# INFLUENCE OF METHODS OF PLANTING AND SHADE ON GROWTH, YIELD AND PLUMBAGIN CONTENT OF 'CHETHIKODUVELI' (*Plumbago rosea* Linn)

By

**JALAJA S. MENON**

**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 Plantation Crops and Spices
COLLEGE OF HORTICULTURE
Vellanikkara Thrissur

**1994**

## DECLARATION

I hereby declare that the thesis entitled "Influence of methods of planting and shade on growth yield and plumbagin content of 'Chethikoduveli' (*Plumbago rosea* Linn )' is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree diploma associateship fellowship or other similar title of any other University or Society

Vellanikkara
26 12 1994

Jalaja S Menon

JALAJA S MENON

Dr E V NYBE
Associate Professor & Head i/c
Dept of Plantation Crops & Spices
College of Horticulture

Velanikkara
26 12 1994

CERTIFICATE

Certified that the thesis entitled "Influence of methods of planting and shade on growth, yield and plumbagin content of 'Chethikoduveli' (*Plumbago rosea* Linn )" is a record of research work done independently by Ms Jalaja S Menon under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship

26/12/94
E V NYBE
Major Advisor

CERTIFICATE

We the undersigned members of the Advisory Committee of **Ms Jalaja S Menon** a candidate for the degree of **Master of Science in Horticulture** with major in Plantation Crops and Spices agree that this thesis entitled **"Influence of methods of planting and shade on growth yield and plumbagin content of 'Chethikoduveli' (*Plumbago rosea* Linn )"** may be submitted by Ms Jalaja S Menon in partial fulfilment of the requirements for the degree

Chairman

25/9/95

Dr E V Nybe
Associate Professor & Head i/c
Dept of Plantation Crops & Spices
College of Horticulture
Vellanikkara

Members

1 Dr G Sreekandan Nair
Professor & Head
Dept of Horticulture
(Plantation Crops & Spices ~~Division~~)
College of Agriculture
Vellayani

2 Dr Alice Kurian
Associate Professor
Dept of Plantation Crops & Spices
College of Horticulture

3 Sri A Augustin
Assistant Professor
AICRP on M & AP
College of Horticulture

25/9/95

EXTERNAL EXAMINER

DR P C SIVARAMAN NAIR

## ACKNOWLEDGEMENTS

I am gratified at the completion of my thesis as I feel I have been able to attain a cherished goal in my academic career I owe a great deal to the whole hearted help and co-operation of my esteemed teachers and friends

First of all I wish to acknowledge my indebtedness to **Dr E V Nybe** Associate Professor and Head i/c Department of Plantation Crops and Spices College of Horticulture Vellanikkara and Major Advisor who played a crucial role in my project I cannot find words to express adequately my gratitude for Dr Nybe's abiding patience and his unreserved help and advice throughout my work In fact without his sincere help and co operation and his kind encouragement at times of despair I would never have been able to accomplish my objective

I am grateful to **Dr G S Nair** the Advisory Committee member and the then Head of the Department who always took keen interest in my work and helped me a great deal with his valuable suggestions He has indeed been a great source of inspiration to me in my work

My sincere thanks are due to **Dr Alice Kurian** Associate Professor Department of Plantation Crops and Spices College of Horticulture Vellanikkara and also

Advisory Committee Member for all her support inspiration and the timely help I also extend my unmitigated thanks to Sri A Augustin Assistant Professor AICRP on M&AP College of Horticulture, Vellanikkara for his helpful suggestion and for providing me all necessary facilities at the Biochemistry laboratory to carry out the biochemical analysis

I gratefully remember the valuable suggestions by Dr P K Ashokan Associate professor College of Forestry Vellanikkara during the preparatory stage of the project

I have great pleasure to acknowledge thankfully all the help and co-operation extended by Dr R Vikraman Nair Professor and Head Department of Agronomy College of Horticulture Vellanikkara including the sparing of the Line Quantum Sensor for my work I also warmly thank Dr A V R Kesava Rao Department of Agrometeorology college of Horticulture Vellanikkara for his valuable suggestions and timely help

I wish to record my sincere thanks to Mr S Krishnan, Assistant Professor Department of Agricultural Statistics College of Horticulture Vellanikkara for his unreserved help rendered for the statistical analysis of the data

I take this opportunity to extend my most cordial thanks to all members of the Department of Plantation Crops and Spices for their support inspiration and valuable suggestions

A word of thanks is also due to Dr Kesavachandran Dr P K Rajeevan and Mr V K Raju Associate Professors for their help and co operation in the preparation of photographs required for the thes s

I have pleasure to extend my sincere thanks to my friends Mr Abraham Ms Rani Mini Sathya Vimi Smitha and all, who extended their whole-hearted support and co operation to me even at the cost of their own work Their kind inspiration has always been a great source of strength for me

I express my thanks to Mr Sugathan Mr Das and Mr Ravi Farm Supervisors and all the labourers for their timely help

I also record my sincere gratitude to Mrs Malathy and Mr Joy for their neat execution of the typing work

On this occasion I have great pleasure in acknowledging the ICAR for the award of Junior Fellowship to me

Lastly but not at all in the least I wish to acknowledge my deep sense of indebtedness to my parents my sisters and my grandmother for their affection help and blessings which have always been a source of great inspi ration for me

And above all I bow my head prayerfully to the Almighty God and seek his gracious benediction at all times

Jalaja S Menon

JALAJA S MENON

CONTENTS

LIST OF TABLES

## LIST OF FIGURES

## LIST OF PLATES

# LIST OF APPENDIX

# Introduction

# INTRODUCTION

In recent years an increasing interest in medicinal and aromatic plants could be observed, worldwide. After having tapped the immense advantages of the synthetic chemistry during the first half of the century, the situation has now changed and the so called 'Green Wave' arose from the idea about the use of nature and natural products for the welfare of mankind.

The demand for traditional drug plants in India and abroad is ever increasing. To cope up with the increased demand and to provide the basic raw materials to the industries at the required level, there is an urgent need to scale up the production by undertaking commercial cultivation of drug plants.

The demand growth rate of medicinal and aromatic plants at the international level is estimated as seven per cent per annum. At the present rate it is expected that by 2000 AD the export demand of the same would be of the value of Rs.3,500.00 million. The present trend of back to nature, 'revitalization of local health traditions' and good health for all by 2000 AD' demands that

the valuable medicinal plant species are not only preserved but also their cultivation developed in order to make available sufficient raw materials for pharmaceutical industry.

*Plumbago rosea* (L.) commonly known as rose-coloured lead wort or 'Chethikoduveli' belonging to the family Plumbaginaceae, is a perennial shrub the roots of which possess immense medicinal properties and is being used extensively in ayurvedic medicines. It is widely distributed in the tropics and is reported to be occuring wild or indegenous to Sikkim or Khasi hills.

The roots of plant contain an acrid crystalline principle called 'Plumbagin', 2-methyl 4 hydroxy 1-4 naphthaquinone upto the extent of 0.9 per cent. Plumbagin is used in the treatment of early cases of chronic skin diseases like leukoderma and baldness, as an abortifacient, for lowering blood pressure and has also got anticancerous, antifungal and antimicrobial properties. Apart from its medicinal and antimicrobial properties, plumbagin can also be used as preservative for non alcoholic drinks and wine. Reports of chromosomal aberrations caused by high concentration of plumbagin are also available (Santhakumari *et al.*, 1980).

To make best use of the available solar radiation, multispecies multistoreyed cropping systems are of great advantage. Kerala agriculture is characterized by small homesteads with coconut as an integral part. As coconut is widely spaced, nearly 75 percentage of the soil and about 50 per cent of solar energy remain unutilized, which offers great scope for intercropping. The extent of light interruption depends upon the age and height of the palm.

Except a few preliminary studies, no systematic work has been done regarding the influence of shade on yield and quality of *P. rosea* and suitability of this crop as an intercrop in coconut garden.

Though 'Chethikoduveli' is highly suited for Kerala conditions and is very important in indegenous drugs, it is paradoxical to note that the cultivation is limited to certain pockets only and that too not in a systematic way. Subha (1990) has reported plumbago as a highly remunerative crop under Kerala conditions. She has also standardised the optimum spacing and suggested stem cutting as the best planting material. The economic part of plumbago being the roots, the method of planting may usually influence the growth and development of roots and ultimately the yield. However, no specific method of planting has been recommended for the crop at present.

The present study was therefore undertaken with the main objectives of identifying suitable method of planting for better growth, root yield and plumbagin content and to study the effect of shade on growth, yield and quality of plumbago. The investigations also envisaged the assessment of the suitability of growing plumbago as intercrop in young coconut garden.

# Review of Literature

# REVIEW OF LITERATURE

*Plumbago rosea* (L.) is an important medicinal plant extensively used in ayurvedic medicines. The crop is indegenous to Sikkim or Khasi hills. The crop is highly suited to Kerala condition and is an important ingredient in the indegenous drugs but the cultivation of the same is limited to certain pockets only. Albeit, a lot of research has been done on chemical constituents and their properties, studies on agrotechnique of this crop are meagre. Since the literature on this crop is scanty, an attempt is made hereunder to review the literature pertaining to the subject irrespective of the crop.

## 2.1 Effect of rooting hormones on rooting of cuttings

At present no scientific information is available on influence of growth hormone on rooting of plumbago. In this section, the literature available on other crops are reviewed.

