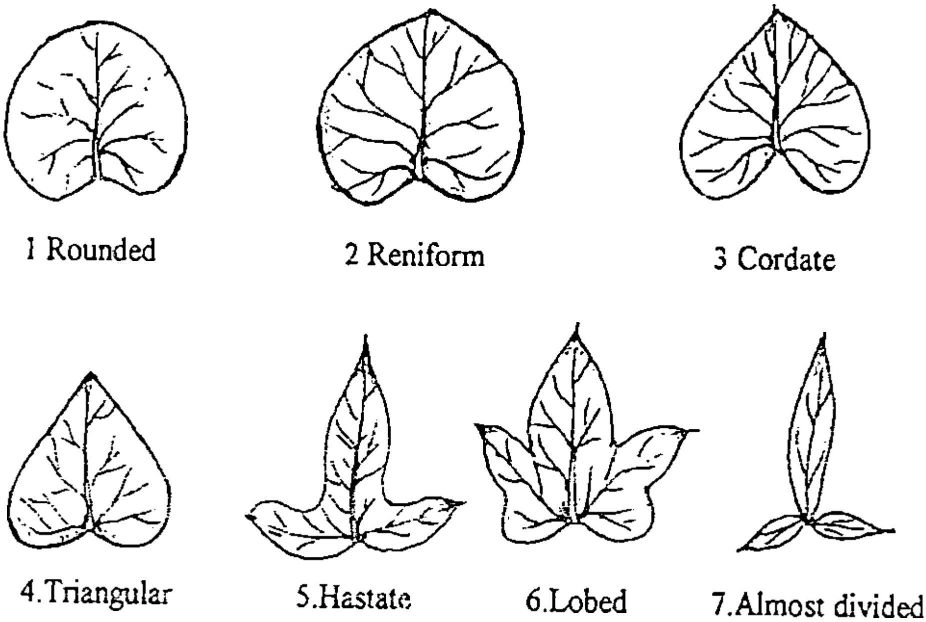
4 Triangular

5 Hastate (trilobular and spear-shaped with the basal lobes more or less divergent)

6 Lobed

7 Almost divided

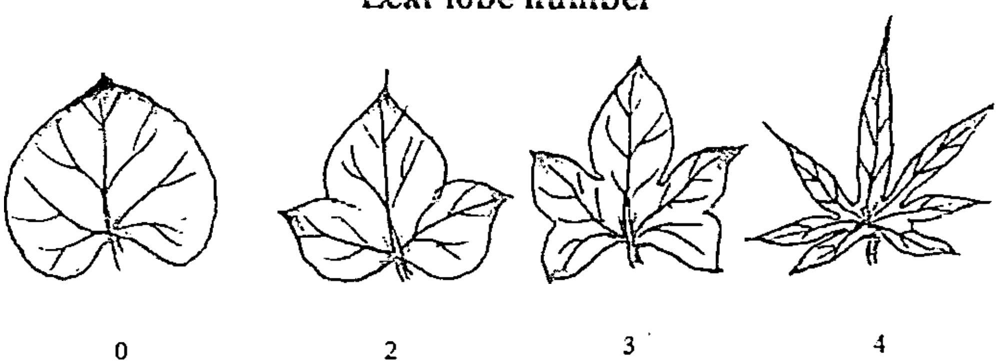
General outline of the leaf



11. Leaf lobe number

0	No lobes
2	3 lobes
3	5 lobes
4	7 lobes

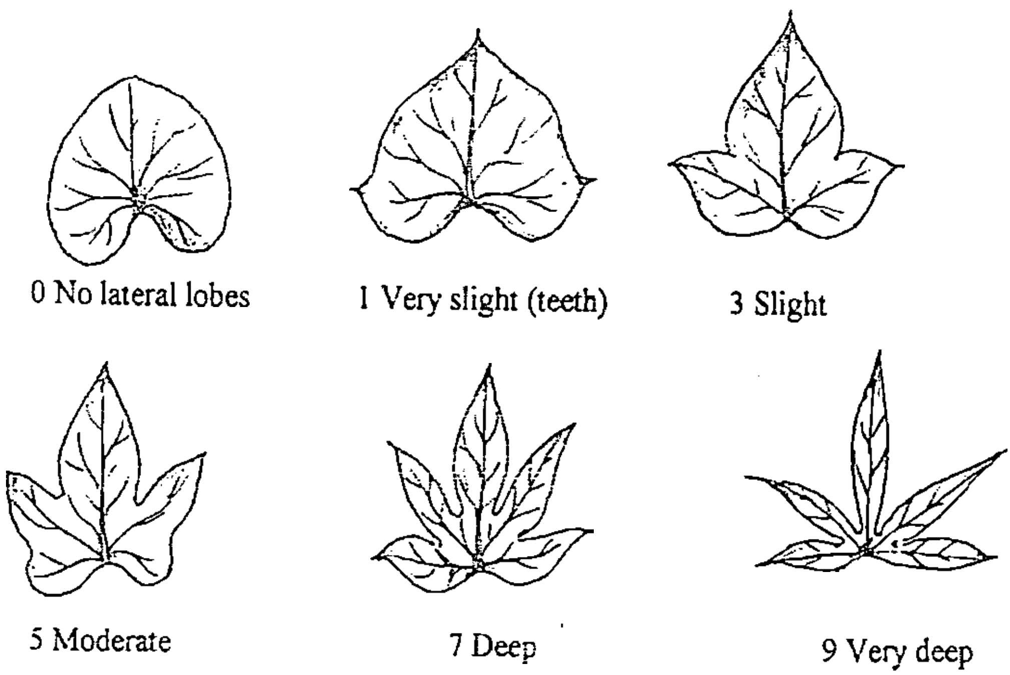
Leaf lobe number



12. Leaf lobes type

0	No lateral lobes (entire)
1	Very slight (teeth)
3	Slight
5	Moderate
7	Deep
9	Very deep

Leaf lobes type



13. Shape of central leaf lobe

0	Absent
1	Toothed
2	Triangular
3	Semi-circular
4	Semi-elliptic
5	Elliptic

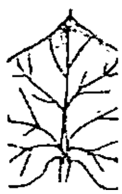
6 Lanceolate

7 Oblanceolate

8 Linear (Broad)

9 Linear (narrow)

Shape of central leaf lobe


1 Toothed


2 Triangular

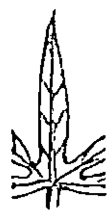

3 Semi-circular


4 Semi-elliptic


5 Elliptic


6 Lanceolate


7 Oblanceolate


9 Linear (narrow)

14. Immature leaf colour

Describe the overall foliage colour considering the colour of fully expanded mature and immature leaves of several plants. The variegation in leaf colour due to virus symptoms should not be considered for recording.

1 Yellow-green

2 Green

3 Green with purple edge

4 Greyish – green (due to heavy pubescence)

5 Green with purple veins on upper surface

6 Slightly purple

7 Mostly purple

8 Green upper, purple lower

9 Both sides Purple

15. Mature leaf colour

1 Yellow-green

2 Green

3 Green with purple edge

4 Greyish-green (due to heavy pubescence)

5 Green with purple veins on upper surface

6 Slightly purple

7 Mostly purple

8 Green upper, purple lower

9 Purple both surface

16. Mature leaf size

Length from the base to the tip of the leaves. Record the average expression of at least 3 leaves located in the middle section of the vine.

3 Small (<8cm)

5 Medium (8-15 cm)

7 Large (16-25 cm)

9 Very large (>2.58 m)

17. Petiole length

Average petiole length, from the base to the insertion with the blade, of at least 5 leaves in the middle portion of a main vine.

1 Very short (<10 cm)

3 Short (10-20 cm)

5 Intermediate (21-30 cm)

7 Long (31-40 cm)

9 Very long (>40 cm)

18. Petiole pigmentation

Distribution of anthocyanin (purple) pigmentation in the petioles of leaves. Indicate the most predominant colour.

1 Green

2 Green with purple tinge near stem

3 Green with purple tinge near lamina/leaf blade

4 Green with purple tinge at both ends

5 Green with purple spots throughout petiole

6 Green with purple stripes

7 Purple with green near leaf lamina.

8 Some petioles purple, others green

9 Totally or mostly purple

19. Vein pigmentation

1 Purple

2 Green

20. Extend of vein pigmentation

1 Full length

2 Halfway

3 Just at base

4 Absent

Inflorescence characters

Although characters related to the flowers are very important and not influenced by environmental conditions, there are strong differences among cultivars in their flowering ability.

21. Flower colour

1 White

2 White limb with purple throat

4 Pale purple limb with purple throat

5 Purple

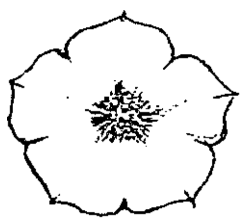
6 Other

22. Flower shape (open corolla)

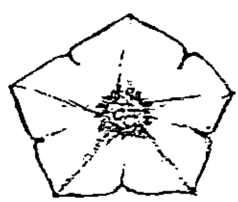
3 Semi-stellate

5 Pentagonal

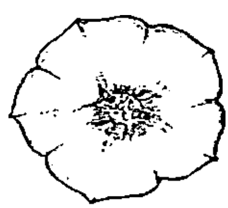
7 Round



3 Semi-stellate



5 Pentagonal



7 Rounded

23. Flower length (cm)

1 Small (>5)

2 Medium (5-10)

3 Large (>10)

24. Flower width (cm)

Diameter of the opened flower

1 Small (>5)

2 Medium (5-10)

3 Large (>10)

25. Sepal shape

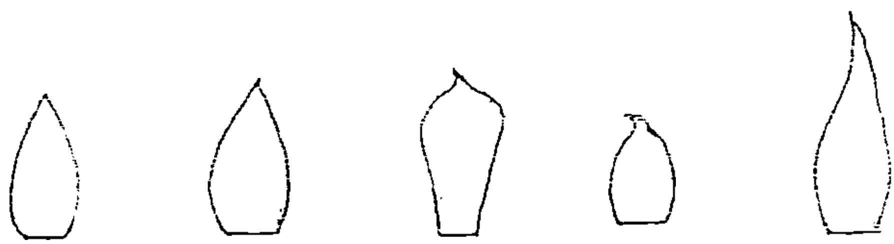
1 Ovate

2 Elliptic

3 Obovate

7 Oblong

9 Lanceolate



1 Ovate 3 Elliptic 5 Obovate 7 Oblong 9 Lanceolate

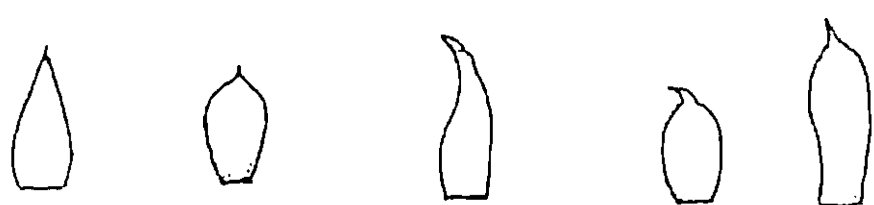
26. Sepal apex

1 Acute

3 Obtuse

5 Acuminate

7 Caudate



1 Acute 3 Obtuse 5 Acuminate 7 Caudate

27. Equality of Sepal length

1 Outer two shorter

2 Equal

28. Sepal pubescence

0 Absent

3 Sparse

5 Moderate

7 Heavy

29. Sepal colour

1 Green

2 Purple

3 Purple tinged

4 Any other

30. Flower Pedicel length

1 Short

2 Medium

3 Long

31. Petal colour

1 White

3 White with purple at the base

5 White with purple at the top

7 White with purple spots throughout

9 Purple

32. Colour of persistent calyx

1 Violet

2 Green

3 Whitish green

4 Others

Fruit characters

33. Swollen pedicel colour

1 Violet

2 Light green

3 Dark green

4 Green with purple patches

5 Others

34. Murication of swollen pedicel

1 Absent

2 Scarce

3 Profuse

35. Swollen pedicel length (cm)

1 Short- < 2

2 Medium- 2-3

3 Long- 3-5

36. Fruit (Capsule) colour

1 Nail colour

2 Light green

3 Dark green

37. Flesh texture

1 Spongy

2 Fibrous

3 Others

38. Latex content

Latex content of fruit at vegetable stage (latex exudates upon breaking at peduncle end

1 Low

2 Medium

3 High

Seed characters

39. Seed colour (mature dry seeds)

1 Black

2 White

3 Brown

4 Cream

5 Black with white shade

6 Any other

40. Seed colour unripe fruit

1 White

2 Others

41. Stress susceptibility

Biotic:

(a) Pests - sphingid moth and cut worm

0 Very low or no visible sign of susceptibility

3 Low

7 High

9 Very high

(b) Diseases - Cercospora leaf spot, Alternaria leaf spot, collar rot, stem rot

0 Very low or no visible symtom

3 Low

7 High

9 Very high

Abiotic:

(a) Drought

3 Low susceptibility

7 High susceptibility

9 Very high susceptibility

(b) High/ low temperature

3 Low susceptibility

7 High susceptibility

9 Very high susceptibility

4.1.2 Botanical description

The botany of clove bean was studied and the description is given below.

Synonym: ***Calonyction muricatum*** **G.Don**

Family: Convolvulaceae.

Status: Found wild in Northern Himalayas, cultivated in Kerala.

Distribution: Distributed in warmer parts of South and south east Asia including Japan, China, Burma, Sri Lanka and Nepal.

