EVALUATION OF GENETIC STOCK OF 'SANGHUPUSHPAM' (*Clitoria ternatea* L.) FOR YIELD, ALKALOID CONTENT AND NITROGEN FIXING POTENTIAL

BY

DEEPA S. NAIR

THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE OF
MASTER OF SCIENCE IN HORTICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

2000

DECLARATION

I hereby declare that this thesis entitled "Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea* L.) for yield, alkaloid content and nitrogen fixing potential" is a *bonafide* record of research work done by me during the course of my research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other Universitv or Societv.

Deepa

Vellayani, **Deepa S. Nair**

5-12-2000

CERTIFICATE

Certified that this thesis entitled "Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea* L.) for yield, alkaloid content and nitrogen fixing potential" is a record of research work done independently by Miss Deepa .S. Nair under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

Dr. B.R. Reghunath
(Chairman, Advisory Committee)
Associate Professor
Department of Horticulture
College of Agriculture
Vellayani
Thiruvananthapuram

Vellayani
5-12-2000

APPROVED BY :

CHAIRMAN

Dr. B.R. REGHUNATH

MEMBERS

1. **Dr. P. MANIKANTAN NAIR**

2. **Smt. P.C. JESSYKUTTY**

3. **Dr. SASIKUMAR NAIR**

25/1/2001

EXTERNAL EXAMINER

(E. VADIVEL)

ACKNOWLEDGEMENT

I bow before God Almighty for all the blessings showered upon me during the course of this research work.

I extend my utmost gratitude and indebtedness to Dr. B.R.Reghunath, Associate Professor, Department of Horticulture and Chairman of the Advisory committee for his inspiring guidance, constructive criticism and constant encouragement throughout the course of research and preparation of the thesis.

My profound gratitude is placed on record to the members of the Advisory Committee, Dr. P. Manikantan Nair, Professor and Head (i/c),Department of Horticulture; Smt.P.C. Jessykutty, Assistant Professor, Department of Horticulture and Dr. Sasikumar Nair, Professor, Department of Plant Pathology for their valuable suggestions and guidance at various stages of the investigation.

I am most grateful to Dr. P.Rajendran, Associate Professor, Department of Soil Science and Agricultural Chemistry; Dr. Philipose Joshua, Associate Professor, Department of Horticulture ; Dr. Meera Bai, Dr. O. Kumari Swadija, Associate Professors, Department of Agronomy for their timely help and co-operation during the course of the study.

I wish to express my profound indebtedness to Dr.G.Sreekantan Nair, Director, TBGRI for the help extended during the course of the study .

With deep sense of gratitude, I remember Sri. Jayakumar, Research Officer, Ayurveda Research Institute, Poojapura and Dr. K.A. Bhat for their whole-hearted support and inspiration throughout the course of this work.

I am grateful to Sri C.E. Ajithkumar, Junior Programmer, Department of Agricultural Statistics for his most valuable help in analyzing the experimental data.

I am extremely thankful to all the teaching and non-teaching staff of the Department of Horticulture, College of Agriculture, Vellayani for their whole-hearted co-operation and support extended throughout the course of this investigation.

Words are scarce to express sincere thanks to my friends Daya, Reshmy, Jyothi ,Beena, Rani, Rakhi, Asha and Susan Chechi, PhD. Scholar, Department of Soil Science and Agricultural Chemistry for their selfless help and constant encouragement throughout the study which helped me to complete the work in time.

With deep sense of gratitude I wish to thank Anilkumar, V.R. who has helped me a lot in literature collection.

I am thankful to Kerala Agricultural University for providing the KAU junior fellowship.

My sincere thanks are due to Data Base Computers, Thycaud, Trivandrum for the timely and neat typing of the manuscript.

I am also grateful to Praveen, Chinchu, Chandu, Deepu chettan, Jai, Uncles and Auntys who have been of constant encouragement.

I remember with gratitude the blessings of my Ammoomma which helped me to overcome uneven situations during the course of the study.

At this moment I recall with love and gratitude, the constant support and inspiration given to me by my parents and my sister, Roopa. I am deeply obliged to them in making this endeavour a success.

Deepa S. Nair

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS

^0C	Degree Celsius
Fig.	Figure
m	metre
cm	centimetre
g	gram
ha^{-1}	per hectare
day^{-1}	per day
%	per cent
CD	Critical difference
LAI	Leaf area index
LAD	Leaf area duration
NAR	Net assimilation rate
CGR	Crop growth rate
RGR	Relative growth rate
AGR	Absolute growth rate
HI	Harvest index
DAS	Days after sowing

1. INTRODUCTION

Clitoria ternatea L., commonly known as butterfly pea is a beautiful creeper with blue, white or pink flowers admired for its unique flower shape. It is a common plant in the homesteads of Kerala known by the name ' Sanghupushpam'. In Ayurveda, the root of the plant is regarded as a good brain tonic. It is an ingredient of '*medhyarasayana*', usually prescribed for enhancing intelligence quotient (IQ) in children (Jessy, 1995). It forms an important constituent of several commercially manufactured brain tonics such as Smrithi granules and Memory plus.

The root of the plant also has diuretic and cathartic properties. Roots are applied as poultice for relief of swollen joints. The seeds are antidotal, aperient, diuretic, purgative and refrigerant and are used in cystis.

Exploitation of the wild population has resulted in serious hazards to the medicinal plant species in their natural habitat. Illicit removal and biotic interferences have increased their vulnerability to the loss of population. With screening of more and more plants as source of drugs, it is comprehended to lose our heritage of medicinal plant wealth through uncontrolled and unscrupulous collection. This is augmented with the destruction of many of the forest areas for other developmental programmes. This has led to adulteration, substitution and high cost of genuine drugs. The need of the hour is the domestication of drug plants for conservation and their cultivation for sustained supply to pharmaceutical industries.

In Kerala, the cropping intensity is very high and hence, there is limited scope for monocropping of medicinal plants. However, there is ample scope for introducing them as intercrops in plantations of oil palm, coconut and rubber. Herbaceous medicinal legumes give dual benefit if grown as intercrop. It contributes to the raw material requirement of the indigenous pharmaceutical industry and at the same time enriches soil fertility by way of nitrogen fixation. Moreover, the aerial plant parts can also be utilised as excellent fodder for cattle.

Lack of authentic varieties in medicinal plants is a major lacuna which hinders quality standardisation of pharmaceutical preparations made out of them. Screening of existing germplasm and evolving superior genotypes and releasing authentic varieties of medicinal plants will certainly help in maintaining the uniformity of raw materials used in pharmaceutical industry leading to sustained quality of the products.

The present study is aimed at

i) screening of accessions of *Clitoria ternatea* for root, seed, biomass yield and alkaloid content,

ii) screening of accessions showing high nitrogen fixing potential and

iii) to confirm the feasibility of cultivating the crop as a promising intercrop in coconut garden.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Plants have fascinated man from time immemorial; they have served him as source of his food, shelter and several other economic goods. Above all from the dawn of human life on earth, plant has been the major source of medicines for his health care and curing diseases. *Clitoria ternatea* L., an important leguminous medicinal plant of the humid tropical regions of the country contributes, considerably to the improvement of memory and intellect. It is regarded as a good brain tonic in the indigenous system of medicine.

The present study in *Clitoria ternatea* comprises collection and screening of various accessions for yield, alkaloid content and nitrogen fixing potential. In this chapter, literature on the above areas in *Clitoria ternatea* is reviewed. Wherever relevant literature in *Clitoria ternatea* was not available, literature on similar aspects reported in other leguminous crops had been reviewed.

2.1 Collection and classification of germplasm of *Clitoria ternatea*

Clitoria ternatea is a small climbing herb that has a pantropical distribution. Whyte *et al.* (1953) described it as a wide spread legume found both in new and old world including Australia. It grows well in the tropics.

Backer *et al.* (1963) is of the view that it originated in Madagascar. According to Randhawa and Mukhopadhyay (1998), the centre of origin of *Clitoria ternatea* is India.

The genus *Clitoria* consists of about 60 species distributed mostly within the tropical belt, with a few species found in temperate areas (Fantz, 1990). *Clitoria ternatea* belong to the family Fabaceae. It is a climber, shrubby at the base with five leaflets. It has papilionaceous flowers, an infundibular calyx with persistent bracteoles, persistent stipules and stipels and stalked ovaries with a geniculate bearded style.

Cultivated species of *Clitoria* in different parts of the world and their occurance, habit and floral characteristics are presented in Table 1 (Fantz, 1991)

2.2 Crop production and management

2.2.1 Soil and climate

Clitoria ternatea is a summer growing perennial found growing between 24^0 N and 24^0 S of the equator. It grows well from MSL upto an altitude of 1800m. Chaterjee and Das (1989) have referred *C. ternatea* to be fairly drought tolerant with some salinity tolerance property.

Table 1 Occurence, habit and floral characteristics of cultivated species of *Clitoria* (Fantz, 1991)

Sl No.	Name of the species	Habit	Flower size and colour	Occurrence
1	*Clitoria arborescens*	Tree	4 - 6 cm violaceous	Trinidad
2.	*Clitoria brachystegia*	Tree	4 - 6 cm violaceous	Florida
3.	*Clitoria dendrina*	Tree	3 - 4 cm dark purple	West. Indies
4.	*Clitoria fairchildiana*	Tree	4 - 6 cm violaceous	Brazil
5.	*Clitoria falcata*	Vine	4 - 6 cm white	Brazil
6.	*Clitoria glaberrima*	Tree	2.5 - 4 cm white	Gautemala
7.	*Clitoria heterophylla*	Vine	2.5 - 3 cm blue	Brazil
8.	*Ciltoria javanica*	Vine	3 - 3.5 cm white	Java
9.	*Clitoria javitensis*	Liana	6 - 8 cm pink/rose	England
10.	*Clitoria lasciva*	Liana	5.5 - 6.5 cm blue	Mauritius
11.	*Clitoria laurifolia*	Subshrub	4.5 - 5.0 cm white	Brazil
12.	*Clitoria mariana*	Herb	4 - 6 cm lilaceous	USA
13.	*Clitoria ternatea*	Vine	4 - 6 cm blue, white	India

Clitoria is usually grown as a green manure crop during summer and incorporated into soil after 90 days growth (Zamora and Octavio, 1995).

2.2.2 Cultural practices

Clitoria ternatea is a seed propagated crop. It is sown in rows taken 30 cm apart (Alencar and Guss, 1985). Singh *et al.* (1985) reported that at 25 cm row spacing *Clitoria* recorded the highest drymatter yield. Chaterjee and Das (1989) suggested to raise *Clitoria* as a rainfed crop as it is drought tolerant. According to Singh *et al.* (1985), *Panicum antidotale* could be intercropped with *Clitoria ternatea.*

2.2.3 Pests and diseases

Clitoria is reported to be tolerant to pests and diseases. However, it is reported as a host of root-knot nematode (Alam, 1981; Ray and Das, 1985). A tymo, yellow vein virus is found to infect *Clitoria* (Bock *et al.*, 1977). Tewari *et al.* (1981) identified *Clitoria* as a host of pea mosaic virus.

2.2.4 Harvest and yield

The green yield of *Clitoria ternatea* in one cutting was 24.3 t ha^{-1} having 21.8 per cent drymatter. The drymatter yield came to 5.4 t ha^{-1} in single cutting.

The first cutting was taken at two months after sowing. Being perennial in nature, subsequent cuttings were taken year round (Katiyar *et al.*, 1970).

2.3 Growth and yield parameters

2.3.1 Biomass yield

Biomass is mainly a function of vegetative growth by virtue of the inherent genetic makeup of each legume (Singh, 1957).

In *Clitoria ternatea*, the highest drymatter yield of 7.99 t ha^{-1} was reported from three cuts at an interval of 70 days (Alencar and Guss, 1985). Ladha *et al.* (1996) reported that *Cajanus cajan* L., *Crotalaria juncea* L. *and Clitoria ternatea* L. produced 4.9 - 9.1 t ha^{-1} of above ground biomass. In *Clitoria ternatea,* Sunitha (1996) obtained 7.2 t ha $^{-1}$ of biomass from a crop grown in open, and in shade, 2.9 t ha^{-1} of biomass was obtained.

2.3.2 Shoot growth parameters

Height of plant is one of the deciding factors contributing to increased crop yield especially in case of fodder crops where vegetative growth is more important. Inspite of being a medicinal plant, *Clitoria* has high fodder value in terms of nutrients and high palatability.

Bhaskaran (1964) observed in *Rauvolfia serpentina* that rate of linear growth in pre-flowering, flowering and seed-ripening stages was greater than at either in the seed setting or in the declining stage. The slow rate of growth during seed setting was attributed to the utilization of metabolic products for seed development. Allen (1975) noticed that soyabean grown under 70 per cent shade grew much taller than those under light. Tarila *et al.* (1977) reported that the high intensity of light reduced plant height in cowpea. Positive influence of shade on plant height was also reported on groundnut (George, 1982). Veerupakshappa (1982) observed negative association of plant length with pod length and number of seeds per pod in cowpea.

Bhaskaran (1964) reported an increasing trend in number of functional leaves till seed setting stage and thereafter their number decreased considerably for rest of the growth period in *Rauvolfia serpentina.* Kulkarni and Karadge (1991) observed similar trend in leaf number in moth bean. Decrease in leaf number was noticed by Jyothi (1995) in cowpea during harvest stage and was attributed to leaf shedding before harvest. Sunitha (1996) reported nearly 50 per cent reduction in leaf number in shade compared to open in *Clitoria ternatea.* Number of leaves is purely a function of genetic make up and environment (Gardner *et al.*, 1988). According to Geetha (1999), highlevels of soil nitrogen significantly influenced the number of leaves per plant in cowpea.

2.3.3 Root characters

According to Warsi *et al.* (1973), application of nitrogenous fertilizers had significant effect on root growth in sorghum. However, too high a concentration of nitrogen in soil can restrict root growth (Hurd and Spartt, 1979). In soyabean, root length and root girth exhibited an increasing trend upto seeding and then declined (Barber, 1978). Sunitha (1996) reported that in *Clitoria ternatea* length of taproot and number of lateral roots produced under open conditions were significantly superior when compared to that grown under shade in coconut garden.

2.3.4 Pod characters

In intercropping systems under coconut, groundnut, black gram and green gram recorded a mean pod yield of 825 kg ha^{-1}, 225 kg ha^{-1} and 353 kg ha^{-1} respectively (Lourduraj *et al.*, 1992). Sunitha (1996) reported a pod yield of 453 g $plant^{-1}$ in *Mucuna pruriens* and 398 g $plant^{-1}$ in *Clitoria ternatea* (on fresh weight basis) in open. Considerable reduction in pod yield (129g $plant^{-1}$) was observed in *Clitoria* under coconut shade. Seed yield was found to be positively correlated with plant height, pod length and number of pods per plant in field pea (Kumar *et al.*, 1998).

2.4 Physiological parameters

Photosynthetic efficiency and biomass production of crop plants are positively correlated with total leaf area of the plant. Increase in total leaf area results in higher LAI (Russell, 1961)

Dhanram *et al.* (1971) reported that application of nitrogen was effective in increasing number of leaves, LAI and growth of cowpea plants. Shanjeevirayar (1978) also observed that application of nitrogen increased number of leaves and LAI at 30th and 60th day after sowing in sorghum. In chickpea (*Cicer arietinum*), progressive trend in LAI in the vegetative phase continued during the reproductive phase as well (Haloi and Baldev, 1986). Ofroi and Sterm (1987) had also observed that in cowpea LAI increased with increase in levels of nitrogen applied. According to Maggie (1989), the LAI of cowpea increased at vegetative and flowering stage and decreased at harvest due to leaf shedding.

NAR and RGR showed high values at initial growth stages compared to reproductive stage in chick pea (Haloi and Baldev, 1986). Kulkarni and Karadge (1991) reported that in moth bean that RGR was the highest during flowering stage, while NAR was higher during the seed maturation stage.

Harvest index varies among legumes according to their genetic make up. Different genotypes of cowpea displayed a range of 0.30 – 0.65 in the value of harvest index (Maggie, 1989). According to Dodwad *et al.* (1998), harvest index and seed yield showed significant differences among the genotypes of green gram. Harvest index was positively correlated with seed yield per plant.

2.5 Nodulation and nitrogen fixation

Biologically fixed nitrogen can contribute directly to the needs of a growing crop or can be added to the soil thereby contributing to its fertility. For long term, sustainability of soil fertility, biological fixation of nitrogen could be relied upon.

Greaves and Jones (1950) reported that by returning the legume crop to the soil, the soil nitrogen content could be significantly increased. Sen and Rao (1953) reported on the marked response to application of phosphorus to the extend of nodulation and nitrogen fixation in legumes where as, Whyte and Trumble (1953) referred to the importance of calcium as a nutrient of legumes as well as nitrogen fixing bacteria. Masefield (1955) and Pate (1958) suggested that nodulation of legume was influenced by the flowering time of host. The total nodule activity, with regard to nitrogen fixation, was related to the number and size of nodules produced, persistence of nitrogen fixing bacteriod-containing tissues in the nodules and specific activity of host tissues (Nutman, 1959). The amount of nitrogen fixing is directly related to nodule size and their abundance (Sen and Bhaduri, 1971).

According to Russell (1961), legumes did not increase the soil nitrogen under all conditions. In case of legumes like peas, beans, soyabeans and groundnut, even if their roots were often well- nodulated, a large proportion of the nitrogen fixed was removed through seeds, straw and other harvested portions of the crop. However, the need for nitrogen application was reduced when the crop was preceded by legumes (Saxena and Yadav, 1975; Lal *et al.*, 1978; Faroda and Singh, 1983). Inclusion of legumes in the cropping system improved soil nitrogen status, thus reducing the need for applying nitrogen to succeeding crop (Palaniappan *et al.*, 1976). According to Sen *et al.* (1980), leguminous plants contributed considerable amount of nitrogen though their root nodules and thus indirectly helped in the maintenance of soil fertility Consequently a boost in the yield of succeeding crop was obtained (Kushwah and Ali, 1988; Jadhav, 1989). Rao (1988) reported that cowpea could fix 74 - 240 kg ha^{-1} of nitrogen annually in tropical conditions.

Nodulation in *Clitoria* is caused by a wide range of *Rhizobium* strains. According to Chaterjee and Das (1989), the symbiotic effectiveness was more than 80 per cent.

INTRODUCTION

Peoples and Herridge (1990) studied the estimates of nitrogen transfer to a companion non-legume crop, which was between 25 and 155 kg ha^{-1} nitrogen. Reports show that nitrogen fixed by a legume range between 50 and 300 kg ha^{-1}. Groundnut and pigeon pea fix 100 -152 kg ha^{-1} and 66 - 88 kg ha^{-1} of nitrogen, respectively (Giller and Wilson, 1991).

Nodulation is the main index of symbiotic nitrogen fixing efficiency in legumes. Atmospheric nitrogen fixed by legumes returns to the soil through nodule sloughings or excretion of fixed nitrogen (Venkataraman and Tilak, 1990).

Clitoria ternatea enriches soil by nitrogen fixation. It was found to increase soil nitrogen by 70 kg ha^{-1} (Sunitha, 1996). She also reported that number of root nodules in open and shaded conditions were 223.25 and 141.5 respectively.

2.6 Role of nutrients (N, P, K)

2.6.1 Nitrogen

According to Singh (1957), readily available soil nitrogen induced excessive vegetative growth. An adequate supply of nitrogen was associated with vigorous vegetative growth. However, excessive quantities of nitrogen prolonged growth period and delayed crop maturity (Tisdale and Nelson, 1970). Reports showed that legume hay contained 2.5 - 3 per cent nitrogen and root contained 5 - 20 per cent nitrogen. But in perennial legumes, the amount range from 25 - 35 per cent. According to Mercy (1981), nitrogen uptake in legume varied between 15 to 60 kg ha^{-1}. Selamat and Gardner (1985) observed that CGR and LAI of *Arachis hypogea* increased with nitrogen application. LAI of fodder cowpea was maximum when 40 kg ha^{-1} of nitrogen was applied (Jena *et al.*, 1995). A starter dose of nitrogen was found to enhance the early growth and establishment of cowpea (Geetha, 1999).

2.6.2 Phosphorus

Phosphorus has a beneficial effect on root growth, flowering, pod formation and seed setting in legumes and in the uptake of nitrogen and other nutrients (Robert and Olsen, 1944). Nair (1966) reported the role of phosphorus in the formation of fruits and seeds in cowpea. Increased phosphorus uptake promotes root proliferation and subsequently, root growth (Tisdale and Nelson, 1970). Cassman *et al.* (1980) opined that phosphorus capture by legumes was low as nodulated plants often had less well-developed root system compared to non-nodulated plants. Mercy (1981) observed an uptake of phosphorus in the range of 2.5 - 5.7 kg ha^{-1} during the growth of the legumes.

According to Zaurong and Munns (1980), phosphorus deficiency caused stunting, delay in flowering and rusty appearance of leaflets in *Clitoria*. Acute deficiency of phosphorus can prevent nodulation in legumes as observed by O' Hara *et al.* (1988). Phosphorus and sulphur are required for nodule metabolism and tend to be concentrated in the nodules when the plant is deficient in these nutrients.

Rajashree (1994) reported that phosphorus influenced growth and development of roots in legumes. A better root system was observed to enhance the rate of nitrogen fixation, which in turn, increased the plant herbage yield.

2.6.3 Potassium

Mercy (1981) reported an uptake of 8.45 - 21.5 kg ha^{-1} of potassium during growth of legumes. Potassium deficiency weakens the plant and reduces crop yield (Tisdale and Nelson, 1970). According to Yahiya (1996), grain legumes in general required high quantity of potassium for normal growth and development as well as for enhancing nodulation and nitrogen fixation. In summer cowpea, potassium helps in effective use of irrigation water and thus overcoming summer stress (Geetha, 1999).

2.7 Chemical constituents in *Clitoria ternatea*

Plants synthesise organic compounds during their metabolic processes when they grow. The nature and amount of these chemical substances vary according to the agro-climatic conditions and growth stage of the plant (Chopra *et al.*, 1958). The active principles may be present in plant parts like cortical region, bark, stem, leaves, flowers, fruits, seeds etc. The main group of phytoconstituents of therapeutic significance are classified as carbohydrates, glycosides, tannins and phenolic compounds, lipids, volatile oils, resin and resin combinations and alkaloids (Handa and Kapoor, 1999).

Pharmacognosy, pharmacology, clinical studies and phytochemistry of *Clitoria ternatea* was reviewed by Aulakh *et al.* (1988).

2.7.1 Leaves

Tiwari and Gupta (1959) reported an O-lactone compound 'aparajitin' (C_{26} H_{50} O_2) from alkaloid extract of dried leaves. An identical compound was reported in *C. mariana* L by Sinha (1960 a). Beta-sitosterol and aparajitin was identified in the leaves of *C. ternatea.* (Aiyar *et al.*, 1973).

2.7.2 Seeds

Chopra *et al.*, (1949) reported that seeds in powdered form constitute a more useful and safer medicine than roots. The seeds contain a resinous principle and tannin (Dymock *et al.*, 1890), a toxic alkaloid (Burkill, 1935 and Quisumbing, 1951) and a yellow fixed oil, gamma-sitosterol (Sinha, 1960 b). Nadkarni (1927) observed brittle testa and starch-filled cotyledons of *Clitoria* seeds. By thin layer chromatography, Kulshrestha *et al.* (1968) detected the cersulfate positive compounds adenosine, kaempferol - 3 - rhamnoglucoside, p-hydroxy cinnamic acid and ethyl-alpha-D-galactopyranoside in seeds. Gupta and Lal (1968) isolated hexacosanol, hepta-sitosterol and an anthoxanthin glucoside from seeds. Debnath *et al.* (1975) and Joshi *et al.* (1981) reported the presence of palmitic, stearic, oleic and linoleic acids in the seeds of blue and white varieties of *C. ternatea.* According to Joshi *et al.* (1981), the seeds contained 10.2 per cent oil, 38.4 per cent crude protein and 44.8 per cent sugar. Mathias *et al.* (1998) isolated alpha-O-beta-D- glycopyranosyl rotenoid from the methanolic extract of seeds of *Clitoria fairchildiana.*

2.7.3 Flowers

Bose (1983) reported the use of flower pigment as acid or alkali indicator. Acetone extract of flower petals of *Clitoria ternatea* was blue, which turned red in the presence of HCl and green in presence of NaOH. Six blue acylated anthocyanins were isolated from the blue flowers (Saito *et al.*, 1988). Terahara *et al.* (1996) reported the use of five anthocyanins - ternatins A_3, B_4, B_3, B_2 and D_2 from flowers of *Clitoria ternatea* as food-colourants.