The application of growth regulator like Indole Acetic Acid (IAA), Indole Butyric Acid (IBA) and Naphthaline Acetic Acid (NAA) promote the development of roots in stem cuttings of many plants (Krishnamoorthy,

1981, Hartman and Kestor, 1983 and Edmond *et al.*, 1985). In *Vitex negundo* and *Sida retusa* the rooting percentage of cuttings, number of roots per cuttings and length of roots were found to be maximum in cuttings treated with 30 ppm IBA for 12 hours whereas in *Piper longum*, the application of 10 ppm IBA recorded maximum rooting percentage of cuttings (Philip *et al.*, 1990 ).

In betel vine cuttings, the number of primary roots and rooting percentage were high in quick dip treatment of IBA 3000 ppm compared to 500, 1000, 2000 and 4000 ppm (Panda and Mohanty, 1990). IBA treatment increased the percentage rooting as well as root growth of *Solanum hispidum*. The treatment stimulated sprouting of axillary buds and growth of shoot (Badola *et al.*, 1991).

IBA 1000 ppm treatment generally promoted rooting and increased percentage survival of rooted cuttings in *Tylophora indica* (Pal *et al.*, 1993a). But in *Datura stramonium* IBA 5000 ppm was more effective than 1000 ppm in promoting the rooting and percentage survival of rooted cuttings (Pal *et al.*, 1993b). The per cent rooting and survival percentage was high in IBA treated cuttings of Patchouli also (Selvarajan and Rao, 1991).

## 2.2 Effect of planting methods and shade on growth and yield

### 2.2.1 Agrotechniques

Subha (1990) had worked out the economics of cultivation of *P. rosea* and reported it as highly remunerative crop under Kerala condition. She had also suggested two-node hard wood stem cutting as the best planting material and worked out the optimum spacing as 50 cm x 15 cm. At present no specific method of planting has been recommended, different methods being followed in different localities. As the economically important part is the underground portion, the plumpy roots, the different planting method may influence the root yield.

### 2.2.2 Influence of method of planting on biometric characters

The influence of method of planting on biometric characters of medicinal plants have not yet been well studied.

Mohanty and Sarma (1978) showed that in ginger, planting in raised beds and application of farm yard manure and fertilizers combined with mulching with green leaves gave increased height of the plant, number of leaves and leaf length and leaf width compared to pit planting.

Investigations by Ramachandran and Muthuswami (1984) revealed that the different planting methods did not exhibit any significant effect in turmeric. This may be due to the similar growth pattern of the plant under different planting method. Under broad ridge method the plant height was slightly greater. The results indicated that this method provide more favourable opportunity for plant growth. This was in contrast to the findings of Anjaneyelu and Krishnamoorthy (1979) who observed significantly more plant height in ridge (30 cm x 15 cm) method when an equal population was maintained in all treatments.

In the case of number of leaves also there was no marked difference among the planting methods, but the plant under broad ridge method produced more leaves suggesting again the usefulness of this method in enhancing the growth although the differences were not significant. This agrees with the findings of Anjaneyalu and Krishnamoorthy (1979).

In amorphophallus, highest shoot length, basal girth and canopy spread were recorded when planting was done followed by complete earthing up compared to flat planting when hand weeding was done (Bhaumik *et al.*, 1988).

### 2.2.3 Influence of method of planting on yield and active principle

Thumininkatti and Patwardhan (1932) observed that the plumbagin content varied according to locality, age of plant, soil and season. The age of the plant and dryness of soil were positively correlated with yield of active principle. There was no marked difference in yield of diosgenin between plants grown on ridges and flat beds in dioscorea.

Planting ginger in raised beds and application of farm yard manure and fertilizers combined with mulching with green leaves gave the highest rhizome yield in ginger (Mohanty and Sarma, 1978). However, raised bed was not conducive to increase in yield unless it was mulched.

The yield of turmeric crop was not affected by any of the planting methods of ridge and furrow, flat bed and broad ridge method (Ramachandran and Muthuswamy, 1984), but broad ridge method yielded slightly more than the other two methods.

Ridge method of planting gave maximum yield of sweet potato tubers followed by furrow method of planting (Prasad, 1988).

In amorphophallus, planting followed by complete earthing up with hand weeding produced the better corm yield than flat planting (Bhaumik *et al.*, 1988).

In turmeric Balashanmugam and Vedamuthu (1989) suggested that broad flattened ridges with two rows of turmeric planted with two rows of onion as intercrop recorded maximum rhizome yield.

### 2.1.4 Influence of shade on biometric characters of intercrop

Solar radiation unlike water and nutrient has to be used instantaneously without storing for future use. Hence the harvest of as much solar energy as possible per unit area and time is more important in intensive cropping. Experimental evidences on growth and yield of different intercrops under various light intensities are available in plenty. But literature regarding the relative suitability of plumbago under such situation is limited. The most promising intercrops in coconut were reported to be tuber and rhizome species.

Ahluwalia (1963) had reported that rauwolfia plants were more robust in open than in shade. Sahu (1970) and Biswas and Badhuri (1975) had confirmed that *R. serpentina* come up well under banana, papaya and mango orchards.

A preliminary study conducted by Nair *et al.*, (1991) revealed the possibility of growing 13 medicinal or aromatic plants including plumbago, rauvolfia and catharanthus as intercrops in 8-20 year old coconut plantations when no other intercrops are usually recommended. The shade did not adversely affect the biometric characters. Rajagopalan *et al.* (1992) suggested five medicinal plants including *Andrographis paniculata* and *Coleus veteveroides* as intercrops in 25 year old coconut garden.

Increase in plant height due to shading has been reported in several other crops. Positive effect of shade on plant height in cassava was reported by Ramanujam *et al.* (1984) and Sreekumari *et al.* (1988). Similar trend was reported in crops like ginger (Aclan and Quisumbing, 1976), ginger, turmeric, coleus and sweet potato (Bai and Nair, 1982). Varughese (1989) has also observed a positive correlation between shade and plant height in ginger and turmeric. Increased height due to shade in ginger was also reported by George (1992). Increase in plant height with shading was also reported in colocasia (Prameela, 1990). Significant increase in vine length with reduction in light intensity was observed in sweet potato by Biswas *et al.* in 1990.

On the contrary, George (1982) was of the opinion that plant height was unaffected by shading in cowpea and black gram and Bai and Nair (1982) in colocasia. In *Mentha arvensis* also, Duriyaprapan and Britten (1982) failed to record any influence of shade on plant height. In cassava, internodal length increased under shade and number of leaves produced reduced (Sreekumari *et al.*, 1988). Varughese (1989) observed a decrease in the number of leaves with shading in ginger and turmeric, while, Sennamarappa and Shanker (1988) reported no significant change in turmeric due to intercropping in arecanut. Similarly no significant effect of shade on number of leaves was noticed in colocasia (Prameela, 1990).

Solar radiation has a decisive role in the tillering and branching pattern of plants. Increased branching at higher light intensity was observed in plants like sweet potato, coleus (Bai, 1981), ginger and turmeric (Bai, 1981; Varughese, 1989). Nalawadi *et al.* (1988) observed more number of branches in Ixora and Pillai (1990) in clocimum grown in open conditions. But no significant difference was perceived between different shade levels with respect to tiller number in ginger (George, 1992).

Ramadasan and Satheesan (1980) recorded high leaf area index, crop growth rate and NAR with three turmeric cultivars grown in open compared to that under shade.

Net assimilation rate increased with increase in shade in ginger (Bai, 1981). In turmeric, the leaf area development and crop growth rate reached their maximum much earlier in pure crop than in intercrop (Ramadasan and Satheesan, 1980). Later in 1992 Satheesan and Ramadasan when investigated the physiological variation in three turmeric cultivars, all the cultivars registered an increase in specific leaf area and leaf air space volume when grown in coconut garden. Low light intensity led to the production of leaves with high specific leaf area in Cassava (Fukai *et al.*, 1982).

It has been established by several workers that shaded plants have a higher chlorophyll content compared to plants exposed to sun. An increase in chlorophyll content with increase in shade levels was reported by Bai (1981) and Varughese (1989) in tuber crops.

All cultivars of turmeric had higher chlorophyll b and lower chlorophyll a/b ratio when intercropped in coconut garden. Chlorophyll b forms a large part of light harvesting pigment for photosystem 11. In light limiting

conditions ability to harvest a large percentage of energy is advantageous (Lewandonisha *et al.*, 1976). Lower chlorophyll a/b ratio are typical of shade ecotypes and may enable more efficient absorption of light under shaded condition due to difference in absorption spectra of chlorophyll a and b and variance in light quality in understorey (Boardman, 1971; Young and Smith, 1980).

An increase in chlorophyll content in the shaded leaves was reported in Colocasia (Bai, 1981; Prameela, 1990) ginger and turmeric (Bai, 1981; Varghese, 1989) and in ginger (George, 1992).

In ginger chlorophyll a to b ratio was not found to be markedly affected by shading (Varughese, 1989) whereas in Colocasia, chlorophyll a to b ratio was found to decrease with shading (Prameela, 1990).

Ravisankar and Muthuswamy (1987) reported higher content of chlorophyll and its components in ginger grown in two year old and six year old arecanut plantation compared to those grown in pure stand in open. Physiological variation in three turmeric cultivars under natural shade in coconut was investigated (Satheesan and Ramadasan, 1992). The cultivar Sugandham had shown lower photosynthetic efficiency and adaptability of this cultivar towards low light intensity was reflected in its

higher contents of chlorophyll a and b, under intercropping system than under the monoculture system.

### 2.1.5 Influence of shade on yield and active principle of intercrops

Productivity of a plant depends upon its capacity to harvest efficiently the solar energy for various metabolic activities and also its efficiency in partitioning the assimilates into harvestable sink.