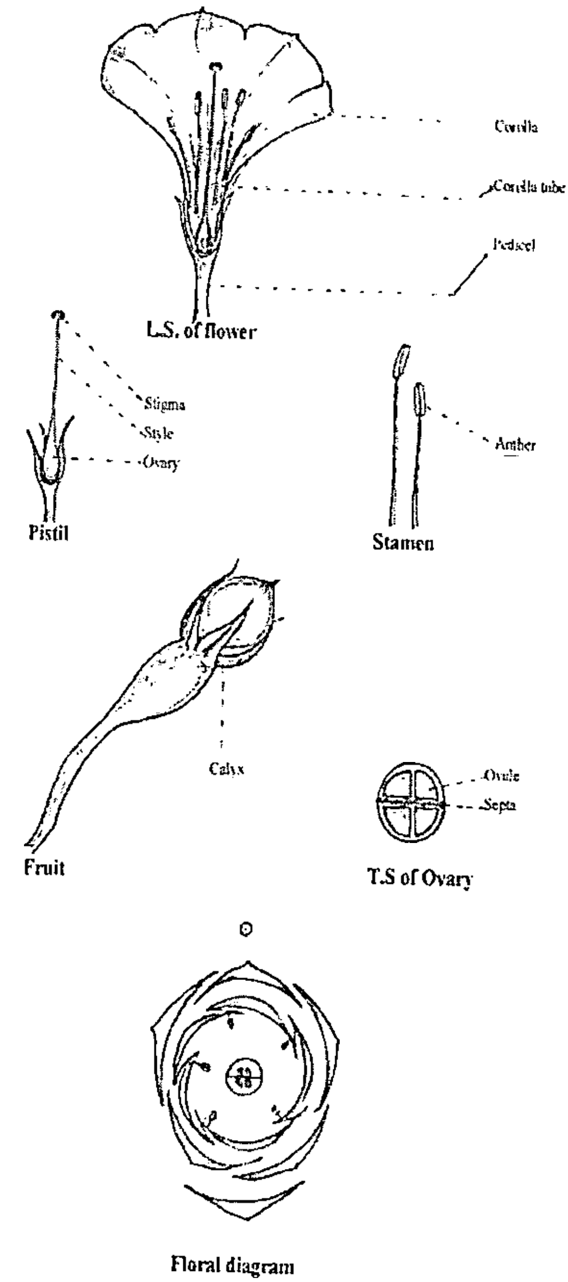


Fig. 1 Botany of clove bean

Salient features: Annual vines, tubercled stem, often with latex in plant parts.

Leaves: Simple, cordate (rarely lobed), alternate and exstipulate.

Inflorescence: Cymose (monochasial scorpioid cyme).

Flower: Flowers are axillary with thick jointed peduncles, pentamerous, bisexual (hermaphrodite), actinomorphic, hypogynous, funnel shaped, often large and showy, ephemeral, usually with intrastaminal disc, generally subtended by bracts.

Calyx: Sepals 5, distinct, free, odd one posterior, unequal and persistent with imbricate (quincuncial) aestivation.

Corolla: Petals sympetalous, entire to slightly 5-lobed, brightly colored (violet/ blue/ white), convolute (twisted) in bud.

Androecium: Stamens 5, filaments distinct, often unequal, epipetalous arising from the pubescent corolla tube, anthers dorsifixed, dehiscing longitudinally, usually introse.

Gynoecium : Stigma lobed & capitate.

Fruit: Clove shaped; an enlarged fleshy fruit stalk with a 4 valved capsule.

Fruit dehiscence: Valvular or septifragal.

Seeds: 3-4 in number, smooth & dark brown in colour. 3 sided, plane on two surfaces and curved on outer side.

Floral formula:

Br ⊕ ⚥ $K_5 C_{(5)} A_{3+2} \underline{G}_{(2)}$

Uses: Immature fruits along with swollen pedicel and calyx are edible and used as cooked vegetable.

Economic value:

Tender fruits along with swollen pedicel and calyx are used as vegetable. The optimum time of picking is 10-12 days after flowering. Edible portion contains 0.97 to 1.67g protein/100g; vitamin C 24 to 48 mg /100g; crude fibre 0.67% to 3.33% ; phosphorus 102 to 150mg/100g; iron 0.13 to 0.19 mg/100g; calcium 184 to 230 mg/100g; 87.0g moisture and 0.69g mineral matter.

Prospects for cultivation

With the onset of monsoon 2-3 seeds per pit were sown. Farm yard manure at the rate of 10-15kg was added per pit as basal application. The vines are trailed on trellis. It responds well to irrigation. Fruits become ready for harvest within 60 days of planting. Individual plant yield of 4.250kg was found in high yielding accessions.

4.1.3 Genetic cataloguing in *Ipomoea muricata* (L.) Jacq.

Twenty five accessions of clove bean were collected from different parts of Kerala and were genetically catalogued based on the descriptor developed. Vegetative and reproductive characters were recorded and accessions were catalogued (Table 2, 3, 4 and 5, Plates 2, 3, 4 and 5)

All the accessions were highly twining with very high canopy cover. The leaf size varied from medium to large. The mature leaf colour varied from purple to full green, though the immature leaf colour was green in all accessions. The flower colour varied from white to purple; the flower size also varied from small to large with some of intermediate size. The pedicel and fruit colour varied from green to violet. The fruit size and seed colour also varied with accessions.

4.2 Evaluation of genotypes of clove bean *Ipomoea muricata* (*L.*) Jacq.

4.2.1 Genetic variability

The analysis of variance of 25 accessions of clove bean showed significant differences between them for the characters studied like vine length, days to first

Table 2. Vegetative characters in *Ipomoea muricata* (L.) Jacq. accessions

	Vegetative characters						
Accession no	Twining	Plant type	Canopy cover	Vine internodal length	Internode diameter	Predominant vine colour	Vine tip pubescence
IM-1	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-2	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-3	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-4	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-5	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-6	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-7	Very high	Highly spreading	Very high	Very high	Very thick	Totally purple	Absent
IM-8	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-9	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-10	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-11	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-12	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-13	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-14	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-15	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-16	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-17	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-18	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-19	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-20	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-21	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-22	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-23	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-24	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent
IM-25	Very high	Highly spreading	Very high	Very high	Very thick	Green with many purple spots	Absent

Contd..

Table 2. continued.

Accession Number	General outline of the leaf	Mature leaf size	Immature leaf size	Mature leaf colour	Petiole length	Vein pigmentation	Extend of vein pigmentation
IM-1	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-2	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-3	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-4	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-5	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-6	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-7	Cordate	Large	Green	Mostly purple	Short	Purple	Half way
IM-8	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-9	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-10	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-11	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-12	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-13	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-14	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-15	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-16	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-17	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-18	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-19	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-20	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-21	Cordate	Large	Green	Green with purple vein	Intermediate	Purple	Half way
IM-22	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-23	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-24	Cordate	Medium	Green	Green	Intermediate	Green	Full length
IM-25	Cordate	Medium	Green	Green	Intermediate	Green	Full length

Table 3. Inflorescence characters of *Ipomoea muricata* (L.) Jacq. accessions

Accession Number	Flower colour	Flower length	Flower width	Flower shape	Petal colour	Flower pedicel
IM-1	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-2	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-3	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-4	Purple	Medium	Medium	Rounded	purple	Long
IM-5	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-6	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-7	White	Large	Large	Pentagonal	White	Long
IM-8	Purple	Medium	Medium	Rounded	Purple	Long
IM-9	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-10	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-11	Purple	Medium	Medium	Rounded	Purple	Long
IM-12	Purple	Medium	Medium	Rounded	Purple	Long
IM-13	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-14	Purple	Medium	Medium	Rounded	Purple	Long
IM-15	Purple	Medium	Medium	Rounded	Purple	Long
IM-16	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-17	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-18	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-19	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-20	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-21	Purple	Medium	Medium	Rounded	Purple	Long
IM-22	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-23	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-24	White limb with purple throat	Medium	Medium	Semi stellate	White	Long
IM-25	White limb with purple throat	Medium	Medium	Semi stellate	White	Long

Contd...

Table 3. Continued.

Accession Number	Sepal pubescence	Sepal colour	Equality of sepal length	Sepal apex	Colour of persistant calyx
IM-1	Absent	Green	Outer two shorter	Obtuse	Green
IM-2	Absent	Green	Outer two shorter	Obtuse	Green
IM-3	Absent	Green	Outer two shorter	Obtuse	Green
IM-4	Absent	Green	Outer two shorter	Obtuse	Green
IM-5	Absent	Green	Outer two shorter	Obtuse	Green
IM-6	Absent	Green	Outer two shorter	Obtuse	Green
IM-7	Absent	Purple	Outer two shorter	Caudate	Purple
IM-8	Absent	Green	Outer two shorter	Obtuse	Green
IM-9	Absent	Green	Outer two shorter	Obtuse	Green
IM-10	Absent	Green	Outer two shorter	Obtuse	Green
IM-11	Absent	Green	Outer two shorter	Obtuse	Green
IM-12	Absent	Green	Outer two shorter	Obtuse	Green
IM-13	Absent	Green	Outer two shorter	Obtuse	Green
IM-14	Absent	Green	Outer two shorter	Obtuse	Green
IM-15	Absent	Green	Outer two shorter	Obtuse	Green
IM-16	Absent	Green	Outer two shorter	Obtuse	Green
IM-17	Absent	Green	Outer two shorter	Obtuse	Green
IM-18	Absent	Green	Outer two shorter	Obtuse	Green
IM-19	Absent	Green	Outer two shorter	Obtuse	Green
IM-20	Absent	Green	Outer two shorter	Obtuse	Green
IM-21	Absent	Green	Outer two shorter	Obtuse	Green
IM-22	Absent	Green	Outer two shorter	Obtuse	Green
IM-23	Absent	Green	Outer two shorter	Obtuse	Green
IM-24	Absent	Green	Outer two shorter	Obtuse	Green
IM-25	Absent	Green	Outer two shorter	Obtuse	Green

Table 4. Fruit characters

Accession Number	Swollen pedicel colour	Swollen pedicel length	Murication of swollen pedicel	Stem murication	Fruit colour	Fruit shape	Flesh texture	Latex content of vegetable stage fruit
IM-1	Green	Short	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-2	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-3	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-4	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-5	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-6	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-7	Violet	Medium	Absent	Non tubercled	violet	Elliptical	Soft spongy	High
IM-8	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-9	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-10	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-11	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-12	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-13	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-14	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-15	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-16	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-17	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-18	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-19	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-20	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-21	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-22	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-23	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-24	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High
IM-25	Green	Medium	Absent	Dense tubercled	Light green	Elliptical	Soft spongy	High

Table 5. Seed and other important characters

Accession No	Seed colour	Seed colour of unripe fruit	Biotic stress susceptibility
IM-1	Black	White	Low
IM-2	Black	White	Low
IM-3	Black	White	Low
IM-4	Black with white shade	White	Low
IM-5	Black	White	Low
IM-6	Black	White	Low
IM-7	Cream	White	Very low
IM-8	Black with white shade	White	Low
IM-9	Black	White	Low
IM-10	Black	White	Low
IM-11	Black with white shade	White	Low
IM-12	Black with white shade	White	Low
IM-13	Black	White	Low
IM-14	Black with white shade	White	Low
IM-15	Black with white shade	White	Low
IM-16	Black	White	Low
IM-17	Black	White	Low
IM-18	Black	White	Low
IM-19	Black	White	Low
IM-20	Black	White	Low
IM-21	Black with white shade	White	Low
IM-22	Black	White	Low
IM-23	Black	White	Low
IM-24	Black	White	Low
IM-25	Black	White	Low

Plate - 2. Variability of vine in clove bean

Plate - 3. Variability of leaves

Plate - 4. Variability of flower colour

IM- 7 with white flower

IM - 3 with white limb and purple throat

IM - 8 with purple flower

Plate - 5. Variability of fruits

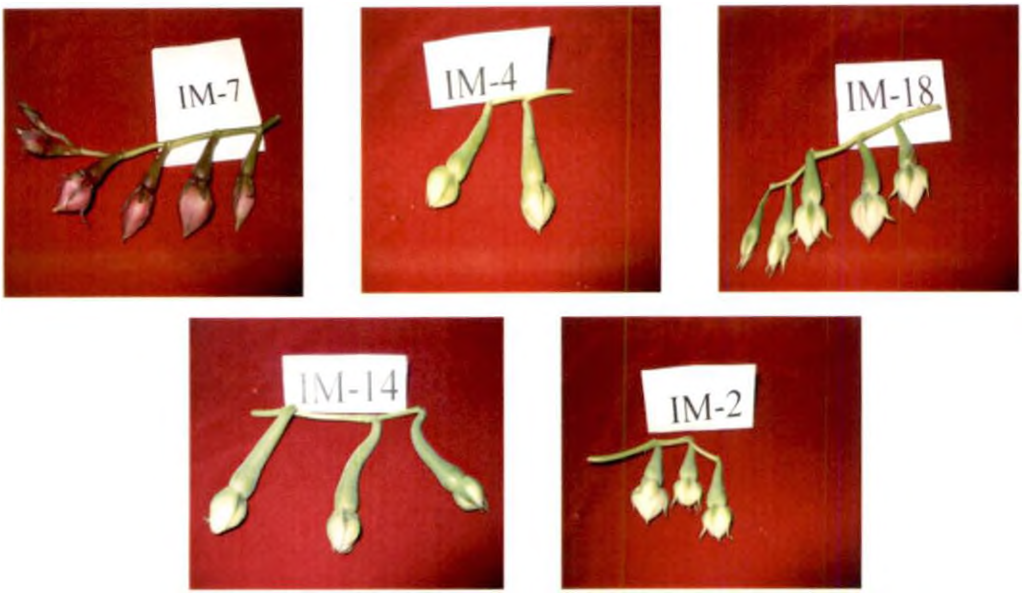


Plate - 6. Different stages of maturity of clove bean fruit

flower production, days to first harvest, length and weight of pedicel, length of fruit, yield per plant, duration of the crop, number of harvests, vitamin C, calcium and phosphorus contents (Table 6). The mean performance of 25 accessions is presented in table 7, 8 and 9. The population mean, range, phenotypic and genotypic coefficient of variation are presented in table 10. Variation in pcv and gcv for yield and its component is discussed in figure 2.

a) Vine length

Significant differences among the genotypes were observed for vine length. It varied from 263.57 cm (IM-18) to 414.48 cm (IM-7) with a mean value of 362.92 cm. The pcv and gcv values were 7.33 and 7.10 respectively.

b) Days to first flower production

There were significant differences between the accessions for days to first flower production. The value ranged from 42.33 days (IM-14) to 60.33 days (IM-7) with a mean value of 51.04. The pcv and gcv values were 9.51 and 9.11 respectively.

c) Days to first harvest

The accessions varied from 54.33 days (IM-14) to 73.33 days (IM-6) for first harvesting with a mean value of 65.15days. The fruits took 13 days from sowing to reach vegetable harvesting maturity (Plate 6). The pcv and gcv values were 8.21 and 7.85 respectively.

d) **Length of pedicel**

Significant differences among the genotypes were observed for length of pedicel (Fig. 3). It varied from 2.27cm (IM-3) to 6.05cm (IM-14) (Plate 7) with a mean of 3.67cm (Table 7 and 10). The pcv and gcv values were 36.18 and 35.64 respectively.