2.7.4 Roots

Banerjee (1937) suggested the use of taraxerol, obtained from ether extract of roots as a substitute for litmus. Taraxerone, a crystalline substance with the molecular formula $C_{30}H_{48}O$ was identified and isolated by Banerjee and Chakravarthi (1964). Kapoor (1990) reported the presence of starch, tannin and resin in root bark. A rotenoid, 6-deoxy clitoriacetal isolated from roots of *Clitoria macrophylla* showed cytotoxic activity against cultured P-388 lymphocytic leukemia cells (Lin *et al.*, 1992). 6-deoxy clitoriacetal 11-o-beta –D-glycopyranoside, the rotenoid glucoside was isolated from the roots of *Clitoria fairchildiana* by da Silva *et al.* (1998)

2.8 Economic importance of *Clitoria ternatea*

2.8.1 *Clitoria* as medicine

Clitoria ternatea L is an important medicinal legume widely used for the treatment of dysentry, bronchitis and asthma (Kritikar and Basu, 1975). Sanghupushpam had shown significant anxiolytic (Singh *et al.*, 1977), tranquilizing and antidepressant activities (Singh *et al.*, 1979) in experimental rats. Experimental diabetic rats fed with ethanol extract of *Clitoria ternatea* flowers significantly lowered the serum sugar level, which indicated its antidiabetic activity (Sharma and Majumdar,1990). Home *et al.* (1992) formulated a hair oil containing *Clitoria ternatea* for the management of *Alopecia areata* (loss of scalp hair). The root of *Clitoria ternatea* is regarded as a good brain tonic in the indigenous system of medicine (Upadhye and Kumbhojkar, 1993). It is an ingredient of *medhyarasayana*, which on administration improved behavioural impairments in mentally retarded people (Ajith,1993) and IQ (intelligence quotient), haemoglobin content and digestive power in children (Jessy,1995). Rao (1997) reported the use of *Clitoria ternatea* in the palliative treatment of skin diseases.

The therapeutic uses of *Clitoria ternatea* L. are illustrated in Table 2 with reference.

2.8.2 *Clitoria* as fodder and food

Clitoria ternatea commonly known as 'Chandrakantha' in Uttar Pradesh and 'Titali matar' in Rajasthan is a drought resistant legume (Bogdan,1997) and is introduced in the pastures of arid and semi arid regions of Rajasthan. It grows in grasslands and waterlogged black clay wastelands upto 1500 feet altitude. The recommended strains are CAZRI-1443, '466', tranquilizing and antidepressant activities (Singh *et al.*, 1979) in experimental rats. Experimental diabetic rats fed with ethanol extract of *Clitoria ternatea* flowers significantly lowered the serum sugar level, which indicated its antidiabetic activity (Sharma and Majumdar,1990). Home *et al.* (1992) formulated a hair oil containing *Clitoria ternatea* for the management of *Alopecia areata* (loss of scalp hair). The root of *Clitoria ternatea* is regarded as a good brain tonic in the indigenous system of medicine (Upadhye and Kumbhojkar, 1993). It is an ingredient of *medhyarasayana*, which on administration improved behavioural impairments in mentally retarded people (Ajith,1993) and IQ (intelligence quotient), haemoglobin content and digestive power in children (Jessy,1995). Rao (1997) reported the use of *Clitoria ternatea* in the palliative treatment of skin diseases.

The therapeutic uses of *Clitoria ternatea* L. are illustrated in Table 2 with reference.

2.8.2 *Clitoria* as fodder and food

Clitoria ternatea commonly known as 'Chandrakantha' in Uttar Pradesh and 'Titali matar' in Rajasthan is a drought resistant legume (Bogdan,1997) and is introduced in the pastures of arid and semi arid regions of Rajasthan. It grows in grasslands and waterlogged black clay wastelands upto 1500 feet altitude. The recommended strains are CAZRI-1443, '466',

Table 2 Therapeutic uses of *Clitoria ternatea* L.

Part	Therapeutic uses	Reference
Root	emetic; aperient; diuretic; emmenagogue, antidote to scorpion sting; antiperiodic; cathartic; against snake bite	Lindley, 1838; Rajan, 1926; Dutt, 1928; Crevost and Petelot, 1929; Chopra *et al.*, 1949; Hocking, 1955; Gardner and Bennett, 1956; Chopra *et al.*, 1958.
Root bark	demulscent; against gonorrhea; laxative	Sanyal and Ghose, 1934; Dastur, 1962; Sheriff, 1891.
Leaf	ear ache and skin eruption curative; against swollen glands; eczema curative; against head ache and ulcers;	Mukraji, 1889; Heyne, 1927; Hocking, 1955; Quisumbing, 1951; Chopra *et al.*, 1958; Dastur, 1962
Flower	eye inflammation curative; emmenagogue	Burkill, 1935; Morton, 1983.
Seed	antihelminthic; laxative; antidote and diuretic	Drury, 1873; Mesa, 1945; Duke, 1986.

'572' and 'IGFRI-23-1' and 'IGFRI-12-1' (Yadav, 1984). Wandera (1984) reported it as one of the most persistent legumes for pasture establishment under favourable conditions.

Clitoria ternatea is found to be a good feed for cattle. It is a productive type of roughage with high digestion coefficient of dry matter, crude protein, hemicellulose and cellulose. Katiyar *et al.* (1970) suggested it as a quality feed for sheep with digestibility of dry matter as high as 74 per cent. According to Ramratan *et al* (1982), the total digestible nutrients was 59.67 kg per 100 kg of dry matter of hay and nutritive ratio being 1:4.23. Barro and Riberio (1983) reported that the *Clitoria* yielded 18-19 t ha^{-1} of hay annually. Upadhyaya and Pachauri (1983) found that *Clitoria ternatea* hay cut at post-flowering stage contained 97.6 per cent dry matter, 13 crude protein, 2.5 ether extract, 23.6 crude fibre, 54.9 nitrogen-free extract, 6.1 per cent ash and gross energy of 4.15 k cal g^{-1}. According to Adjei and Fianu (1985) leaf crude protein content of *Clitoria* was 24 per cent and the yield was 26 t ha^{-1}. Pachauri and Patil (1985) opined that forage legumes formed an important part of rations of livestock, as they are rich in calcium, vitamin A, riboflavin, niacin and vitamin E. They also observed that *Clitoria*, had high protein content during 1^{st} and 2^{nd} month of growth.

Green pods of *Clitoria ternatea* are eaten as vegetables in Asia (Allen and Allen, 1981) and Kunkel (1984) reported that pods could be eaten like beans. Flowers and young pods are used as vegetables in Philippines (Rehm and Espig, 1991).

2.8.3 *Clitoria* as dyes and fibres

Clitoria ternatea is the only species of the genus reported to be used as a dye plant. Burkill (1935) suggested that the juice of leaves of *Clitoria* could be used to impart green colour to food. Blue flowers were boiled with rice to give it a bluish tinge (Uphof, 1968 and Abbiw, 1990) and to dye mats (Allen and Allen, 1981). Blue flowers gave temporary colour to white cloth (Burkill, 1935). The use of flowers as colourants were also reported by Kunkel (1984) and Ambasta (1986). Abbiw (1990) reported that both seeds and corolla were used as litmus substitute.

Stems of *Clitoria lasciva* are the source of a fibre used by natives of Madagascar for making ropes (Uphof, 1968).

2.8.4 *Clitoria* as an ornamental plant

Most species of *Clitoria* have potential for becoming economically important as ornamentals because of their large (4 - 8 cm long) showy flowers. White or pigmented (pink, blue to purplish) corolla often has yellow centre with dark red to violet veins extending to the margins.

Among ornamental *Clitoria,* climbing species are the well-accepted ones. Most tropical Floras cite *C. ternatea* as cultivated and an escapee. Other species cited as ornamentals include *C. mariana, C. fairchildiana,* and *C. falcata* (Allen and Allen, 1981) and *C. javitensis* (Standley, 1933).

Breyne (1678) reported that *C. ternatea* is most widely cultivated ornamental in East Africa. The cultivated species of ornamental value are double flowered forms called as *Clitoria ternatea* var *pleniflora* (Commelin, 1701), white-flowered forms called as *Clitoria ternatea* var *ternatea f. albiflora* (Tournefort, 1706) and *Clitoria heterophylla* (Curtis, 1820). Petiver (1704) reported the cultivation of *Clitoria mariana* for ornamental purpose in United States. *Clitoria cajanifolia* is a subshrub species of *Clitoria* that is native to neo-tropics (Holland and Joachin, 1933).

2.9 Intercropping of medicinal plants in coconut shade

Inter or mixed cropping in coconut gardens is very popular in the important coconut growing states of India. The major objectives in inter- cropping is to produce an additional crop without affecting too much the yield of base crop, to obtain higher economic returns, to optimize the use of natural resources including light, water and nutrients (Donald, 1963) and to stabilize the yield of crop.

Kushwah *et al.* (1973) reported that the root zone of coconut palm is concentrated laterally to a radius of 2 m only and vertically between depths of 30cm and 120 cm from the surface.

Coconut has the advantage of having two periods (initially upto ten years after planting and again twenty years after upto senescence) in its life span during which it allows sufficient light to penetrate to the ground when intercropping could be practised (Nair *et al.*, 1974).

Growth habit of coconut palm and the pattern of its utilisation of soil nutrients and solar energy that permits other crops to grow in compatible combination was studied by Nair and Balakrishnan (1976) and Thampan (1982).

According to Leela and Bhaskaran (1978), only 28 per cent of the land area is utilised by coconut palm and the rest is available for intercropping.

The factor that decides the compatibility of a crop combination in a cropping system such as coconut culture is the ability of associated crops to come up under shade. According to Bai and Nair (1982), this ability varied between species of plants.

Intercropping is a source of additional income from coconut plantation (Pillai, 1985). Singh *et al.* (1990) reported successful intercropping of medicinal and cash crop in coconut garden.

Intercropping system is remunerative and gives yield advantage over sole crop provided it is properly planned and crops are not competitive to each other (Sanwi and Roy, 1990).

Jha and Gupta (1991) studied intercropping of medicinal plants with poplar and their phenology.

Nair *et al.* (1991) reported the possibility of growing thirteen medicinal and aromatic plants as intercrops in 8 - 20 year old coconut plantations when no other intercrops are usually recommended. The potential plants identified were greater galangal, periwinkle, iruveli, channakkuva, ocimum (3 species), koduveli, sarpagandha (2species), mangoginger and kacholam. Viswanathan *et al.* (1992,1993) observed that *Andrographis paniculata, Sida retusa, Coleus aromaticus and Maranta arundinaceae* are also well suited to grow under shaded condition.

2.10 Legumes as intercrop in coconut shade

Legumes have an important role in the intercropping system because of their potential to transfer the excreted nitrogen to the associated non-legumes (Virtanen *et al.*, 1937 and Ruschel *et al.*, 1979).

Tremendous potentialities of intercropping with promising legumes exist in coconut plantations. Nair *et al.* (1974) is of the view that shade tolerant short duration crops such as horse gram, black gram and green gram can be recommended for raising under coconut trees taking advantage of north east monsoon rains.

Almost all tropical grain legumes are very sensitive to partial shade existing in coconut garden (Nair, 1979). Grain legumes are potential intercrops because of the relatively short duration and high protein content. Zakra *et al.* (1986) suggested groundnut as a suitable intercrop in coconut garden. Soybean is yet another legume suitable for intercropping in coconut garden according to Gautham and Lamba (1988). Lourduraj *et al.*, (1992) observed that in intercropping system under coconut, cowpea, groundnut, black gram and green gram recorded a mean pod yield of 825 kg ha^{-1}, 680 kg ha^{-1}, 221kg ha^{-1} and 353 kg ha^{-1} respectively.

Sunitha (1996) reported that biomass yield of *Clitoria ternatea* in coconut shade was 2.3 t ha^{-1}.

2.11 Residual effect of intercropping on soil

Ayyangar (1942) found that intercropped legumes increased the available phosphorus, potassium and calcium in soil. Singh and Chatterjee (1968) reported that nitrogen accumulated in the soil wherever legumes grow well. The available phosphorus content of the soil increased with crop sequences inclusive of legumes (Sharma and Singh, 1970).

White *et al.* (1976) opined that growing forage grasses increased nitrogen content of the soil. Skerman (1977) recorded more nitrogen fixation in shade than in open areas.

Pillai (1985) noted a reduction in soil pH due to intercropping. He also found a reduction in available nitrogen content of the soil where as the phosphorus and potassium content of the soil were not much affected by intercropping.

Bindhu (1999) reported that available phosphorus content of the soil increased with crop sequences inclusive of legumes.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present study entitled 'Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea*.L.) for yield, alkaloid content and nitrogen fixing potential' was conducted at the Department of Horticulture, College of Agriculture, Vellayani from June 1999 to January 2000. The details of the materials used and the techniques adopted for the study are esented in this chapter.

The work was carried out in four phases *viz.*,

Collection of accessions of *Clitoria ternatea.*

2. Seed characterization and germination studies.

3. Cultural trial of selected accessions under shade in coconut garden.

4. Phytochemical analysis.

3.1 PHASE I : Collection of accessions of *Clitoria ternatea*

Seeds of twenty different accessions of *Clitoria ternatea* were collected from inside and outside the state. The accessions were duly registered in the Medicinal and Aromatic plant accession register of the Department of Horticulture, College of Agriculture, Vellayani and accession numbers were allotted.

3.2 PHASE II : Seed characterization and germination studies

Observations such as hundred seed weight, seed colour and description of external appearance of the seeds were made on each accession. Details of 20 accessions of *C. ternatea* collected for the study are presented in Table 3.

The viability of seeds collected was estimated as described below. Thirty seeds of each accession were surface sterilized using 0.1 per cent mercuric chloride for one minute and then washed thrice with distilled water. They were then placed on moistened filter paper in petri dishes. Seeds were considered to have germinated when the radicle emerged out of the seed coat. Seed germination count was taken from the second day and germination percentage of each accession was worked out. The number of days taken for 50 per cent seed germination in each accession was also recorded.

3.3 PHASE III. Cultural trial of selected accessions under shade in coconut garden

3.3.1 Experimental site

The site is located at 8^{O} 5' North latitude, 77^{O} 1' East latitude and at 29m above MSL. Soil of the experimental site is red loam belonging to

Plate 1 Field view of the experimental plot

A. General view
B. Plants trailed on stakes

Table 3 Details of *Clitoria ternatea* accessions colleted for the study

Sl. No.	Acession No.	Date of collection	Source / place of collection	Flower colour& type
1.	*MP – 73	10. 1. 99	Thiruvattar	White, single floret
2.	*MP – 74	18. 1. 99	Vattiyoorkavu	Blue, single floret
3.	MP – 75	20. 1. 99	Plamoodu	Blue, double floret
4.	*MP – 76	23 . 1. 99	Vattiyoorkavu	White, single floret
5.	MP – 77	25. 1. 99	Ayurveda College	White, single floret
6.	*MP – 78	25. 1. 99	Vazhuthacaud	White, single floret
7.	*MP – 79	30. 1. 99	Parassala	Blue, single floret
8.	*MP – 80	5. 2. 99	Muvattupuzha	Blue, single floret
9.	*MP – 81	16. 2. 99	Vellayani	Blue, double floret
10.	*MP – 82	20. 2. 99	Vellayani	Blue, single floret
11.	*MP – 83	22. 2. 99	Thirumala	Blue, single floret
12.	MP – 84	30. 2. 99	Thovala	Blue, single floret
13.	*MP – 85	15. 3. 99	Thirumala	White, single floret
14.	MP – 86	15. 3. 99	Thirumala	Purple, single floret
15.	*MP – 87	16. 3. 99	Kachani	White, single floret
16.	*MP – 88	16. 3. 99	Kachani	Blue, single floret
17.	MP – 89	21. 3. 99	Coimbatore	Blue, Single floret
18.	*MP – 90	25. 3. 99	Thiruvattar	Blue, single floret
19.	MP-91	27.3.99	Poojappura	Blue, single floret
20.	MP – 92	27 .3. 99	Poojapura	White, single floret

The marked (*) accessions are selected for the cultural trail

Plate 2 Natural variations in *Clitoria ternatea* accessions: floral characters

A. Blue single floret
B. Blue double floret
C. White flower
D. Pale pink flower


A
B
Ç
D

Vellayani series. The area enjoys a humid tropical climate. An eighteen year old coconut garden was selected for the trial

3.3.2 Weather

Climatic parameters like temperature, relative humidity, rainfall and number of rainy days are presented in Annexure – I.

3.3.3 Experimental design and lay out

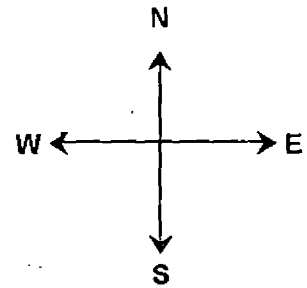
The experiment was laid out in randomised block design with two replications. Based on germination studies, 13 accessions (MP-73, MP-74, MP-76, MP-78, MP-79, MP-80, MP-81, MP-82, MP-83, MP-85, MP-87, MP-88 and MP-90) were selected for cultural trial. Ninety plants of each accession were maintained in each plot at a spacing of 60 x 60 cm. Plot size was 6.0 x 5.4 m. The lay out of the experimental plot is presented in Fig 1.

Destructive sampling was done at pre-flowering, flowering, seeding and seed maturation stages. Six plants per plot per replication were utilised for the periodic sampling. After taking biometric observations, samples were partitioned to stem, roots, flowers and pods for growth and yield analysis.

3.3.4 Field preparation and sowing

The land was thoroughly prepared by digging and levelling. Dried and powdered cow dung was incorporated at the rate of 3 kg m^{-2}. Seeds were sown in polyethene covers filled with sand and watered daily. Seedlings were

Fig 1. Layout of the experimental plot



Replication I	MP 74	MP 76	MP 79	MP 80	MP 82	MP 78	MP 81	MP 87	MP 88	MP 85	MP 83	MP 73	MP 90
Replication II	MP 76	MP 74	MP 87	MP 85	MP 73	MP 88	MP 90	MP 83	MP 81	MP 78	MP 82	MP 79	MP 80

transplanted three weeks after sowing. Staking was done using casurina poles one month after transplanting.

Chemical fertilizers and plant protection chemicals were not applied as the plants were intended for use in ayurvedic pharmaceutical industry.

3.3.5 Growth parameters

Biometric observations were recorded at four plant growth stages, *viz.*, 1.Pre-flowering stage (50 DAS), 2. Flowering stage (100 DAS), 3. Seeding stage (150 DAS) and 4. Seed maturation stage (200 DAS).

3.3.5.1 Plant length (cm)

Plants, marked at random for periodical harvest and observation, were uprooted and plant length was measured from the collar region to the tip of the plant.

3.3.5.2 Number of leaves per plant

Number of leaves in each observational plant were counted and recorded.

3.3.5.3 Leaf area (cm^2)

Leaf area of the observational plants was measured using a LI- 3100 leaf area meter.

3.3.5.4 Number of pods per plant.

Number of pods in each observational plant were counted and recorded.

3.3.5.5 Pod length (cm)

The length of ten pods selected at random from each observational plant was measured during the seed maturation stage using a measuring scale.

3.3.5.6 Number of seeds per pod

Number of seeds in each pod of the observational plants were counted and the mean value was worked out.

3.3.5.7 Root length (cm)

Observational plants were uprooted and taproots and lateral roots were held together. Root length of each observational plant was measured from the collar region to the farthermost tip of the root system.

3.3.5.8 Root girth (cm)

Root girth at collar region was measured in each observational plant using a thread and measuring scale.

3.3.6 Root nodules

3.3.6.1 Number of effective root nodules

Effective root nodules were detached from the root system of observational plants and their total count per plant was recorded.

3.3.6.2 Fresh and dry weight of root nodules (g)

Fresh weight of effective root nodules obtained from each observational plant was taken using a Sartorius analytic electronic balance. Root nodules were then dried in a hot air oven (Kemi) at 60°C for three days until consistent dry weights were obtained.

3.3.7 Yield attributes

3.3.7.1 Fresh and dry weight of leaves (g)

Fresh weight of leaves of each observational plant was taken separately using a Digiweigh (IIPA scale) Model ITB 22/01 electronic balance. Leaf samples were then dried in a hot air oven (Kemi) at 60°C for five days until consistent dry weights were obtained.

3.3.7.2 Fresh and dry weight of shoots (g)

Fresh weight of shoot portion of each observational plant was taken. The samples were then oven dried at 60°C until consistent dry weights were obtained.

3.3.7.3 Fresh and dry weight of roots (g)

Fresh and dry weight of the root portion of each observational plant was taken in a similar manner as described above.

3.3.7.4 Fresh and dry weight of pods (g)

The pods from observational plants were collected and fresh weight was recorded. The pods were then dried in a hot air oven at 60°C until consistent dry weights were obtained.

3.3.8 Physiological parameters

3.3.8.1 Leaf area index (LAI)

Leaf area was measured using a LI- 3100 leaf area meter and LAI was worked out as per the method suggested by Williams (1946).

$$\text{LAI} = \frac{\text{Total leaf area of the plant } (m^2)}{\text{Area of land covered by the plant } (m^2)}$$

3.3.8.2 Leaf area duration (LAD) (days)

Leaf area duration was calculated using the formula of Power *et al.* (1967).

$$\text{LAD} = \frac{(L_1 + L_2) \times (T_2 - T_1)}{2}$$

where,

L_1 = LAI at time T_1

L_2 = LAI at time T_2

3.3.8.3 Net assimilation rate (NAR) (g $m^{-2}day^{-1}$)

The method proposed by Williams (1946) was employed for calculating NAR on leaf dry weight basis.

$$NAR = \frac{(W_2 - W_1)\ (\log_e W_2 - \log_e W_1)}{(T_2 - T_1)\ (L_2 - L_1)}$$

where,

W_1, W_2 : dry weights of whole plants in g at time T_1 and T_2 respectively.

L_1, L_2 : leaf area of the plant in m^2 at the time T_1 and T_2 respectively.

$T_2 - T$: Time interval in days.

3.3.8.4 Crop growth rate (CGR) (g $m^{-2}day^{-1}$)

The CGR was calculated using the formula of Watson (1958).

$$CGR = \frac{(W_2 - W_1)}{P\ (T_2 - T_1)}$$

where,

W_1, W_2 : Whole plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: time interval in days.

P : ground area in m^2 on which W_1 and W_2 are estimated.

3.3.8.5 Relative growth rate (RGR) (g day^{-1})

The RGR was determined as per the formula of by Williams (1946).

$$RGR = \frac{\log_e W_2 - \log_e W_1}{(T_2 - T_1)}$$

where,

W_1, W_2 : plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: time interval in days.

3.3.8. 6 Absolute growth rate (AGR) (g day^{-1})

The AGR was determined using the formula given by Watson (1958).

$$AGR = \frac{(W_2 - W_1)}{(T_2 - T_1)}$$

where,

W_1, W_2 : Plant dry weights in g at time T_1 and T_2

$T_2 - T_1$: Time interval in days

3.3.8.7 Harvest index (H I)

Harvest index was calculated in terms of pod yield and root yield. Havest index (pod yield) was worked out from the data of pod yield and biological yield (total plant dry matter) and harvest index (root yield) from root yield and biological yield (total plant dry matter). Harvest Index was determined using the formula.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.4 PHASE IV : Phytochemical observations

3.4.1 Soil NPK analysis before and after the experiment (kg ha^{-1})

Soil samples were drawn individually from every plot before the commencement of experiment and after the harvest of the crop. Samples were taken at 0 - 15 cm depth, shade dried and passed through a 2 mm size.