Positive influence of partial shading on yield was reported in ginger which gave as much yield as that under full sunlight (Aclan and Quisumbing, 1976; Bai, 1981).

Highest yield was recorded in ginger and turmeric at 25 per cent and 50 per cent shade levels respectively by Bai and Nair (1982). This was further confirmed by Varugheese (1989), who also obtained highest yield in ginger at 25 per cent shade.

All the ginger cultivars in shade performed better than those in open in terms of rhizome yield. Yield parameters like harvest index and total dry weight were also highest at 25 per cent shade. However, the performance of all cultivars was poor in terms of rhizome yield under natural shade in coconut garden (Varugheese, 1992).

Ravisankar and Muthuswamy (1987) recorded the highest yield of ginger at low light intensity of 15.3 klux. Similar trend was noticed by Prameela (1990) in colocasia. The yield superiority observed in the pure crop of turmeric was attributed to the higher crop growth rate during tuberisation and higher solar energy input under open condition (Satheesan and Ramadasan, 1992).

Negative correlation of shade with yield was reported in many crops like turmeric (Ramadasan and Satheesan, 1980 and Varugheese, 1989) and cassava (Ramanujan *et al.*, 1984, Okoti and Wilson, 1986).

Nair *et al.*, 1991 showed that yield of plumbago, rauwolfia and catharanthus when grown under natural shade of coconut was on par with the yield obtained under open conditions.

Rajagopalan *et al.* (1992) showed that *Andrographis paniculata* grown under full shade (60-90 per cent) and partial shade (30-60 per cent) in coconut garden yielded significantly superior to that under open condition (0-30 per cent). *Coleus veteveroides* was also found to produce high yield under partial shade and was on par with the yield under open. In the case of *Kaempferia galanga, Marantha arundinaceae* and *Sida retusa* yield was not sig-

nificantly affected by the shade levels.

Highest yield of Patchouli (*Pogostemon patchouli*) was obtained when the plant was grown under 50 per cent shade (Radhakrishnan *et al.*, 1991).

In a trial cultivation of *Captis japonica* the dry weight of rhizomes grown in the unshaded field was less than that in shaded fields (Shibata *et al.* 1992).

In geranium the weight of air dried aerial part was heavier when no shading or 22 per cent shading was given and toxin content was higher when 22 per cent shading was given (Kan, 1991).

The growth habit, yield and alkaloid content of the plants vary under different agroclimatic conditions. Biswas (1955) observed that there was no significant difference in the alkaloid content of roots of *Rauvolfia serpentina* under irrigated agriculture and forestry systems. Tuber yield, protein and alkaloid content of *Holostemma annulare* was compared under domesticated and wild condition by Samuel *et al.* (1993) and found that it was high in tubers obtained from domesticated plots when compared to the market sample.

Light regime of a plant also determine the productivity and quality of its produce (Tikhominov *et al.*,

1976). Shade exerts its positive influence on the quality of the produce in many crops. Quality of produce or alkaloid content also vary with the fertilizer application. In *Costus speciosus* Yadav *et al.* (1983) reported that total diosgenin content increased with N and K application whereas it decreased with P application. The antiemetic activity of tubers of *Pinellia ternata* was highest in the N and K fertilized plots while P reduced it (Kesahara and Hikino, 1983) whereas fertilizers like N and P had no appreciable effect on yield in *Withania somnifera* (Nigam *et al.*, 1984).

Shade improved the quality of products of *Cinchona ledgeriana, Rauvolfia gunnanensis* etc. (Feng, 1982).

In a study conducted at Tamil Nadu Agricultural University, Coimbatore, the quality of ginger improved when grown under arecanut canopy (Ravisankar and Muthuswamy, 1987). It was later supported by George (1992); wherein the shade grown ginger recorded high values of oil and oleoresin content compared to that grown in open.

In contrast to the above findings, a negative correlation of shade and quality of the produce was also reported. Oil content of clocimum grown under shade was low compared to that in open (Balyan *et al.*, 1982; Pillai,

1990). Curcumin content of turmeric rhizome showed a progressive decrease with increase in shade (Varugheese, 1989). Pillai (1990) also suggested that oil yield and oil content of clocimum were high in the open compared to that under shade. In colocasia, oxalic acid and starch contents were higher in open compared to that under shade (Prameela, 1990). However, in *Captis japonica* no significant difference in berberine type alkaloid content was observed (Shibata et al., 1992).

Twenty four medicinal species were identified as potential intercrop in rubber during the immaturity period. Among the plants *Adhatoda beddomei, Plumbago rosea, Kaempferia rotunda* were reported to come up well under deep shade (RRII, 1989). Vijayakumar *et al.* (1989) also supported that some shade tolerant species like *Holostemma annulare, Kaempferia galanga, Alpinia galanga, Sida rhombifolia* etc. can be successfully cultivated in rubber plantations.

Raghavan (1992) catalogued the medicinal plants seen naturally in the Vellanikkara rubber estate and reported favourable growth of *Hemidesmus indicus* and *Curculigo orchioides* under the dense canopy of rubber.

# Materials and Methods

# MATERIALS AND METHODS

The investigations reported herein were carried out at the College of Horticulture, Vellanikkara, Thrissur, Kerala from 1993 April to 1994 August. The area was located at 10°32′ N latitude, 76°10′ E longitude and at an altitude of 22.25 m above Mean Sea level. The soil of the experimental plot was a deep laterite with clay loam texture. The meteorological data of the locality for the last three years are furnished in Appendix-I.

## 3.1 Effect of rooting hormone on rooting of cuttings

A preliminary trial was carried out in order to assess the influence of rooting hormone, IBA (Indole butyric acid) on rooting of cutting of plumbagin.

IBA at two concentrations, 500 and 1000 ppm for 30, 45 and 60 seconds were tried. A control was maintained by dipping the cuttings in distilled water for 60 seconds. Two noded cuttings were planted in polybag of size 12 cm x 18 cm (150 guage) at a density of four cuttings per bag.

The experiment was laid out in a completely randomised design (CRD). Each treatment consisted of 100 cuttings. The cuttings were kept under shade and irrigated regularly with a rosecan.

Cuttings were daily watched for the bud break and the days for emergence of sprout was noted when the sprouts were 1-2 cm long. The percentage survival after one month was recorded and data on root and shoot characters were gathered three months after planting (ie. the stage at which transplanting is done).

The observations recorded were

1) Time taken for sprouting
2) Percentage survival after one month
3) Length of root after three months
4) Number of roots after three months
5) Leaf number after three months
6) Shoot length after three months

## 3.2 Influence of method of planting and shade on growth and yield

### 3.2.1 Soil analysis

Soil samples were collected from each plot and composite samples were drawn for each treatment for chemical analysis, before planting and after harvest of the crop.

Organic carbon was estimated by Walkley and Black method, available phosphorus by Bray and Kurtz method and

available potassium by Flame Photometric method (Amma, 1989).

3.2.2 Experimental details and lay out

The particulars of the treatments and other experimental details are given below.

| | |
|---|---|
| Design | : Randomised Block Design |
| Treatments | : $T_1$ ridge and furrow |
| | $T_2$ flat bed |
| | $T_3$ mound |
| | $T_4$ pit followed by mound |
| Number of replications | : 6 |
| Gross plot size | : 3 x 2.7 $m^2$ |
| Net plot size | : 2x 0.9 $m^2$ |
| Spacing | : 50 cm x 15 cm |
| Gross number of plants/plot | : 108 |
| Net number of plants/plot | : 24 |
| Total experimental area | : 388.8 $m^2$ |

Two sets of experiments were conducted one under open condition (Fig.1) and other under natural shade in young coconut plantation of 15 years old (Plates 1 and 2).

In coconut plantation, (7.5 m x 7.5 m) the plots were taken at the middle of four coconut palms (Fig. 2).