Plate 7. IM 14 - High yielding accession

Table 6. Analysis of variance for 19 characters in 25 accessions of *Ipomoea muricata* (L.) Jacq.

Source of variation	Df	Mean squares								
1	2	3	4	5	6	7	9	10	11	12
		Vine length	Days to first flower production	Days to first harvest	Length of pedicel (cm)	Girth of pedicel (cm)	Weight of pedicel (g)	Length of fruit (Cm)	Girth of fruit (g)	Weight of fruit (g)
Replication	2	26	1.43	2.56	0.04	0.01	0.001	0.04	0.07	0.17
Treatment	24	2035.55**	66.8**	81.33**	5.1 **	0.37	1.87*	5.8**	0.35	1.07
Error	47	44.76	1.91	2.83	0.05	0.01	0.002	0.02	0.11	0.06

*P =0.05

**P =0.01

Contd...

Table 6. Continued.

Source of variation	Df	Mean squares									
		Yield per plant (Kg)	Duration of the crop	Number of harvests	Shelf life in open conditions	Vitamin C	Iron	Calcium	Protein	Phosphorus	Crude fibre
		13	14	15	16	17	18	19	20	21	22
Replication	2	0.02	44.37	0.01	0.01	937.4	0.0001	9913.87**	0.01	25	0.36
Treatment	24	2.35**	193.54**	3.86**	0.57	233.2**	0.0009	2690.74**	0.12	643.9**	1.75
Error	47	0.04	34.31	0.01	0.001	100.4	0.00008	5674.31**	0.006	5.25	0.3

*P = 0.05

**P = 0.01

Table7: Vegetative and fruit characters

Accessions	Vine length (cm)	Length of Pedicel (cm)	Girth of pedicel (cm)	Weight of pedicel (g)	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (g)
IM-1	356.47	2.95	3.68	1.21	1.88	5.46	1.66
IM-2	364.57	2.96	3.45	1.38	2.10	5.71	2.11
IM-3	356.13	2.27	3.39	0.83	2.30	6.07	2.30
IM-4	375.65	5.53	3.88	2.39	2.31	5.88	2.13
IM-5	369.81	2.28	2.87	2.01	2.05	5.37	0.45
IM-6	361.54	3.01	3.62	1.10	2.16	5.85	1.58
IM-7	414.48	3.36	3.84	1.07	2.96	6.62	2.79
IM-8	366.48	5.33	4.08	2.30	2.28	5.67	2.91
IM-9	371.48	2.57	3.57	1.08	2.19	5.87	2.11
IM-10	353.64	2.95	3.68	1.09	2.21	6.01	2.14
IM-11	363.67	5.69	4.25	2.79	2.34	6.23	2.73
IM-12	378.07	5.71	4.20	2.87	2.40	6.47	2.97
IM-13	366.78	3.15	3.74	1.16	2.22	5.55	1.68
IM-14	398.42	6.05	4.49	3.20	2.80	6.61	5.27
IM-15	387.69	5.83	4.28	3.13	2.49	5.91	3.13
IM-16	369.37	2.97	3.47	1.06	2.15	5.83	2.31
IM-17	358.35	3.16	3.71	1.19	2.38	6.08	2.27
IM-18	263.57	3.15	3.80	1.33	2.27	6.04	2.27
IM-19	349.59	3.09	3.73	1.09	2.19	5.78	2.03
IM-20	362.02	3.00	3.78	1.21	2.20	5.82	2.12
IM-21	373.48	5.70	4.16	2.80	2.40	6.16	2.73
IM-22	369.57	3.12	3.79	1.24	2.13	5.99	2.04
IM-23	345.32	2.67	3.54	1.21	2.03	5.45	1.88
IM-24	343.59	2.41	3.31	0.70	2.07	5.41	1.75
IM-25	353.69	2.94	3.50	1.08	2.20	5.73	1.81

Table 8: Flowering and maturity characters

Accessions	Days to first flower production	Days to first harvest	Fruit yield /plant (kg)	Number of harvests	Shelf life (Days)	Duration of the crop (Days)
IM-1	56.33	73.33	2.14	8	4	150.00
IM-2	50.33	63.33	1.28	7	4	163.67
IM-3	53.33	68.67	1.45	7	4	155.00
IM-4	48.00	63.00	2.82	9	5	167.00
IM-5	55.67	70.00	0.81	5	4	139.00
IM-6	55.33	73.33	1.89	8	4	158.00
IM-7	60.33	73.00	1.54	7	4	170.00
IM-8	47.67	61.67	2.86	9	5	153.00
IM-9	46.67	63.00	1.92	8	4	145.00
IM-10	51.33	61.67	1.85	8	4	149.00
IM-11	49.33	62.33	2.22	9	5	167.00
IM-12	44.33	62.33	3.86	9	5	150.00
IM-13	56.33	63.00	2.39	9	4	153.00
IM-14	42.33	54.33	4.24	10	5	168.00
IM-15	43.33	55.33	4.13	10	5	161.00
IM-16	55.67	62.33	1.82	8	4	153.67
IM-17	52.67	61.67	2.09	8	4	158.00
IM-18	52.00	69.00	2.01	8	4	149.00
IM-19	53.33	66.00	1.30	7	4	150.00
IM-20	48.67	66.67	1.82	8	4	150.00
IM-21	43.33	61.00	3.15	9	5	167.00
IM-22	53.67	63.67	2.15	8	4	150.00
IM-23	49.33	66.33	1.88	8	4	154.00
IM-24	51.33	71.33	1.15	6	4	160.00
IM-25	55.33	72.33	2.40	9	4	152.00

Table 9: Quality parameters

Accessions	Protein (g)	Phosphorus (mg/100 g)	Iron (mg/100 g)	Ca (mg/100 g)	Ascorbic acid (mg/100 g)	Crude fibre (%)
IM-1	1.37	102.00	0.13	230	30	1.33
IM-2	1.67	150.33	0.14	276	24	2.00
IM-3	1.33	133.00	0.15	184	30	3.33
IM-4	1.17	121.67	0.14	230	42	1.83
IM-5	1.43	105.00	0.15	184	48	2.5
IM-6	1.44	145.00	0.14	184	36	1.67
IM-7	1.17	126.00	0.13	230	48	1.17
IM-8	1.06	123.33	0.16	184	36	1.83
IM-9	0.98	136.33	0.14	230	30	1.00
IM-10	1.17	126.33	0.14	276	24	3.33
IM-11	1.30	129.00	0.16	230	24	2.83
IM-12	1.05	124.00	0.18	184	42	0.83
IM-13	1.05	119.00	0.19	230	48	0.67
IM-14	1.23	144.00	0.16	184	30	1.17
IM-15	1.13	148.33	0.19	184	24	1.67
IM-16	1.08	133.00	0.16	230	30	1.67
IM-17	1.30	138.00	0.15	184	42	1.17
IM-18	1.47	113.67	0.17	230.67	36	1.67
IM-19	1.23	103.33	0.15	184	48	2.33
IM-20	1.40	141.33	0.17	230	42	1.50
IM-21	1.67	146.33	0.14	230	30	1.67
IM-22	1.01	150.00	0.19	184	24	2.17
IM-23	1.03	138.00	0.15	184	48	2.50
IM-24	0.97	112.33	0.19	184	42	2.17
IM-25	1.43	131.67	0.15	184	36	2.67

Table 10: Range, mean, phenotypic co-efficient of variation and genotypic co-efficient of variation of different characters in *Ipomoea muricata* (L). Jacq.

Sl. No.	Characters	Range	Mean + SE	pcv	gcv
1	Length of pedicel (cm)	2.27-6.05	3.675+0.131	36.18	35.64
2	Girth of pedicel (cm)	2.87-4.49	3.752+0.078	9.90	9.22
3	Weight of pedicel (g)	0.83-3.20	1.621+0.113	49.76	48.27
4	Length of fruit (cm)	1.88-2.80	2.268+0.094	11.72	9.21
5	Girth of fruit (cm)	5.37-6.61	5.905+0.197	7.48	4.74
6	Weight of fruit (g)	0.45-3.27	2.207+0.148	28.74	26.28
7	Fruit yield / plant (kg)	0.81-4.24	2.208+0.0404	40.21	40.09
8	Days to first flower production	42.33-60.33	51.04+8.01294	9.51	9.11
9	Days to first harvest	54.33-73.33	65.147+9.7256	8.27	7.85
10	Vine length(cm)	263.57-414.48	362.92+0.0386	7.33	7.10
11	Duration of the crop(days)	139-170	155.72+0.06764	6.00	4.68
12	Protein (g)	0.97-1.67	1.245+0.045936	16.90	15.65
13	Phosphorus (mg)	102-150.33	129.64+1.322	11.39	11.26
14	Iron (mg)	0.13-0.19	0.156+5.4027	12.22	10.64
15	Calcium (mg)	184-230.67	209.79+43.4906	35.91	0.02
16	Vitamin C (mg)	24-48	35.52+0.05786	33.87	18.73
17	Crude fibre (%)	0.67-3.33	1.907+0.318	46.51	36.42