The status of available nitrogen was estimated using the alkaline potassium permanganate method. (Subbiah and Asija, 1956).

The available phosphours content was estimated using Bray's colourimetric method (Jackson, 1973).

The ammonium acetate method given by Jackson (1973) was used to estimate the available potassium.

3.4.2 Nitrogen content of the plant (per cent)

The plant samples were oven dried for five days at 60°C and were ground and passed through a 20-mesh sieve and subjected to acid extraction. Nitrogen content of the plant was determined by modified Kjeldahl method (Piper, 1966).

3.4.3 Crude alkaloid content (per cent)

The crude alkaloid content of the medicinally important plant part was estimated gravimetrically by solvent extraction of the powdered material. (Sunitha, 1996).

3.4.3.1 Extraction of alkaloids

The powdered material was eluded with lime solution. The solution was filtered and the filtrate was taken in a separating funnel. 80 ml of ether (organic solvent) was added. The solvent layer was retained in the funnel and was treated with dilute sulphuric acid (1:4 dilution), to get the alkaloid precipitated. This was then filtered through a muslin cloth and was air dried. A light brown precipitate was obtained. It was weighed until consistent weights were obtained.

3.4.4 Incidence of pests and diseases

Throughout the duration of the crop, periodical surveilance was conducted for detection of pests and diseases.

Statistical Analysis

Qualitative as well as quantitative parameters of thirteen accessions under trial were recorded from six observational plants at four different stages of growth. Data relating to each parameter were analysed by applying the analysis of variance technique as applied to randomised block design described by Cochran and Cox (1965) and the significance was tested by F test (Snedecor and Cochran,1967). In cases where the effects were found to be significant, CD values were calculated by using standard technique.

Selection indices were worked out through the application of discriminant function proposed by Smith (1936). The characters used for the construction of selection index were shoot yield, root yield, seed yield, nodule characters *viz.*, nodule count and nodule weight (on dry weight basis) and crude alkaloid content. Separate selection indices were worked out for root and pod yield; root, shoot and pod yield; and root yield, shoot yield & pod yield, root nodule number & root nodule weight and crude alkaloid content.

RESULTS

4. RESULTS

The results of the study on 'Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea*.L) for yield, alkaloid content and nitrogen fixing potential' are presented in this chapter. Phase I consists of collection of accessions of *Clitoria ternatea*. Phase II consists of seed characterization and germination studies. Phase III consists of cultural trial of selected accessions under shade in coconut garden and phase IV consists of phytochemical analysis.

4.1 PHASE I : Collection of accessions of *Clitoria ternatea*

Seeds of different accessions of *Clitoria ternatea* were collected from inside and outside the state. List of collected accessions with their sources is given in Table 3

4.2 PHASE II : Seed characterization and germination studies

Seeds of twenty accessions collected were subjected to germination test. Observations on the hundred seed weight, seed colour, external appearance of seeds, germination percentage and days to fifty per cent germination were recorded for each accession. The results of the seed germination test are presented in Table 4.

Based on the results of seed germination test, 13 accessions which recorded higher percentage of seed germination were selected. Accessions selected were MP-73, MP-74, MP-76, MP-78, MP-79, MP-80, MP-81, MP-82, MP-83, MP-85, MP-87, MP-88 and MP-90.

4.3 PHASE III : Cultural trial of selected accessions under coconut garden

Thirteen selected accessions were raised under shade in coconut garden. Observations were made at four stages of growth *viz.*, Pre-flowering stage, flowering stage, seeding stage and seed maturation stage. The results of the experiments are presented in the following pages.

4.3.1 Growth parameters

4.3.1.1 Plant length

Plant length differed significantly among 13 accessions at all stages of growth. (Table 5)

At pre-flowering stage, maximum plant length was recorded by MP-80 (24.60 cm) closely followed by MP-76 (24.12 cm). MP-80 and MP-76 were on par. MP-81 (13.32 cm) and MP-83 (14.6 cm) recorded the least plant lengths, which were also on par.

Table 4 Seed characterization and germination studies of accessions of *Clitoria ternatea*

Sl. No.	Accession Number	Seed colour and external appearance	100 seed weight (g)	Seed germination percentage	No.of days to 50 per cent germination
1.	MP-73	Light brown and cylindrical	4.0	90	15
2.	MP-74	Brown seeds	5.5	80	21
3.	MP-75	Brown and bold seeds	4.5	7	0
4.	MP-76	Light brown and cylindrical seeds with white hilum	6.0	80	20
5.	MP-77	Very light brown and spotted seeds	6.0	0	0
6.	MP-78	Dark brown or black seeds	5.0	95	14
7.	MP-79	Light brown with black dots	6.0	80	22
8.	MP-80	Light brown with slightly dot and perfectly oval seeds	4.5	84	17
9.	MP-81	Dark brown with pure white hilum	5.5	75	20
10.	MP-82	Dark brown seeds	5.0	90	17
11.	MP-83	Brown and perfectly oval seeds	4.0	90	20
12.	MP-84	Dark brown with dark spots size of the seed is small	4.0	0	0
13.	MP-85	Light brown	5.0	75	22
14.	MP-86	Light brown	4.5	3	0
15.	MP-87	Light brown	6.0	82	17
16.	MP-88	Dark brown	6.0	84	18
17.	MP-89	Dark brown with white hilum	5.5	0	0
18.	MP-90	Brown seeds	5.0	90	16
19.	MP-91	Light brown	4.5	0	0
20.	MP-92	Light brown	4.0	10	0

Plate 3 Natural variation in *Clitoria ternatea* accessions : seed characters

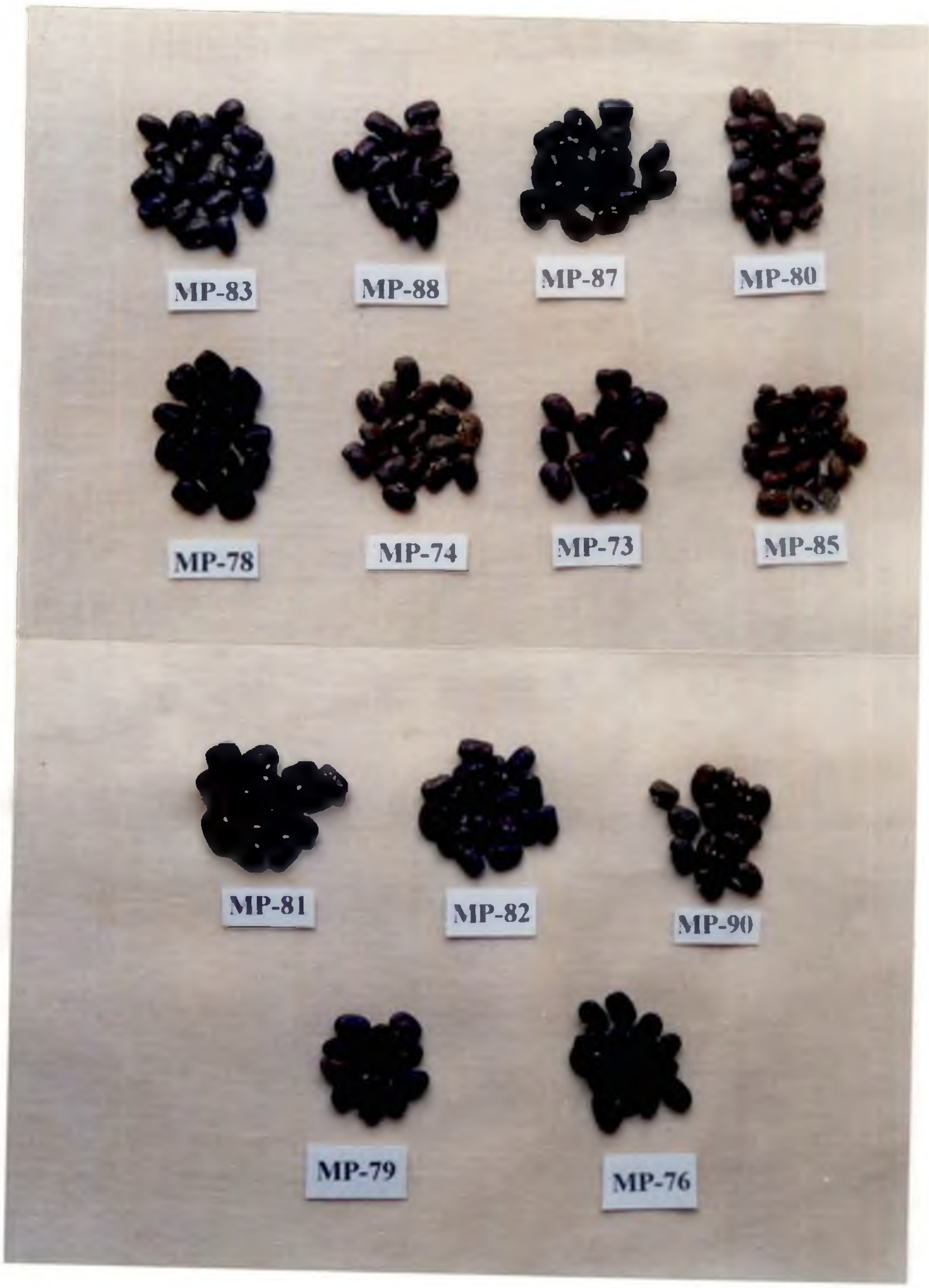

MP-83
MP-88
MP-87
MP-80
MP-78
MP-74
MP-73
MP-85
MP-81
MP-82
MP-90
MP-79
MP-76

Table 5 Growth parameters of *Clitoria ternatea* at four stages of plant growth: plant length (cm)

Sl. No.	Accession Number	Pre-flowering (50 DAS)	Flowering (100 DAS)	Seeding (150 DAS)	Seed maturation (200 DAS)
1.	MP-74	14.65	134.17	143.52	154.11
2.	MP-76	24.12	103.00	173.67	207.05
3.	MP-79	16.30	78.84	123.65	136.75
4.	MP-80	24.60	75.92	141.70	155.22
5.	MP-82	18.05	74.05	147.17	170.35
6.	MP-78	21.44	90.85	155.89	173.33
7.	MP-81	13.32	79.40	142.50	174.29
8.	MP-87	15.05	64.30	156.94	172.45
9.	MP-88	15.65	59.24	130.09	176.27
10.	MP-85	16.30	91.77	141.33	191.79
11.	MP-83	14.60	117.45	158.00	175.67
12.	MP-73	17.70	87 .07	136.00	169.50
13.	MP-90	17.53	109.88	151.77	192.50
	CD	1.22	1.42	2.24	1.28

DAS – Days after sowing

At flowering stage, maximum plant length was recorded by MP-74 (134.17 cm) followed by MP-83 (117.45 cm). Minimum plant length was recorded by MP-88 (59.24 cm).

At seeding stage, MP-76 recorded maximum plant length (173.67 cm) followed by MP-83 (158.00 cm). The least plant length was observed in MP-79 (123.65 cm) preceded by MP-88 (130.09 cm).

At seed maturation stage, significantly superior plant length was observed in MP-76 (207.05 cm). This was followed by MP-90 (192.50 cm) and MP-85 (191.79 cm). At this stage, the lowest plant length was observed in MP-79 (136.75 cm) preceded by MP-74 (154.11 cm) .

4.3.1.2 Number of leaves per plant

The number of leaves per plant showed significant difference among the accessions at all stages of growth (Table 6).

At pre-flowering stage, number of leaves per plant was the highest for MP-79 (6.45) followed by MP-81 (5.99) and they were on par. There was no significant difference in the number of leaves per plant between MP-81 (5.99), MP-80 (5.85) and MP-73 (5.67). At this stage, the lowest number of leaves per plant was recorded by MP-83 (3.67) preceded by MP-74 (4.17)

At flowering stage, MP-74 (100.22) recorded maximum number of leaves and was significantly superior to all other accessions. At this stage, the least number of leaves per plant was recorded by MP-81 (14.15) preceded by MP-80 (16.00).

At seeding stage, MP-90 recorded maximum number of leaves per plant (207.15), which was followed by MP-74 (175.67) and MP-76 (166.34). The lowest number of leaves per plant was observed in MP-79 (30.67) preceded by MP-80 (47.00).

At seed maturation stage, number of leaves per plant was significantly superior in MP-90 (190.00). Minimum value was observed in MP-79 (26.15) preceded by MP-80 (34.50).

4.3.1.3 Leaf area

Leaf area varied significantly among accessions at all stages of plant growth. (Table 6)

At pre-flowering stage leaf area was maximum in MP-79 (306.35 cm^2) followed by MP-81 (265. 86 cm^2). Minimum leaf area was observed in MP-78 (147.07 cm^2) preceded by MP-83 (159.72 cm^2), which were on par.

Table 6 Growth parameters of *Clitoria ternatea* at four stages of plant growth: number of leaves per plant and leaf area (cm^2)

Sl. No.	Accession Number	Pre-flowering (50 DAS)		Flowering (100 DAS)		Seeding (150 DAS)		Seed maturation (200 DAS)	
		No. of leaves	Leaf area (cm^2)	No. of leaves	Leaf area (cm^2)	No. of Leaves	Leaf area (cm^2)	No. of leaves	Leaf area (cm^2)
1.	MP-74	4.17	168.65	100.22	4053.75	175.67	7109.17	81.67	3304.99
2.	MP-76	5.15	224.34	29.34	1273.73	166.34	7222.27	97.00	4211.74
3.	MP-79	6.45	306.35	17.35	817.71	30.67	1445.32	26.15	1232.45
4.	MP-80	5.85	177.80	16.00	487.68	47.00	1432.51	34.50	1051.56
5.	MP-82	5.15	216.38	29.00	1214.52	98.50	4125.18	87.33	3657.52
6.	MP-78	4.50	147.07	24.85	811.85	127.67	4170.87	113.34	3702.66
7.	MP-81	5.99	265.86	14.15	626.99	66.33	2939.12	43.84	1941.00
8.	MP-87	5.00	204.65	18.50	757.27	91.50	3745.10	76.67	3137.97
9.	MP-88	5.00	170.85	20.00	683.40	73.50	2511.50	62.67	2141.27
10.	MP-85	5.15	189.62	38.50	1412.95	105.33	3865.73	85.00	3119.50
11.	MP-83	3.67	159.72	23.15	1008.42	87.35	3804.97	84.84	3695.42
12.	MP-73	5.67	237.72	34.67	1454.41	163.02	6838.50	103.67	4348.80
13.	MP-90	4.80	219.48	44.84	2035.96	207.15	9407.39	190.00	8627.15
	CD	0.47	19.84	1.83	74.63	2.01	81.76	1.53	63.45

DAS – Days after sowing

At flowering stage, maximum leaf area was observed in MP-74 (4053. 75 cm^2) followed by MP-90 (2035.96 cm^2). The least leaf area was recorded in MP-80 (487.68 cm^2) preceded by MP-81 (626. 99 cm^2).

At seeding stage, leaf area was significantly superior in MP-90 (9407.39 cm^2). This was followed by MP-76 (7222.27 cm^2). Minimum leaf area in this stage was observed in MP-80 (1432.51 cm^2). This was preceded by MP-79 (1445.32 cm^2). MP 80 and MP 79 were on par.

At seed maturation stage, the highest leaf area was recorded in MP-90 (8627.15 cm^2), which was followed by MP-73 (4348.8 cm^2) and MP-76 (4211. 74 cm^2). MP-80 recorded the lowest leaf area (1051.56 cm^2) among the accessions.

4.3.1.4 Number of pods per plant

Significant differences were observed among accessions in seeding and seed maturation stage with respect to number of pods per plant (Table 7).

At seeding stage MP-83 recorded maximum number of pods per plant (13.5) followed by MP-87 (12.17). This was the least in MP-81 (4.17) and was preceded by MP-88 (5.5) and MP-74 (5.5).

At seed maturation stage, number of pods per plant was significantly superior, in MP-83 (37.97). This was followed by MP-87 (31.35). Number of pods per plant was the least in MP-81 (9.85).

4.3.1.5 Pod length

Pod length showed significant variation among accessions in seeding and seed maturation stages. (Table 7)

MP-79 recorded maximum pod length (7.19 cm) at seeding stage followed by MP-76 (6.94 cm). The least length was recorded in MP-81 (5.08 cm) and MP-87 (6.05 cm), which were on par.

Maximum pod length was observed in MP-79 (10.30 cm) at seed maturation stage. This was followed by MP-88 (9.90 cm) and MP-76 (9.85 cm). Minimum pod length was recorded in MP-81 (8.00 cm) followed by MP-74 (8.25 cm), which were on par.

4.3.1.6 Number of seeds per pod.

Number of seeds per pod showed significant variation among accessions at seeding and seed maturation stages.(Table 7)

At seeding stage, MP-76 and MP-90 recorded the highest number of seeds per pod (7.8 each). This was on par with MP-78 (7.6), MP-73 (7.6) and MP-83 (7.5). The lowest number of seeds per pod was recorded in MP-81 (5.8).

Table 7 Growth parameters of *Clitoria ternatea* at seeding and seed maturation stages: number of pods per plant, pod length (cm) and number of seeds per pod

Sl. No.	Accession Number	Seeding (150 DAS)			Seed maturation (200 DAS)		
		No.of pods per plant	Pod length	No.of seeds per pod	No.of pods per plant	Pod length	No.of seeds per pod
1.	MP-74	5.50	6.60	6.40	17.35	8.25	7.55
2.	MP-76	6.30	6.94	7.80	18.50	9.85	8.40
3.	MP-79	5.50	7.19	6.90	15.85	10.30	7.40
4.	MP-80	6.34	6.82	7.10	18.20	9.80	7.75
5.	MP-82	11.67	6.57	6.50	30.00	8.90	7.05
6.	MP-78	8.50	6.52	7.60	23.35	9.10	8.45
7.	MP-81	4.17	5.08	5.80	9.85	8.00	6.50
8.	MP-87	12.17	6.05	6.70	31.35	9.00	7.70
9.	MP-88	5.50	6.60	6.30	15.85	9.90	7.40
10.	MP-85	9.17	6.57	7.00	25.00	9.00	7.50
11.	MP-83	13.50	6.75	7.50	37.97	9.43	8.35
12.	MP-73	6.98	6.50	7.60	19.82	8.85	8.35
13.	MP-90	9.50	6.39	7.80	25.45	9.45	8.60
	CD	0.15	0.04	0.57	3.41	0.26	0.18

DAS - Days after sowing

At seed maturation stage number of seeds per pod was the highest in MP-90 (8.60). This was on par with MP-78 (8.45). Minimum number of seeds per pod was observed in MP-81 (6.50) followed by MP-82 (7.05).

4.3.1.7 Root length

Root length differed significantly among accessions at all stages of observation. (Table 8)

At pre-flowering stage, maximum root length was observed in MP-81 (11.38 cm) followed by MP-76 (10.45 cm). MP-76 (10.45 cm), MP-73 (10.24 cm) and MP-87 (10.20 cm) were on par. Root length was the least in MP-88 (4.80 cm) preceded by MP-83 (6.15 cm).

At flowering stage, root length was the highest in MP-74 (38.50 cm) followed by MP-88 (29.75 cm), MP-79 (28.5 cm) and MP-76 (28.5 cm). Minimum root length was recorded in MP-73 (15.05 cm) preceded by MP-78 (21.77 cm).

At seeding stage, root length was the highest in MP-74 (46.55 cm) followed by MP-90 (43.15 cm) and MP-87 (42.15 cm). Minimum root length was observed in MP-85 (29.79 cm) preceded by MP-80 (33.17 cm).

At seed maturation stage, maximum root length was recorded in MP-87 (40.33 cm), followed by MP-74 (38.84 cm). MP-74, MP-83 (38.57 cm) and MP-81 (37.95 cm) were on par. The lowest root lengths

Table 8 Growth parameters of *Clitoria ternatea* at four stages of plant growth: root length (cm) and root girth (cm)

Sl. No.	Accession Number	Pre-flowering (50DAS)		Flowering (100 DAS)		Seeding (150DAS)		Seed Maturation (200 DAS)	
		Root length	Root girth	Root length	Root girth	Root length	Root girth	Root length	Root girth
1.	**MP-74**	9.70	1.02	38.50	2.03	46.55	2.65	38.84	2.25
2.	**MP-76**	10.45	0.68	28.50	1.40	34.88	1.90	25.42	1.67
3.	**MP-79**	7.20	0.60	28.50	1.15	35.60	1.35	32.00	1.10
4.	**MP-80**	7.65	0.84	24.30	1.25	33.17	1.39	30.60	1.19
5.	**MP-82**	8.12	0.93	23.14	1.10	35.45	1.75	32.25	1.43
6.	**MP-78**	9.47	0.97	21.77	1.35	37.42	1.92	31.53	1.45
7.	**MP-81**	11.38	1.08	26.50	1.30	41.42	1.65	37.95	1.50
8.	**MP-87**	10.20	1.04	24.30	1.45	42.15	1.83	40.33	1.70
9.	**MP-88**	4.80	0.87	29.75	1.45	33.51	.2.00	27.89	1.90
10.	**MP-85**	6.44	0.77	25.85	1.50	29.79	1.80	24.20	1.70
11.	**MP-83**	6.15	1.05	22.33	1.47	41.62	1.80	38.57	1.67
12.	**MP-73**	10.24	0.95	15.05	1.20	33.70	1.88	29.17	1.40
13.	**MP- 90**	8.52	0.92	23.30	1.50	43.15	2.50	34.17	2.40
	CD	0.83	0.09	1.03	0.12	0.94	0.09	1.47	0.04

DAS –Days after sowing

were observed in MP-85 (24.2 cm) and MP-76 (25.42 cm), which were on par.

4.3.1.8 Root girth.

Root girth varied significantly among accessions all stages of plant growth (Table 8).

At pre-flowering stage maximum root girth was observed in MP-81 (1.08 cm). This was on par with MP-83 (1.05 cm), MP-87 (1.04 cm) and MP-74 (1.02 cm). Root girth was the least for MP-79 (0.60 cm) followed by MP-76 (0.68 cm), which were on par.

At flowering stage, MP-74 (2.03 cm) recorded maximum root girth followed by MP-85 (1.50 cm), MP-90 (1.50 cm), MP-83 (1.47 cm), MP-87 (1.45 cm), MP-88 (1.45 cm) and MP-76 (1.40 cm). MP-85, MP-90, MP-83, MP-87, MP-88 and MP-76 were on par. However, MP-74 was significantly superior. The lowest root girth was recorded in MP-82 (1.10 cm). This was on par with MP-73 (1.20 cm) and MP-79 (1.15 cm).

At seeding stage, root girth was maximum in MP-74 (2.65 cm) followed by MP-90 (2.50 cm) and MP-88 (2.00 cm). The least value was recorded in MP-79 (1.35 cm). This was on par with MP-80 (1.39 cm).

Table 8 Growth parameters of *Clitoria ternatea* at four stages of plant growth: root length (cm) and root girth (cm)

Sl. No.	Accession Number	Pre-flowering (50DAS)		Flowering (100 DAS)		Seeding (150DAS)		Seed Maturation (200 DAS)	
		Root length	Root girth	Root length	Root girth	Root length	Root girth	Root length	Root girth
1.	MP-74	9.70	1.02	38.50	2.03	46.55	2.65	38.84	2.25
2.	MP-76	10.45	0.68	28.50	1.40	34.88	1.90	25.42	1.67
3.	MP-79	7.20	0.60	28.50	1.15	35.60	1.35	32.00	1.10
4.	MP-80	7.65	0.84	24.30	1.25	33.17	1.39	30.60	1.19
5.	MP-82	8.12	0.93	23.14	1.10	35.45	1.75	32.25	1.43
6.	MP-78	9.47	0.97	21.77	1.35	37.42	1.92	31.53	1.45
7.	MP-81	11.38	1.08	26.50	1.30	41.42	1.65	37.95	1.50
8.	MP-87	10.20	1.04	24.30	1.45	42.15	1.83	40.33	1.70
9.	MP-88	4.80	0.87	29.75	1.45	33.51	.2.00	27.89	1.90
10.	MP-85	6.44	0.77	25.85	1.50	29.79	1.80	24.20	1.70
11.	MP-83	6.15	1.05	22.33	1.47	41.62	1.80	38.57	1.67
12.	MP-73	10.24	0.95	15.05	1.20	33.70	1.88	29.17	1.40
13.	MP- 90	8.52	0.92	23.30	1.50	43.15	2.50	34.17	2.40
	CD	0.83	0.09	1.03	0.12	0.94	0.09	1.47	0.04

DAS –Days after sowing

At seed maturation stage, MP-90 (2.40 cm) recorded the highest root girth followed by MP-74 (2.25 cm). Minimum root girth was recorded in MP-79 (1.10 cm) preceded by MP-80 (1.19 cm).