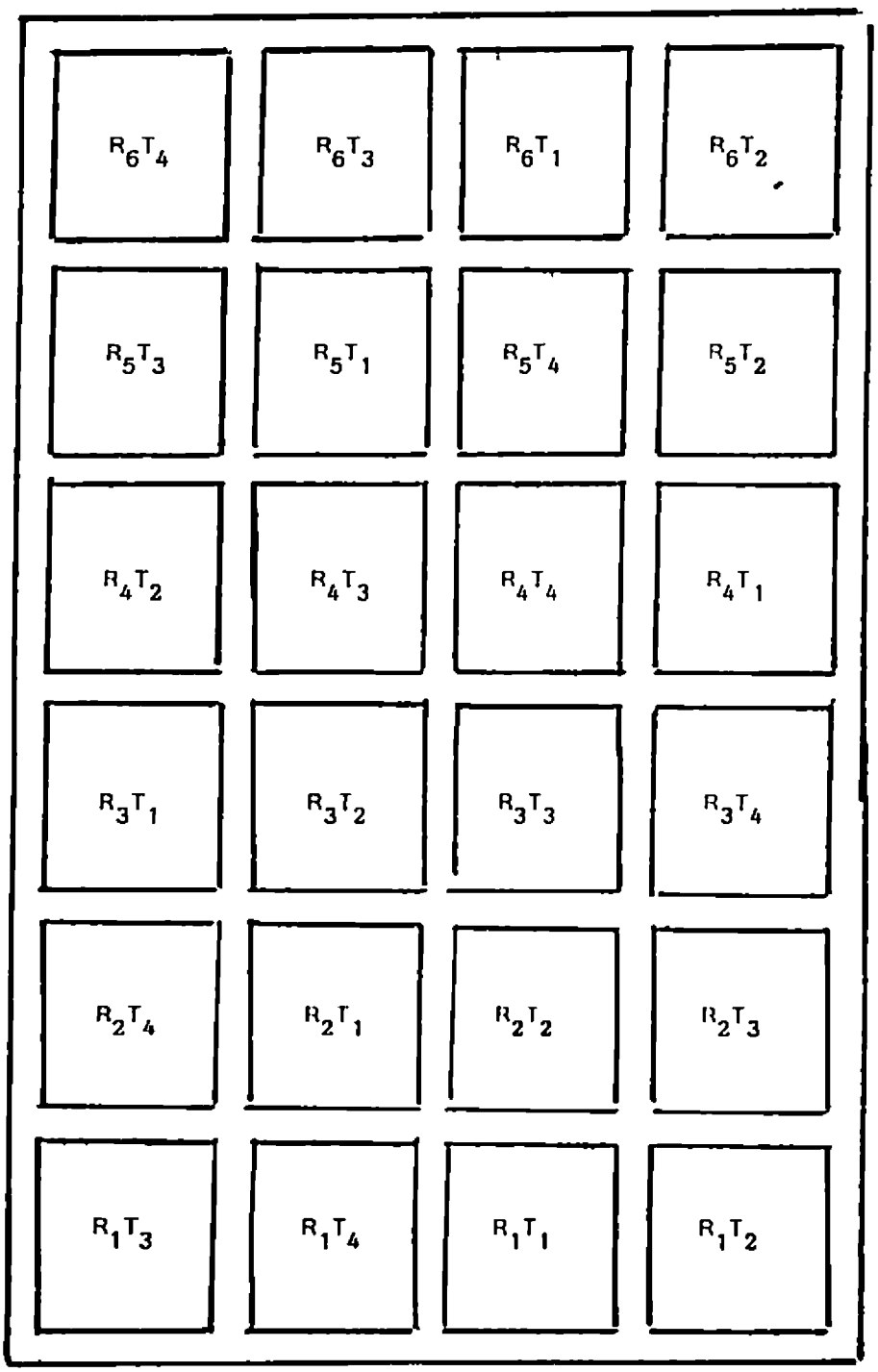



Fig 1 Layout of field under open condition

R - Replication $T_1$ - ridge and furrow $T_2$ - flat bed

$T_3$ Mound $T_4$ Pit followed by mound

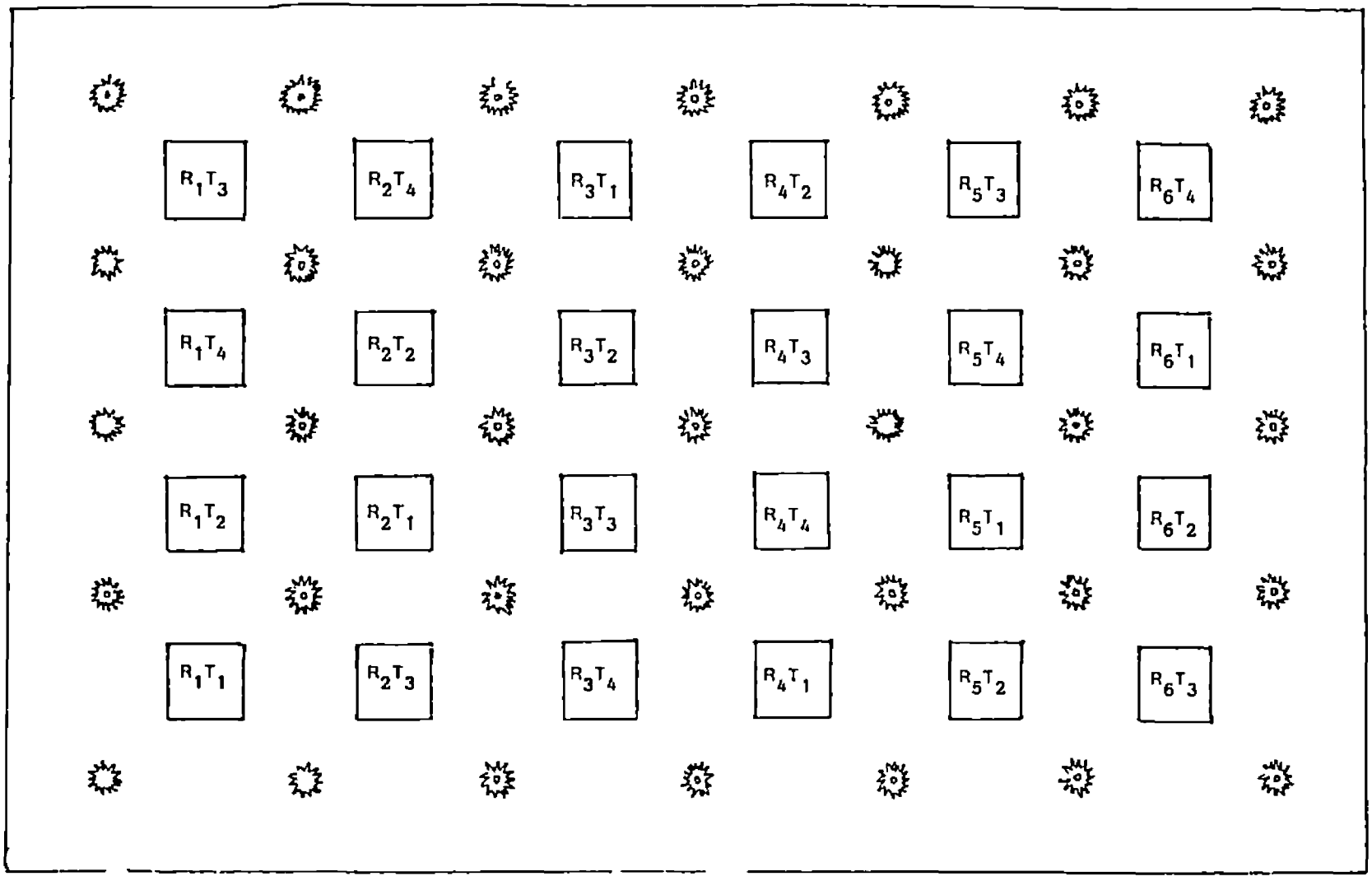



Fig 2 Layout of field in coconut plantation

R Replication $T_1$ ridge and fu ow $T_2$ flo bed $T_3$ Mound

$T_4$ Pit followed by mound

Plate 1. General view of the experimental field under natural shade of coconut

Plate 2 General view of the exper mental field under open condition


INFLUENCE OF METHODS OF PLANTING
& SHADE ON GROWTH YIELD AND
FLAVONOID CONTENT OF

Ridges of 30 cm height and 30 cm width were taken at a spacing of 50 cm in North South direction For the preparation of flat bed plots of 3 x 2 7 $m^2$ were divided into two by making a furrow of 30 cm in between and the two beds of 30 cm height were taken

Mounds of 30 cm height and diameter were prepared at a spacing of 90 cm x 50 cm so that in each plot there were 18 mounds and the central four mounds constituted the net area In a similar manner pits were taken (30 cm depth and 30 cm diameter) But they were levelled after two months of transplanting and after five months converted into mounds

3 2 3 Planting material

The planting material required for the study was procured from progressive farmers from Vellanikkara and Attur areas of Thrissur district Nursery was raised during April after the receipt of premonsoon showers

Two noded cuttings were prepared from the semihard wood portion The leaf blades were removed with the petiole intact and planted in plolybags (12 cm x 18 cm with 150 guage thickness) with one node above the soil surface

Potting mixture used contained soil sand and cowdung in the ratio 1 1 1 In each bag four cuttings were planted and kept under shade and judiciously watered with a rosecan Termite attack observed in the nursery could be effectively controlled by drenching BHC 50 WP at 0 2 per cent

3 2 4 Planting

The land was dug well and the soil was brought to a fine tilth Plots of 3 x 2 7 $m^2$ were prepared according to the experimertal design

After the onset of SW monsoon three months old rooted cuttings were planted in the mainfield during the second fortnight of July 1993 In the case of mounds and pits six rooted cuttings were planted in each In flat bed planting was done at a spacing of 50 cm x 15 cm where as on ridges taken at 50 cm apart the cutting were planted in single row in each ridge at 15 cm spacing

The field establishment of cuttings were noted one month after planting and first gap filling was done with fresh cuttings The gap filled ones were tagged and avoided from recording further observations Gap filling was continued upto two months after planting

At the time of planting FYM @ 10 t/ha was given Fertilizers were applied at the rate of 50 25 50 kg NPK/ha Two third of the total dose was given at two months after planting and the remaining one third five months after planting

Fertilizer application was followed by earthing up The plot was kept clean weeded and the crop was raised as irrigated

Leaf blight and die back were noticed during summer periods and three sprays of Indofil 0 3 per cent was given to control the same Mite attack observed could be controlled by Ekalux 0 2 per cent spray

3 3 Sampling technique

Random sampling technique was adopted to select the sample plants for recording various biometric and quality characters Ten plants were selected at random within the net area of each plot which were used for recording pre harvest and post harvest observations

## 3 4 Collection of data

### 3 4 1 Pre harvest observations

#### 3 4 1 1 Height

The height of the plant was measured at monthly interval commencing from two months after planting in the main field The measurements were taken from the ground level to the tip of the topmost leaf using a metre scale and expressed in centimeter

#### 3 4 1 2 Internodal length

The distance between the point of attachment of the first fully opened leaf from the top and that of the leaf just below was measured and recorded as internodal length