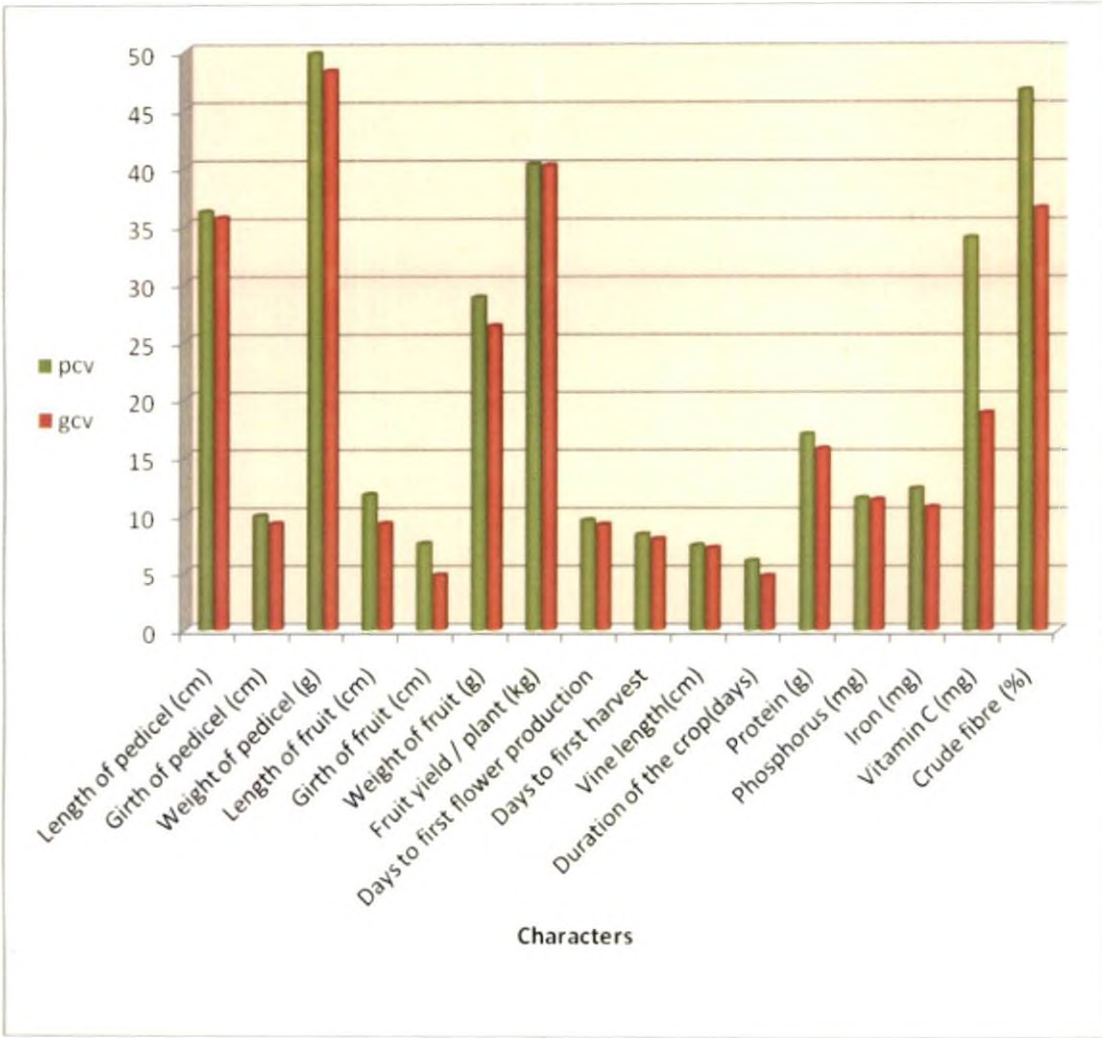


Fig. 2 Variation in pcv and gcv for yield and its components

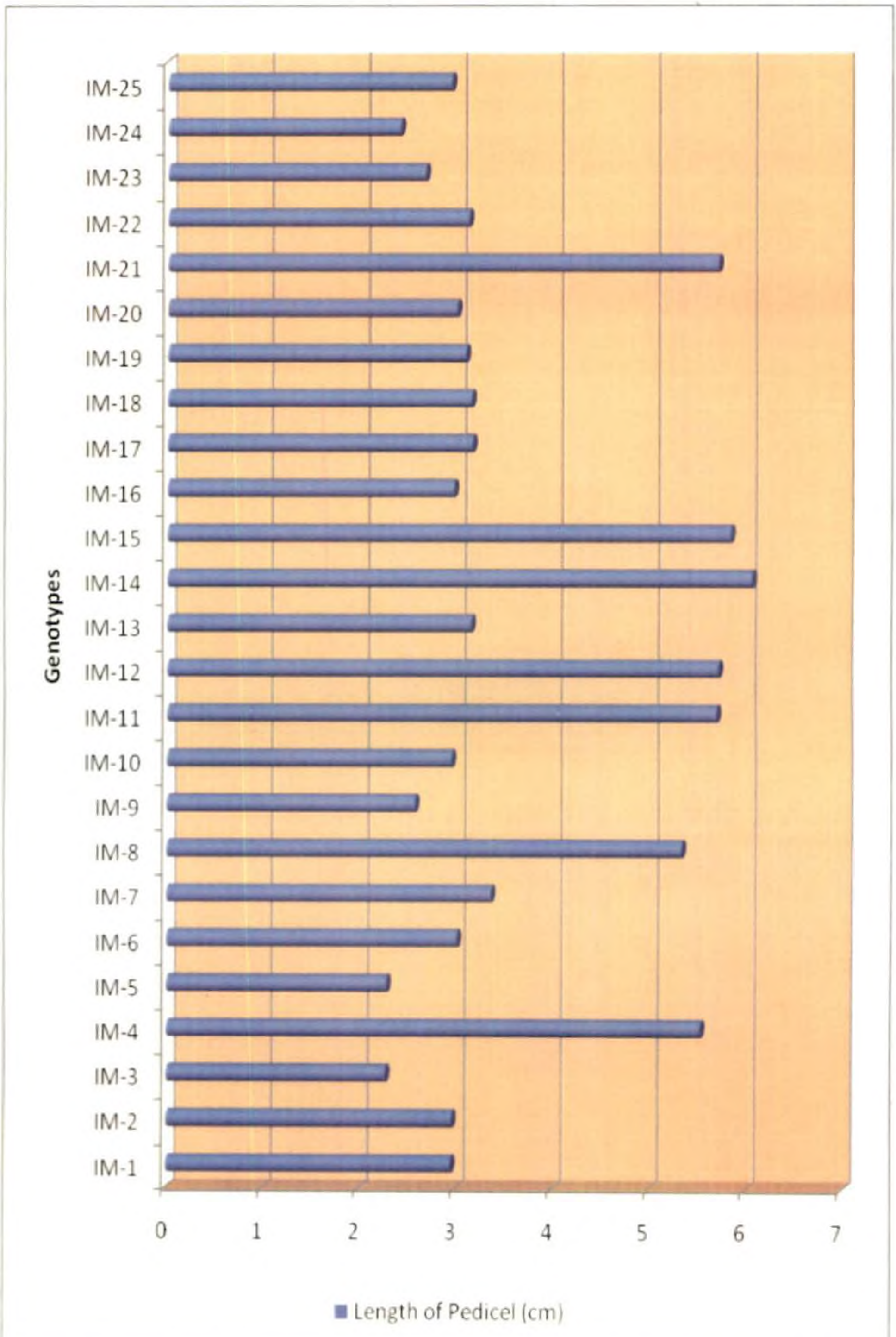


Fig.3 Comparison of length of pedicel of 25 accessions of clove bean

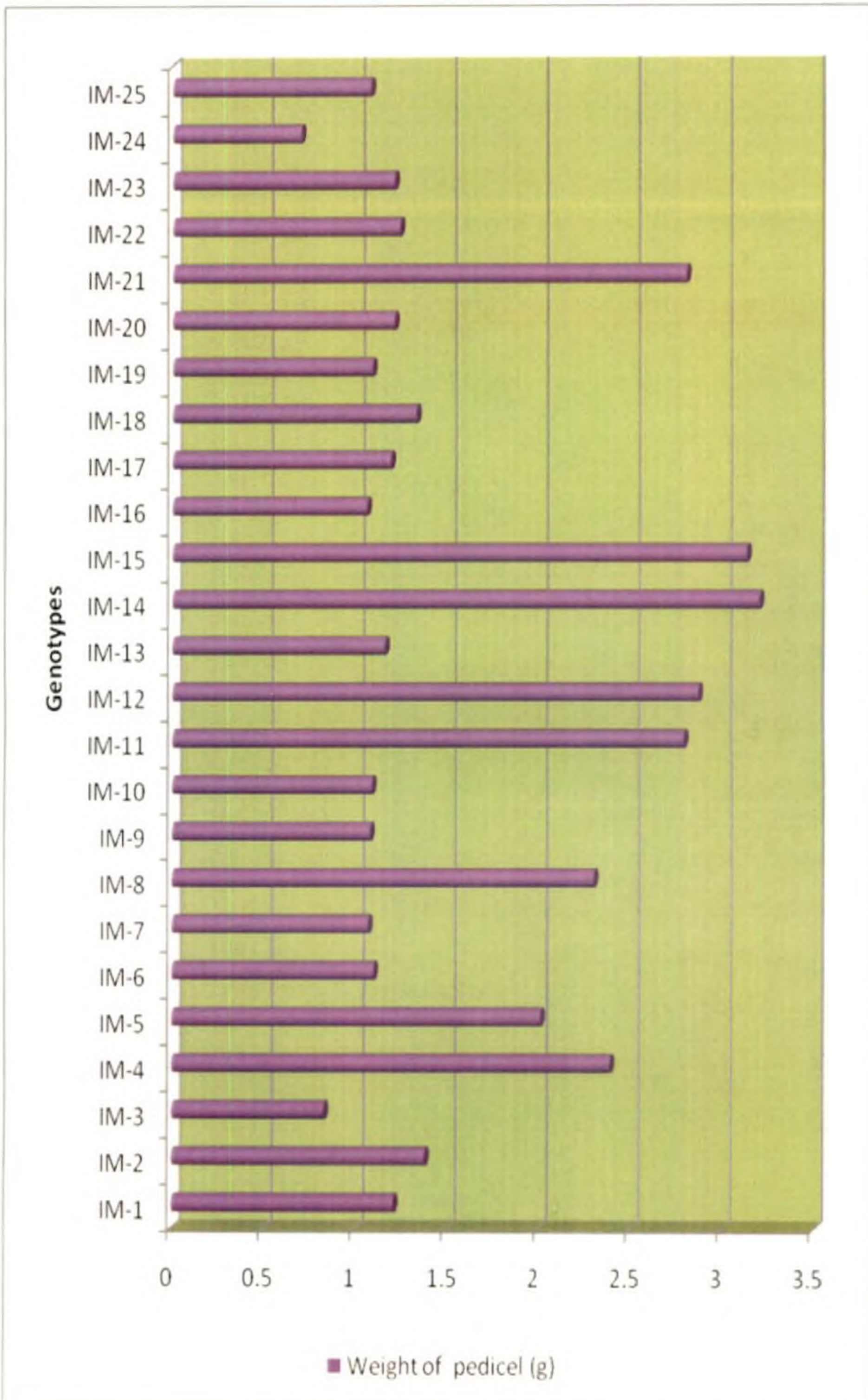


Fig. 4 Comparison of weight of pedicel of 25 accessions of clove bean

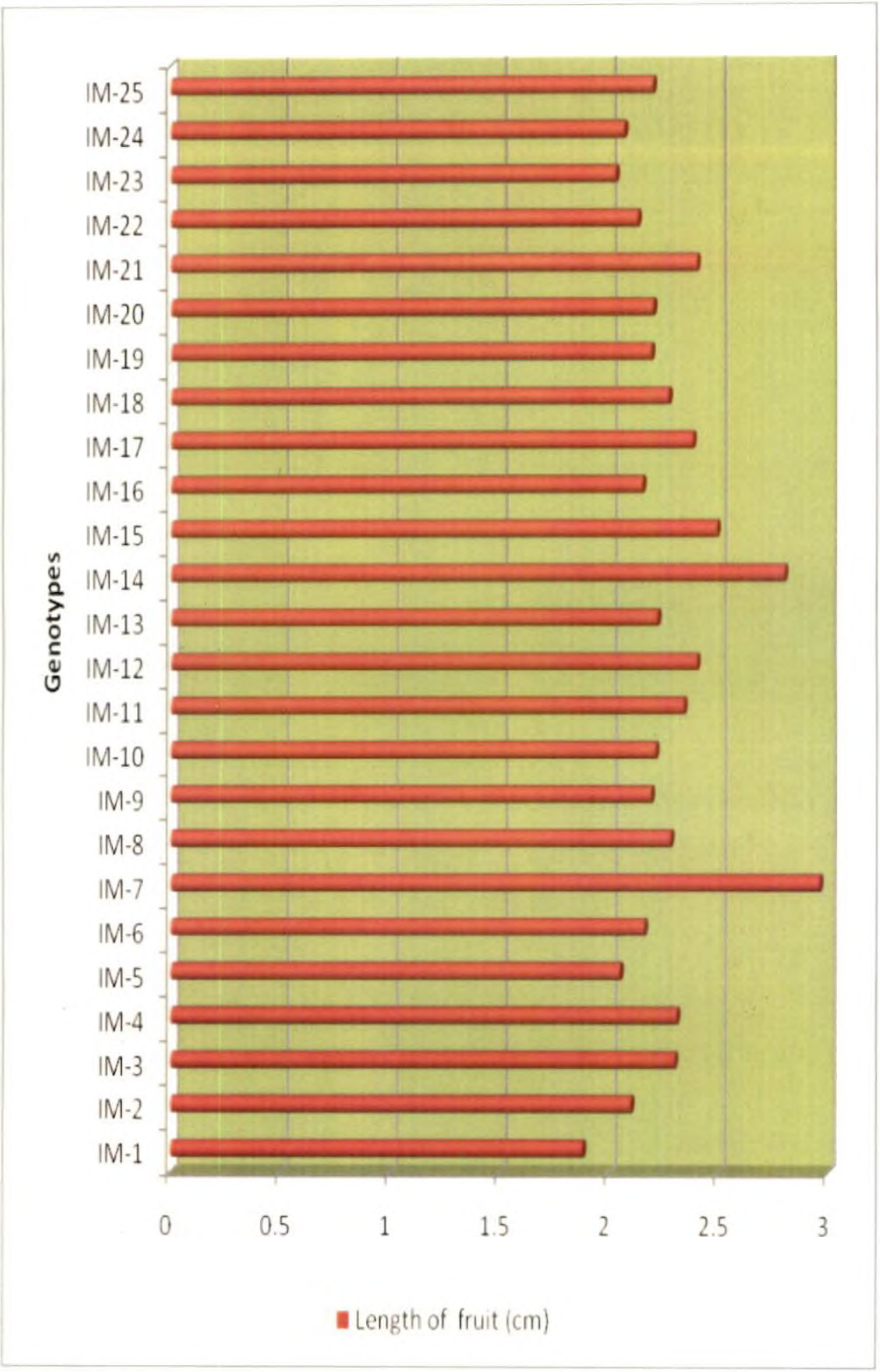


Fig.5 Comparison of length of fruit of 25 accessions of clove bean

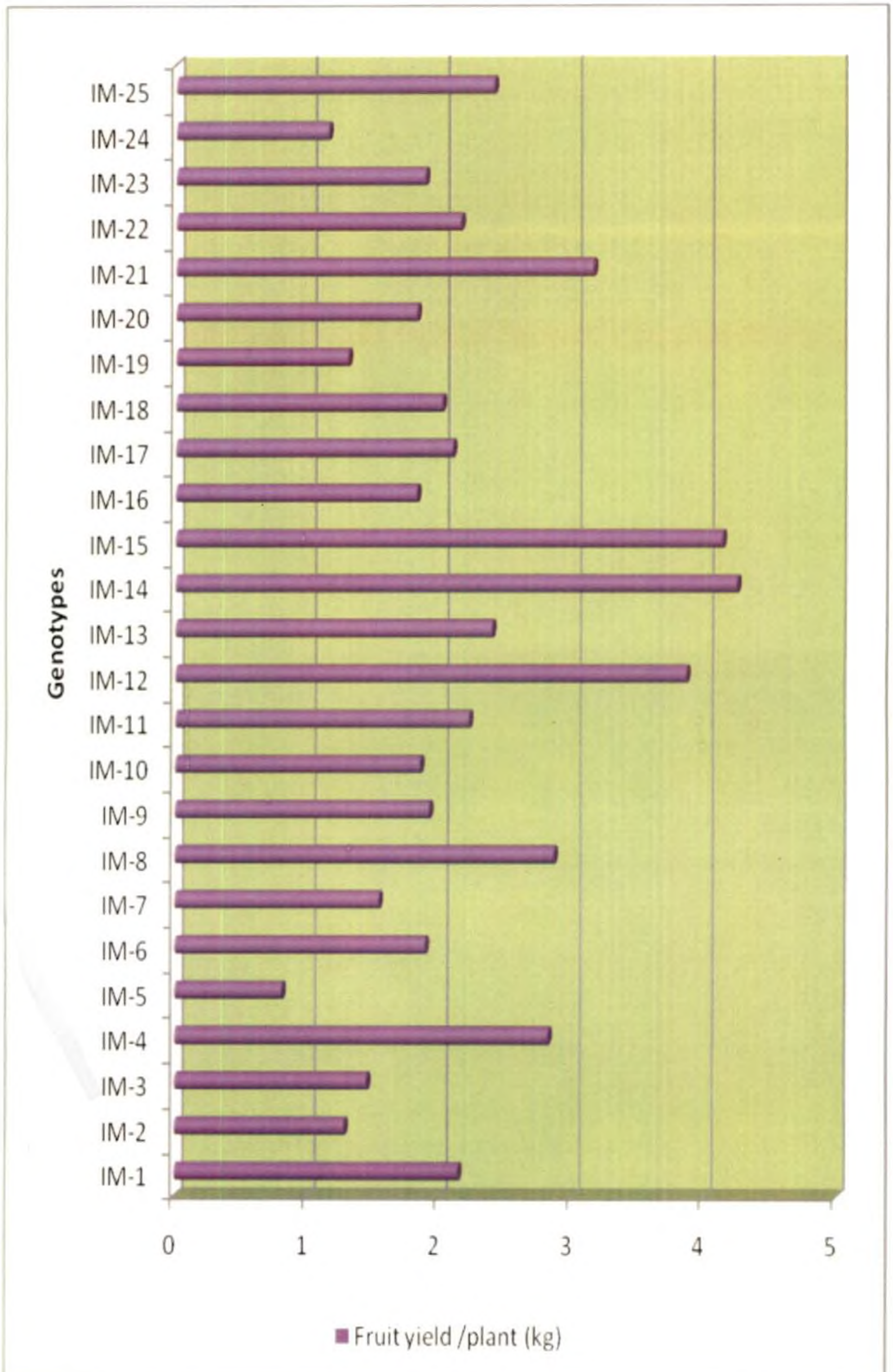


Fig.6 Comparison of fruit yield per plant

e) Girth of pedicel

The girth of pedicel ranged from 2.87cm (IM-5) to 4.49cm (IM-14) with a mean of 3.75cm.The pcv and gcv values were 9.9 and 9.22 respectively.

f) Weight of pedicel

Analysis of variance for weight of pedicel revealed that there was significant variation among the different genotypes for this character (Fig.4). The value ranged from 0.83g (IM-3) to 3.20g (IM-14) with a general mean of 1.62g. It recorded a pcv of 49.76 and gcv of 48.27.

g) Length of fruit

There was significant difference between the accessions for length of fruit (Fig.5). The value ranged from 1.88cm (IM-1) to 2.80cm (IM-14) with a general mean value of 2.27cm. The pcv and gcv values were 11.72 and 9.21 respectively.

h) Girth of fruit

Girth of fruit ranged from 5.37cm (IM-5) to 6.62cm (IM-7) (Plate 8) with a mean value of 5.90cm.The pcv and gcv values were 7.48 and 4.74 respectively.

i) Weight of fruit

The highest weight of fruit was obtained for the accession IM-14 (3.27g) and the lowest was recorded by IM-5 (0.45g) with a mean value of 2.21g. The pcv and gcv values were 28.74 and 26.28 respectively.

j) Fruit yield per plant

The fruit yield per plant varied significantly among different accessions (Table 3) (Fig. 6). The accession IM-5(0.81kg) had the lowest yield and IM-14(4.24kg) had the highest yield with a mean value of 2.208 kg. The pcv and gcv estimates were 40.21 and 40.09 respectively.

Plate 8. IM 7 – Accessions with maximum girth of fruit and vine length

Plate - 9. Sphingid moth and cut worm attack in clove bean

k) Duration of the crop

Total duration of the crop varied from 139 days (IM-5) to 170days (IM-7) with a mean value of 155.72days. The pcv and gcv value were 6 and 4.68 respectively.

l) Number of harvests

Total number of harvests varied from 5(IM-5) to 10(IM-14), (IM-15) with a mean value 8.04.

m) Shelf life in open conditions

Shelf life ranged from 4 days (18 accessions) to 5days (7 accessions) in open room conditions at vegetable maturity, with a mean value of 4.24 days.

n) Reaction to pest and diseases

No symptom of any disease was observed in any of the accessions during the period of cultivation. Mild attack of sphingid moths and cut worms was noticed after 25 days of germination (Plate 9). Sphingid moth infestation was observed to be mainly confined to the accessions IM-1, IM-5, IM-6, IM-9, IM-11, IM-20, IM-20 and IM-22. Though mild attack of cut worms was seen on IM-3, I M-5, IM-17, IM-19 and IM-22, no other pests were seen on the crop at any stages of growth.

o) Colour of vine

Vine colour showed little variation. Majority of accessions had green with many purple spots while IM-7 had purple vine colour.

p) Colour of flower

Accession IM-7 had white flower, while white limb with purple throat was observed in flowers of IM-I, M-2, IM-3, IM-5, IM-6, IM-9, IM-10, IM -13, IM-16, IM-17, IM-18, IM-19, IM-20, IM-22, IM-23, IM-24, IM-25. Purple flower was seen in accessions IM-4, I M-8, IM-11, IM-12, IM-14, IM-15 and IM-21.

Chemical properties