4.3.2 Nodule characters

4.3.2.1 Number of effective root nodules per plant

Number of effective root nodules varied significantly among accessions in the pre-flowering, flowering and seeding stages. Number of root nodules increased upto seeding but were absent in the seed maturation stage (Table 9).

At pre-flowering stage, maximum number of effective nodules was observed in MP-79 (4.0) and MP-81 (4.0). This was followed by MP-78 (3.5), MP-88 (3.33), MP-87 (3.2) and MP-74 (3.0). MP-79, MP-81, MP-78, MP-88, MP-87 and MP-74 were on par. The lowest number of nodules was observed in MP-90 (2.0). This was on par with MP-73 (2.17), MP-83 (2.17), MP-82 (2.5), MP-76 (2.5), MP-85 (2.67), MP-80 (2.84) and MP-74 (3.0).

At flowering stage, MP-90 (12.15) recorded the maximum number of effective nodules. This was on par with accessions MP-78 (11.5), MP-85 (11.2), MP-79 (9.0), MP-83 (9.0), MP-88 (8.65) and MP-73 (8.65). Minimum number of nodules was observed in MP-74 (3.94). This was on par with accessions MP-87 (4.0), MP-81 (4.7) MP-80 (7.3), MP-76 (7.5) and MP-82 (7.52).

At seeding stage, number of effective nodules was the highest in MP-76 (24.34) followed by MP-82 (22.83) and MP-83 (19.7). MP-83 (19.7), MP-78 (19.67), MP-74 (19.34) and MP-73 (18.17) were on par. MP-81 (16.5), MP-90 (15.5) and MP-79 (14.0) did not show significant difference. The least value was observed in MP-88 (9.70). This was on par with MP-80 (11.00) and MP-85 (11.30).

Nodules were absent at seed maturation stage in all the 13 accessions.

4.3.2.2 Fresh weight and dry weight of root nodules

Fresh weight of effective root nodules did not show significant difference at pre-flowering stage (Table 9). Maximum fresh weight was observed in MP-79 (0.05 g) and MP-81 (0.05 g). The lowest fresh weight of the root nodules was recorded in MP-90 (0.03 g), MP-87 (0.03 g), MP-88 (0.03 g) and MP-82 (0.03 g).

Dry weight of root nodules, however varied significantly among the accessions at this stage. The highest dry weight was recorded in MP-88 (0.023 g) followed by MP-81 (0.018 g). The least dry weight was observed in MP-82 (0.003 g). This was preceded by MP-80 (0.004 g) and MP-76 (0.004 g), which were on par with MP-82.

At flowering stage, fresh weight and dry weight of effective root nodules differed significantly among the accessions. At this stage, maximum fresh weight of effective root nodules was recorded in MP-83 (0.37 g) followed by MP-85 (0.32 g), which were on par. MP-82 (0.22 g), MP-73 (0.22 g) and MP-90 (0.22 g) were on par with MP-85. MP-82, MP-73 and MP-90 did not vary significantly from MP-78 (0.19 g), MP-80 (0.17 g), MP-79 (0.17 g), MP-76 (0.15 g), MP-81 (0.15 g), MP-88 (0.15 g) and MP-87 (0.12 g). The least value was recorded in MP- 74 (0.07 g) followed by MP-87 (0.12 g). MP-74 was on par with MP-78, MP-80, MP-79, MP-76, MP-81, MP-88 and MP-87.

At flowering stage, dry weight was maximum in MP-85 (0.112 g). This was on par with MP-88 (0.107 g), MP-83 (0.092 g) and MP-81 (0.083 g). Minimum dry weight was observed in MP-74 (0.012 g) preceded by MP-82 (0.015 g) and MP-76 (0.016 g). MP-74 was on par with MP-82, MP-76, MP-80 (0.018 g), MP-87 (0.020 g), MP-79 (0.030 g), MP-73 (0.030 g), MP-90 (0.33 g) and MP-78 (0.037 g).

At seeding stage, fresh weight and dry weight of effective root nodules varied significantly among the accessions (Table 9).

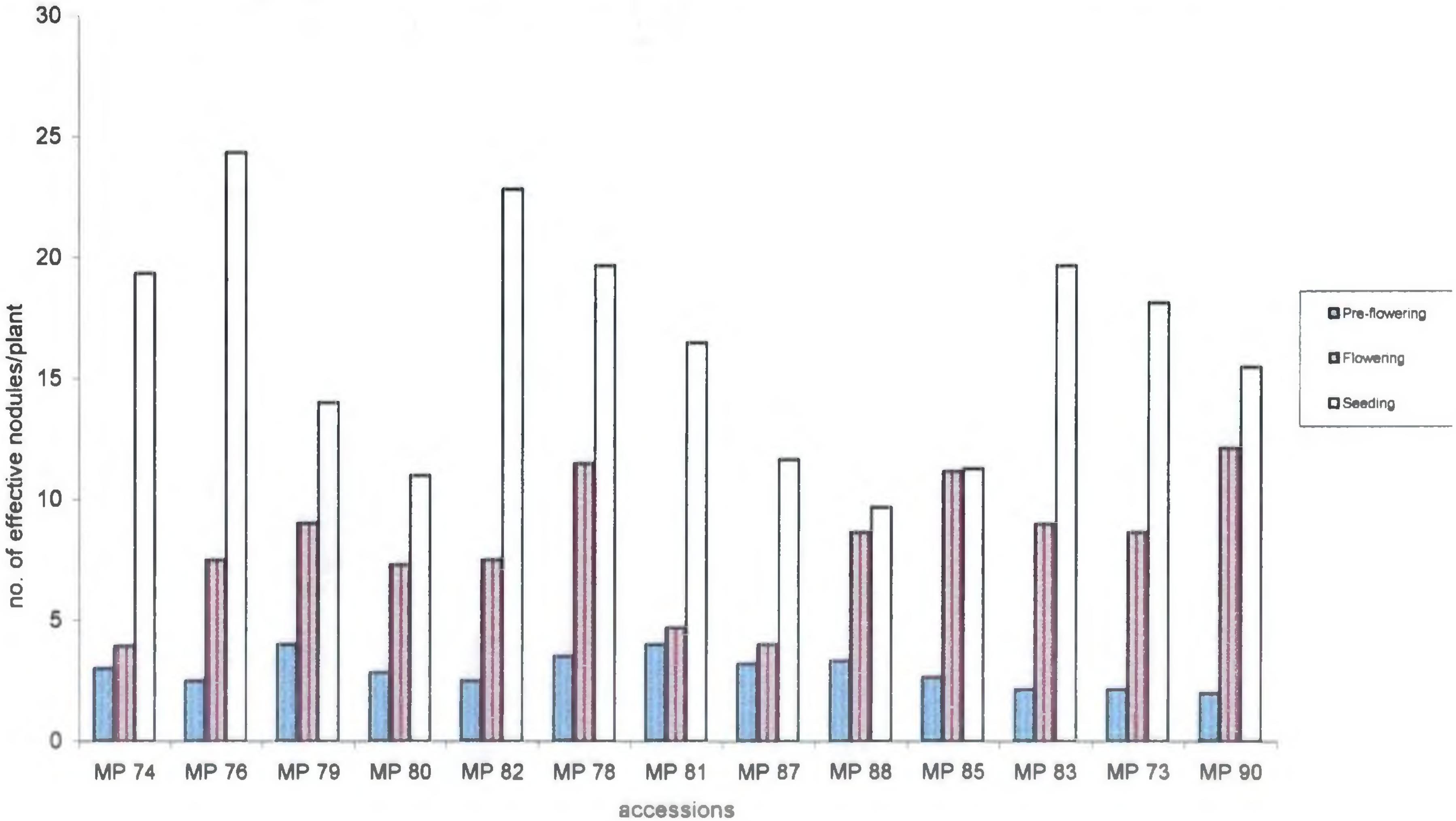
At this stage, the fresh weight of effective root nodules was maximum for MP-90 (2.52 g) followed by MP-76 (2.00 g). MP-83 (1.78 g) and MP-82 (1.75 g) were on par. MP-73 (1.49 g) and MP-78 (1.35 g) were

Table 9 Root nodule characteristics of *Clitoria ternatea* : nodule (effective) number ,fresh weight and dry weight of effective root nodules per plant (g) at three stages of growth

Sl. No.	Accession Number	Pre-flowering (50 DAS)			Flowering (100 DAS)			Seeding (150 DAS)		
		Effective nodule no.	Fresh weight	Dry weight	Effective nodule no.	Fresh weight	Dry weight	Effective nodule no.	Fresh weight	Dry weight
1.	MP-74	3.00	0.04	0.007	3.94	0.07	0.012	19.34	0.83	0.213
2.	MP-76	2.50	0.04	0.004	7.50	0.15	0.016	24.34	2.00	0.216
3.	MP-79	4.00	0.05	0.014	9.00	0.17	0.030	14.00	0.26	0.042
4.	MP-80	2.84	0.04	0.004	7.30	0.17	0.018	11.00	0.43	0.043
5.	MP-82	2.50	0.03	0.003	7.52	0.22	0.015	22.83	1.75	0.127
6.	MP-78	3.50	0.04	0.011	11.50	0.19	0.037	19.67	1.35	0.270
7.	MP-81	4.00	0.05	0.018	4.70	0.15	0.083	16.50	1.33	0.306
8.	MP-87	3.20	0.03	0.005	4.00	0.12	0.020	11.67	0.35	0.060
9.	MP-88	3.33	0.03	0.023	8.65	0.15	0.107	9.70	0.32	0.285
10.	MP-85	2.67	0.04	0.014	11.20	0.32	0.112	11.30	0.40	0.136
11.	MP-83	2.17	0.04	0.008	9.00	0.37	0.092	19.70	1.78	0.383
12.	MP-73	2.17	0.04	0.006	8.65	0.22	0.030	18.17	1.49	0.208
13.	MP-90	2.00	0.03	0.005	12.15	0.22	0.033	15.50	2.52	0.403
	CD	1.00	-	0.001	4.56	0.12	0.030	1.68	0.14	0.026

DAS – Days after sowing

Fig 2 Number of effective root nodules in *Clitoria ternatea* accessions at three different growth stages



on par. The least fresh weight was recorded for MP-79 (0.26 g). This was on par with MP-88 (0.32 g), MP-87 (0.35 g) and MP-85 (0.40 g). MP-85 was or par with MP-80 (0.43 g).

At seeding stage, maximum dry weight of the root nodules observed in MP-90 (0.403 g) followed by MP-83 (0.383 g), which were on par. The least dry weight was recorded in MP-79 (0.042 g) preceded by MP-80 (0.043 g) and MP-87 (0.060 g), which were on par.

4.3.3 Yield and yield attributes

4.3.3.1 Fresh and dry weight of leaves

Fresh and dry weight of leaves varied significantly among accessions at all stages of plant growth (Table 10).

At pre-flowering stage, maximum fresh weight of leaves was observed in MP-79 (1.12 g). MP- 79 was found to be significantly superior. This was followed by MP-76 (0.68 g) and MP-81 (0.67 g). The least fresh weight of leaves was recorded in MP-80 (0.39 g). This was on par with MP-87 (0.40 g), MP-73 (0.42 g), MP-85 (0.42 g) MP-83 (0.43 g) and MP-88 (0.43 g).

At this stage, maximum dry weight of leaves was also observed in MP-79 (0.25 g) followed by MP-81 (0.20 g) and MP-76 (0.18 g). The least dry weight of leaves was observed in MP-73 (0.10 g). MP-87 (0.11 g), MP-

Table 10 Yield parameters of *Clitoria ternatea* at four stages of plant growth: fresh weight and dry weight of leaves per plant(g)

Sl. No.	Accession Number	Pre-flowering (50 DAS)		Flowering (100 DAS)		Seeding (150 DAS)		Seed maturation (200 DAS)	
		Fresh weight	Dry Weight	Fresh weight	Dry weight	Fresh Weight	Dry weight	Fresh weight	Dry weight
1.	MP-74	0.60	0.12	30.07	8.12	52.69	13.47	24.52	7.42
2.	MP-76	0.68	0.18	10.68	2.75	57.24	9.64	32.37	7.70
3.	MP-79	1.12	0.25	7.02	2.18	12.24	3.17	10.80	2.87
4.	MP-80	0.39	0.13	3.15	0.85	9.85	2.73	7.35	2.05
5.	MP-82	0.49	0.17	6.88	2.12	24.12	5.35	21.37	4.62
6.	MP-78	0.47	0.14	5.40	1.23	28.20	6.40	24.95	5.57
7.	MP-81	0.67	0.20	4.75	1.25	23.17	4.57	15.50	4.12
8.	MP-87	0.40	0.11	3.95	1.16	20.99	4.47	17.60	4.04
9.	MP-88	0.43	0.15	4.50	1.22	17.28	4.37	14.70	3.70
10.	MP-85	0.42	0.11	9.18	2.20	25.20	6.40	20.50	5.50
11.	MP-83	0.43	0.12	7.60	2.04	30.15	8.55	29.20	6.90
12.	MP-73	0.42	0.10	8.72	2.22	40.57	9.65	25.90	5.90
13.	MP-90	0.53	0.15	15.77	3.92	73.45	16.35	67.67	13.15
	CD	0.06	0.02	0.32	0.14	0.80	0.28	0.60	0.19

DAS – Days after sowing

85 (0.11 g), MP-74 (0.12 g) and MP-83 (0.12 g) were found to be on par with MP-73.

At flowering stage, however fresh weight of leaves was maximum for MP-74 (30.07 g) followed by MP-90 (15.77 g). MP-80 (3.15 g) recorded lowest fresh weight of leaves (3.15 g).

At this stage maximum dry weight was recorded in MP-74 (8.12 g) followed by MP-90 (3.92 g). The lowest dry weight was observed in MP-80 (0.85 g).

At seeding stage, MP-90 (73.45 g) recorded maximum fresh weight of leaves followed by MP-76 (57.24 g). The least value was observed in MP-80 (9.85 g).

At seeding stage, MP-90 (16.35 g) recorded the highest dry weight of leaves followed by MP-76 (13.47 g). The lowest dry weight of leaves was recorded in MP-80 (2.73 g).

At seed maturation stage, MP-90 (67.67 g) recorded maximum fresh weight followed by MP-76 (32.37 g). The lowest fresh weight was recorded in MP-80 (7.35 g).

At this stage, dry weight was maximum for MP-90 (13.15 g) followed by MP-76 (7.70 g). MP-80 (2.05 g) recorded minimum dry weight of leaves among accessions.

4.3.3.2 Fresh and dry weight of sh

Fresh weight and dry weight of shoot varied significantly among accessions in at all stages of plant growth (Table 11).

MP-79 (2.5 g) recorded maximum fresh weight at pre-flowering stage. This was followed by MP-81 (1.48 g), MP-76 (1.40 g), and MP-74 (1.40 g), which were on par. The least fresh weight of shoot was recorded in MP-80 (0.69 g).

At pre-flowering stage, MP-79 (0.36 g) recorded maximum dry weight followed by MP-81 (0.29 g) and MP-82 (0.27 g). MP-81 and MP-82 were on par. The least dry weight of shoot was observed in MP-87 (0.14 g).

At flowering stage, maximum weight of shoot was observed in MP-74 (66.60 g) followed by MP-90 (29.34 g). Minimum fresh weight of shoot was recorded in MP-80 (7.35 g).

At this stage, MP-74 (17.31 g) recorded maximum shoot dry weight followed by MP-90 (7.85 g). The least fresh weight was recorded in MP-80 (1.74 g).

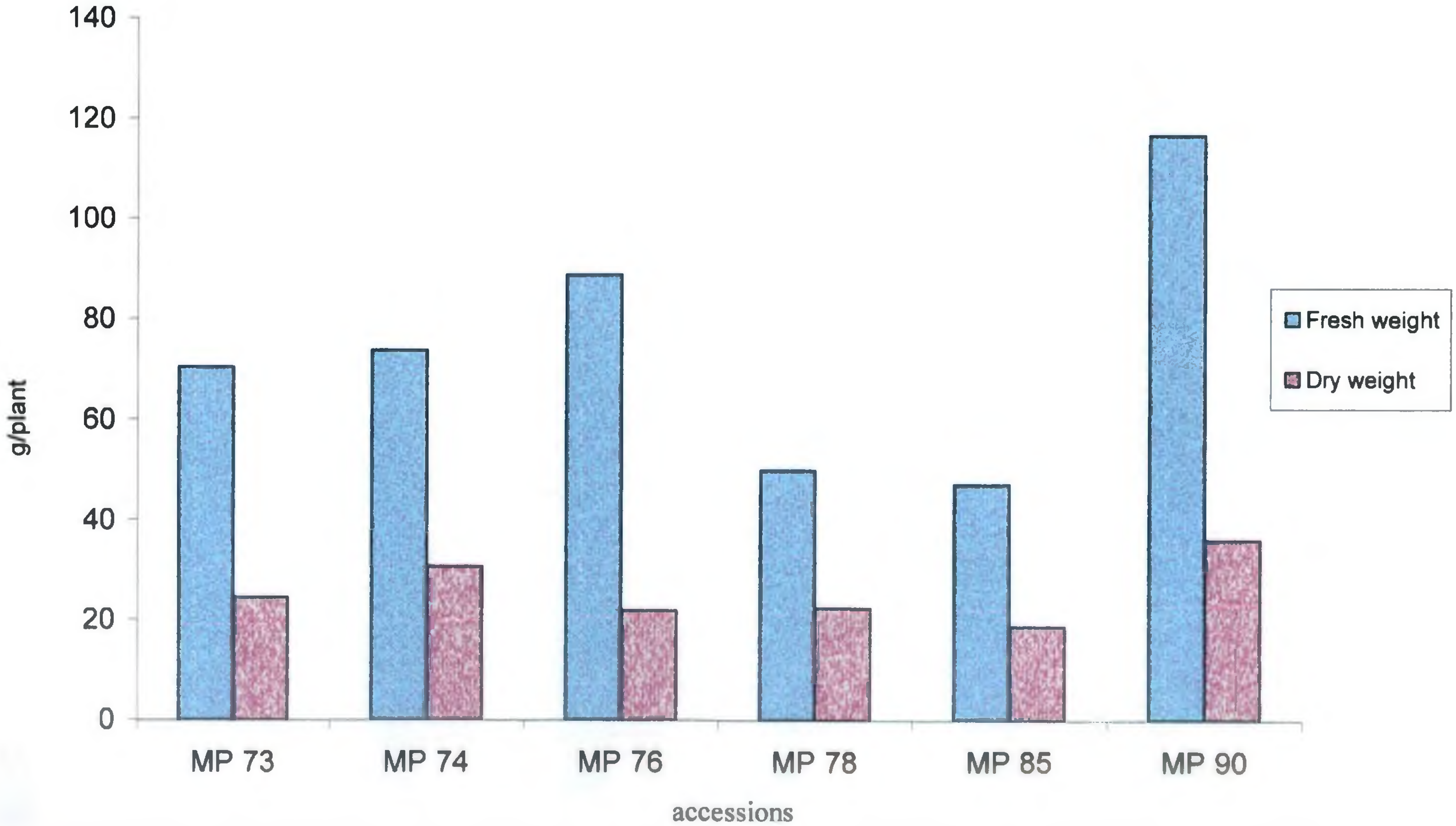
At seeding stage, shoot fresh weight was the highest in MP-90 (149.70 g) followed by MP-74 (110.09 g). Minimum shoot fresh weight was observed in MP-80 (19.37 g)

Table 11 Yield parameters of *Clitoria ternatea* at four stages of plant growth : fresh weight and dry weight of shoot per plant (g)

Sl. No.	Accession Number	Pre-flowering (50 DAS)		Flowering (100 DAS)		Seeding (150 DAS)		Seed maturation (200 DAS)	
		Fresh weight	Dry Weight	Fresh weight	Dry weigt	Fresh weight	Dry weight	Fresh weight	Dry weight
1.	MP-74	1.40	0.17	66.60	17.31	110.09	27.55	73.79	30.7
2.	MP-76	1.40	0.21	18.07	5.87	98.03	18.47	88.99	21.95
3.	MP-79	2.50	0.36	13.84	4.60	24.00	6.85	21.14	9.95
4.	MP-80	0.69	0.22	7.35	1.74	19.37	5.84	15.75	9.57
5.	MP-82	1.18	0.27	14.22	4.15	48.72	11.5	46.54	15.12
6.	MP-78	1.29	0.26	10.35	2.48	60.65	15.45	49.93	22.45
7.	MP-81	1.48	0.29	9.27	2.59	46.05	9.62	42.93	17.45
8.	MP-87	0.97	0.14	7.93	2.52	43.15	9.73	39.90	15.23
9.	MP-88	1.12	0.20	9.64	2.50	35.42	9.80	32.34	12.95
10.	MP-85	1.02	0.16	8.20	4.68	50.82	12.83	47.15	18.85
11.	MP-83	1.12	0.16	14.74	3.61	65.55	16.80	64.00	16.30
12.	MP-73	0.95	0.24	17.50	4.43	84.05	18.47	70.47	24.50
13.	MP-90	1.30	0.20	29.34	7.85	149.70	34.80	117.00	36.05
	CD	0.14	0.02	0.45	0.22	1.10	0.60	1.24	0.91

DAS – Days after sowing

Fig 3 Shoot yield of selected accessions of *Clitoria ternatea* at seed maturation stage



At this stage, maximum dry weight was recorded in MP-90 (34.80 g) followed by MP-74 (27.55 g). Minimum shoot dry weight was recorded in MP-80 (5.84 g).

At seed maturation stage, MP-90 (117.00 g) recorded maximum shoot fresh weight followed by MP-76 (88.99 g). The least shoot fresh weight was observed in MP-80 (15.75 g).

At this stage, maximum shoot dry weight was observed in MP-90 (36.05 g) followed by MP-74 (30.7 g). The lowest dry weight of shoot was recorded in MP-79 (8.95 g) preceded by MP-80 (9.57 g), which were on par.

4.3.3.3 Fresh weight and dry weight of roots

Fresh weight and dry weight of roots showed significant variation at all stages of plant growth (Table 12).

At pre-flowering stage, root fresh weight was the highest in MP-78 (0.77 g) followed by MP-73 (0.42 g). MP-73 (0.42 g), MP-76 (0.38 g), MP-80 (0.37 g), MP-83 (0.35 g) and MP-90 (0.35 g) were on par. The least fresh weights of roots were observed in MP-74 and MP-79 (0.20 g each). These were on par with MP-82 (0.25 g), MP-81 (0.28 g), MP-85 (0.29 g), MP-88 (0.29 g) and MP-87 (0.29 g).