#### 3 4 1 3 Number of suckers per plant

The number of suckers per plant was counted and recorded at monthly interval

#### 3 4 1 4 Total number of leaves per plant

The number of leaves per plant was counted for each observational plant and the average number of leaves per plant was worked out

3 4 1 5 Length of leaf

The length of the first fully opened leaf from the top was recorded The distance between the point of attachment of the leaf blade to the stem and upto the tip of the leaf blade was taken as the length and expressed in centimeter

3 4 1 6 Width of leaf

The width of the first fully opened leaf from the top, the length of which was recorded was measured at the point of maximum width and expressed in centimeter

3 4 1 7 Leaf area

Using the relationship between length width and mean area of leaf a correction factor was worked out employing the formula $\frac{EA}{L \times W}$

EA - Area of a leaf determined by graphical method

L - Maximum length of leaf

W - Maximum width of leaf

To compute the correction factor 100 leaf samples were used The leaf area was calculated by multiplying the maximum length and width of each leaf with the correction factor obtained (0 70)

3 4 1 8 Number of days taken for blooming

Number of days taken for flowering in each plot and also the number of plants flowered in each plot ~~was~~ were recorded

3 4 1 9 Chlorophyll estimation

The first fully matured leaf from the top was selected for chlorophyll estimation A four square centimetre fresh leaf portion was ground in a mortar with chilled acetone A pinch of $CaCo_3$ was added to prevent pheophytin formation Repeated the extraction and made upto 50 ml with acetone

Measured the absorbance of the extract at 645 nm and 663 nm The chlorophyll content on fresh weight basis was calculated based on the following equations

Total chlorophyll (g/l) $= (0\ 0202)\ (OD_{645}) + (0\ 00802)\ (OD_{663})$

Chlorophyll a (g/l) $= (0\ 01271)\ (OD_{663}) - (0\ 00269)\ (OD_{645})$

Chlorophyll b (g/l) $= (0\ 0229)\ (OD_{645}) - (0\ 00488)\ (OD_{663})$

3 4 1 10 Light infiltration

The photosynthetically active radiation (PAR) was

measured using a point quantum sensor and LI-1000 Datalogger Observations were taken five times a day at two hours interval starting from 8 am from January to April Simultaneous observations were taken both inside the plantation and in open condition and the percentage infiltration was worked out

3 4 2 Post harvest observations

Harvesting was done nine months after transplanting to the main field All the ten observational plants from each plot was dug out separately taking care to keep the roots intact Then the roots were separated and both the shoots and roots were washed in water to remove the adhering soil particles and the data on the following parameters were recorded

3 4 2 1 Length of root

The length of the longest root was measured separately for each observational plant and mean worked out and expressed in centimeter.

3 4 2 2 Girth of root

Girth of the boldest root was measured separately for each observational plant and the mean worked out and expressed in centimeters

3 4 2 3 Number of roots

The number of primary roots in each observational plant was counted separately and mean worked out and expressed as number per plant

3 4 2 4 Volume of roots

Volume of roots were recorded separately for each observational plant using a measuring jar sufficiently large to hold the roots and expressed in millilitre

3 4 2 5 Fresh weight of roots

Fresh weight of roots for each observational plant was recorded separately and the mean per plant was worked out and expressed in gram

3 4 2 6 Fresh weight of shoot

The fresh weight of shoot for each observational plant was recorded separately and the mean shoot weight per plant was worked out and expressed in gram

3 4 2 7 Dry weight of root

After taking the fresh weight of the roots 10 g of root sample from each observational plant was dried in hot air oven at 70 C to a constant weight After drying the

samples were weighed separately and the percentage drıage was calculated The dry weıght of root per plant was then worked out

3 4 2 8 Dry weıght of shoots

Shoot samples after recordıng the fresh weıght were drıed ın a hot aır oven at 70 C Then the samples were weıghed separately and mean dry weıght of shoot per plant was computed and expressed ın gram

3 4 2 9 Shoot root ratıo

The ratıo between dry shoot weıght and dry root weıght was calculated and expressed as shoot root ratıo

3 4 2 10 Estımatıon of plumbagın

The procedure descrıbed by Subha (1990) whıch was a partıally modıfıed procedure suggested by Thumınınkattı and Patwardhan (1932) was adopted for ısolatıon and quan tıfıcatıon of plumbagın

3 4 2 10 1 Preparatıon of samples

A small bıt of root from each of the selected ten sample plants was collected and pooled to get a composıte sample Those bıts were then chopped ınto small pıeces mıxed thoroughly quartered and three representatıve

samples of 20 g each were drawn for the estimation of plumbagin

Extraction was carried out from samples on the day of collection itself

3 4 2 10 2 Extraction of crude plumbagin

A sample of 20 g was macerated and constantly extracted with 100 ml acetone and kept as such for 24 hours in darkness The clear supernatent containing plumbagin was collected and filtrated Repeated the extraction thrice with acetone and the combined extract was used for further analysis

The extract was transferred into a separating funnel and equal quantities of diethyl either and water were added Shook well and allowed to stay for 20 minutes The epiphase of diethyl ether layer containing plumbagin was separated The extraction was repeated three to four times, and the combined extract was evaporated under vacuum system Drying and weighing of crude plumbagin were repeated to obtain a constant weight

3 4 2 10 3 Purification of crude plumbagin

Two millilitres of three per cent NaOH was added to the crude plumbagin and kept over a water bath at about

60 C for 30 minutes The saponified material was transferred to the separating funnel and extracted with diethyl ether Repeated the extraction four times with ether followed by concentration of the extract under vacuum at 60 C Kept it as such at room temperature for crystallisation of plumbagin After complete crystallisation the weight of the purified plumbagin was noted Weighing was repeated so as to obtain a constant weight The yield was expressed as percentage of plumbagin on fresh weight basis

## 3 5 Statistical analysis

The data for the various parameters under consideration were subjected to statistical analysis for a Randomised Block Design separately for the open and natural shade conditions Whenever necessary the data were pooled and analysed as groups of experiments in order to bring out the impact of shade on different planting methods (Nigam and Gupta 1971) Wherever error mean squares are heterogeneous, results under shade and open conditions were discussed separately

# RESULTS

The observations recorded on growth yield and quality of plumbago under natural shade of coconut and open condition were tabulated after due statistical analysis wherever necessary and are presented here under

## 4 1 Effect of IBA on rooting of cuttings

The data on the results of treatment of the cuttings with IBA are presented in Table 1 The highest number of roots was 19, when the cuttings were treated with IBA 500 ppm for 60 seconds though this was not significantly different from the treatments at the same concentration for lesser periods The root length recorded was also maximum (5 26 cm) at this concentration but was significant at 10 per cent error only when compared with other concentrations The time taken for sprouting could be very much reduced to seven days when treated with IBA 500 ppm for one minute as compared to 10 days in the control In general, IBA at 500 ppm influenced the root number and root length (Plate 3)

Table 1 Effect of IBA on sprouting and root characters

| IBA concentration (ppm) | Period of treatment (seconds) | Percentage survival (after one month) | Number of roots after three months | Root length after three months (cm) | Time taken for sprouting (days) |
|---|---|---|---|---|---|
| 500 | 30 | $84^{a}$ | $3\ 57^{ab}$ (13 00) | 3 63 | $2\ 95^{bc}$ (9 00) |
| | 45 | $75^{b}$ | $3\ 80^{ab}$ (14 00) | 3 14 | $2\ 79^{d}$ (8 00) |
| | 60 | $77^{b}$ | $4\ 37^{a}$ (19 00) | 5 26 | $2\ 67^{d}$ (7 00) |
| 1000 | 30 | $74^{b}$ | $3\ 19^{bc}$ (10 00) | 0 90 | $2\ 73^{d}$ (7 00) |
| " | 45 | $69^{b}$ | $3\ 59^{ab}$ (13 00) | 1 57 | $3\ 16^{a}$ (10 00) |
| | 60 | $63^{b}$ | $3\ 31^{bc}$ (11 00) | 2 80 | $2\ 92^{cd}$ (9 00) |
| 0 | 60 | $60^{b}$ | $2\ 29^{c}$ (5 00) | 1 96 | $3\ 11^{ab}$ (10 00) |
| | | S | S | NS | S |

Note Figures in parenthesis are original values and others are square root transformed ones

Figures with the same superscripts form one homogeneous group

NS Non significant S - Significant

Plate 3 Cuttings of *Plumbago rosea* L treated with IBA


60s
45s
30s
IBA 500 ppm
CONTROL

The results of the investigations have also revealed that the percentage survival recorded after one month was higher in the case of cuttings which were subjected to a quick dip with IBA 500 ppm for 30 seconds followed by IBA 500 ppm 60 seconds (84 per cent and 74 per cent respectively) In general, all the treatments recorded higher survival as compared to the control (60 per cent) When a comparison was made between the concentrations of the hormone irrespective of the time 500 ppm was found to give a better survival of 78 per cent as against 68 per cent in the case of 1000 ppm

**4 2. General observations**

4 2 1 Percentage survival in the field

The percentage survival or field establishment was found to be highly influenced by the planting methods and growing conditions (Table 2) The crops under natural shade of coconut recorded a higher percentage survival (90 44 per cent) as compared to open (66 85 per cent)

Of the different planting methods tried, the flat bed method recorded the lowest percentage of survival both under open and shade whereas cuttings planted on mound recorded a higher survival percentage

Table 2 Percentage survival in the field after three months

| Planting method | Shade | Open |
|---|---|---|
| Ridge and furrow | 93 75 | 78 48 |
| Flat bed | 81 20 | 27 78 |
| Mound | 94 45 | 86 81 |
| Pit followed by mound | 92 36 | 74 31 |
| Mean | 90 44 | 66 85 |