q) Ascorbic acid

The ascorbic acid content of the edible part at vegetable maturity was the lowest for accessions IM-2, IM-10, IM-11, IM-22 and highest for accessions IM-5, IM-7, IM-13, IM-19 and IM-23.The values ranged between 48 mg and 24 mg with a mean value of 35.52 mg. The pcv was 33.87 and gcv was 18.73.

r) Iron

Iron content of the edible part at vegetable maturity was the highest for accessions IM-13, IM-15, IM-22 and lowest for accessions IM-1 and IM-7. The values ranged between 0.13mg and 0.19mg with a mean value of 0.15 mg. The pcv was 12.22 and gcv was 10.64.

s) Calcium

Calcium content of the edible part at vegetable maturity ranged from IM-18 (230.67 mg) to 184 mg (13 accessions) with a mean value of 209.79 mg. The pcv was 35.91 and gcv was 0.02.

t) Protein

The protein content of the edible part at vegetable maturity was maximum for IM-21(1.67g) and minimum for IM-24(0.97g) with a mean value of 1.245g.The pcv and gcv value estimates were 16.9 and 15.65 respectively.

u) Phosphorus

Phosphorus content of the edible part at vegetable maturity ranged from 102 mg (IM-1) to 150.33 mg (IM-2) with a mean value of 129.64 mg. The pcv was 11.39 and gcv was 11.26

Table 11: Heritability, genetic advance and genetic gain for different characters in *Ipomoea muricata* (L.) Jacq.

Sl.No	Characters	Heritability %	Genetic advance	Genetic gain %
1	Length of pedicel(cm)	97.1	2.66	72.38
2	Girth of pedicel(cm)	86.7	0.66	23.10
3	Weight of Pedicel(g)	94.1	1.56	9.62
4	Length of fruit(cm)	61.8	0.34	14.99
5	Girth of fruit(cm)	40.4	0.37	6.27
6	Weight of fruit(g)	83.4	1.09	49.38
7	Fruit yield per plant(kg)	99.4	1.82	82.44
8	Days to first flower production	91.8	9.18	17.98
9	Days to first harvest	90.2	10.01	15.36
10	Vine length(cm)	93.7	51.36	14.15
11	Duration of the crop(days)	60.7	11.70	7.51
12	Protein(g)	85.7	0.37	29.70
13	Phosphorus(mg)	97.6	29.69	22.90
14	Iron(mg)	75.9	0.03	19.24
15	Calcium(mg)	0.01	0.01	4.77
16	Ascorbic acid (mg)	30.6	7.58	21.34
17	Crude fibre%	61.3	1.12	58.74

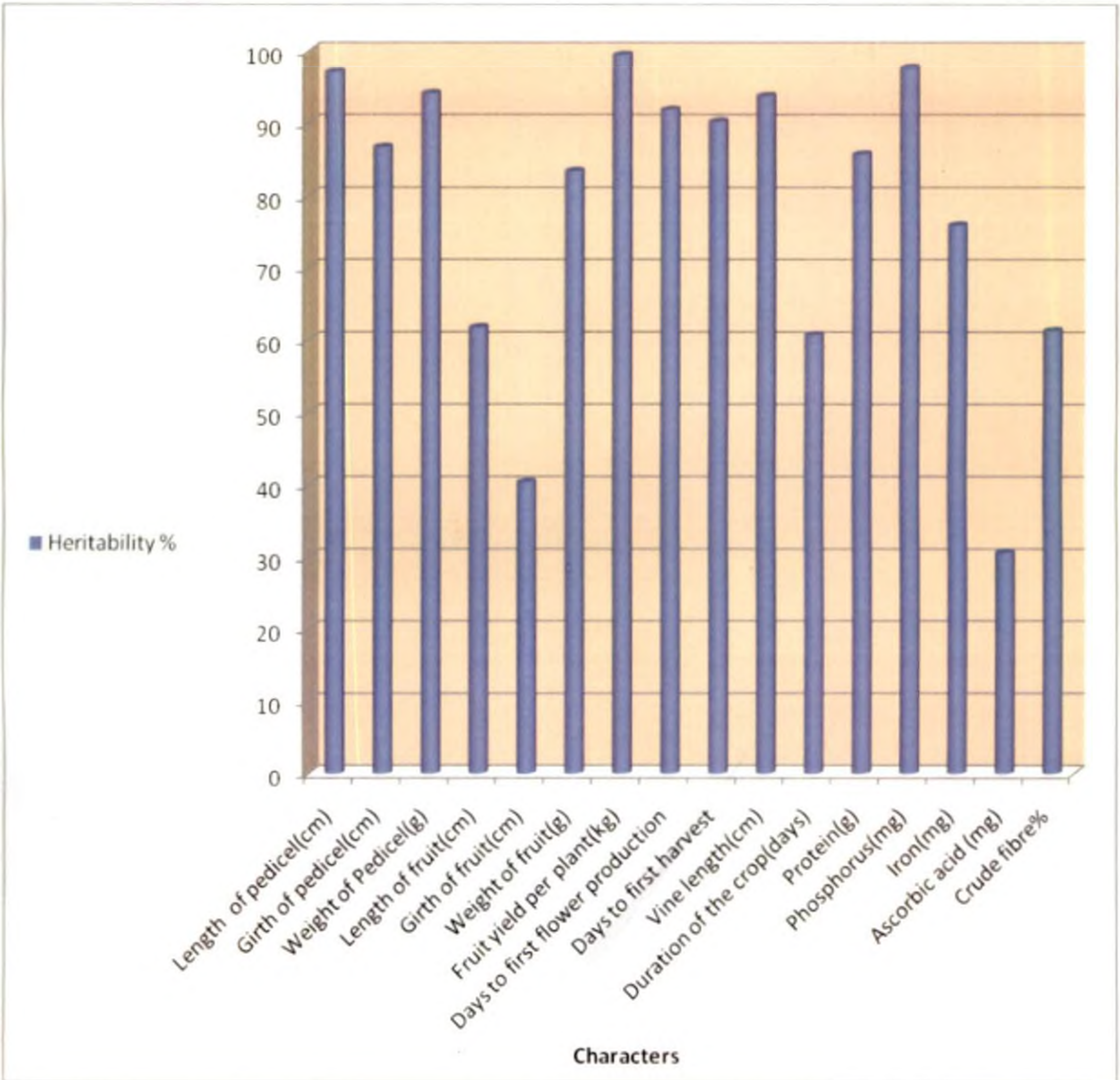


Fig. 7 Variation in heritability for yield and its components

v) Crude fibre

Crude fibre content of the edible part at vegetable maturity stage was maximum for IM-3 and IM-10 and minimum for IM-13. The value ranged from 0.67 per cent to 3.33 per cent with a mean value of 1.91%. The pcv value was 46.51 and gcv value was 36.42.

4.2.2 Heritability, genetic advance and genetic gain

Heritability, genetic advance and genetic gain for different characters are presented in table 11 (Fig 7).

Highest heritability was observed for the characters yield per plant (99.1%) followed by phosphorus content (97.6%). Other characters with high heritability were length of pedicel (97.1%), weight of pedicel (94.1%), vine length (93.7%), days to first flower production (91.8 %) and days to first harvest (90.2%). Low heritability value was observed for calcium content in fruits (0.01%).

Genetic advance was the highest for vine length (51.36) and the lowest for calcium content of fruit (0.01).

Highest magnitude of genetic gain was manifested by yield per plant (82.44%) and the lowest by calcium content of fruits (4.77%). The characters like length of pedicel (72.38%), weight of fruit (49.38%), crude fibre (58.75%), protein content (29.70%), girth of pedicel (23.10%), phosphorus content (22.90%), vitamin C content (21.34%) also had high genetic gain.

4.2.3 Correlation

The genotypic and phenotypic correlations between different pairs of characters were estimated and presented in the table 12.