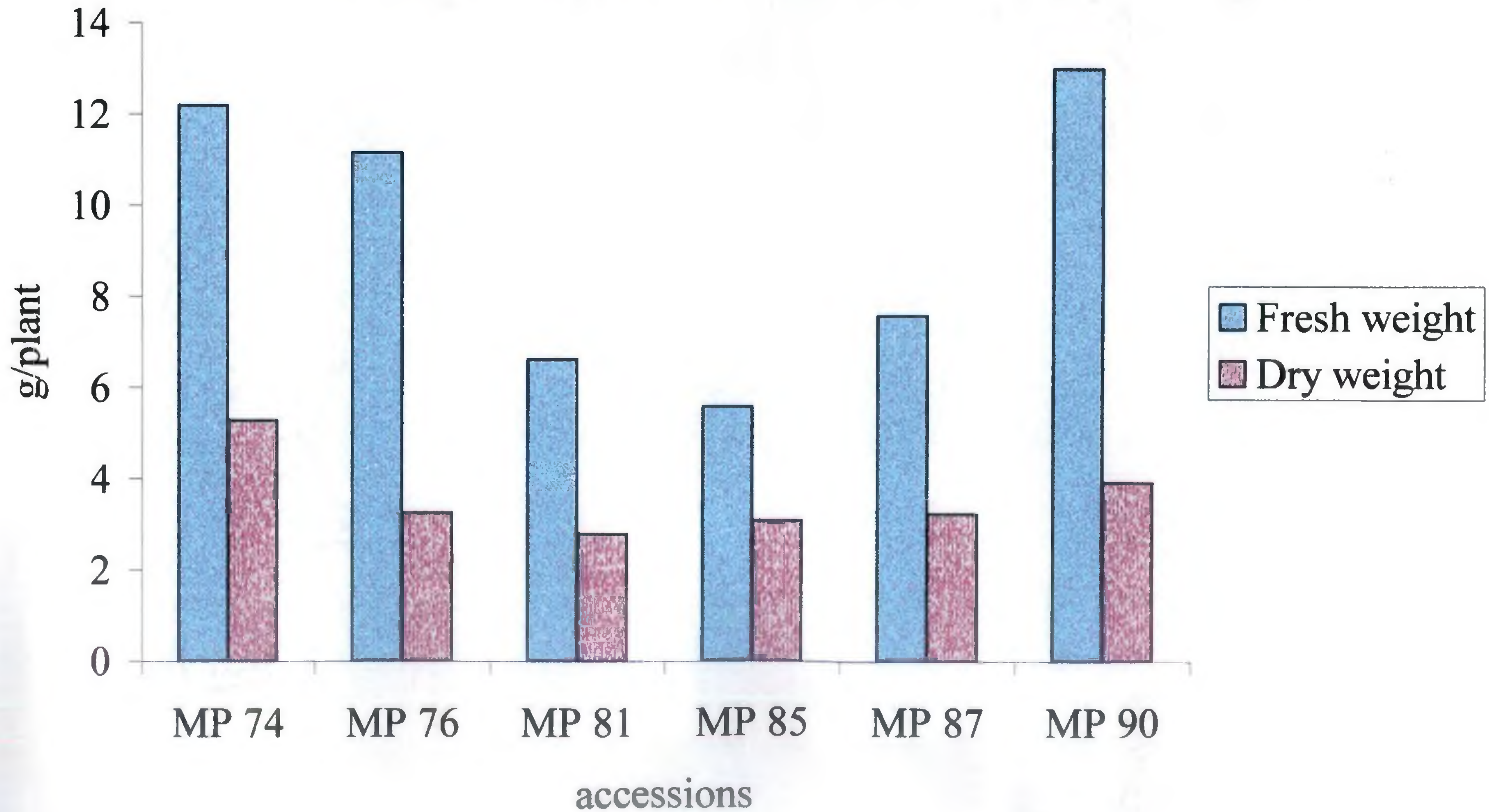
At this stage, maximum root dry weight was observed in MP-78 (0.22 g). This was followed by MP-80 (0.17 g) and MP-73 (0.16 g). MP-80

Table 12 Yield parameters of *Clitoria ternatea* at four stages of plant growth : fresh weight and dry weight of root per plant (g)

Sl. No.	Accession Number	Pre-flowering (50 DAS)		Flowering (100DAS)		Seeding (150 DAS)		Seed maturation (200 DAS)	
		Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weights
1.	MP-74	0.20	0.05	12.43	2.95	18.47	6.39	12.18	5.28
2.	MP-76	0.38	0.11	5.02	2.20	11.67	3.65	11.15	3.25
3.	MP-79	0.20	0.11	2.65	1.05	4.75	1.80	4.95	1.47
4.	MP-80	0.37	0.17	2.47	1.12	4.34	2.00	3.40	1.69
5.	MP-82	0.25	0.09	2.82	1.25	5.15	1.95	4.48	1.72
6.	MP-78	0.77	0.22	2.50	1.10	9.62	3.29	8.57	2.62
7.	MP-81	0.28	0.09	2.40	1.07	7.03	2.93	6.62	2.79
8.	MP-87	0.29	0.09	2.75	1.35	8.94	3.43	7.58	3.23
9.	MP-88	0.29	0.11	2.55	1.22	5.40	2.63	4.89	2.20
10.	MP-85	0.29	0.08	3.99	1.65	6.40	3.43	5.60	3.10
11.	MP-83	0.35	0.10	3.75	1.07	8.90	3.32	6.65	2.60
12	MP-73	0.42	0.16	3.07	1.49	7.87	2.70	6.30	2.45
13.	MP-90	0.35	0.10	4.97	1.50	15.25	4.43	13.00	3.93
	CD	0.10	0.02	0.15	0.08	0.56	0.22	0.19	0.14

DAS – Days after sowing

Fig 4 Root yield of selected accessions of *Clitoria ternatea* at seed maturation stage



and MP-73 were on par. Root dry weight was the least in MP-74 (0.05 g) at pre-flowering stage.

At flowering stage, fresh weight of root was maximum in MP-74 (12.43 g). The least fresh weight of roots was recorded in MP-81 (2.4 g) preceded by MP-80 (2.50 g), MP-78 (2.50 g) and MP-88 (2.55 g). MP-81, MP-80, MP-78 and MP-88 were on par.

At flowering stage, maximum root dry weight was observed in MP-74 (2.95 g). The least dry weight was recorded in MP-79 (1.05 g). This was on par with MP-81 (1.07 g), MP-83 (1.07 g), MP-78 (1.10 g) and MP-80 (1.12 g).

At seeding stage, maximum fresh root weight was observed in MP-74 (18.47 g). Root fresh weight was the lowest in MP- 80 (4.34 g). This was on par with MP-79 (4.75 g).

At this stage, dry weight of roots was the highest in MP-74 (6.39 g). Root dry weight was the least in MP-79 (1.80 g) followed by MP-82 (1.95 g) and MP-80 (2.00 g). MP-79, MP-82 and MP-80 were on par.

At seed maturation stage, MP- 90 (13.00 g) recorded maximum root fresh weight followed by MP-74 (12.18 g). The least fresh weight of roots was observed in MP-80 (3.40 g).

At this stage, the highest dry weight of roots was observed in MP-74 (5.28 g) followed by MP-90 (3.93 g). MP-79 (1.47 g) recorded the lowest dry weight among accessions followed by MP-80 (1.69 g).

4.3.3.4 Fresh and dry weight of pods and seeds

Fresh and dry weight of pods and seeds varied significantly during the seed maturation stage (Table 13).

At seeding stage, maximum fresh weight of pods and seeds was recorded in MP-83 (18.52 g) followed by MP-87 (13.69 g). The least fresh weight was observed in MP-81 (4.29 g).

At this stage, dry weight was the highest for MP-83 (11.02 g) and MP-74 recorded the lowest dry weight of 2.62 g. This was on par with MP-81 (2.84 g).

At the seed maturation stage, MP-83 (55.7 g) recorded maximum fresh weight of pods and seeds followed by MP-87 (33.2 g) and MP-90 (31.60 g). MP-87 and MP-90 were on par. The lowest fresh weight of pods and seeds was observed in MP-81 (9.40 g).

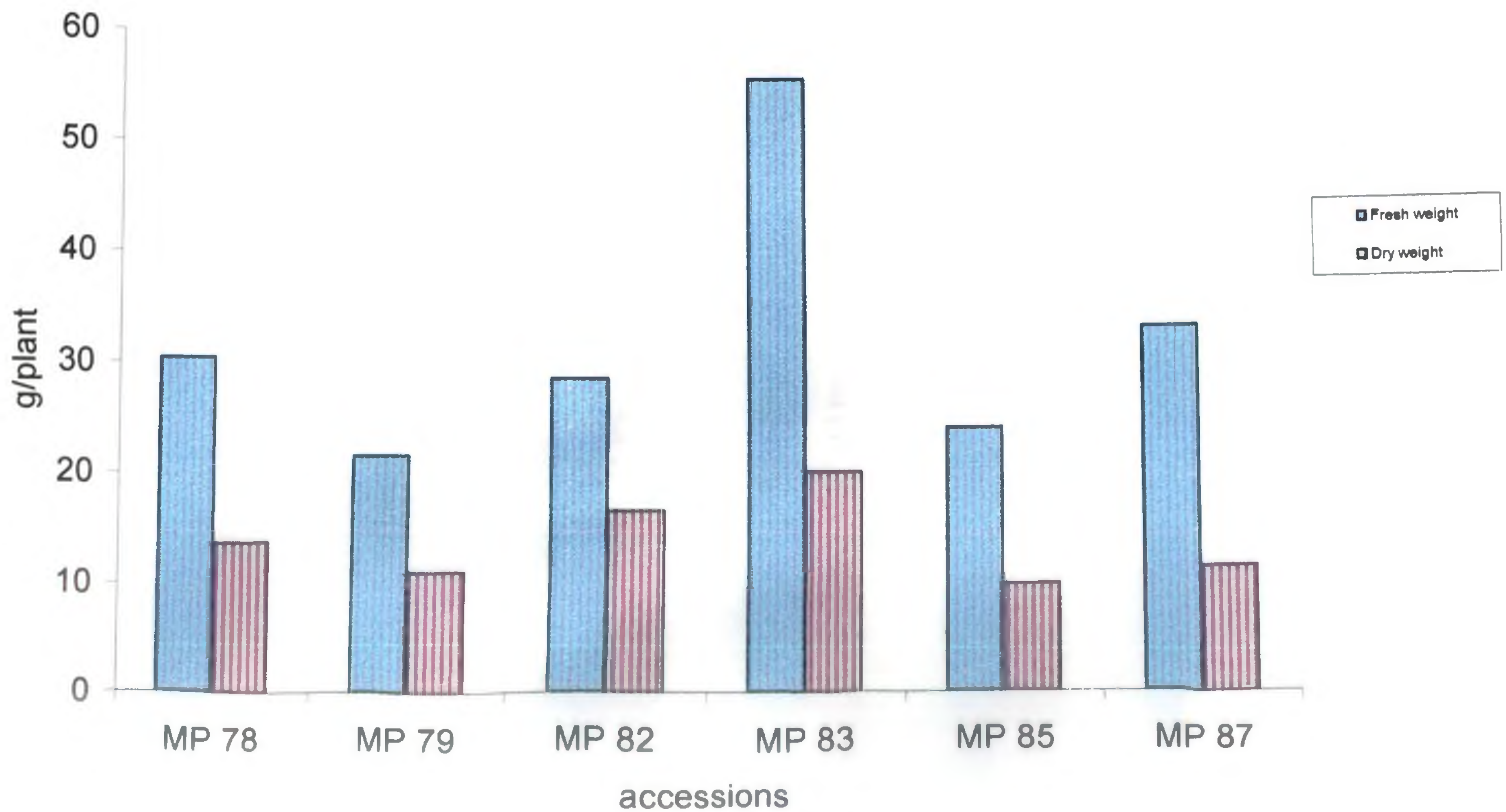
At this stage, maximum dry weight of pods and seeds was observed in MP-83 (20.15 g) followed by MP-82 (16.7 g). Dry weight was recorded the least in MP-81 (5.45 g). This was followed by MP-73 (5.50 g), MP-74

Table 13 Yield parameters of *Clitoria ternatea* at seeding and seed maturation stages : fresh weight and dry weight of pods per plant (g)

Sl. No.	Accession Number	Seeding (150 DAS)		Seed maturation (200 DAS)	
		Fresh weight	Dry weight	Fresh weight	Dry Weight
1.	MP-74	5.07	2.62	16.00	5.55
2.	MP-76	8.07	4.43	22.80	6.05
3.	MP-79	8.57	5.85	21.60	10.79
4.	MP-80	8.66	5.24	22.35	7.25
5.	MP-82	10.67	6.92	28.80	16.70
6.	MP-78	12.51	5.60	30.40	13.75
7.	MP-81	4.29	2.84	9.40	5.45
8.	MP-87	13.69	6.29	33.20	11.25
9.	MP-88	6.50	3.90	19.85	9.20
10.	MP-85	9.40	4.77	24.10	10.00
11.	MP-83	18.52	11.02	55.70	20.15
12.	MP-73	8.66	3.80	22.55	5.50
13.	MP-90	12.86	5.67	31.60	8.13
	CD	0.08	0.33	1.79	1.06

DAS – Days after sowing

Fig 5 Pod yield of selected accessions of *Clitoria ternatea* at seed maturation stage



4.3.4.2 Leaf area duration (LAD)

Leaf area duration varied significantly among the accessions during the three periods of growth (Table 14).

For the period from pre-flowering to flowering stage (50-100 DAS), MP-74 (29.33 days) had the highest LAD. MP-90 (15.67 days) followed MP -74. The least LAD was observed in MP-80 (4.63 days).

During the period from flowering to seeding (100-150 DAS), MP-90 (79.50 days) recorded maximum LAD followed by MP-74 (77.63 days). The lowest LAD was recorded in MP-80 (13.25 days) preceded by MP-79 (15.63 days).

During the period from seeding to seed maturation (150-200 DAS), MP-90 had the highest LAD of 125.25 days. LAD was the least for MP-80 (17.25 days) preceded by MP-79 (18.50 days).

4.3.4.3 Net assimilation rate (NAR)

NAR varied significantly among accessions during the three periods of plant growth (Table 15).

During the period from pre flowering-to-flowering stage, MP-79 was observed as having the maximum NAR of 1.27 g m^{-2} day^{-1}. This was followed by MP-76 (1.22 g m^{-2} day^{-1}). MP-79 and MP-76 were on par. The least was observed in MP-73 (0.76 g m^{-2} day^{-1}) preceded by MP-78

Table 14 Leaf area index at four stages and leaf area duration (days) for three periods of plant growth of *Clitoria ternatea*

Sl. No.	Accession Number	Leaf area index				Leaf area duration		
		Pre-flowering (50 DAS)	Flowering (100 DAS)	Seeding (150DAS)	Seed maturation (200 DAS)	Period 1 50-100 DAS	Period 2 100-150 DAS	Period 3 150-200 DAS
1.	MP-74	0.05	1.13	1.98	0.92	29.33	77.63	72.25
2.	MP-76	0.06	0.36	2.01	1.17	10.41	59.00	79.38
3.	MP-79	0.09	0.23	0.40	0.34	7.81	15.63	18.50
4.	MP-80	0.05	0.14	0.40	0.30	4.63	13.25	17.25
5.	MP-82	0.06	0.34	1.15	1.02	9.94	37.00	54.13
6.	MP-78	0.04	0.23	1.16	1.03	6.67	34.50	54.50
7.	MP-81	0.08	0.18	0.82	0.54	6.20	24.63	33.75
8.	MP-87	0.06	0.21	1.04	0.87	6.68	31.25	47.75
9.	MP-88	0.05	0.19	0.70	0.60	5.93	22.13	32.25
10.	MP-85	0.05	0.40	1.07	0.87	11.13	36.50	48.50
11.	MP-83	0.04	0.28	1.06	1.03	8.12	33.25	52.00
12.	MP-73	0.07	0.41	1.90	1.21	11.75	57.63	77.50
13.	MP-90	0.06	0.57	2.62	2.40	15.67	79.50	125.25
	CD	0.01	0.02	0.02	0.02	0.57	0.83	0.65

DAS – Days after sowing

(0.77 g m^{-2} day^{-1}) and MP-82 (0.82 g m^{-2} day^{-1}). MP-73, MP-78 and MP-82 were on par.

For the period from flowering to seeding stage, maximum NAR was observed in MP-80 (1.45 g m^{-2} day^{-1}) followed by MP-83 (1.41 g m^{-2} day^{-1}). MP- 80 and MP - 83 were on par. The least NAR was recorded in MP-74 (0.46 g m^{-2} day^{-1}). This was preceded by MP-76 (0.52 g m^{-2} day^{-1}), MP-73 (0.57 g m^{-2} day^{-1}) and MP- 82 (0.74 g m^{-2} day^{-1}).

During the period from seeding to seed maturation stage, MP-79 recorded maximum NAR of 1.09 g $m^{-2}day^{-1}$ followed by MP-81 (1.03 g m^{-2} day^{-1}) and MP-80 (1.02 g m^{-2} day^{-1}). MP-79, MP-81 and MP-80 were on par. The least NAR was observed in MP-90 (0.07 g $m^{-2}day^{-1}$) preceded by MP-76 (0.22g $m^{-2}day^{-1}$).

4.3.4.4 Crop growth rate (CGR)

Crop growth rate varied significantly among accessions during the three periods of plant growth (Table 15).

For the period from pre-flowering to flowering, maximum CGR was observed in MP-74 (1.12 g m^{-2} day^{-1}) followed by MP-90 (0.51 g m^{-2} day^{-1}). The least CGR was observed in MP-80 (0.14 g m^{-2} day^{-1}).

During the period from flowering to seeding stage, maximum CGR was recorded in MP-90 (1.99 g m^{-2} day^{-1}). This was followed by MP-83

Table 15 Physiological parameters of *Clitoria ternatea* : net assimilation rate(NAR) (g m^{-2} day^{-1}) and crop growth rate (CGR) (g m^{-2} day^{-1}) for three periods of plant growth

Sl. No.	Accession Number	Period 1 (50-100 DAS)		Period 2 (100-150 DAS)		Period 3 (150-200 DAS)	
		NAR	CGR	NAR	CGR	NAR	CGR
1.	MP-74	0.99	1.12	0.46	0.91	0.29	0.27
2.	MP-76	1.22	0.45	0.52	1.04	0.22	0.25
3.	MP-79	1.27	0.29	1.24	0.50	1.09	0.37
4.	MP-80	1.02	0.14	1.45	0.57	1.02	0.30
5.	MP-82	0.82	0.28	0.74	0.85	0.72	0.73
6.	MP-78	0.77	0.18	1.01	1.17	0.77	0.79
7.	MP-81	1.09	0.19	0.83	0.67	1.03	0.56
8.	MP-87	0.98	0.21	0.84	0.87	0.65	0.57
9.	MP-88	1.03	0.20	1.02	0.71	0.72	0.43
10.	MP-85	0.88	0.35	0.77	0.82	0.69	0.60
11.	MP-83	0.90	0.25	1.41	1.49	0.41	0.42
12.	MP-73	0.76	0.31	0.57	1.07	0.34	0.41
13.	MP-90	0.90	0.51	0.76	1.99	0.07	0.16
	CD	0.09	0.02	0.03	0.04	0.12	0.09

DAS – Days after sowing

(1.49g m^{-2} day^{-1}), MP-78 (1.17 g m^{-2} day^{-1}) and MP-73 (1.07g m^{-2} day^{-1}). MP- 79 (0.50g m^{-2} day^{-1}) recorded the lowest CGR.

During the period from seeding to seed maturation stage, MP-78 and MP-82 were found to have maximum CGR of 0.79 g m^{-2} day^{-1} and 0.73 g m^{-2} day^{-1} respectively. MP-78 and MP-82 were on par. The lowest CGR was observed in MP-90 and MP-76 with values 0.16 g m^{-2} day^{-1} and 0.25 g m^{-2} day^{-1} respectively, which were on par. MP-76 and MP-74 (0.27g m^{-2} day^{-1}) were on par.

4.3.4.5 Relative growth rate (RGR)

RGR varied significantly among accessions during the three periods of plant growth (Table 16).

During the period from pre-flowering to flowering stage, MP-74 recorded maximum RGR (0.090 g day^{-1}). This was followed by MP-90 (0.069 g day^{-1}). Least RGR was recorded in MP-80 and MP-78 (0.040 g day^{-1} each).

For the period from flowering to seeding stage, the highest RGR (0.038 g day^{-1}) was observed in MP-78 and MP-83 followed by MP-87 (0.032 g day^{-1}). The least RGR was recorded in MP-74 (0.012 g day^{-1}). This was preceded by MP-79 (0.019 g day^{-1}).

During the period from seeding to seed maturation stage, MP-82 & MP-81 (0.01g day^{-1}each) recorded the highest RGR followed by MP-78, MP-87 and MP-85 (0.009 g day^{-1} each). MP-82, MP-81, MP-78, MP-85 and MP-87 were on par. The least RGR was recorded in MP-90 (0.001g day^{-1}) and MP-74 (0.003 g day^{-1}).

4.3.4.6. Absolute growth rate (AGR)

AGR showed significant variation among accessions during the three periods of plant growth (Table 16).

For the period from pre-flowering to flowering stage, AGR was the highest for MP-74 (0.401 g day^{-1}) followed by MP-90 (0.183 g day^{-1}). It was the lowest for MP- 80 (0.50 g day^{-1}).

For the period from flowering to seeding stage, MP-90 (0.72 g day^{-1}) recorded maximum AGR. AGR was the lowest in MP-79 (0.18 g day^{-1}).

During the period from seeding to seed maturation, maximum value of AGR was observed MP-78 (0.28 g day^{-1}), which was on par with MP-82 (0.25 g day^{-1}). The least value was observed in MP-90 (0.060 g day^{-1}), which was on par with MP 74 (0.090 g day^{-1}).

Table 16 Physiological parameters of *Clitoria ternatea* : relative growth rate (RGR) (g day^{-1}) and absolute growth rate (AGR) (g day^{-1}) for three periods of plant growth.

Sl. No.	Accession Number	Period 1 (50-100 DAS)		Period 2 (100-150 DAS)		Period 3 (150-200 DAS)	
		RGR	AGR	RGR	AGR	RGR	AGR
1.	MP-74	0.090	0.401	0.012	0.329	0.003	0.095
2.	MP-76	0.065	0.155	0.024	0.374	0.003	0.090
3.	MP-79	0.049	0.104	0.019	0.177	0.008	0.134
4.	MP-80	0.040	0.050	0.031	0.205	0.007	0.108
5.	MP-82	0.054	0.099	0.027	0.304	0.010	0.261
6.	MP-78	0.040	0.062	0.038	0.420	0.009	0.285
7.	MP-81	0.050	0.069	0.029	0.238	0.010	0.200
8.	MP-87	0.060	0.074	0.032	0.313	0.009	0.204
9.	MP-88	0.049	0.070	0.030	0.255	0.008	0.155
10	MP-85	0.066	0.124	0.024	0.295	0.009	0.216
11.	MP-83	0.059	0.091	0.038	0.535	0.005	0.151
12.	MP-73	0.054	0.111	0.029	0.385	0.005	0.146
13.	MP-90	0.069	0.183	0.031	0.716	0.001	0.060
	CD	0.002	0.006	0.001	0.012	0.001	0.035

DAS – Days after sowing

4.3.4.7 Harvest indices (HI)

Harvest indices varied significantly among accessions for root yield, seed yield and root and seed yield taken together. (Table17)

Root yield

Highest HI for root yield was obtained in MP-74 (0.13) followed by MP-81 (0.11), MP-87 (0.11), MP-76 (0.11), MP-85 (0.10) and MP-90 (0.10). MP-81, MP-87 & MP-76, MP-85 and MP-90 were on par. The lowest harvest index in terms of root yield was obtained in MP-82 (0.05) preceded by MP- 78 (0.07), MP-79 (0.07), MP-83 (0.07) and MP-73 (0.08). MP-78, MP-79, MP-83 and MP-73 were on par.

Pod yield

HI (pod yield) was the highest for MP-83 (0.52) followed by MP-79 (0.51) and MP-82 (0.50). MP-83, MP-79 and MP-82 were on par. The least HI was observed in MP-74 (0.14), MP-73 (0.17) and MP-90 (0.17), which were on par.

Root + Pod yield

MP-83 (0.59) recorded maximum HI followed by MP-79 (0.58). MP-83 and MP-79 were on par. The lowest HI was recorded in MP-73 (0.25) and MP-90 (0.25) preceded by MP-74 (0.27).

Table 17 Comparison of harvest indices of *Clitoria ternatea* in terms of root yield, pod yield, root + pod yield

Sl. No.	Accession Number	Harvest indices		
		Root yield	Pod yield	Root + Pod yield
1.	MP-74	0.13	0.14	0.27
2.	MP-76	0.11	0.20	0.30
3.	MP-79	0.07	0.51	0.58
4.	MP-80	0.09	0.40	0.49
5.	MP-82	0.05	0.50	0.55
6.	MP-78	0.07	0.36	0.43
7.	MP-81	0.11	0.21	0.32
8.	MP-87	0.11	0.38	0.49
9.	MP-88	0.09	0.38	0.47
10.	MP-85	0.10	0.32	0.42
11.	MP-83	0.07	0.52	0.59
12.	MP-73	0.08	0.17	0.25
13.	MP-90	0.08	0.17	0.25
	CD	0.01	0.03	0.03

4.4 Phase IV : Photochemical analysis

4.4.1 Soil analysis before and after experiment for content of N, P and K

4.4.1.1 Soil nitrogen

Before the commencement of the experiment, the soil analysis revealed a value of 98.6 kg ha^{-1} of soil nitrogen.