4 2 2 Soil nutrient status

The soil analysis data (Table 3) showed a marked difference in the major nutrient contents in the soil before planting and after harvest The percentage reduction of organic carbon and available potassium were high in the open field (19 15 per cent and 30 20 per cent respectively) Among the major nutrients studied phosphorus showed a very high reduction amounting to 47 58 per cent under shaded condition and 36 82 per cent under open

4 2 3 Incidence of diseases and pests

Visual observations were made for assessing the intensity of incidence of pests and diseases

During the summer months high incidence of leaf blight was noticed The crops under open condition was affected more seriously than that under the shade However Indofil spray could control the disease effectively and since irrigation was continuing, new leaves were produced which were free from blight

Mite damage was also noticed during summer months It was severe in shade as compared to open The incidence could be controlled by spraying Ekalux

Table 3 Average nutrient content in the soil before planting and after harvest

| | Organic carbon (%) | | | | Available phosphorus kg/ha | | | | Available potassium kg/ha | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Open | | Shade | | Open | | Shade | | Open | | Shade | |
| | Before planting | After harvest | Before planting | After harvest | Before planting | After harvest | Before planting | After harvest | Before planting | After harvest | Before planting | After harvest |
| Ridge and furrow | 0 95 | 0 75 | 1 09 | 0 94 | 20 11 | 14 90 | 53 97 | 19 38 | 128 8 | 81 2 | 176 4 | 120 4 |
| Flat bed | 1 01 | 0 68 | 0 92 | 0 92 | 30 74 | 13 34 | 27 09 | 13 76 | 112 0 | 100 8 | 151 2 | 114 8 |
| Mound | 0 86 | 0 79 | 0 92 | 0 90 | 13 76 | 13 65 | 18 03 | 12 51 | 106 4 | 81 2 | 159 6 | 145 6 |
| Pit followed by mound | 0 92 | 0 83 | 0 94 | 0 92 | 22 93 | 13 44 | 18 03 | 15 73 | 134 4 | 72 8 | 190 4 | 137 2 |
| Mean | 0 94 | 0 76 | 0 97 | 0 92 | 21 89 | 13 83 | 29 28 | 15 35 | 120 4 | 84 0 | 169 4 | 129 5 |
| % reduction | 19 15 | | 5 15 | | 36 82 | | 47 58 | | 30 20 | | 23 55 | |

Nematode (root knot nematode) attack was observed under both the conditions but the intensity was high in the open The affected plants showed slight yellowing and in some cases the floral parts were transformed into small leaves with stunting of the peduncle When the infected roots were observed both single and multiple galls were noticed (Plate 4) The affected roots failed to develop and were hairy with numerous galls

4 2 4 Light infiltration in coconut plantation

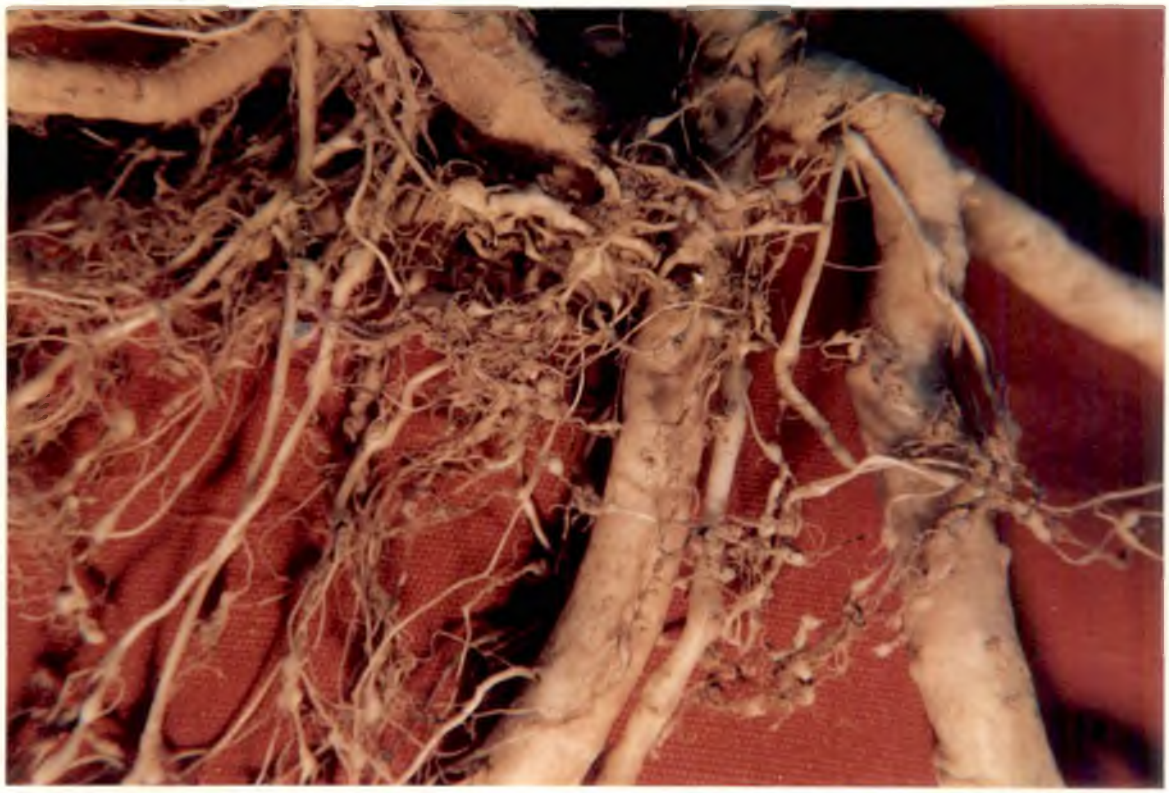
The percentage of light infiltration in the inter-cropped coconut plantation was measured from January to April The maximum was found to be 35 per cent which was recorded during April and the minimum was 27 per cent during January

The variation in the quantum of light infiltered in a day for each month is depicted in Figure 3 It could be seen that during all the months the maximum infiltration was noticed at 12 00 noon and a maximum of 67 per cent was recorded during March

4 2 5 Flowering

The flower initiation was comparatively early in the open as compared to shade The flowering intensity in

Plate 4 Plumbago roots infected with root knot nematode



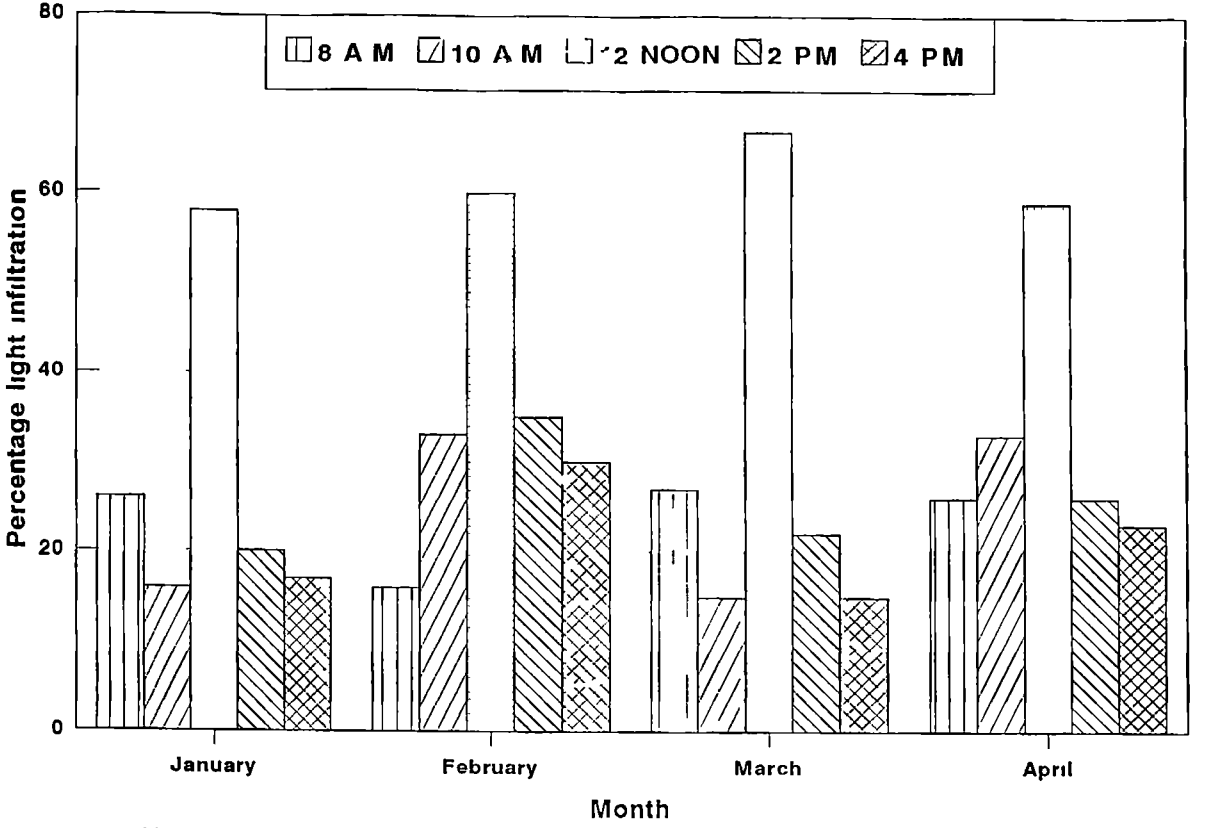



Fig 3 Variation of light infiltration in coconut plantation

terms of number of plants flowered and the number of flowers per plant was also high in the plants grown under open condition (Plate 5 and 6)