It was observed that yield was significantly and positively correlated with length of pedicel (rg = 0.859, rp = 0.842), girth of pedicel (rg = 0.872, rp = 0.800), weight of pedicel (rg = 0.798, rp = 0.776), weight of fruit (rg = 0.734, rp = 0.667)

Table 12: Phenotypic and genotypic correlation coefficients between yield and its components

Characters	Length of pedicel	Girth of pedicel	Weight of pedicel	Length of the fruit	Girth of the fruit	Weight of fruit	Yield/ plant	Days to first flower production	Days to first harvest	Number of harvests	Vine length	Shelf life	Duration of the crop	Protein	Phosphorus	Iron	Ascorbic acid	Crude fibre
Length of pedicel		0.832**	0.902**	0.458	0.412	0.697*	0.842**	-0.681*	-0.628*	0.693*	0.366	0.897**	0.468	-0.023	0.225	0.158	-0.156	-0.223
Girth of pedicel	0.906**		0.700**	0.564*	0.467	0.770*	0.800**	-0.569*	-0.566*	0.761*	0.261	0.705*	0.474	-0.633*	0.311	0.167	-0.172	-0.298
Weight of pedicel	0.941**	0.740*		0.354	-0.288	0.524	0.776**	-0.691*	-0.626*	0.538	0.353	0.883*	0.357	0.058	0.199	0.172	-0.155	-0.192
Length of the fruit	0.601*	0.654*	0.507		0.654*	0.578*	0.412	-0.209	-0.255	0.315	0.414	0.407	0.434	-0.018	0.288	-0.038	-0.044	-0.223
Girth of the fruit	0.660*	0.860**	0.563*	1.066**		0.608*	0.376	-0.227	-0.270	0.297	0.271	0.408	0.250	-0.010	0.266	-0.043	-0.180	-0.141
Weight of fruit	0.763*	0.916**	0.581*	0.805**	0.898**		0.667*	-0.542	-0.567*	0.622*	0.284	0.561*	0.456	-0.147	0.387	0.079	-0.308	-0.204
Fruit yield/plant	0.859**	0.872**	0.798**	0.537	0.607*	0.734*		0.684*	-0.678*	0.896**	0.320	0.772*	0.298	-0.140	0.341	0.233	0.191	-0.339
Days to first flower production	-0.729*	-0.665*	-0.758**	-0.249	-0.366	-0.624*	-0.715*		0.700*	-0.542	-0.134	0.701*	-0.195	0.027	-0.391	-0.199	0.235	0.114
Days to first harvest	-0.672*	-0.667*	-0.669*	-0.414	-0.461	-0.654*	-0.676*	0.756*		-0.587*	-0.293	0.578*	-0.243	0.226	-0.432	-0.280	0.301	0.160
Number of harvests	0.703*	0.818**	0.555*	0.403	0.468	0.680*	0.899**	-0.566*	-0.618*		0.195	0.569*	0.274	-0.122	0.419	0.140	0.218	-0.306
Vine length	0.378	0.289	0.373	0.537	0.436	0.309	0.331	-0.136	-0.322	0.202		0.357	0.345	-0.204	0.320	-0.158	0.045	-0.175
Shelf life	0.910**	0.757*	0.911**	0.517	0.643*	0.614*	0.775**	-0.731	-0.608*	0.569	0.369		0.474	0.035	0.230	0.167	-0.168	-0.155
Duration of the crop	0.616*	0.571*	0.411	0.766*	0.754*	0.669*	0.384	-0.286	-0.281	0.352	0.458	0.608*		0.155	0.399	-0.112	-0.060	-0.106
Protein	-0.026	-0.115	0.082	-0.074	0.065	-0.173	-0.145	0.063	0.234	0.132	-0.222	0.038	0.173		0.129	-0.380	-0.102	0.127
Phosphorus	0.233	0.321	0.119	-0.295	0.443	0.433	0.345	-0.401	-0.459	0.424	0.334	0.233	0.434	0.135		0.021	-0.333	0.012
Iron	0.188	0.227	0.215	-0.071	-0.102	0.111	0.269	-0.227	-0.290	0.160	-0.204	0.191	0.150	-0.416	0.18		-0.083	-0.049
Ascorbic acid	-0.308	-0.426	-0.293	0.125	-0.319	-0.439	-0.335	-0.401	0.459	-0.394	0.107	-0.303	-0.254	-0.309	-0.611*	0.101		-0.152
Crude fibre	-0.278	-0.353	0.212	-0.451	-0.239	-0.239	-0.424	0.197	0.158	-0.391	-0.271	-0.198	-0.178	0.064	0.025	0.056	-.489	

* Significant at 5% level

** Significant at 1% leve

and number of harvests (rg = 0.880, rp = 0.662) both genotypically and phenotypically.

The character, days to first flower production (rg = -0.715) exhibited significant negative correlation with yield genotypically but its correlation with yield was positive (rp = 0.684) phenotypically. Days to first harvest exhibited negative correlation with yield (rg = -0.676, rp = -0.678) both genotypically and phenotypically.

Significant and positive genotypic and phenotypic correlations were observed between length of pedicel and girth of pedicel (rg = 0.906, rp = 0.836), weight of pedicel (rg = 0.941, rp = 0.902), weight of fruit (rg = 0.732, rp = 0.697), number of harvests (rg = 0.703, rp = 0.693) and shelf life (rg = 0.910, rp = 0.897). Significant positive correlation was obtained between length of pedicel and girth of fruit (rg = 0.660), length of fruit (rg = 0.601) and duration of the crop (rg = 616) genotypically. But pedicel length was negatively correlated with days to first flower production (rg = -0.729, rp = -0.681) and days to first harvest (rg = -0.672, rp = -0.628) both genotypically and phenotypically.

Significant and positive correlation was observed between girth of pedicel and weight of pedicel (rg = 0.740, rp = 0.700), length of fruit (rg = 0.664, rp = 0.564), weight of fruit (rg = 0,916 rg = 0.761), shelf life (rg = 0.757, rp = 0.705). Its correlation with girth of the fruit (rg = 0.860) and duration of crop (rg = 0.571) was significant and positive genotypically. But negative significant correlation was obtained between girth of pedicel and days to first harvest (rg = -0.667, rp = 0.566) both genotypically and phenotypically.

With regard to weight of pedicel, its correlation with shelf life (rg = 0.911, rp = 0.883) was positive both genotypically and phenotypically and with girth of the fruit (rg = 0.563), weight of fruit (rg = 0.581) and number of harvest (rg = 0.555) genotypically. But negative correlation was observed with days to first flower production (rg = -0.758, rp = -0.691) and days to first harvest (rg = -0.669, rp = 0.626).

Significant positive correlation was observed between length of the fruit and weight of fruit (rg = 0.805, rp = 0.578) both phenotypically and genotypically and with duration of the crop (rg = 0.766) genotypically .

Girth of fruit was significantly and positively correlated with weight of fruit (rg = 0.898, rp = 0.608) both genotypically and phenotypically.Its correlation with shelf life (rg = 0.643) and duration of the crop (rg = 0.754) was positive and significant genotypically.

With regard to weight of fruit, its correlation with number of harvests (rg = 0.680, rp = 0.622) and shelf life (rg =0.614, rp = 0.561) was positive and significant both phenotypically and genotypically and with duration of the crop (rg = 0.669) genotypically only. But negative significant correlation was obtained between weight of fruit and days to first flower production (rg = -0.624, rp = -0.542) and days to first harvest (rg = -0.654, rp = -0.567) both genotypically and phenotypically.

Significant positive correlation was obtained between days to first flower production and days to first harvest (rg = 0.756, rp = 0.700) both genotypically and phenotypically and its correlation with shelf life (rp = 0.701) was positive and significant phenotypically, but negatively associated with number of harvests (rg = -0.566, rp = -0.542) both genotypically and phenotypically.

Number of harvests was significantly and positively associated with shelf life (rp = 0.569) phenotypically.

Shelf life was significantly and positively associated with duration of the crop (rg = 0.608) genotypically.

Significant negative correlation was obtained between phosphorus and ascorbic acid (rg = -0.611) genotypically.

No significant correlation was observed between protein content, iron content, crude fibre content and other characters both genotypically and phenotypically.

Table 13: Path coefficient analysis of yield and component characters.

Characters	Length of pedicel	Girth of pedicel	Weight of pedicel	Length of the fruit	Girth of the fruit	Weight of fruit	Days to first flower production	Days to first harvest	Vine length	Duration of the crop	Genotypic correlation with yield
Length of pedicel	**-0.464**	-0.482	0.653	-0.053	-0.132	0.817	-0.218	-0.171	0.041	0.197	0.859
Girth of pedicel	-0.421	**-0.532**	0.514	-0.058	-0.172	0.198	-0.200	-0.170	0.031	-0.183	0.872
Weight of pedicel	-0.437	-0.393	**0.695**	-0.045	-0.113	0.622	-0.228	-0.170	0.040	-0.132	0.798
Length of the fruit	-0.279	-0.348	0.352	**-0.088**	-0.214	0.863	-0.075	-0.105	0.058	-0.246	0.537
Girth of the fruit	-0.307	-0.457	0.391	-0.094	**-0.201**	0.962	-0.110	-0.117	0.047	-0.242	0.607
Weight of fruit	-0.354	-0.487	0.404	-0.071	-0.180	**1.071**	-0.188	-0.166	0.033	-0.214	0.734
Days to first flower production	0.337	0.354	-0.526	0.022	0.0737	-0.668	**0.301**	0.192	-0.015	0.092	-0.715
Days to first harvest	0.312	0.355	-0.465	0.036	0.092	-0.701	0.228	**0.254**	-0.035	0.090	-0.676
Vine length	-0.175	-0.154	0.259	-0.047	-0.087	0.330	-0.041	-0.131	**0.108**	-0.147	0.331
Duration of the crop	-0.286	--0.304	0.286	-0.067	-0.151	0.717	-0.086	-0.071	0.050	**-0.321**	0.384

Residual effect = 0.0092

4.2.4 Path coefficient analysis

By partitioning the correlation between yield and component characters into direct and indirect effects, the direct and indirect contribution of the component characters towards yield can be found out. The result of the path coefficient analysis of 25 accessions of *Ipomoea muricata* (L.) Jacq. for different characters is furnished in table 13.

In path coefficient analysis, the highest positive direct effect on yield was exhibited by weight of fruit (1.071) followed by weight of pedicel (0.695). Direct effect of length of pedicel on yield was negative (-0.464) and its correlation with yield was found to be positive (0.859) due to high indirect effects of weight of pedicel (0.653) and weight of fruit (0.817).

Girth of pedicel (-0.532) had direct negative effect on yield, but its genotypic correlation with yield was positive (0.872) due to high indirect effect of weight of pedicel (0.514) and weight of fruit (0.198).

Direct effect of weight of pedicel on yield was positive (0.695) and its genotypic correlation with yield was also found to be positive (0.798), even though indirect effects of length of pedicel (-0.437) and girth of pedicel (-0.393) were found negative.

Length of fruit had direct negative effect (-0.088) on yield due to its high indirect effect on girth of pedicel (-0.348), length of pedicel (-0.279) and girth of fruit (-0.214).

Direct effect on girth of the fruit on yield was negative (-0.201) due to its indirect effect through length of pedicel (-0.307), girth of pedicel (-0.457) and length of fruit (-0.094). But its genotypic correlation with yield was found to be positive (0.607)

Direct effect on weight of the fruit on yield was positive (1.071) and its genotypic correlation with yield was positive (0.734), even though indirect effect of length of fruit (-0.071) and girth of fruit (-0.180) were found negative.

Days to first flower production had positive (0.301) direct effect on yield. But its genotypic correlation with yield was negative (-0.715) through indirect effects like weight of pedicel (-0.526) and weight of fruit (-0.668)

Days to first harvest had positive (0.254) direct effect on yield, but its genotypic correlation with yield was negative (-0.676) through indirect effects like weight of pedicel (-0.465) and weight of fruit (-0.701).

Direct effect of vine length on yield was positive (0.108) and its genotypic correlation was positive (0.331).even though days to first flower production (-0.041) and days to first harvest (-0.131) were negative.

Direct effect of duration of the crop on yield was negative (-0.322) due to high negative indirect effects through days to first flower production (-0.086) and days to first harvest (-0.071) but its correlations with yield was positive (0.384).

Residual effect due to unknown factors on yield was 0.0092, which is very minimal.

4.2.5 Genetic divergence

Twenty five accessions of *Ipomoea muricata* (L.) Jacq. were grouped into 6 clusters using Mahalanobis D^2 statistics. The clustering pattern and the variable means of clusters are presented in tables 14 and 15.

Among the 6 clusters, cluster number I had maximum number of accessions (9), cluster IV had 4 accessions, cluster II, III, V and VI had 3 accessions each.

Accessions included in cluster I were IM-6, IM-9, IM-10, IM-16, IM-17,IM-20,IM-22,IM-23 and IM-25. This cluster recorded lowest mean value for vine length (241.8cm).