The soil nitrogen content after the experiment varied significantly in each plot where the accessions were grown. (Table 18)

Soil nitrogen was the highest in the plot where MP-88, was grown. The soil nitrogen content was 127.7 kg ha^{-1}. This was on par with the plot of MP-80 (126.02 kg ha^{-1}). This was followed by plots where MP-79 and MP-81 were grown, which had the soil nitrogen content of 122.64 kg ha^{-1} and 122.34 kg ha^{-1} respectively. The least soil nitrogen content was shown by plot of MP-78 (99. 89 kg ha^{-1}) preceded by MP-83 (102.90 kg ha^{-1})

4.4.1.2 Soil phosphorus

Before the commencement of the experiment, the soil phosphorus content was observed to be 48.63 kg ha^{-1}.

After the experiment soil phosphorus content varied significantly among the different plots. (Table 18)

Table 18 Nitrogen, phosphorus, potassium status (kg ha^{-1}) in soil after harvest (200 DAS) of *Clitoria ternatea*

Sl. No.	Accession Number	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
1.	MP-74	115.23	20.26	139.78
2.	MP-76	111.71	16.21	69.89
3.	MP-79	122.64	40.53	174.72
4.	MP-80	126.02	36.47	96.23
5.	MP-82	111.71	44.58	96.77
6.	MP-78	99.89	32.42	99.46
7.	MP-81	122.34	36.47	145.15
8.	MP-87	117.52	24.31	185.47
9.	MP-88	127.70	32.42	198.92
10.	MP-85	117.71	28.37	190.85
11.	MP-83	102.90	28.37	96.77
12.	MP-73	114.69	24.31	139.78
13.	MP-90	109.37	12.16	153.22
	CD	3.48	0.03	8.54

The plot of MP-82 showed the highest phosphorus content of 44.58 kg ha^{-1}. This was followed by the plot of MP-79 with 40.53 kg ha^{-1}. The least soil phosphorus content was observed in plot of MP-90 (12.16 kg ha^{-1}) preceded by MP-76 (16.21 kg ha^{-1}).

4.4.1.3 Soil potassium

The soil potassium content before the commencement of the experiment was found to be 212.35 kg ha^{-1}.

After the experiment soil potassium content varied significantly among the different plots. (Table 18)

The highest soil potassium content was observed in the plot of MP-88 (198.92 kg ha^{-1}) followed by plots of MP-80 (196.23 kg ha^{-1}) and MP-85 (190.85 kg ha^{-1}). The soil potassium content of plots of MP-88, MP-80 and MP-85 were on par. Least potassium content was observed in the plot of MP-76 (69.89 kg ha^{-1}).

4.4.2 Plant nitrogen

Plant nitrogen content varied significantly among accessions at all stages of plant growth (Table 19).

At pre-flowering stage, MP-79 (3.85 per cent) recorded the highest plant nitrogen content. This was followed by MP-76 and MP-81 (3.5 per cent each). The least value was observed in MP-80 (2.51 per cent).

Table 19 Nitrogen content (per cent) of *Clitoria ternatea* at four stages of plant growth

Sl. No.	Accession Number	Pre-flowering (50 DAS)	Flowering (100 DAS)	Seeding (150 DAS)	Seed maturation (200 DAS)
1.	MP-74	3.27	4.26	3.78	3.49
2.	MP-76	3.50	3.84	3.67	3.53
3.	MP-79	3.85	3.71	2.75	2.41
4.	MP-80	2.51	2.83	2.48	2.23
5.	MP-82	2.91	3.78	3.10	2.87
6.	MP-78	2.97	3.25	3.14	2.90
7.	MP-81	3.50	3.57	3.11	2.85
8.	MP-87	2.59	2.97	2.90	2.83
9.	MP-88	2.80	3.19	2.80	2.80
10.	MP-85	2.65	3.89	3.14	2.89
11.	MP-83	2.76	3.77	3.33	3.18
12.	MP-73	2.61	3.81	3.57	3.47
13.	MP-90	3.11	3.91	3.85	3.67
	CD	0.06	0.06	0.07	0.06

DAS – Days after sowing

At flowering stage maximum plant nitrogen content was recorded in MP-74 (4.26 per cent) followed by MP-90 (3.91 per cent). The lowest value was observed in MP-80 (2.83 per cent) preceded by MP-87 (2.97 per cent).

At seeding stage, the plant nitrogen content was the highest in MP-90 (3.85 per cent), which was on par with MP-74 (3.78 per cent). The least value was observed in MP-80 (2.48 per cent). This was preceded MP-79 (2.75 per cent) and MP 88 (2.80 per cent). MP-78 and MP-88 were on par.

At seed maturation stage, the plant nitrogen content was maximum in MP-90 (3.67 per cent) followed by MP-76 (3.53 per cent) and MP-74 (3.49 per cent). MP-76 and MP-74 were on par. MP-80 (2.23 per cent) recorded the lowest plant nitrogen content.

4.4.3 Crude alkaloid content

The estimation of crude alkaloid content was done both with seeds and roots. The alkaloid was trace in the roots of the accessions. The seed alkaloid content varied significantly among accessions. The crude alkaloid content of *Clitoria* accessions are given in Table 20.

The maximum alkaloid content was recorded in MP-74 and MP-76 (0.39 per cent each). These were on par with MP-78 and MP-73 (0.38per cent each). The least alkaloid content was found in MP-87, MP-88

Table 20 Crude alkaloid content (per cent) in *Clitoria ternatea*

Sl. No.	Accession Number	Alkaloid content	
		Seed	Root
1.	MP-74	0.39	Traces
2.	MP-76	0.39	-do-
3.	MP-79	0.18	-do-
4.	MP-80	0.19	-do-
5.	MP-82	0.17	-do-
6.	MP-78	0.38	-do-
7.	MP-81	0.22	-do-
8.	MP-87	0.17	-do-
9.	MP-88	0.17	-do-
10.	MP-85	0.33	-do-
11.	MP-83	0.36	-do-
12.	MP-73	0.38	-do-
13.	MP-90	0.34	-do-
	CD	0.02	

and MP-82 (0.17 per cent each). These were on par with MP-79 (0.18 per cent).

Selection index

Discriminant function technique was adopted for the construction of selection index based on biomass yield, root yield, seed yield, root nodule characteristics and crude alkaloid content. The b-coefficient calculated for the characters are presented in Table 21. The index value for each accession was determined and the accessions were ranked accurately. The selection indices are presented in Table 21 along with the ranking of each genotype.

As far as medicinal use is concerned, roots are the most important part. However, seeds, aerial parts and whole plant are used for medicinal purpose. Based on the root yield, MP-74 ranked first followed by accessions MP-90, MP-76, MP-87, MP-85 and MP-81. In terms of pod yield, MP-83 accounted for maximum yield followed by accessions MP-82, MP-78, MP-87, MP-79 and MP-85.

When root and pod yield were considered together, MP-83 ranked first followed by MP-82. These were followed by accessions MP-78, MP-87, MP-85 and MP-79.

Table 21 Selection indices and ranks of *Clitoria ternatea* accessions

Sl. No	Accession Number	Ry* Rank	Sy* Rank	Py* Rank	Ry + Py Selection index	Ry + Py Rank	Ry + Sy +Py Selection index	Ry + Sy +Py Rank	Ry+Sy+Py+Nn*+Nw*+Ac* Selection Index	Ry+Sy+Py+Nn*+Nw*+Ac* Rank
1.	MP-74	1	2	11	21.23	9	82.46	2	128.10	2
2.	MP-76	3	5	10	18.27	10	62.01	8	117.40	5
3.	MP-79	13	12	5	24.14	6	41.93	12	72.79	11
4.	MP-80	12	13	9	17.59	11	36.63	13	61.87	13
5.	MP-82	11	10	2	36.29	2	66.33	5	113.78	6
6.	MP-78	7	4	3	32.22	3	76.90	4	123.64	4
7.	MP-81	6	7	13	16.18	7	50.95	10	87.57	9
8.	MP-87	4	9	4	28.49	4	58.84	9	84.56	10
9.	MP-88	10	11	7	22.44	8	48.23	11	70.73	12
10.	MP-85	5	6	6	25.77	5	63.32	7	92.52	8
11.	MP-83	8	8	1	44.82	1	77.23	3	123.70	3
12.	MP-73	9	3	12	15.62	13	64.41	6	108.10	7
13.	MP-90	2	1	8	23.69	7	95.50	1	153.25	1
	b- coefficient	-	-	-	Ry = 0.97	-	Ry = 0.99	-	Ry = 0.87	
					Py = 0.99		Sy = 0.99		Sy = 0.99	
							Py = 0.98		Py = 0.99	
									Nn = 0.94	
									Nw = 0.64	
									Ac = 1.25	

Ry*-Root yield, Sy*- Shoot yield, Py*-Pod yield, Nn*-Number of root nodules, Nw*- Weight (dry) of root nodules, Ac*-Crude alkaloid content

Shoot forms excellent feed for cattle, hence accessions with maximum shoot yield were also identified. MP-90 gave maximum shoot yield followed by accessions MP-74, MP-73, MP-78, MP-76 and MP-85.

Alkaloid content of seeds was also estimated. MP-74 and MP-76 contained maximum alkaloid (0.39 per cent) followed by MP-78 (0.38 per cent), MP-73 (0.38 per cent), MP-83 (0.36 per cent) and MP-90 (0.34 per cent).

Selection index was also worked out with characters like root yield, pod yield and shoot yield. Here also MP-90 recorded maximum score. This was followed by MP-74, MP-83, MP-78, MP-82 and MP-73.

To identify the accessions with high yield, nitrogen fixing potential and alkaloid content selection index was worked out with characters like root yield, shoot yield, pod yield, effective root nodule number, root nodule weight and crude alkaloid content. MP-90 ranked first followed by MP-74, MP-83, MP-78, MP-76 and MP-82.

Depending upon the purpose, the top ranking accessions under various selection criteria could be selected for cultivation under partially shaded condition in coconut plantation.

DISCUSSION

5. DISCUSSION

The present study entitled 'Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea*,L.) for yield, alkaloid content and nitrogen fixing potential was carried out at College of Agriculture, Vellayani from June 1999 to January 2000. The study aimed at selecting the most promising ones out of the various accessions collected. The results of the study are discussed in this chapter.

5.1 Seed characterization and germination

Out of the twenty accessions subjected to seed germination trial, 13 accessions having high germination capacity (75 - 95 per cent) were selected (Table 4). Five accessions MP-78, MP-83, MP-73, MP-82 and MP- 90 exhibited more than 90 per cent germination. This may be due to the higher general vigour of these accessions over others. The accessions MP-73, MP- 78 and MP- 90 took least number of days to achieve 50 per cent germination. MP- 86, MP-75 and MP- 92 exhibited poor germination percentage of 3, 7 and 10 respectively. Four accessions did not germinate at all inspite of providing favourable conditions for germination. This may be due to the presence of germination inhibitors (Hay, 1967) or rudimentary embryos. (Salisbury and Ross, 1992).

The hundred seed weight of the accessions ranged between 4 – 6 g. Of the 13 accessions selected for trial, MP-76, MP-77, MP-79, MP- 87 and MP- 88 had the highest hundred seed weight of 6 g.

Variation was observed in seed colour, seed weight and appearance of different accessions, which may be attributed to their genetic makeup.

5.2 Growth parameters

Growth parameters namely shoot characters, pod characters and root characters showed significant variations among accessions in all stages of plant growth observed.

5.2.1 Shoot characters

Shoot characters include plant length, number of leaves and leaf area. (Tables 5 and 6). Variation in plant length within legumes is purely a function of genetic make up (Bose, 1963). Sunitha (1996) observed a plant length of 309 cm in *Clitoria ternatea* under coconut shade. As per the observation maximum plant length recorded is 207. 05 cm. This may be due to the poor soil fertility and high shade. The plant length was found to increase throughout the growth period. Similar trend was observed in moth bean by Kulkarni and Karadge (1991). Maximum plant length was recorded in MP-80 and MP-74 in the pre-flowering and flowering stages. MP-76 was found to have the highest plant length in seeding and seed maturation stages. The observations indicated that same accessions did not show superior performance during all stages of plant growth. Plant length was the least in MP-81 and MP-88 in pre-flowering and flowering stages, respectively. MP-79 recorded the least plant length in seeding and seed maturation stages.

Variation in number of leaves among accessions may be attributed to the fact that it is purely a function of genetic makeup and environmental conditions (Gardner *et al.*, 1988).

Number of leaves per plant was the highest in accessions MP-79 and MP-74, respectively during the pre-flowering and flowering stages. MP- 90 recorded the highest value in seeding and seed maturation stages. The least number of leaves per plant was observed in MP- 83 and MP- 81 respectively during pre- flowering and flowering stages. MP-79 recorded the lowest value during the seeding and seed maturation stages.

Leaf production increased upto the seeding stage and then showed a declining trend towards seed maturation stage. Similar trend was observed in mothbean by Kulkarni and Karadge (1991). Later, Jyothi (1995) observed similar trend in vegetable cowpea.

Leaf area of the accessions showed significant variation among accessions. Leaf area exhibited same trend as the number of leaves, since leaf area is a function of leaf number.

Leaf area was maximum for MP -79 and MP - 74 respectively at pre-flowering and flowering stages. MP - 90 had the highest leaf area in seeding and seed maturation stages. It was the lowest in MP-83 and MP-81 respectively, in pre-flowering and flowering stages. MP-79 recorded the least leaf area at seeding and seed maturation stages.

5.2.2 Pod characters

Pod characters namely number of pods per plant, pod length and number of seeds per pod exhibited significant variation among accessions (Table 7). Pod number was maximum in MP-83 and least in MP-81 in seeding and seed maturation stages. Pod length was maximum in MP-79 followed by MP-76 in seeding and seed maturation stages. The lowest pod length was observed in MP-81 in both the stages. Seed number per plant was the highest in MP-76, MP-78, MP-73 and MP-83 in the seeding stage and MP- 90 in seed maturation stage. Minimum seed number was recorded in MP-81, in both the stages.

The pod characters varied among accessions in accordance with characteristic genetic make up. This is in justification with the reports of Nair (1966) regarding pod characters in cowpea.

5.2.3 Root characters

Root characters namely, root length and root girth showed significant variations among accessions in all stages of growth (Table 8).

MP- 81 recorded maximum root length in pre-flowering stage. It was maximum in MP- 74 in flowering and seeding stage. The least values were recorded in MP- 88 and MP-73 in pre-flowering and flowering stages. MP- 85 recorded the lowest root length in seeding and seed maturation stages.

Root girth was maximum in MP- 81 in pre-flowering, MP-74 in flowering and seeding stages and MP- 90 in seed maturation stage. The least values were recorded in MP-79 in pre-flowering, seeding and seed maturation stages and MP-82 in flowering stage.

Both root length and root girth exhibited an increasing trend upto seeding and then declined. Similar trend in root length was observed in soyabean (Barber, 1978).

5.3 Nodule characters

Nodule characters *viz.,* number of effective root nodules and their fresh and dry weight varied significantly among accessions in all stages of plant growth except for fresh weight of nodules in pre-flowering stage (Table 9).

MP-79 and MP-81 recorded maximum nodule number in pre - flowering stage and MP-90 in flowering and MP-76 in seeding stage.

The lowest nodule number was recorded in MP-90 in pre-flowering, MP-74 in flowering and MP-88 in seeding stages.

Nodule numbers showed an increasing trend upto seeding. At seed maturation nodules were absent. This may be due to the degeneration of nodules as reported by Venkataraman and Tilak (1990).

Fresh weight of nodules was maximum in MP-79 and MP-81 in pre-flowering, MP-83 in flowering and MP-90 in seeding stage. While dry weight was maximum in MP-88, MP-85 and MP-90 respectively in pre-flowering, flowering and seeding stages. The least fresh weight was recorded in MP-90, MP-87, MP-88 and MP-82 in pre-flowering stage. MP-74 recorded the least fresh weight in flowering stage and MP-79 in seeding stage. Dry weight of nodules was the least in MP-82 in pre-flowering, MP-74 in flowering and MP-79 in seeding stages.

Greater fresh weight did not always correspond with greater dry weight. This may be due to the variation in the driage of nodules. Moreover, it was observed that higher nodule number is not always related to higher nodule weight. This may be ascribed to the variation in nodule size.

Based on the data on nodule characters superior performance was observed in MP-90, MP-76 and MP-81. Poor performance was recorded in MP-88 and MP-79.

(Kulkarni and Karadge, 1991). Decline in root weight may be due to poor primary root growth, (Gardner *et al.*,1988). A similar rooting pattern was observed in soyabean by Mitchell and Russell (1971).

Similar to fresh weight, dry weight of leaves and root increased up to seeding and then showed a decrease towards seed maturation. However, the dry weight of shoot exhibited a slight increase. This may be due to less driage of the stem portion of the shoot.

Maximum fresh and dry weight of pods and seeds was observed in MP-83, at seeding and seed maturation stages. Better performance in this regard was observed in accessions in MP-87, MP-82, MP-78 and MP-79. Poor pod weight was observed in accessions MP-74, MP-76 and MP-81 (Table 13).

From the data, it is observed that pod yield is negatively related to leaf and shoot yield. This was in conformation with the findings of Anitha (1989) that vegetative growth increase at the expense of reproductive growth. This is because leaves, stem and other vegetative parts competes with pods for photosynthates and minerals (Gardner *et al.*, 1988).

The lowest nodule number was recorded in MP-90 in pre-flowering, MP-74 in flowering and MP-88 in seeding stages.

Nodule numbers showed an increasing trend upto seeding. At seed maturation nodules were absent. This may be due to the degeneration of nodules as reported by Venkataraman and Tilak (1990).

Fresh weight of nodules was maximum in MP-79 and MP-81 in pre-flowering, MP-83 in flowering and MP-90 in seeding stage. While dry weight was maximum in MP-88, MP-85 and MP-90 respectively in pre-flowering, flowering and seeding stages. The least fresh weight was recorded in MP-90, MP-87, MP-88 and MP-82 in pre-flowering stage. MP-74 recorded the least fresh weight in flowering stage and MP-79 in seeding stage. Dry weight of nodules was the least in MP-82 in pre-flowering, MP-74 in flowering and MP-79 in seeding stages.

Greater fresh weight did not always correspond with greater dry weight. This may be due to the variation in the driage of nodules. Moreover, it was observed that higher nodule number is not always related to higher nodule weight. This may be ascribed to the variation in nodule size.

Based on the data on nodule characters superior performance was observed in MP-90, MP-76 and MP-81. Poor performance was recorded in MP-88 and MP-79.

5.4 Yield and yield attributes

The fresh weight and dry weight of all plant parts namely leaves, ... _nd roots varied significantly among accessions at all stages of plant growth (Tables 10,11 and 12). Seed and pod weight also showed significant variation among accessions in the seeding and seed maturation stages (Table 13).

At pre-flowering stage, maximum fresh and dry weight of leaves and shoot was recorded in MP-79. Root weight was the highest in MP-78. At flowering stage, MP-74 recorded the highest vegetative biomass in terms of leaves, shoot and root. Vegetative dry matter was also maximum for this accession. At seeding stage, MP-90 recorded maximum herbage yield in terms of leaves and shoot. However, root weight was the highest in MP-74. Pod and seed weight was the highest in MP-83. At seed maturation stage, MP-90 recorded maximum weight in terms of leaves, shoot and root. Pod and seed weight was the highest in MP-83.

Based on the available data on root and shoot yield, MP-90 gave a superior performance followed by MP-74 and MP-76. MP-80, MP-79 and MP- 88 exhibited the least performance.

Increasing trend was observed in the fresh weight of leaves, shoot and root up to seeding and then exhibited a decline towards seed maturation. This decline may be attributed to the leaf shedding and senescence

(Kulkarni and Karadge, 1991). Decline in root weight may be due to poor primary root growth, (Gardner *et al.*,1988). A similar rooting pattern was observed in soyabean by Mitchell and Russell (1971).

Similar to fresh weight, dry weight of leaves and root increased up to seeding and then showed a decrease towards seed maturation. However, the dry weight of shoot exhibited a slight increase. This may be due to less driage of the stem portion of the shoot.

Maximum fresh and dry weight of pods and seeds was observed in MP-83, at seeding and seed maturation stages. Better performance in this regard was observed in accessions in MP-87, MP-82, MP-78 and MP-79. Poor pod weight was observed in accessions MP-74, MP-76 and MP-81 (Table 13).

From the data, it is observed that pod yield is negatively related to leaf and shoot yield. This was in conformation with the findings of Anitha (1989) that vegetative growth increase at the expense of reproductive growth. This is because leaves, stem and other vegetative parts competes with pods for photosynthates and minerals (Gardner *et al.*, 1988).

5.5 Physiological parameters

The physiological parameters *viz.*, LAI, LAD, NAR, CGR, RGR and AGR, varied significantly among the accessions at all stages of plant growth (Tables 14, 15 and 16).

5.5.1 Leaf area index (LAI)

An increasing trend was observed in LAI up to seeding and then it decreased towards seed maturation. Maximum LAI was observed in MP-79 and MP-74, respectively in pre-flowering and flowering stages. MP-90 recorded the highest leaf area towards seeding and seed maturation stages. As per the data, superior LAI was observed in accessions MP-90, MP-74, MP-76, MP-82 and MP-83. LAI was the least in MP-80, MP-81 and MP-88 (Table 14).

LAI had a trend of variation similar to the number of leaves per plant as leaf area index is a function of number of leaves in the plant.

LAI was observed to have a positive association with dry matter production of leaves and shoot. This is in agreement with the reports of Pearce and Mitchell (1992) that LAI is the prime factor that determines the rate of dry matter production.

5.5.2 Leaf area duration (LAD)

Leaf area duration varied significantly among accessions in three periods of plant growth *viz.*, pre-flowering to flowering (50- 100 DAS), flowering to seeding (100-150 DAS) and seeding to seed maturation (150 -200 DAS).

LAD was maximum in MP-74 during pre-flowering to flowering. MP-90 had the highest LAD during flowering to seeding and seeding to seed maturation. The least value was observed in MP-80 in all the three stages.

LAD increased throughout the growth period as dry matter yield. Positive relation of LAD to dry matter production is reported by Gardner *et al.* (1988).

LAD is a function of LAI which in turn is associated with the number of leaves. Though, the number of leaves decreased during seed maturation, the decrease was not considerable as to cause a reduction in LAD. This may be ascribed to the perennial nature of the crop. As for perennial legumes, vegetative shoots are generated from axillary buds to replace them at the senescence of fruiting shoots (Gardner *et al.*, 1988).

maturation stages, respectively. MP-80, MP-79 and MP-90 respectively recorded the least CGR during the three periods (Table 15).

CGR showed an increasing trend up to seeding and then decreased as per the data available. This was similar to that of LAI. Pearce and Mitchell (1990) opined that CGR is closely related to LAI.

5.5.5 Relative growth rate (RGR)

RGR was maximum in MP-74 and MP-78 & MP-83 respectively in pre-flowering to flowering and flowering to seeding stage. During seeding to seed maturation, MP-81 and MP-82 recorded the highest RGR. RGR was the lowest in MP-80 and MP-78 during pre-flowering to flowering stage. MP-74 and MP-90 respectively showed the least value during flowering to seeding and seeding to seed maturation stage.

RGR showed a declining trend throughout the growth period (Table 16). As per the data obtained, RGR was the highest during pre-flowering to flowering stage. Haloi and Baldev (1986) reported high values of RGR at the initial growth stage in *Cicer arietinum*.