## 4 3 Pre-harvest observations

### 4 3 1 Plant height

The data pertaining to the effect of shade and different planting methods on total plant height are furnished in the Table 4 It could be seen that the two different growing conditions had no significant influence on plant height except during the initial period of growth ie October During October the plant height was 14 77 cm which was significantly higher than that of the plants under open condition (8 92 cm) During December the plants under open recorded a height of 22 70 cm which was almost comparable to the height of the plants under shade (23 64 cm) during the same period However from January onwards the plants under open were taller as compared to that under shade (Fig 4)

When different planting methods were considered irrespective of the growing conditions the treatments did not vary significantly with respect to plant height But when the performance of the planting methods under open and shade conditions were assessed separately the flat bed method was found to be significantly superior to all

Plate 5 Single plant under shaded condition with less number of inflorescence

Plate 6 Plants under open condition showing higher intensity of flowering

Table 4 Effect of shade and planting methods on plant height (cm)

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall shade | Overall open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (14 77) | (8 92) | S |
| Shade | 3 75(13 16) | 3 98(15 14) | 4 28(17 63) | 3 74(13 14) | NS | | | |
| Open | 3 19( 9 31) | 2 85( 7 17) | 3 23( 9 51) | 3 22( 9 68) | | | | |
| Pooled | 3 47(11 24) | 3 42(11 15) | 3 75(13 57) | 3 48(11 41) | NS | | | |
| **November** | | | | | | (20 04) | (14 77) | NS |
| Shade | 4 03(15 41) | 5 28(27 40) | 4 50(19 95) | 4 26(17 40) | 0 96 | | | |
| Open | 3 64(12 65) | 3 39(10 53) | 4 12(16 38) | 4 33(19 52) | | | | |
| Pooled | 3 84(14 03) | 4 33(18 97) | 4 31(18 17) | 4 29(18 46) | NS | | | |
| **December** | | | | | | (23 64) | (22 70) | NS |
| Shade | 4 38(18 31) | 5 83(34 22) | 4 74(22 2) | 4 51(19 84) | NS | | | |
| Open | 4 24(17 73) | 4 21(16 96) | 4 99(25 0) | 5 35(31 09) | | | | |
| Pooled | 4 31(18 02) | 5 02(25 59) | 4 87(23 6) | 4 93(25 47) | NS | | | |
| **January** | | | | | | (31 82) | (33 15) | NS |
| Shade | 4 96(23 87) | 6 69(44 82) | 5 37(28 61) | 5 49(29 98) | 0 89 | | | |
| Open | 5 24(27 17) | 5 37(28 04) | 6 00(36 11) | 6 20(41 29) | NS | | | |
| Pooled | 5 10(25 52) | 6 03(36 43) | 5 68(32 36) | 5 84(35 63) | NS | | | |
| **February** | | | | | | (32 66) | (35 88) | NS |
| Shade | 4 98(23 94) | 6 72(45 27) | 5 52(30 17) | 5 60(31 26) | 0 91 | | | |
| Open | 5 72(32 49) | 5 43(28 71) | 6 31(40 40) | 6 26(41 93) | NS | | | |
| Pooled | 5 33(28 21) | 6 08(36 99) | 5 94(35 29) | 5 93(36 59) | NS | | | |
| **March** | | | | | | (33 72) | (35 88) | NS |
| Shade | 5 09(24 99) | 6 85(47 12) | 5 65(31 53) | 5 63(31 30) | 0 89 | | | |
| Open | 5 77(33 31) | 5 62(30 96) | 6 30(39 73) | 6 28(41 64) | NS | | | |
| Pooled | 5 43(29 15) | 6 24(39 04) | 5 98(35 63) | 5 96(36 47) | NS | | | |
| **April** | | | | | | (33 72) | (36 41) | NS |
| Shade | 4 97(23 87) | 6 88(47 29) | 5 56(30 62) | 5 78(33 12) | 0 89 | | | |
| Open | 5 93(35 22) | 5 57(30 28) | 6 31(39 91) | 6 02(38 12) | NS | | | |
| Pooled | 5 45(29 54) | 6 22(38 78) | 5 94(35 27) | 5 90(35 62) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones

S - Significant NS Non significant

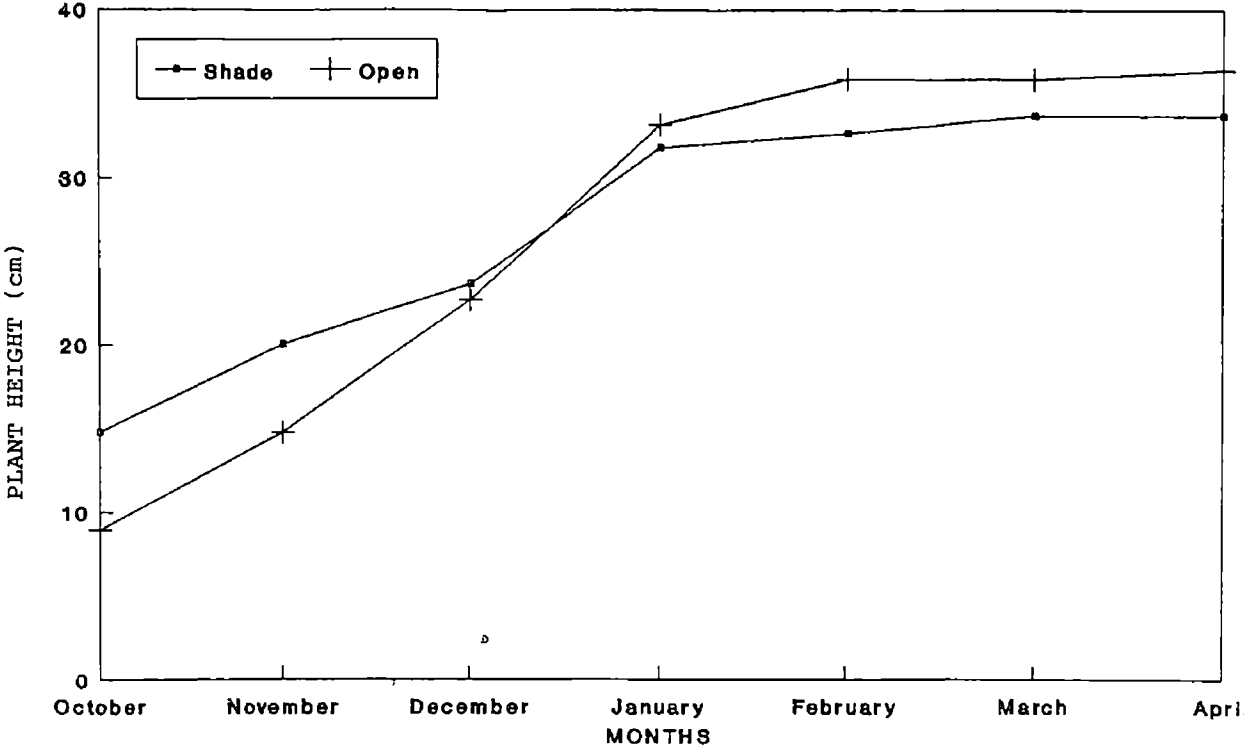



Fig 4 Influence of shade on plant height

other treatments under shade However, no such differential performance of various treatments could be observed under open condition

The data on the monthly increase in plant height irrespective of the planting methods tabulated in Table 5 revealed that the increase in height was more under open during all the months Maximum growth was noticed during December - January ie phase III (Fig 5) The plants grown under open recorded 10 46 cm growth in height as compared to 7 72 cm observed in the case of plants under shade However, the plants under both the conditions recorded almost the same quantum of increase in height during the initial period of October to November (5 46 cm and 5 93 cm for shade and open respectively)

4 3 2 Plant spread

4 3 2 1 EW spread

The data presented in Table 6 clearly indicate that the different planting methods or shade could not significantly influence the EW spread of the plant The EW spread noticed during the initial period of October ie three months after transplanting was 11 86 cm under shade which was significantly higher than that under open (8 88 cm) This difference narrowed as time advanced and from January onwards the plants under open recorded higher EW

Table 5 Monthly increase in plant height as influenced by the growing conditions

| Growth phase | Period | Plant height (cm) Shade | Open |
|---|---|---|---|
| I | October-November | 5 46 | 5 93 |
| II | November December | 4 24 | 7 93 |
| III | December January | 7 72 | 10 46 |
| IV | January February | 1 22 | 3 03 |
| V | February-March | 1 46 | 2 11 |
| VI | March-April | 0 99 | 1 10 |