Table 14: List of *Ipomoea muricata* (L.) Jacq. accessions in different clusters

Cluster Number	No. of accessions in each cluster	Accessions
I	9	IM-6, IM-9, IM-10, IM-16, IM-17, IM-20, IM-22, IM-23, IM-25
II	3	IM-12, IM-14, IM-15
III	3	IM-5, IM-19, IM-24
IV	4	IM-4, IM-8, IM-11, IM-21
V	3	IM-2, IM-3, IM-7
VI	3	IM-1, IM-13, IM-18

Table 15: Means of variables for six clusters

Clusters	Vine length (cm)	Length of pedicel (cm)	Girth of pedicel (cm)	Weight of pedicel (g)	Length of fruit (cm)	Girth of fruit (cm)	Weight of fruit (cm)	Fruit yield /plant (kg)
I	241.80	2.93	3.62	1.14	2.18	5.85	2.02	1.98
II	388.06	5.86	4.32	3.06	2.58	6.33	3.12	4.07
III	354.33	2.59	3.30	1.27	2.10	5.52	1.41	1.08
IV	369.82	5.56	4.09	2.57	2.33	5.98	2.62	2.57
V	378.39	2.86	3.56	1.09	2.45	6.13	2.40	1.42
VI	328.94	3.08	3.74	1.23	2.12	5.68	1.87	2.18

Clusters	Days to first flower	Days to first harvest	Number of harvests	Duration	Shelf life
I	52.07	65.67	8.11	152.18	4
II	43.33	57.33	9.67	159.66	5
III	53.44	69.11	6.00	149.67	4
IV	47.08	62.00	8.25	161.75	5
V	54.66	68.33	7.00	162.89	4
VI	53.44	68.44	8.33	150.67	4

Clusters	Protein (mg/ 100 g)	Phosphorus (mg/100 g)	Iron (mg/100 g)	Calcium (mg/100 g)	Ascorbic acid (mg/100 g)	Crude fibre(%)
I	1.20	137.63	0.15	209.55	34.67	2.07
II	1.13	138.78	0.18	184.00	32.00	1.22
III	1.21	106.89	0.16	184.00	46.00	2.33
IV	1.30	142.58	0.15	218.50	33.00	2.04
V	1.47	136.44	0.14	230.00	34.00	2.16
VI	1.29	111.55	0.16	230.22	36.00	1.22

Table 16: Inter and Intra cluster D^2 value among six clusters of *Ipomoea muricata* (L.) Jacq. germplasm

Clusters	I	II	III	IV	V	VI
I	**119.00**					
II	2028.40	**107.35**				
III	628.31	3695.12	**381.51**			
IV	674.11	654.36	1575.49	**172.23**		
V	289.60	3155.89	467.96	1280.91	**222.10**	
VI	385.58	1736.38	730.29	578.53	732.05	**308.74**

The values printed in bold indicates intra cluster D^2 values

Cluster II included the accessions IM-12, IM-14 and IM-15 and they had the highest mean value for vine length (388.06cm), length of pedicel (5.86cm), girth of pedicel (4.32cm), weight of fruit (3.12g), number of harvests (9.67), shelf life (5days), yield (4.07kg) and iron content (0.18mg). The lowest mean value for days to first flower production (43.33 days), days to first harvest (57.33 days), protein (1.13g) and ascorbic acid content (32mg) was also recorded in this cluster.

The accessions IM-5, IM-19 and IM-23 were included in cluster III which had the highest mean value of ascorbic acid content (46mg) and crude fibre (2.33%) and lowest mean value for length of pedicel (2.59), girth of pedicel (3.30cm), length of fruit (2.10cm), weight of fruit (1.41g), number of harvests (6), duration of the crop (149.67days) and yield (1.08 kg/plant).

Cluster IV included the accessions I M-4, IM-8, IM-11 and IM-21.

Three accessions were in cluster V which included IM-2, IM-3 and IM-7. They had the highest mean value for days to first flower production (54.66days), duration of crop (162.89days), highest protein content (1.47g) and the lowest mean value for yield (1.42 kg), length of pedicel (2.86cm), weight of pedicel (1.09) and iron content (0.14mg).

Accessions included in cluster VI were IM-1, IM-13 and IM-18. The highest mean value for days to first harvest (68.44 days) and calcium content (230.22mg) and the lowest mean value of phosphorus content (111.55mg) and crude fibre (1.22) was recorded in this cluster.

Inter and intra D^2 values among the 6 clusters are given in table 16.

Cluster III had the maximum intra cluster value (381.5) and cluster I had the minimum (119.0). The intra cluster distance for other clusters were 107.35(cluster II), 172.23 (cluster IV), 222.10 (cluster V) and 308.74 (cluster VI).

Table 17: Estimation of selection index

Sl. No.	Accession No.	Selection index	Rank according to	
			Selection index	Yield
1	IM-14	4.100	1	1
2	IM-15	4.024	2	2
3	IM-12	3.834	3	3
4	IM-11	3.420	4	9
5	IM-21	3.360	5	4
6	IM-8	2.876	6	5
7	IM-4	2.510	7	6
8	IM-22	2.503	8	10
9	IM-20	2.422	9	18
10	IM-9	2.414	10	14
11	IM-13	2.390	11	8
12	IM-17	2.306	12	12
13	IM-7	2.191	13	19
14	IM-16	2.186	14	13
15	IM-18	2.171	15	20
16	IM-6	2.113	16	15
17	IM-19	2.092	17	22
18	IM-10	2.057	18	17
19	IM-23	2.034	19	16
20	IM-2	2.006	20	23
21	IM-1	1.944	21	11
22	IM-25	1.835	22	7
23	IM-24	1.803	23	24
24	IM-3	1.588	24	21
25	IM-5	1.217	25	25

The maximum statistical distance was found between cluster II and III (3695.12) followed by cluster II and V (3155.89).The distance between the cluster I and V displayed the lowest degree of divergence (289.60).

4.3.6 Selection index

Based on reliable and effective characters, a selection index can help to select suitable genotypes from a mass population (Table 17).

Selection index involving the characters like vine length, days to first flower production, length of pedicel, girth of pedicel, weight of pedicel, length of fruit, girth of fruit, protein, phosphorus, iron, ascorbic acid and crude fibre was selected for *Ipomoea muricata* (L.) Jacq. to identify superior genotypes.

Based on selection index, the accession IM-14 was found to be the most superior one followed by accessions IM-15, IM-12, IM-11 and IM-21. Accession IM-14 was the highest yielder with a mean yield of 4.24 kg/plant and had the maximum length (6.05cm), girth (4.49cm) and weight of pedicel (3.20g).

Discussion

5. DISCUSSION

Ipomoea muricata (L.) Jacq. is one of the most promising underexploited vegetable crops. Very little attention has been paid for the improvement of this crop. Systematic improvement of crop species, the breeder has to estimate the extent of variability present in the available germplasm. Knowledge about nature and magnitude of variation among the cultivars, heritability of different economic traits and association between different characters are essential for the success of any crop improvement programme.

In the present study, accessions of *Ipomoea muricata* (L.) Jacq. collected from different parts of Kerala were evaluated for variability, heritability, genetic gain, genetic divergence and correlation among yield and its component characters. The results are discussed here under.

5.1 Genetic characterisation in *Ipomoea muricata* (L.) Jacq.

On characterising the accessions, collected from different parts of Kerala, based on descriptor for *Ipomoea muri*cata (L.) Jacq. wide range of morphological variation was observed. Fruit size ranged from medium to large and fruit colour varied from green to purple. Variation in leaf shape, leaf colour and seed colour was also observed.

5.2 Variability

The success of any crop improvement programme depends upon the precise information available on the genetic variability of the crop.

In the present study, significant differences among the genotypes for the characters like vine length, days to first flower production, days to first harvest, length and weight of pedicel, length of fruit, yield per plant, duration of the crop, number of harvests and contents of Ascorbic acid, calcium and phosphorus were noticed. The existence of considerable variation indicated enough scope for improvement. Variability in many of the economic characters had been observed by many workers like Resmi (1998), Pournami (2000) and Vidya (2000) in yard long bean; Ajith (2001) and Philip (2004) in cowpea; Singh *et al.* (2004) in lablab bean; Mahalakshmi *et al.* (2005) in groundnut and Ranjan *et al.* (2006) in peas.

High environmental effects on phenotype for days to first flower production, days to first harvest, length of fruit, girth of fruit, duration of the crop were evident from their higher pcv as compared to gcv. Days to first flowering and days to first harvest are considered as indices of earliness. The accession IM-14 was found to be the earliest accession, which produced first flower in 42.33 days.

Length and girth of pedicel, vine length and days to first flower production had higher pcv than gcv suggesting the influence of environment on these characters. For all the three characters, gcv was very nearer to pcv and hence effect of genotypes on phenotypic expression was also high. Sreekanth (2007) reported higher pcv than gcv for six characters in bush dolichos bean.

Yield per plant, weight of pedicel and crude fibre had high gcv and pcv indicating maximum variability among the different accessions and the scope for effective selection. High gcv and pcv for yield per plant observed in this study is supported by similar findings of Rajaravindran and Das (1997), Vardhan and Savithramma (1998), Selvam *et al.* (2000) and Vineetakumari *et al.* (2003) in cowpea; Vidya (2000) in Yard long bean and Sharma *et al.* (2007) in peas.

Weight of fruit, biochemical constituents like protein, phosphorus, iron, ascorbic acid and crude fibre were found to be influenced by environment as indicated by higher pcv (28.74, 16.90, 11.39, 12.22, 33.87 respectively) compared to gcv (26.26, 15.65, 11.26, 10.64, 18.73). Mathew (2000) also found that quality parameters were highly influenced by environment in most of the vegetables studied. In the present study, crop duration had very low estimates for gcv. Low gcv for crop duration was also reported by Ajith (2001) in cowpea.

5.3 Heritability

High heritability value indicated that the character is least affected by environment and low heritability indicates high influence of environment. If the effect of environment is high, genetic improvement through selection will be difficult due to masking effects of environment on genotype. Presence of additive genes is indicated by high genetic advance and genetic gain.

Results of the present study revealed that yield per plant, phosphorus content, and length of pedicel exhibited high heritability (99.4, 97.6, 97.1 respectively) and genetic gain (82.44, 22.90, 72.38 respectively) indicating that these characters were least affected by environment. The observations revealed that the variation for the above characters was mainly due to the action of additive genes and these traits can be improved by selection, hence there is ample scope for selection for the improvement of these traits.

In the present investigation, yield per plant exhibited high heritability which is in agreement with the reports of Sobha (1994), Backiyarani *et al.* (1996), Rajaravindran and Das (1997), Nehru and Manjunath (2001) in cowpea; Pournami (2000) and Vidya (2000) in yard long bean; Uddin and Newaz (1997) in lablab bean and Deepalakshmi and Ganesamurthy (2007) in sorghum.

High heritability for fruit length noticed in this study is supported by similar results reported by Sudhakumari (1993), Sawant (1994), Ajith (2001), and Philip (2004) in cowpea; Sreekumar *et al.* (1996) in yard long bean and Nandhi and Oommen (2007) in clusterbean. The genetic gain was the lowest for the character calcium content (4.77) and highest for the character yield per plant (82.44).

In the present study yield per plant recorded low genetic advance. This is quite contrary to the observations made by Pournami (2000) and Vidya (2000) in yard long bean.

High heritability coupled with low genetic gain was observed in the characters like weight of pedicel and duration of the crop. This may be attributed to the action of non additive gene effects. Hence straight selection has limited scope for improving these traits. Calcium content has low heritability and low genetic gain indicating that the character is highly influenced by environment and selection by this character will be ineffective.

High heritability together with high genetic advance indicates the predominance of additive gene effect. Thus vine length and phosphorus content were the characters forming reliable index for selection. Tsegaye *et al.* (2007) also reported high heritability coupled with high genetic advance for vine length in sweet potato.

High heritability together with low genetic advance exhibited by days to first flower, days to first harvest, length, girth and weight of pedicel, length and girth of fruit, yield, contents of protein, iron and crude fibre may be attributed to the action of non additive genes. Hence straight selection has limited scope for improving these traits.

5.4 Correlation studies

Yield is a complex character contributed by many mutually related components. Hence information on the magnitude of the relationship of individual yield component to the final yield and inter relationship among themselves would help the breeder for identification of characters which would influence the economic traits.

The results of the present study showed that genotypic correlation coefficient were higher than phenotypic correlation coefficients for length, girth and weight of pedicel and fruit (Table 12) indicating that environment had smaller effect on these characters.

In the present investigation yield was significantly and positively correlated with length, girth and weight of pedicel, weight of fruit and number of harvests at both phenotypic and genotypic levels. The results indicated that these traits had certain inherent relationship with yield suggesting their importance in determining fruit yield. This is in concurrence with the findings of Basawana *et al.* (1980), Sathyanarayana and Gangadharappa (1982) in lablab bean; Ajith (2001), Kutty *et al.* (2003) and Peksen (2004) in cowpea and Pournami (2000) and Vidya (2000) in yard long bean.

Highly positive genotypic correlation of length of fruit with weight of fruit as reported in the present investigation is in agreement with the reports by Resmi (1998), Ye and Zhang (1987) and Sharma *et al.* (1988) in yard long bean.

Length of pedicel was significantly and positively correlated with girth and weight of pedicel indicating that the higher the pedicel length, the higher will be its girth and weight.

Pedicel girth was significantly and positively correlated with shelf life which showed that when pedicel girth is higher, shelf life will be more.

Genotypic correlation between yield and length, girth and weight of pedicel and weight of fruit was higher than the phenotypic correlation which indicated the presence of strong association between these characters and yield. Low phenotypic correlations can be attributed to the smaller effect of environment. Higher phenotypic correlation between number of harvests and yield was also observed.

Yield was found to be positively correlated with vine length, length of fruit, duration of the crop, phosphorus and iron content and negatively correlated with protein and crude fibre. However these correlations were found to be insignificant indicating the independent nature of these characters in relation to yield. This is in agreement with the findings of Sreekumar *et al.* (1996), Chattopadhyay *et al.* (1997), Ushakumari *et al.* (2001), Neema and Palanisamy (2003), Renukadevi and Subbalakshmi (2006).

5.5 Path coefficient analysis

Path coefficient analysis helps to identify whether the association of different characters with yield is due to their direct effects on yield or is a consequence of their indirect effects through other component characters. It is used to predict the effect of selection based on an independent character with reference to its dependent character.

On partitioning of the correlation into direct and indirect effects, it was observed that weight of fruit, weight of pedicel and days to first flower production had high direct positive effect on yield. It revealed a true relationship between these characters and yield and hence direct selection for these traits would be rewarding for yield improvement.

Length of fruit exhibited negative correlation with yield though the direct effect of weight of fruit on yield was positive. Similar results were obtained by Sawant (1994), Kumari *et al.* (2003) and Sharma *et al.* (2007).

The direct effect of weight of fruit on yield and correlation coefficient was positive and also there was direct effect of weight of pedicel, vine length and duration of the crop. Hence direct selection via these characters should be considered. The positive direct effect of fruit weight on yield as observed in the study was supported by Ajith (2001) and Subbiah *et al.* (2003) in cowpea and Resmi (1998) and Vidya (2000) in yard long bean.

The direct effect of weight of pedicel on yield was positive and correlation coefficient was positive. There was also direct effect of vine length and weight of fruit on yield. Hence direct selection via these characters should be considered.