5.5.6 Absolute growth rate (AGR)

MP-74, MP-90 and MP-78 recorded maximum AGR during pre-flowering to flowering, flowering to seeding and seeding to seed

5.5.2 Leaf area duration (LAD)

Leaf area duration varied significantly among accessions in three periods of plant growth *viz.*, pre-flowering to flowering (50- 100 DAS), flowering to seeding (100-150 DAS) and seeding to seed maturation (150 -200 DAS).

LAD was maximum in MP-74 during pre-flowering to flowering. MP-90 had the highest LAD during flowering to seeding and seeding to seed maturation. The least value was observed in MP-80 in all the three stages.

LAD increased throughout the growth period as dry matter yield. Positive relation of LAD to dry matter production is reported by Gardner *et al.* (1988).

LAD is a function of LAI which in turn is associated with the number of leaves. Though, the number of leaves decreased during seed maturation, the decrease was not considerable as to cause a reduction in LAD. This may be ascribed to the perennial nature of the crop. As for perennial legumes, vegetative shoots are generated from axillary buds to replace them at the senescence of fruiting shoots (Gardner *et al.*, 1988).

5.5.3 Net assimilation rate (NAR)

NAR varied significantly among accessions in all periods of plant growth (Table 15). NAR was maximum in MP-79 during period from pre-flowering to flowering and from seeding to seed maturation. However, during flowering to seeding stage, maximum NAR was recorded in MP- 80. The least NAR was recorded in MP-73, MP-74 and MP-90 during the period from pre-flowering to flowering, flowering to seeding and seeding to seed maturation, respectively.

NAR showed a declining trend towards seeding and seed maturation stages. As per the data available, NAR was the highest during initial stage. Similar trend in NAR was reported in *Cicer arietinum* by Haloi and Baldev (1986). Downward drift of NAR with plant age was observed by Gardner *et al.* (1988). It was observed that the trend of NAR variation is not alike LAI or LAD. This may be due to the fact that accessions with lower leaf weight and comparatively higher plant weight have higher NAR. Another reason is that as LAI increases, more leaves become shaded, resulting in the decrease of photosynthetic rate; hence NAR decreases, as growing season progresses (Gardner *et al.*, 1988).

5.5.4 Crop growth rate (CGR)

CGR was maximum in MP-74, MP-90 and MP-82 during pre - flowering to flowering, flowering to seeding and seeding to seed maturation stages, respectively. MP-80, MP-79 and MP-90 respectively recorded the least CGR during the three periods (Table 15).

CGR showed an increasing trend up to seeding and then decreased as per the data available. This was similar to that of LAI. Pearce and Mitchell (1990) opined that CGR is closely related to LAI.

5.5.5 Relative growth rate (RGR)

RGR was maximum in MP-74 and MP-78 & MP-83 respectively in pre-flowering to flowering and flowering to seeding stage. During seeding to seed maturation, MP-81 and MP-82 recorded the highest RGR. RGR was the lowest in MP-80 and MP-78 during pre-flowering to flowering stage. MP-74 and MP-90 respectively showed the least value during flowering to seeding and seeding to seed maturation stage.

RGR showed a declining trend throughout the growth period (Table 16). As per the data obtained, RGR was the highest during pre-flowering to flowering stage. Haloi and Baldev (1986) reported high values of RGR at the initial growth stage in *Cicer arietinum*.

5.5.6 Absolute growth rate (AGR)

MP-74, MP-90 and MP-78 recorded maximum AGR during pre-flowering to flowering, flowering to seeding and seeding to seed maturation stages. The least value in this regard was recorded in MP-80, MP-79 and MP-90 respectively during the above stages.

As per the data obtained, AGR increased towards seeding and then decreased (Table 16). AGR followed same trend as CGR.

5.5.7 Harvest indices (HI)

Harvest indices varied significantly among accessions for root yield seed yield and root and seed yield taken together (Table 17).

Highest HI for root yield was observed in MP-74 and the lowest in MP-82 and for seed yield, the highest HI was observed in MP-83, MP- 79 and MP-82 and the lowest in MP-74, MP-73 and MP-90.

When seed and root yield were considered together, the highest HI was observed in MP-83 followed by MP-79.

HI is related to economic yield. As per data available, it is found that as seed yield increased, the HI for seed yield also increased. This was true with regard to root yield, as well.

5.6 Phytochemical observation

5.6.1 Soil nutrient status

5.6.1.1 Soil nitrogen content

The soil nitrogen content varied significantly among the plot of individual accessions (Table 18). The soil nitrogen content of the experimental site before the experiment was 98. 6 kg ha^{-1}. The difference between the final and initial soil nitrogen content gave the amount of nitrogen fixed in the soil by that accession. The amount of nitrogen fixed by the crop in terms of soil nitrogen was in the range of 1.29-29.1 kg ha^{-1}. However, maximum soil nitrogen content was observed in the plot of MP-88 (127.7 kg ha^{-1}) and MP-80 (126.02 kg ha^{-1}). The least soil nitrogen was observed in MP-78 (99.89 kg ha^{-1}) and MP-83 (102.90 kg ha^{-1}).

Low nitrogen fixation may be related to low light intensity. In this heavy shaded coconut plantation, the rate of photosynthesis may be low and hence, the translocation of photosynthates to nodule formation may be reduced. As such, the nodule count may be less. This may be a reason for low nitrogen fixation. Very low nitrogen content in soil could be attributed to the plant uptake (Russell, 1961). Another reason for low nitrogen status is due to the leaching loss incurred during rainfall (Annexure1). Moreover, the plots were not supplemented with any chemical fertilizers.

5.6.1.2 Soil phosphorus content

Soil phosphorus content varied significantly among the accessions (Table 18). The soil phosphorus before the experiment was 48.63 kg ha^{-1}.

After the experiment, soil phosphorus status was maximum for the plots of MP-82 and MP-79. This indicates that these accessions had low phosphorus uptake. The least phosphorus content was observed in plots of MP-90 and MP-76, which indicates high phosphorus uptake of plants. It was observed that accessions which had higher phosphorus uptake had better root growth in terms of root length, root girth and root mass. This also promoted vegetative growth.. This observation is in conformation with the finding of Rajashree (1994) that phosphorus influence the growth and development of root system in legumes, which in turn increases rate of nitrogen fixation (due to increased nodule count) and herbage yield.

5.6.1.3 Soil potassium content

The soil potassium content after the experiment varied significantly among the accessions (Table 18).

The soil potassium content before the commencement of the experiment was 212.35 kg ha^{-1}. Maximum soil potassium was observed in plots where accessions MP-88, MP-80 and MP-85 were grown, which were on par. These accessions had low potassium uptake ability. Maximum uptake of potassium was observed in MP-76 whose soil potassium content was the lowest.

From the data, a positive association was observed between the uptake of soil potassium and nitrogen fixation (in terms of nodule count). This was in agreement with the findings of Yahiya (1996) that grain legumes require high quantity of potassium for enhancing nodulation and nitrogen fixation.

5.6.2 Plant nitrogen content

Percentage of plant nitrogen varied significantly among accessions in all stages of growth (Table 19).

The maximum plant nitrogen content was recorded in MP-79 at the pre-flowering stage, MP-74 in flowering stage and MP-90 in both seeding and seed maturation stages. While minimum plant nitrogen was observed in accession MP-80 in all the four stages.

The plant nitrogen content increased up to flowering and then decreased during seeding and seed maturation stage. The plant nitrogen content was found positively related to vegetative growth and nodule count.

5.6.3 Crude alkaloid content

The crude alkaloid content in seeds varied significantly among accessions.(Table 20). Alkaloid was present only in trace in roots.

The highest alkaloid content was recorded in MP-74 and MP-76. The lowest was observed in their accessions MP-87, MP-88 and MP-82.

Selection index

Discriminant function analysis developed by Fisher (1936) gave information on proportionate weightage to be given to a yield component. A selection index was formulated to increase the efficiency of selection by taking into account the important characters contributing to yield and nodule character. Further Hazel (1943) suggested that selection based on a suitable index was more efficient that individual selection for the character.

In this study, the selection is based on five aspects namely; shoot yield, root yield seed yield, number of root nodules, dry weight of root nodules and crude alkaloid content. To suit various purposes, separate selection indices were worked out for root and pod yield; root, shoot and pod yield; root, shoot & pod yield, root nodule number & weight and crude alkaloid content. Similarly Banerjee *et al.* (1976) recorded that an index based on days to flower, pods per plant and yield was more efficient in black gram.

Based on the selection index values, the top ranking six accessions were identified to be genetically superior from others under partially shaded condition in coconut garden. In terms of root and pod yield (parts valued for medicinal purpose) accessions MP- 83, MP- 82, MP-78, MP- 87, MP- 85 and MP-79 were found to be superior. Considering the economically important traits of the crops, the accessions MP-90, MP-74, MP-83, MP-78, MP-76 and MP- 82 were found suitable for cultivation as intercrop in coconut plantation.

SUMMARY

6. SUMMARY

A study on "Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea* L.) for yield , alkaloid content and nitrogen fixing potential" was carried out at College of Agriculture, Vellayani from June 1999 to January 2000. The experiment was conducted in four phases namely, collection of accessions, seed characterisation and germination studies, cultural trial of selected accessions under shade in coconut garden and photochemical analysis.

Phase I

Seeds of twenty accessions of *Clitoria ternatea* were collected from various locations inside and outside the state.

Phase II

Seed colour, seed shape, hundred seed weight, germination percentage and days to fifty per cent germination were observed. Seeds of MP-78 recorded the highest rate of germination (98 per cent) and the days to attain fifty per cent germination was the least (14 days) for this accession.

Phase III

Thirteen accessions with higher rate of seed germination (75 – 95 per cent) were selected for the cultural trial. They were grown as intercrop under shade in eighteen year old coconut garden. Growth and yield parameters as well as physiological parameters were studied. Selection of the accessions was done with the help of selection index worked out based on the performance at seed maturation stage. Seeding stage was selected for analysing the nodule characters as maximum nodules were obtained during that stage.

Plant length was significantly superior in MP-76 (207.05 cm), which was followed by MP-90 (192.50 cm) and MP-85 (191.79 cm). Number of leaves and leaf area were significantly superior in MP-90 (190.00 cm, 9407.39 cm^2 respectively).

Number of pods per plant was maximum in MP-83 (37.97). MP-79 recorded the highest pod length (10.30 cm). MP-90 and MP-78 were significantly superior with regard to number of seeds per pod (8.60 and 8.45, respectively).

MP-87 and MP-90 were significantly superior in terms of root length (40.33 cm) and root girth (2.40 cm), respectively.

Number of root nodules was the highest in MP-76 (24.34). MP-90 recorded maximum nodule weight on fresh weight (2.52 g) and dry weight (0.403 g) basis.

MP-90 recorded maximum leaf yield (67.67 g, 13.15 g) and shoot yield (117.00 g, 36.05 g) on fresh as well as on dry weight basis. MP-90 recorded maximum root yield (13.00 g) on fresh weight and MP-74 (5.28 g) on dry weight basis. Pod yield was significantly superior in MP-83 (55.7 g, 20.15 g) both on fresh and dry weight basis.

MP-90 recorded greater leaf area index (2.4) followed by MP-73 (1.21). Leaf area duration was the highest during the growth period from seeding to seed maturation (150 – 200 DAS) and the highest value was recorded in MP-90 (125.25 day^{-1}).

Net assimilation rate was the highest during pre-flowering to flowering stage (50- 100 DAS). MP-79 recorded the highest value (1.27 g $m^{-2}day^{-1}$) during this stage and also in seeding to seed maturation stage (1.09 g $m^{-2}day^{-1}$).

The highest crop growth rate was observed during the period from flowering to seeding stage (100 –150 DAS). MP-90 recorded maximum value (1.99 g $m^{-2}day^{-1}$) during this stage. It was the highest in MP-78 (0.79 g $m^{-2}day^{-1}$) during seeding to seed maturation stage.

Pre-flowering to flowering stage observed the highest relative growth rate values. MP-74 was significantly superior in relative growth rate (0.090 g day^{-1}) during this stage. During seeding to seed maturation MP-81 and MP-82 recorded the highest values (0.010 g day^{-1} each).

Absolute growth rate was the highest in flowering to seeding stage and MP-90 recorded maximum value (0.72 g day^{-1}). MP-78 was significantly superior in absolute growth rate value (0.28 g day^{-1}) during seeding to seed maturation stage.

The highest harvest index for root yield (0.13) and seed yield (0.52) was observed in MP-74 and MP-83, respectively.

Phase IV

The amount of nitrogen fixed by the crop in terms of soil nitrogen is very negligible. However, plot of MP-88 had the highest amount of fixed soil nitrogen (127.7 kg ha^{-1}) followed by MP-80 (126.02 kg ha^{-1}). The highest phosphorus content was observed in plot of MP-82 (44.58 kg ha^{-1}). The soil potassium was maximum in the plot of MP-88 (198.92 kg ha^{-1}).

The plant nitrogen content was the highest in the flowering stage. MP-74 had greater nitrogen content (4.26 per cent) during this stage. At seed maturation stage MP-90 had significantly superior plant nitrogen content (3.67 per cent).

Crude alkaloid content in the seeds of various accessions was estimated. Seeds of MP-74 and MP-76 contained significantly superior amount of crude alkaloid (0.39 per cent each). Crude alkaloid content was only 'trace' in the roots of all the thirteen accessions.

Among the thirteen accessions studied, six accessions were selected for better performance under shade in terms of yield (root yield, shoot yield and pod yield), root nodule characters (number and weight) and crude alkaloid content. MP-90, MP-74, MP-83, MP-78, MP-76 and MP-82 were selected based on the above characters.

Results of the present study conducted in a coconut garden consisting of palms of age 18 years and with a shade intensity of more than 75 per cent, indicated that intercropping *Clitoria ternatea* under this situation is not highly economical. However, in a state like Kerala, where monocropping of medicinal plants has limited scope due to high cropping intensity, utilization of interspaces of plantation crops, such as that of coconut, has to be explored. No intercrops are usually recommended in coconut plantations between eighth and twentieth year of planting due to heavy shade (range from 75 – 90 per cent). Medicinal plants found in their natural habitat usually experience heavy shaded situations and hence believed to have an inherent ability to tolerate such situations. The present study indicated that *C. ternatea* could be a better preposition as an intercrop in coconut garden with comparatively lesser shade (less 50 per cent) than the heavy shaded situation of the present experiment. It may be worth studying in detail the performance of the crop as an intercrop in very young coconut garden, with palms of less than eight years of age as well as aged plantations, with palms of more than twenty years of age.

REFERENCES

REFERENCES

Abbiw, D.K. 1990. *Useful plants of Ghana*. Intermediate Technology Publication, London.p.195-197

Adjei, M. B. and Fianu, F. K. 1985. The effect of cutting on the yeild and nutritive value of some tropical legumes on the coastal grassland of Ghana. *Tropical Grassland*. **19** : 4

Aiyar,V. N., Narayanan, V., Seshadri, T. R. and Vydeeswaran, S.1973. Chemical components of some Indian medicinal plants. *Indian J. Chem.* **11** : 89-90

Ajith, R. V. 1993. Management of mental retardation with medhyarasayana. .MD(Ayurveda)thesis, University of Kerala, Trivandrum

Alam, M. M. 1981. Some additions to the hosts of root knot nematodes. *Indian Phytopathol.* **34** **(2)** : 243

Alencar, J. A. de and Guss, A. 1985. Effect of cutting interval on drymatter (DM) and crude protein (CP) yeilds in *Clitoria ternatea* L..*In Cachoeiro de ItapemirimesPesquisa-em-Andamento.* **26** : 3

Allen, L. H. J. 1975. Shade cloth microclimate of soyabeans. *Agron. J.* **67** : 175-181.

Allen, O. N. and Allen, E. K. 1981. *The Leguminosae-a source book of characteristics ,uses and nodulation.* Univ. Wincosin Press, Madison, WI.p. 171-172

Ambasta, S. P. 1986. *The useful plants of India.* Publications and Information Directorate, New Delhi.p.133

Anitha, A.R. 1989. Potential for drought tolerance in green gram. (*Vigna radiata* (L.) Wilczek). MSc (Ag.) thesis, Kerala Agricultural University, Thrissur

Aulakh, G. S., Narayana, S. and Mahadevan, G. 1988. Phytochemistry and pharmacology of Sankupushi-4 varieties. *Ancient Sci. Life.* **7** (3&4) : 149-156

Ayyangar, C. N. R. 1942. Mixed cropping in India. *Indian Fmg.* **3** : 255 –276

Backer, C. A., Vanden, B. and Brink, R. C. 1963. *Flora of Java.* Vol.1. NVP Noordhoff, Gronigen.

Bai, L and Nair, R.V. 1982. Shade response of some common rainfed intercrops *Placrosym V*: 394-401.

Banerjee, H. N. 1937. Chemical examination of *Clerodendron infortunatum*. *J. Indian Chem. Soc.* **14** : 51

Banerjee, S. K. and Chakravarthi, R. N. 1964. Taraxerone from *Clitoria ternatea*. *Bull. Calcutta Sch. Trop. Med.* **12** (23)

Banerjee, S.P., Majumdar, M.K., Chatterjee, S.D. and Bhattacharya, R. 1976. Application of path analysis and discriminant function for selection in black gram (*Phaseolus mungo* L.). *Acta Agronomic Academiae Scientarium Hungaricae*. **25** : 423-430

Barber, S.A. 1978. Growth and nutrient uptake of soyabean roots under field condition. *Agron. J.* **70** : 457-461

Barro, C and Ribeiro, A. 1983. The study of *Clitoria ternatea* L. hay as a forage alternative in tropical countries – evolution of the chemical composition at four different growth stages. *J. Sci. Fd. Agric.* **34** : **8**

Bhaskaran, U. P. 1964. Investigation on the effect of propagation materials and N,P,K on growth ,yield and alkaloid content of *Rauvoulfia serpentina* Benth. MSc. (Ag.) thesis, College of Agriculture, Kerala University , Trivandrum

Bindhu, J. S. 1999. Production potential and economies of sesamum-pulse intrecropping in Onattukara tract. *MSc. (Ag.) thesis*. Kerala Agricultural University, Thrissur

Bock, K. K., Guthrie, E. J. and Meredith, G. 1977. *Clitoria* yellow vein virus, a tymo virus from Kenya. *Annals of Applied Biology*. **85** (1) : 97-103

Bogdan, A. V. 1977. *Tropical pasture and fodder plants*. Longman, London and New York.p.335-336

Bose, B. 1983. Economic use of the pigments of some common flowers as acid / alkali indicators. *National Academy of Sciences Science Letters*. **6** (8) : 249-251

Bose, H.L. 1963. Comparative studies on the fixation of nitrogen by certain legumes. MSc. (Ag.) thesis, Kerala Agricultural University, Thrissur

Breyne, J. 1678. Exoticum aliaromque minus cognitarum plantarum centuria prima. Danzig. p .76-78

Burkill, I. H. 1935. A dictionary of economic products of the Malay Peninsula. Vol.1. Crown Agents, London. p .588 –589

Cassman, K. G., Whitney, A. S. and Stockinger, K. R. 1980. Root growth and dry matter distribution of soyabean as affected by phosphorus stress, nodulation and nitrogen source. *Agron. J.* **20** : 239-246

Chaterjee, B. N. and Das, P. K. 1989. *Forage crop production : principles and practices* . Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi. p. 156.

Chopra, R. N., Chopra, I. C., Honda, K. L. and Kapur, L. D. 1958. *Indigenous drugs of India.* 2nd ed. U. N. Dhur & Sons, Calcutta. p. 501- 607.

Chopra, R. N., Badwar, R. L and Ghosh, S. 1949. *Poisonous plants of India.* Vol. 1. Govt. of India press, Calcutta. p. 340-467.

Cochran, W. C. and Cox, G. M. 1965. *Experimental designs*. John Wiley and Sons Inc., NewYork

Commelin, K. 1701. *Horti medici Amestelaedam rariorum plantarum descriptio et icones.* Vol. 1. P & J. Breau, Amsterdam p.47.

Crevost, C. H. and Petelot, A. 1929. Catalogue de products de L'Indo – Chine (plantas medicinales). *Bull. Econ. de L'Indo - Chine.* **32** : 325

Curtis, W. 1820. *Bot. Mag.* *47*. L. Reeve, London. p. 2111.

da Silva, R. P., Bernado, R. R. and Parente, J. P. 1998. A new rotenoid glucoside – 6 – deoxyclitori – acetal – 11 – o - beta D-glucopyranoside, from the roots of *Clitoria fairchildiana*. *Planta Medica.* **64** (3) : 855

Dastur, J. F. 1962. *Medicinal plants of India and Pakisthan.* 2nd ed. Taraporevala Sons & Co., Bombay. p. 59-60

Debnath, N. B., Chakravarthi, D., Ghosh, A. and Chakravarti, R. N. 1975. Fatty acids of *Clitoria ternatea* Linn. seed oils . *J. Inst. Chemists* (India) XLVI : 238-240

Dhanram, P. S., Tomer, P. S. and Tripathi, H. P. 1971. of cuttings and levels of phosphorus and nitrogen on summer cowpea forage. *Haryana Agri. Univ. J. Res.* **11** : 39 – 43

Dodwad, I. S., Salimath, P. M and Patel, S. A. 1998. Evaluation of green gram collection for dry matter accumulation and its partitioning. *Legume Res.* **21** (3/4) : 209 – 212

Donald, C. M. 1963. Competition among crop and pasture plants. *Adv. Agron.* **15** : 1-18.

Drury, C. N. 1873. *The useful plants of India.* Richardson, London. p. 145

Duke,J.A. 1986. *Isthmian ethnobotanical dictionary.* 3rd ed. Scientific Publishers, Jodhpur. p. 58

Dutt, N. B. 1928. *Commercial drugs of India.* Bwahar, Calcutta

Dymock, W., Warden, C. H. and Hooper, D. 1890. *Pharmacographia India.* Shri, Calcutta

Fantz, P. R. 1990. *Clitoria* (Leguminosae) antillarum. *Moscosoa.* **6** : 152 – 166

Fantz, P. R. 1991. Ethnobotany of Clitoria (Leguminosae). *Econ. Bot.* **45** (44) : 511- 520

Faroda, A. S. and Singh, R. C. 1983. Effect of preceeding crops on the nitrogen need of succeeding wheat crop. *Indian J. Agric. Sci.* **53** : 123 – 128

Fischer, R.A. 1936. The use of multiple measurements in taxonomic problems. *Ann. Eugen.* 7 : 179-188

Gardner, C. and Bennet, H. W. 1956. *The toxic plants of Western Australia.* Western Australian Newspapers, Perth

Gardner, F. P., Pearce, R.B. and Mitchell, R.L. 1988. *Physiology of crop plants.* Scientific Publishers, Jodhpur

Gautham, H. C. and Lamba, K. S. 1988. Prospects and constraints in the cultivation of soyabean in India. *J. Oilseeds Res* . **5** : 72 – 79

Geetha, S. 1999. Effect of levels of irrigation and fertilisers on growth and yield of cowpea (*Vigna unguiculata* (L.) Walp.). MSc. (Ag) thesis, Kerala Agricultural University, Thrissur

George, S. 1982. Shade response of common rainfed intercrops of coconut. Part3-Legumes. MSc.(Ag.) thesis, Kerala Agricultural University, Thrissur

Giller, K. E. and Wilson, K. F. 1991. *Nitrogen fixation in tropical cropping system.* CAB International, Wallingford. p. 128

Greaves, J. E. and Jones, L. W. 1950. Influence of legumes on soil nitrogen. *Soil Sci.* 69 : 71- 83

Gupta, R. K. and Lal, L. B. 1968. Chemical components of seeds of *Clitoria ternatea* Linn. *Indian J. Pharm.* **30** (77) : 167 – 168

Haloi, B. and Baldev, B. 1986. Effect of irrigation on growth attributes in chickpea when grown under different dates of sowing and population pressure. *Indian J. Pl. Physiol.* **21** (1) : 14 – 27

Handa, S. S. and Kapoor, V. K. 1999. *Pharmacognosy.* Vallabh Prakashan, Delhi . p. 42.