Girth of pedicel exhibited negative direct effect on yield, while correlation coefficient was positive. This emphasizes the need for selection for girth of pedicel through weight of pedicel, weight of fruit and vine length.

The direct effect of vine length on yield was positive and correlation coefficient was also positive. There was also direct effect due to weight of pedicel and fruit and hence direct selection via these characters should be considered.

Weight of fruit exhibited high direct effect on yield and its correlation coefficient with yield was also positive. Hence direct selection can be done for weight of fruit. High direct effect of fruit weight on yield has also been reported in lablab bean by Rai *et al.* 2004 and Sreekanth (2007).

Girth of fruit, length of fruit and crop duration even though had negative direct effect, correlation coefficient was positive. This emphasizes the need for selection for girth and length of fruit through weight of fruit, weight of pedicel and crop duration through vine length.

5.6 Genetic divergence

Mahalanobis D^2 statistics is a valuable multivariate analytical tool used for obtaining quantitative estimates of divergence between biological populations. Genetically divergent parents are essential to generate new variability and desired recombinants. In the present study, the 25 accessions of *Ipomoea muricata* (L.) Jacq. were grouped into six clusters, indicating considerable genetic diversity prevailing among them. Genotypes belonging to the same place of cultivation were distributed among different clusters, thus ruling out the association between geographical distribution of genotypes and genetic divergence which supports the earlier findings of Sobha (1996) and Golani *et al.* (2006).

Analysis of inter cluster distance revealed that the genetic divergence was maximum between cluster II and III (3695.12) followed by cluster II and V (3155.89) suggesting wider genetic divergence among them compared to other clusters.

The intercluster distance between cluster I and V was low (289.60) suggesting less genetic divergence among them compared to other clusters.

Hybridization between genotypes of cluster II and III, II and V is likely to give high heterosis for yield attributes due to high divergence between these clusters. Cluster II exhibited highest yield per plant (4.07 kg) followed by cluster IV (2.57kg).

Cluster V recorded maximum number of days for first flower production (54.66), while cluster II had the minimum (43.33).

Maximum girth (4.32 cm), length (5.86cm) and weight (3.06g) of pedicel were recorded by cluster II while minimum by cluster III.

5.7 Quality.

Being an underexploited crop the nutrient quality parameters like Ascorbic acid, iron, calcium, protein, phosphorus and iron were analyzed using standard procedures and these were compared with those of legumes. Calcium content was found to be 209 mg/100g higher than that of winged bean (201 mg/100g) (Neeliyara, 1998) but, the iron content was found to be inferior to winged bean. Crude fibre content was between 0.67% to 3.33% on dry weight basis in clove bean. Similar results was published by NIN (1999) in French bean (1.8%). Phosphorus content was observed to be higher than almost all legumes except faba bean. The range of ascorbic acid (35mg) was also higher when compared to legumes except that of cluster bean (49 mg/100g) as reported earlier by Neeliyara (1998). It is low in protein when compared to legumes.

5.8 Selection index

Selection index helps to select the best suitable genotypes from germplasm based on minimum number of reliable and effective characters.

The selection index involving all the yield components namely days to first flower production, vine length, girth , length and weight of pedicel, length and girth of fruit, and biochemical characters like content of protein, phosphorus, ascorbic acid and crude fibre were observed to have the maximum efficiency compared to direct selection based on yield alone. The model suggested by Smith (1936) was selected for ranking the genotypes.

Ranking based on selection index showed IM-14 as the most superior one followed by IM-15 and IM-12. It indicated that superiority of these genotypes were stable and reliable since the selection index value was calculated considering other yield contributing factors. Selection index was also worked out in vegetables like bottlegourd (Mathew, 1999), chilli (Cherian, 2000) and lablab bean (Sreekanth, 2007).

The accession IM-14 identified as the best performer was found to have an average fruit yield of 4.24kg/plant. It is the earliest one and took only 42.33 days for flowering and 54.33 days for first harvest. It expressed the highest length, girth and weight of pedicel and weight and length of fruits. Next in line was IM-15 with an yield of 4.13kg/plant. It was followed by IM-12 with 3.86kg/plant and flowered in 44.33days.

Thus the study revealed that the accessions IM-14, IM-15 and IM-12 were the most promising ones with respect to yield, earliness and other important economic characters.

Summary

6. SUMMARY

The present study on "Performance analysis of clove bean *Ipomoea muricata* (L.) Jacq. genotypes " was carried out in the Department of Olericulture, College of Horticulture, Vellanikkara, during 2007 – 2008.

The programme envisaged cataloguing of available germplasm in *Ipomoea muricata* (L.) Jacq; assessment of genetic variability and divergence; assessment of association of different traits with yield including the direct and indirect effects of traits on yield and analysis of nutritional profile and formulation of a selection index to identify superior genotypes.

Field experiment was laid out in RBD with three replications and the experimental materials consisted of 25 accessions of *Ipomoea muricata* (L.) Jacq. collected from different parts of Kerala. Observations on different quantitative and qualitative characters were recorded in each replication. The assessment of different parameters was done using appropriate statistical tools. The salient findings of the study are summarized below.

- A basic minimal descriptor was designed for clove bean and the genotypes were catalogued. The proposed descriptor based on morphological and other important features of clove bean would allow rapid characterization and increase their potential successful utilization.

- The twenty five accessions showed significant differences for the characters studied viz. vine length, length and weight of pedicel, length of fruit, yield per plant, earliness, duration of the crop, number of harvests, ascorbic acid content, calcium and phosphorus content.

- Accession IM-14 was the earliest in flowering (42.33 days) and was the highest yielder with 4.24 kg/plant followed by IM-15 with 4.13 kg/plant. The accession IM-7 possessed maximum vine length (414cm).

- The protein content was found to be the highest in IM-21(1.67g/100g), phosphorus in IM-1 (1.2mg/100gm), crude fibre in IM-3 and IM-10(3.33%), calcium content ranged from 184mg/100g to 230.67mg/100g, Iron ranged from 0.13mg/100g to 0.19mg/100g and ascorbic acid from 28 mg/100g to 48mg/100g.

- The genotypic and phenotypic coefficients of variation were maximum for weight of pedicel. Yield per plant and crude fibre content exhibited high gcv and pcv.

- Heritability estimate was found to be the highest (99.4%) for yield per plant but the genetic advance (1.82) was low. The genetic advance was highest for vine length, yield per plant and length of pedicel which exhibited high genetic gain also.

- Correlation studies revealed strong association between yield and length, girth and weight of pedicel and weight of fruit.

- Results of path coefficient analysis brought out that weight of the fruit had highest positive direct effect on yield followed by weight of pedicel. Length of pedicel imparted highest negative effect on yield followed by girth of pedicel. Duration of the crop had negative direct effect on yield.

- The twenty five genotypes were grouped into six clusters based on genetic distance. There was no parallelism between geographical distribution and genetic diversity. Intra cluster distances were much lesser than inter cluster distances, suggesting homogeneity and heterogeneity of the strains within and between the clusters respectively. Therefore, it is possible to exploit heterosis in *Ipomoea muricata* (L.) Jacq.

- A selection model was formulated consisting of the characters, viz. length, girth and weight of pedicel, length and girth of fruit, days to first flower production, vine length, content of protein, phosphorus, iron, ascorbic acid and crude fibre with good efficiency over direct selection.

- Comparison of different genotypes based on the index value revealed the superiority of genotypes IM-14 followed by IM-15, IM-12 and IM-11.

- There was much variability among the genotypes for most of the morphological characters observed. The vine colour varied from green to purple through mixed combinations of green and purple. The flower colour ranged from pure white, white limb with purple throat, to pure deep purple. The pods were green and purple in colour.

- The fruit length varied from 1.88cm (IM-1) to 2.80cm (IM-14). The pedicel length was highest in IM-14 (6.05cm) and lowest in IM-3 (2.27cm). Maximum fruit girth was also expressed by IM-14.

- The accession IM-14 was superior in fruit length (2.80 cm) and fruit weight (3.27g). It possessed highest pedicel length (6.05cm), pedicel girth (4.49cm) and weight of pedicel (3.20g). Invariably IM-14 was the highest yielder (4.24 kg/plant).

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Appendices

Appendix. 1. Meteorological data (mean monthly)

Source : Department of Agricultural Meteorology, KAU, Vellanikkara.

Months	Max. Temperature (^{0}C)		Min. Temperature (^{0}C)		RH (%)		Rainfall (mm)		Rainy days		Sunshine (hr.)		Wind speed (km/hr.)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
January	32.5	32.3	22.0	21.7	54	59	0.0	0	0	0	268.5	292.9	9.2	7
February	34.0	33.6	22.2	22.9	55	61	0.0	29.7	0	3	275.5	236.9	4.9	4.5
March	36.0	33.2	24.4	23.4	63	64	0.0	205.3	0	7	254.4	212.5	4.3	4.8
April	35.1	-	25.0	-	69	-	61.0	-	4	-	230	-	4.3	-
May	32.8	-	24.6	-	76	-	240.5	-	10	-	205.1	-	3.7	-
June	30.1	-	23.5	-	84	-	826.5	-	23	-	105.5	-	3.8	-
July	28.4	-	22.9	-	88	-	1131.9	-	28	-	22.1	-	3.2	-
August	29.0	-	22.8	-	84	-	549.7	-	19	-	100.5	-	2.7	-
September	29.4	-	22.9	-	86	-	765.9	-	23	-	75.1	-	3.0	-
October	30.5	-	22.5	-	79	-	383.8	-	14	-	135.2	-	3.2	-
November	31.7	-	21.6	-	67	-	24.8	-	3	-	239.2	-	4.5	-
December	31.6	-	22.7	-	56	-	8.7	-	1	-	207.1	-	8.6	-

Appendix 2. Fruit and seed characters

Accessions	Weight of edible portion (g)	Fruit pedicel ratio	Number of fruits in 1 kg	Shelling %	100 seed weight (g)
IM-1	2.87	1.30	349	78.73	18.48
IM-2	3.46	1.52	289	84.49	19.04
IM-3	3.13	2.77	318	85.51	19.52
IM-4	4.52	0.89	220	76.58	33.40
IM-5	2.46	0.22	404	80.63	18.72
IM-6	2.68	1.43	370	81.75	17.68
IM-7	3.86	2.60	254	80.23	31.12
IM-8	5.21	1.26	190	66.35	39.12
IM-9	3.19	1.95	316	76.32	20.12
IM-10	3.23	1.96	303	70.57	19.35
IM-11	5.52	0.97	179	62.37	34.52
IM-12	5.84	0.33	170	60.23	39.88
IM-13	2.84	1.43	352	82.40	19.80
IM-14	8.47	8.47	119	81.24	36.52
IM-15	6.26	1.00	156	76.49	36.56
IM-16	3.37	2.17	295	77.79	16.56
IM-17	3.46	1.90	287	87.21	20.12
IM-18	3.60	1.70	277	81.90	19.12
IM-19	3.12	1.86	321	78.18	20.32
IM-20	3.33	1.75	301	75.24	20.96
IM-21	5.53	0.65	178	77.29	40.82
IM-22	3.28	1.64	302	66.59	20.72
IM -23	3.09	1.55	321	81.77	18.68
IM-24	2.45	2.50	406	79.80	17.44
IM-25	2.89	1.67	342	81.87	18.00

PERFORMANCE ANALYSIS OF CLOVE BEAN *Ipomoea muricata* (L.) JACQ. GENOTYPES

By

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ABSTRACT OF THE THESIS

Submitted in partial fulfilment of the
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Abstract

ABSTRACT

An experiment was carried out in the Department of Olericulture, College of Horticulture, Kerala Agricultural University, Vellanikkara during August 2007 - January 2008 to analyze the performance of different accessions of clove bean *Ipomoea muricata* (L.) Jacq. The major objectives of the study were to genetically catalogue the germplasm and to assess the genetic variability, divergence, heritability, genetic gain and correlation of different traits with yield. Twenty five accessions collected from different parts of Kerala were grown in randomized block design with three replications.

Cataloguing of the germplasm evidenced significant differences for the characters like vine length, days to first flower production, days to first harvest, length and weight of pedicel, length of fruit, yield per plant, duration of the crop, number of harvests and contents of ascorbic acid , calcium and crude fibre. There was also much variability in the germplasm with regard to colour shades of vine, flower and fruit.

The accession IM-14 was found to be the highest yielder (4.24kg/plant) coupled with maximum length (3.675cm), girth (4.49cm) and weight of pedicel (93.27g) and length (2.8cm), girth (6.61cm) and weight of fruits (3.27g). Maximum vine length was observed in IM-7 (414.48cm). The accession IM-15 was the second best yielder (4.13 kg/plant) with superior yield contributing characters.

Among quality attributes, protein content was found to be highest in IM-21, phosphorus in IM-2 and crude fibre in IM-10 and IM-3. The iron content ranged from 0.13mg/100g to 0.19mg/100g, ascorbic acid ranged from 24mg/100g to 48 mg/100g and calcium content ranged from 230.67mg/100g to 209.79mg/100g.

Highest genotypic and phenotypic coefficients of variation were observed for weight of pedicel, yield per plant and crude fibre content. High heritability coupled with genetic gain was observed for yield per plant. The 25 accessions were grouped

into six clusters and no parallelism between geographical distribution and genetic diversity was observed.

Strong association was revealed between fruit yield and length, girth and weight of pedicel and weight of fruit. Highest positive direct effect on yield was contributed by weight of individual fruits.

A selection model was also formulated using characters like length, girth and weight of pedicel, length and girth of fruit, days to first flower production, vine length, protein, phosphorus, iron, ascorbic acid and crude fibre. Based on selection index accession IM-14 was identified as the best performer followed by the accessions IM-15, IM-12 and IM-11.