Hay, J.R. 1967. *In Physiologie, Okologie and Biochemic der keimumg.* Ernst-Moritz-Arndt Universitat

Hazel, L. . N. 1943. The genetic basis for constructing selection index. *Genetics.* **28** : 476-490

Heyne, K. 1927. De nuttige planten Netherlandsch Indie. Ruygrok , Batavia . p . 82

Hocking, G. M. 1955. A dictionary of terms in pharmacognosy and other divisions of economic botany. Charles C. Thomas , Springfield, IL.

Holland, T. and Joachim, A. 1933. A soil erosion experiment. *Trop. Agric. Ceylon.* **80** (4) : 199 – 207

Home, C., Roy, L. and Roy, A. 1992. Management of Khalitya (*Alopecia areata*) by ayurvedic approach. *International Seminar-Traditional Medicine* : 124

Hurd, E. A. and Spartt, E. D. 1979. Root patterns in crops as related to water and nutrient uptake. *Physiological aspects of dryland farming.* (ed. Gupta,U.S.). Oxford and IBH Publishing Co., New Delhi. p. 167-181.

Jackson, M. L. 1973. *Soil chemical analysis.* 2nd ed. Prentice Hall of India (Pvt.) Ltd., New Delhi. p. 1-498.

Jadhav, A. S. 1989. Nutrient balance with reference to fertilizer management under wheat based cropping system. *J. Maharashtra Agric. Univ.* **14** (3) : 288 – 291.

Jena, V. C., Pradhan, L. and Mohapatra, B. K. 1995. Effect of nitrogen , phosphorus and cutting management on fodder yield of cowpea (*Vigna unguiculata*). *Indian J. Agron.* **40** (2) : 321- 322.

Jessy, P. C. 1995. The efficacy of an Ayurvedic compound in improving the 1Q of primary school going children. M. D. (Ayurveda) thesis, University of Kerala, Thiruvananthapuram.

Jha, K. K. and Gupta, C. 1991. Intercropping of medicinal plants with poplar and their phenology. *Indian Forester.* **117** (7): 535-544.

Joshi, S. S., Shrivastava, R. K. and Shrivastava, D. K. 1981. Chemical examination of *Clitoria ternatea* seeds. *J. Am. Oil Chem. Soc.* **58** (6) : 714 -715.

Jyothi, L. 1995. Effect of irrigation on vegetable cowpea under graded doses of nitrogen and phosphorus. MSc.(Ag.) thesis, Kerala Agricultural University, Thrissur.

Kapoor, L. D. 1990. *Handbook of Ayurveda medicinal plants*. CRC Press Inc, Siorida . p. 126-127.

Katiyar, R. C., Ranjhan, S. K and Shukla, K. S. 1970. Yield and nutritive value of *Clitoria ternatea* – A wild perennial legume for sheep. *Indian J. Dairy Sci.* **23** (1): 79 -- 81

Kirtikar, K. R and Basu, B. D. 1975. *Indian medicinal plants-I.* Bishen Singh, New Delhi.

Kulkarni, H. and Karadge, B.A. 1991. Growth and mineral nutrition of moth bean (*Phaseolus aconitifolium* Jacq.) under saline conditions. *Inidan J. Plant Physiol.* **34** (1): 14-24

Kulshrestha, Kumar, D. and Khare, M. P. 1968. Chemical investigation of the seeds of *Clitoria ternatea* . L. *Chem Ber.* **101**: 2096 - 2105.

Kumar, D., Malik, B. P. S and Ray, L. 1998. Genetic variability and correlation studies in field pea (*Pisum sativum* L.). *Legume Res.* **21** (1) : 23 -29.

Kunkel, G. 1984. *Plants for human consumption : an annotated checklist of the edible phanerogams and ferns.* Koeltz Scientific books. Germany. p. 98.

Kushwah, B. L and Ali, M. 1988. Effect of Kharif legumes on productivity and nitrogen economy in succeeding wheat. *Indian J. Pulses Res.* **1** : 2-17.

Kushwah, B. L., Nelliat, E.V., Markose, V. J and Sunny, A. E. 1973. Rooting pattern of coconut. *Indian J. Agron.* **18** : 71-74.

Ladha, J. K., Kundu, D. K., Angelo-van-Coppenolle, M. G., Peoples, M. B., Carangal, V. R and Dart, P. J. 1996. Legume productivity and soil nitrogen dynamics in lowland rice-based cropping systems. *Soil Sci. Soc. Am. J.* **60** (1) : 183-192.

Lal, R.B., De Bajat and Singh, R.K. 1978. Legume contribution to the fertilizer economy in legume-cereal rotation. *Indian J. Agric. Sci.* 46: 419-424.

Leela , K and Bhaskaran, V. P. 1978. Effect of intercropping coconut stands with groundnut on soil fertility and plantation management. *Proc. PLACROSYM I.* Central Plantation Crops Research Institute, Kasargod, Kerala, India .p. 393-398.

Lindley, J. 1838. *Flora medica.* Longmans London . p . 242 -243.

Lin, L. J., Ruangrungsi, N., Cordel, G. A., Shieh, H. L., You, M. and Pezzutuo, J.M. 1992. 6- Deoxyclitoriacetal from *Clitoria macrophylla. Phytochemistry.* **31** (12) : 4329-4331.

Lourduraj, A.C., Geethalakshmi, V., Rajamanickam, K., Kennedy, F.J.S and Myiswani, V. 1992. Intercropping of pulses in coconut. *Indian Coconut Journal.* **22** (9) 7-8.

Maggie, M. 1989. Potential for drought tolerance in cowpea (*Vigna ungui iculata* (L.) Walp.). MSc.(Ag.) thesis, Kerala Agricultural University, Thrissur.

Masefield, G. B. 1955. Conditions affecting the nodulation of leguminous crops in the field. *Emp. J. Exptl. Agric.* **23** (89): 17-24.

Mathias, L., Viena, I. J. C., Braz. Filho, R. and Rodrigues- filho, E. 1998. Novel 11 alpha-o-beta-d-glucopyranosyl rotenoid isolated from *C. fairichildiana. Natural Product Letters.* **11** (2) : 119-126

Mercy, G. 1981. Fodder production potential of maize-legume mixtures in coconut gardens. MSc.(Ag.) thesis, Kerala Agriculture University, Thrissur.

Mesa, J.T.R. 1945. *Plantas medicinales aromaticas o venenosas de Cuba.* Republica de cuba Ministerio de Agriculture, Havana. p. 235-236.

Mitchell, R.L. and Russell, W.J. 1971. Rooting pattern in soyabean. 63 : 313-316

Morton, J.F. 1983. *Atlas of medicinal plants of middle America, Bahamas to Yucatan.* Charles C. Thomas, Springfield, IL. p. 303-304.

Mukraji. 1889. Clitoria . *A dictionary of the economic products of India.* (ed. Watt, G.). Supt. Govt. Printing, Calcutta. p. 288.

Nadkarni, K.M. 1927. India materia medica. Shributhar, Bombay.

Nair, G.S., Sudhadevi, P.K and Kurian, A. 1991. Introduction of medicinal and aromatic plants as intercrops in coconut plantation - Recent advances medicinal, aromatic and spice crops. Today and Tomorrow Pub. New Delhi India p. 163-165.

Nair, P.K.R. 1979. *Intensive multiple cropping with coconut in India - principles, programmes and prospects.* Verlag Paul Parey, Berlin p. 147.

Nair, P.K.R and Balakrishnan, T.K. 1976. Pattern of light interception by canopies in a coconut-cocoa crop combination. *Indian J. Agri. Sci.* **46** : 453-462

Nair, P.K.R., Ramavarma and Nelliat, E.V. 1974. Intercropping for enhanced profits from coconut plantation. *Indian Fmg.* **24** (4) : 11-13

Nair, R. 1966. Studies on performance of five varieties of cowpea (*Vigna unguiculata* (L.) Walp) and their response to nitrogen and phosphorus fertilizers. MSc. (Ag.) thesis, Kerala Agricultural University ,Thrissur

Nutman, P.S. 1959. Sources of incompatibility affecting nitrogen fixation in legume symbiosis . *Symp. Soc. Exptl. Biol.* 13: 42-58

Ofroi, F. and Sterm, W. R. 1987. The combined effect of nitrogen fixation and density of the legume component of production efficiency in a maize and cowpea intercropping system. *Field Crop Res.* **16** : 43-52

O'Hara, G.W., Boonkerd, N. and Dilworth, M. J. 1988. Mineral constraints to nitrogen fixation. *Pl. Soil.* **108**: 93-110

Pachauri, V.C and Patil, B.D. 1985. Note on the nutritional value of some tropical pasture legumes at three stages of growth. *Indian Vet. J.* **62**: 426-428

Palaniappan, S.P., Balasubramaniyan, A. and Ramaswami, C. 1976 Intercropping sorghum with legume for saving nitrogen. *Sorghum News Letter.* **19** : 86

Pate, J.S. 1958. Nodulation studies in legumes I - synchronization of host and symbiotic developments in the field pea, *Pisum arvense* L. *Aus. J. Biol. Sci.* **2** : 366-381

Pearce, G. and Mitchell, D. 1990. *Physiology of crop plants*. Harper, New York. p. 43-94

Peoples, M. B. and Herridge, D.F. 1990. Nitrogen fixation of legumes in tropical and subtropical agriculture. *Adv. Agron.* **44** : 155-223

Petiver, J. 1704. *Catalogus plantarum in hortis ficcis*. Petiverianis quoe vel ineditae aut hactenus obscure descriptae funct, London .p. 243

Pillai, M.D. 1985. Inter and multiple cropping with coconuts- a bibliography. *Indian Coconut Journal*. **15** (11) : 15-24

Piper, C. S. 1966. *Soil and plant analysis*. Hans Publications, Bombay

Power, J.E., Wills, W.O., Gvanes, D.L. and Reichman,G.A. 1967. Effect of soil temperature, phosphorus and plant age on growth analysis of barley. *Agron. J.* **59** : 231-234

Quisumbing, E. 1951. Medicinal plants of the Philippines. *Dept. Agric. Nat. Resources Philippines Tech. Bull.* **16** : 387-389

Rajan, R.S. 1926. An interesting case of narcotic poisoning and recovery. *Indian Med. Gaz.* **16** : 128-129

Rajashree, P.S. 1994. Herbage production of leguminous crops in summer rice fallows. MSc.(Ag.) thesis, Kerala Agricultural University, Thrissur

Ramratan, Kundu, S.S. and Bhatia, D.R. 1982 . Note on the nutritive value of *Clitoria ternatea* hay for sheep. *Indian J. Anim. Sci.* **52** (4) : 265-267

Randhawa, G.S and Mukhopadhyay, A. 1998. *Floriculture in India*. Allied Publisher limited, New Delhi. p.111

Rao, M.P. 1997. A re-classification of Ayurvedic herbs indicated in skin diseases. *Ancient Sci. life*. **16** (4) : 347-356

Rao, N.S. 1988. Biological nitrogen fixation potentialities, prospects and limitations. *Biological nitrogen fixation : Recent development* (ed. Rao, N.S.). Oxford & IBH Publishing Co, New Delhi.p. 1-21

Ray, S. and Das, S.N. 1985. Plant parasitic nematodes associated with medicinal plants and forest trees in Orissa. *Indian J. Nematol.* **15** (1) : 103-105

Rehm, S. and Espig, G. 1991. *The cultivated plants of the tropics and subtropics - cultivation, economic value, utilization* . CTA, Scientific books. p. 419

Robert, L. and Olsen, F.R. 1944. Influence of phosphorus and potash on symbiotic nitrogen fixation. *J. Am. Soc. Agron.* **36** : 637-647

Ruschel, A.P., Salali, E and Vose, P.P. 1979. Nitrogen enrichment of soil and plant by *Rhizobium phaseoli -Phaseolus vulgaris, symbiosis. Pl. Soil.* **51**: 425-429

Russell, E.J. 1961. *Soil conditions and plant growth.* Harold and Sons Ltd, Norwich.p . 47-58

Saito, N., Abe, K., Honda, T., Timberlake, C.F. and Bridle, P. 1985. Acylated delphinidin glucosides and flavanols from *Clitoria ternatea. Phytochemistry.* **24** (7) : 1583-1586

Salisbury, F.B. and Ross, C. 1992. *Plant physiology*. Wadsworth Publishing Company, California. p. 492

Sanwi, R.C. and Roy, A. 1990. Possibilities of increasing production of oil seeds through intercropping system. *J. Oilseeds Res.* **7** : 14-21

Sanyal, D. and Ghose, R. 1934. *Valuable drugs of India.* Dehradun, Calcutta .p. 374

Saxena, M.C. and Yadav, D.G. 1975. Multiple cropping with short duration pulses. *Indian J. Genet.* **35** : 194-208

Selamat, A. and Gardner, F.P. 1985. Growth nitrogen uptake and partitioning in nitrogen fertilized nodulating and non-nodulating peanut. *Agron. J.* **77** (6) : 862-867

Sen, A., Sau, A., Naskar, K. and Bhattacharjee. 1980. Studies on nodulation of some useful leguminous plants. *Bull. Bot. Surv. India.* **22** (1-4): 166-172

Sen, R. and Bhaduri, P.N. 1971. Relationship between the number and volume of nodules in different species of *Phaseolus* and *Glycine max.* *Indian Agric* .**15** (1&2) : 175-183

Sen, S. and Rao, V.B. 1953. Phosphate fertilization of legumes. *I.C.A.R. Rev. Series.* **3** (4): 31-42

Shanjeevirayar, L. 1978. Studies on methods of planting under graded nitrogen and phosphorus levels of sorghum (CO-21). MSc.(Ag.) dissertation, Tamil Nadu Agricultural University, Coimbatore

Sharma, A.K. and Majumdar, M. 1990. Some observations on the effect of *Clitoria ternatea* Linn. on changes in serum sugar level and small intestinal mucosal carbohydrases activities in allexan diabetes. *Calcutta Med. J.* **87** (11 & 12) : 168-171

Sharma, R.P.R. and Singh, A. 1970. Effect of growing legumes on certain properties of alluvial soils of Northern India. *Indian J. Agric. Sci.* **40** (1): 45-53

Sheriff, M. 1891. *Materia medica of Madras*. Madras Govt. Press, India

Sinha, A. 1960 a. Isolation of a I-lactone compound from the leaves of *Clitoria mariana* Linn. *Nature*. **187** (4732): 149-150

Sinha, A. 1960 b. Gamma-sitosterol from the seeds of *Clitoria ternatea* Linn *Curr. Sci.* **29** (6) : 180-181

Singh, K.A., Niranjan, K.P. and Kumar, A. 1985. Effect of row spacing on the productivity of blue panic intercropped with butterfly pea in semi-arid condition. *Indian J. Agron.* **30** (3) : 349-352

Singh, K.V., Singh, A. and Kothari, S.K. 1990. Aromatic plants as efficient intercrops under poplars. *Indian Forester.* **116** (3). 189-193

Singh, K.V., Singh, J.P. and Kothari, S.K. 1985. Cultivation of medicinal and aromatic plants along agro forestry. *Indian Farmers' Digest.* **18** (9): 34-35.

Singh, R.D and Chatterjee, B. N. 1968. Growth analysis of perennial grasses in tropical India II - herbage growth in mixed grain-legume swards. *Exptl. Agric.* **4** : 127-134

Singh, R.H., Binha, B.N., Sarkar, S.H. and Udupu, K.N. 1979. Comparative biochemical studies on the effect of 4 medhyarasayana drugs on brain in rats. *J. Res. Indian Med.* **14** (3): 1-7

Singh, R.H., Mehta, A.K., Sarkar, F.H. and Udupa, K.N. 1977. Studies on the psychotropic effects of medhyarasayana drug, Sankhapushpi. *J. Res. Indian Med.* **12** (3): 42-47

Singh, S. 1957. Effects of organics and inorganics on yield of jowar, arhar and groundnut. *Indian J. Agron.* **1** : 151-157

Skerman, P.J. 1977. *Tropical forage legumes*. Food and Agriculture Organization of United Nations, Rome. p. 609

Smith, H.F. 1936. A discriminant function for plant selection. *Ann. Eugenics.* **7** : 240-250

Snedecor, G. W. and Cochran, W. G. 1967. Statistical methods. 16th ed. Oxford and IBH Publishing Company, Calcutta. p. 349-351

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.* **25** (8): 259-260

Sunitha, C. 1996. Collection, description and performance evaluation of herbaceous medicinal leguminous plants of Kerala. MSc. (Hort.) thesis, Kerala Agriculture University, Thrissur

Standley, P.C. 1933. *The flora of Barro Colorado Island, Panama.* The Arnold arboretum of Harvard University Jamaico plan

Tarila, A.G.I., Onmrod, D.P. and Adedipe, N.O. 1977. Effect of phosphorus nutrition and light intensity on the growth and development of cowpea (*Vigna unguiculata*). *Ann. Bot.* **41** (11) : 75-83

Terahara, N., Oda, M., Matsui, T., Osajima, Y., Saito, N., Toki, K. and Honda, T. 1996. Five new anthocyanins, ternatins A_3, B_4, B_3, B_2, and D_2 from *Clitoria ternatea* flowers. *J. Nat. Prod.* **59** (2) : 139-144

Tewari, J.P., Shukla, D.S. and Shukla, I.K. 1981. *Clitoria ternatea* L. A new host of pea mosaic virus from Inida. *Environ. India.* **4** (I&II): 92-93

Thampan, P.K. 1982. *Hand book on coconut palm.* 2nd ed. Oxford and IBH Publishing Co., New Delhi .p . 286-303

Tisdale, S.L. and Nelson, V.L. 1970. *Soil fertility and fertilizers.* The Macmillan Company, London. p.126

Tiwari, R.D. and Gupta, P.K. 1959. Chemical examination of the leaves of *Clitoria ternatea* Linn. *J. Indian Chem. Soc.* **36** (4): 243-246.

Tournefort, M. 1706. Suite de I' establishment quelques nouveaux genres des plants. *Mem. Man Phys. Acad. Roy. Sci. Amst.* **5** : 104-105

Upadhye, A.S. and Kumbhojkar, M.S. 1993. Studies on the Ayurvedic drug Shankhapushpi from Western Maharashtra.-medico-botanical aspect. *Bull. Medico-Ethnobot. Res.* 14 (1-2) : 64-69

Upadhyaya, R.S and Pachauri, V.C. 1983. Nutritive value of *Clitoria ternatea* L. hay for Barbari goats. *Indian J. Anim. Sci.* **53** : 9

Uphof, J.C. 1968. *Dictionary of economic plants* . 2nd ed. Stechert-Harfner Service Agency, New York. p. 1968

Veerupakshappa, K. 1982. Note on correlation in different segregating generations of cowpea. *Indian J. Agric. Sci.* 50 : 977-981

Venkataraman, G.S and Tilak, K.V. 1990. *Soil fertility and fertilizer use*. PBS Publishers, Pune. p . 82-205

Virtanen, A.I., Vanttanusen, S. and Laine, T. 1937. Investigation on the root-nodule bacteria of leguminous plants. XX excretion of nitrogen in associated culture in legumes and non-legumes. *J. Agric. Sci.* **27**: 585-610.

Viswanathan, T.V., Radhakrishnan, V.V., Reghunath, B.R. and Prassana Kumari, K.T. 1992. Patchouli (*Pogostemon cablin*) as an intercrop in young coconut garden. *Indian J. Agric. Sci.* **62** (9) : 616-617

Viswanathan, T.V., Radhakrishnan, V.V., Reghunath, B.R., Prassanakumari, K.T. and Cheriyan, S. 1993. Patchouli- A potential essential oil yielding crop for coconut garden. *Indian Perfumer.* **37** (1) : 12-13

Wandera, D.F. 1984. A review of pasture research work at Katumani, Kenya . *East African Agricultural and Forestry Journal.* **44**: 416

Warsi, A.S., Bill, C. and Wright. 1973. Influence of nitrogen on root growth of grain sorghum. *Indian J. Agric. Sci.* **43** : 142-147

Watson, D. J. 1958. The dependence of net assimilation rate on LAI. *Ann. Bot.* **23**: 431-439

White, E. M., Kruerger, C.R. and Moore, R.A. 1976. Changes in total nitrogen, organic matter, available phosphorus and bulk densities of cultivated soil, eight years after time pasturey were established. *Agron. J.* **68** (4) : 581-583

Whyte, R.O., Neelson, C. and Trumble, W.C. 1953. *FAO : Agricultural studies*. FAO, Rome

Whyte, R.O. and Trumble, H.C. 1953. *Legumes in Agriculture*. FAO. Rome .p . 21-46

William, R.F. 1946. The physiology of plant growth with special reference to the concept of NAR. *Ann. Bot.* **10**: 41-72

Yadav, M.S. 1984. Improved varieties of forage grasses and legumes for arid range lands. *Indian Fmg.* **34** (7): 49-50

Yahiya, M. 1996. Influence of potassium on growth and yield of legumes. *Indian J. Agron.* 41 (3) : 416-419

Zakra, A.N., Pomier, M and Taffin, G.D.E. 1986. First result of an intercropping trial of coconuts and food crops in the Middle Ivory Coast. *Oleagineux.* 41 (8 &9) : 381-387

Zamora, P. and Octavio. 1995. Green manure crop evaluation in a semi-arid climate of Colima State, Mexico. *Cuadros.* **13** (3) : 347-359

Zaurong, M. G. and Munns, D. N. 1980. Effect of phosphorus and sulphur nutrition on soluble sugars and growth in *Clitoria ternatea* L. *Pl. Soil.* **55** (2) : 243-250

ANNEXURE - I

Weather data during the crop period (monthly mean)

Sl. No.	Month	Temperature °C		Relative humidity (%)	Total rainfall (cm)	No. of rainy days
		Max	Min			
1.	June 1999	29.48	23.91	85.25	397.4	18
2.	July 1999	29.00	23.45	84.09	164.2	21
3.	August 1999	29.69	22.95	83.23	108.4	16
4.	Septemper 1999	31.12	23.89	78.58	10.6	8
5.	October 1999	28.96	23.26	86.80	374.9	21
6.	November 1999	29.79	23.17	81.78	156.8	13
7.	December 1999	30.71	21.67	81.77	6.6	4
8.	January 2000	30.92	21.71	77.95	18.4	4

EVALUATION OF GENETIC STOCK OF 'SANGHUPUSHPAM' (*Clitoria ternatea* L.) FOR YIELD, ALKALOID CONTENT AND NITROGEN FIXING POTENTIAL

BY

DEEPA S. NAIR

ABSTRACT OF THE THESIS

SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENT FOR THE DEGREE OF

MASTER OF SCIENCE IN HORTICULTURE

FACULTY OF AGRICULTURE

KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF HORTICULTURE

COLLEGE OF AGRICULTURE

VELLAYANI, THIRUVANANTHAPURAM

2000

ABSTRACT

The present study entitled "Evaluation of genetic stock of 'Sanghupushpam' (*Clitoria ternatea* L.) for yield, alkaloid content and nitrogen fixing potential" was carried out at the Department of Horticulture, College of Agriculture, Vellayani from June 1999 to January 2000. Seeds of twenty different accessions were collected from various locations from inside and outside the state. Thirteen accessions having high rate of seed germination were raised as intercrop in young coconut garden and maintained till seed maturation stage. The performance of the accessions in terms of growth, yield and physiological parameters were evaluated.

Growth and yield parameters with respect to shoot, pod, root and root nodule characters were evaluated. Physiological parameters evaluated included leaf area index, leaf area duration, net assimilation rate, crop growth rate, relative growth rate, absolute growth rate and harvest index. Number of effective nodules was taken as an index for assessing nitrogen fixing potential of the plant.

Leaf yield, shoot yield and root yield were significantly superior in the accession MP-90. MP-83 recorded significantly superior pod yield. The

number of nodules was the highest in accessions MP-76 and MP-82. Crude alkaloid content was significantly superior in seeds of MP-74 and MP-76.

Six accessions were selected based on yield , nodule characters and crude alkaloid content *viz* ., MP-90, MP-74, MP-83, MP-78, MP-76 and MP-82.

Results of the present study indicated that *Clitoria ternatea*, is not a good proposition as an intercrop in young coconut garden. However, it may be worth studying the performance of the crop as a pure crop under open condition or as an intercrop in coconut garden with comparatively lesser shade (less than 50 per cent) than the situation of the present study.