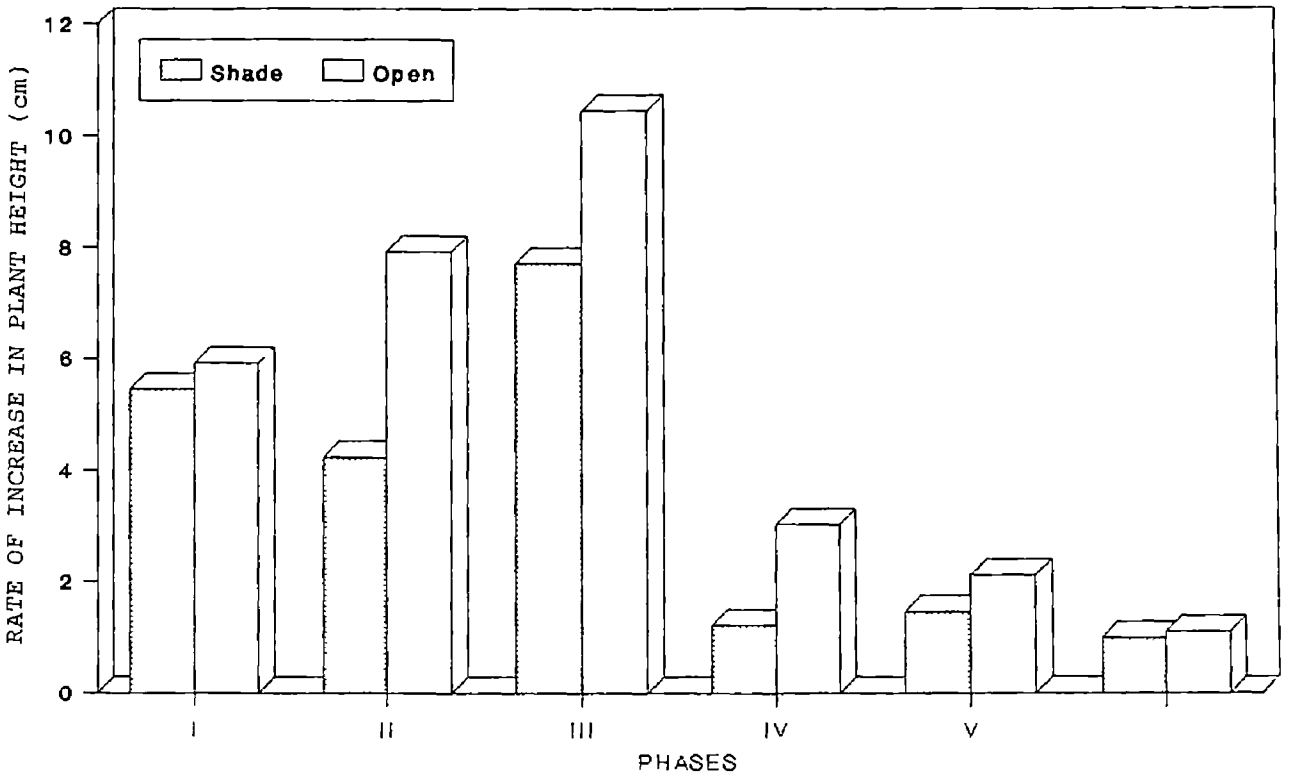



Fig 5 Effect of shade on rate of increase in plant height

Table 6 Effect of shade and planting methods on EW spread of plant (cm)

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall Shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (11 86) | (8 88) | S |
| Shade | 3 46(10 99) | 3 78(13 36) | 3 56(11 68) | 3 52(11 43) | | | | |
| Open | 3 08( 8 56) | 2 83( 7 01) | 3 13( 8 85) | 3 46(11 11) | 0 31 | | | |
| Pooled | 3 27( 9 78) | 3 30(10 19) | 3 34(10 26) | 3 49(11 27) | NS | | | |
| **November** | | | | | | (14 20) | (14 04) | NS |
| Shade | 3 64(12 26) | 4 12(16 10) | 3 84(13 89) | 3 92(14 54) | 0 31 | | | |
| Open | 3 52(11 55) | 3 37(10 54) | 4 19(16 75) | 4 25(17 34) | 0 68 | | | |
| Pooled | 3 58(11 90) | 3 75(13 32) | 4 02(15 32) | 4 09(15 94) | NS | | | |
| **December** | | | | | | (15 25) | (14 59) | NS |
| Shade | 3 81(13 58) | 4 19(16 69) | 4 04(15 37) | 4 03(15 34) | NS | | | |
| Open | 3 79(13 48) | 3 66(12 48) | 4 24(15 11) | 4 22(17 29) | NS | | | |
| Pooled | 3 80(15 53) | 3 92(14 58) | 4 14(15 24) | 4 12(16 31) | NS | | | |
| **January** | | | | | | (13 11) | (13 73) | NS |
| Shade | 3 55(11 61) | 4 01(15 20) | 3 68(12 61) | 3 71(13 03) | NS | | | |
| Open | 3 68(12 62) | 3 55(11 72) | 3 96(14 85) | 4 04(15 72) | | | | |
| Pooled | 3 61(12 11) | 3 78(13 46) | 3 82(13 73) | 3 88(14 37) | NS | | | |
| **February** | | | | | | (14 10) | (14 67) | NS |
| Shade | 3 48(11 11) | 4 32(17 71) | 3 79(13 11) | 3 92(14 48) | 0 37 | | | |
| Open | 3 90(14 64) | 3 72(12 93) | 4 09(15 94) | 3 99(15 18) | NS | | | |
| Pooled | 3 69(12 87) | 4 02(15 32) | 3 92(14 52) | 3 96(14 83) | NS | | | |
| **March** | | | | | | (14 15) | (15 19) | NS |
| Shade | 3 53(11 50) | 4 20(16 73) | 3 86(13 99) | 3 90(14 37) | 0 35 | | | |
| Open | 3 91(14 62) | 3 92(14 51) | 4 05(15 52) | 4 10(16 13) | NS | | | |
| Pooled | 3 72(13 06) | 4 06(15 62) | 3 96(14 75) | 4 00(15 25) | NS | | | |
| **April** | | | | | | (17 91) | (19 79) | NS |
| Shade | 3 73(13 00) | 4 73(21 52) | 4 20(17 09) | 4 56(20 01) | 0 38 | | | |
| Open | 4 49(19 31) | 4 45(18 98) | 4 68(21 08) | 4 50(19 82) | NS | | | |
| Pooled | 4 11(16 15) | 4 59(20 25) | 4 44(19 08) | 4 53(19 91) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS - Non significant

spread, though not significant When different planting methods were considered in combination with the growing conditions it was observed that the minimum spread of 7 01 cm was recorded by the plants grown on flat bed under open shade which was on par with ridge and furrow under shade and open and mound under shade Maximum spread (13 36 cm) was noticed in the case of flat bed method under shade followed by mound and pit under shade

When individual analysis data were taken into consideration from February onwards the flat bed planting recorded the maximum spread and ridge method contributed a minimum spread for the plants grown under the natural shade imparted by coconut canopy

4 3 2 2 NS spread

From Table 7 it could be easily read out that the different planting methods or shade had no significant influence on the NS spread of the plant During October the plants under natural shade of coconut recorded significantly higher spread of 12 02 cm as compared to 8 97 cm under full sunlight

As per results of the individual analysis in the case of plants grown under full sunlight the flat bed method of planting recorded a minimum spread during the

Table 7 Effect of shade and planting methods on NS spread of plant (cm)

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall Shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| October | | | | | | (12 02) | (8 97) | S |
| Shade | 3 54(11 57) | 3 74(13 05) | 3 55(11 60) | 3 59(11 89) | NS | | | |
| Open | 3 06( 8 46) | 2 78( 6 76) | 3 22( 9 47) | 3 47(11 21) | 0 43 | | | |
| Pooled | 3 30(10 02) | 3 26( 9 90) | 3 38(10 53) | 3 53(11 55) | NS | | | |
| November | | | | | | (13 56) | (12 20) | NS |
| Shade | 3 49(11 22) | 4 07(15 66) | 3 79(13 50) | 3 83(13 87) | 0 27 | | | |
| Open | 3 29( 9 90) | 3 22( 9 44) | 3 93(14 76) | 3 89(14 71) | 0 67 | | | |
| Pooled | 3 39(10 56) | 3 65(12 55) | 3 86(14 13) | 3 86(14 29) | NS | | | |
| December | | | | | | (14 75) | (14 86) | NS |
| Shade | 3 78(13 48) | 4 26(17 34) | 3 83(13 76) | 3 91(14 40) | NS | | | |
| Open | 3 83(13 93) | 3 73(12 95) | 4 02(15 46) | 4 18(17 08) | NS | | | |
| Pooled | 3 80(13 70) | 4 00(15 14) | 3 92(14 61) | 4 05(15 74) | NS | | | |
| January | | | | | | (12 91) | (13 48) | NS |
| Shade | 3 50(11 31) | 4 02(15 18) | 3 63(12 21) | 3 72(12 94) | 0 25 | | | |
| Open | 3 65(12 48) | 3 63(12 19) | 3 90(14 43) | 3 93(14 81) | NS | | | |
| Pooled | 3 58(12 05) | 3 82(13 68) | 3 77(13 32) | 3 83(13 87) | NS | | | |
| February | | | | | | (13 74) | (13 65) | NS |
| Shade | 3 52(11 46) | 4 27(17 29) | 3 64(12 30) | 3 85(13 89) | 0 28 | | | |
| Open | 3 80(13 61) | 3 66(12 57) | 3 94(14 71) | 3 80(13 69) | NS | | | |
| Pooled | 3 66(12 53) | 3 97(14 93) | 3 79(13 56) | 3 82(13 79) | NS | | | |
| March | | | | | | (13 44) | (15 10) | NS |
| Shade | 3 52(11 48) | 4 15(16 23) | 3 63(12 29) | 3 84(13 79) | 0 25 | | | |
| Open | 4 01(15 46) | 3 89(14 26) | 4 08(15 69) | 3 97(15 02) | NS | | | |
| Pooled | 3 76(13 47) | 4 02(15 24) | 3 85(13 99) | 3 90(14 40) | NS | | | |
| April | | | | | | (16 06) | (19 08) | NS |
| Shade | 3 70(12 79) | 4 57(20 02) | 3 82(13 79) | 4 20(17 64) | 0 47 | | | |
| Open | 4 33(18 58) | 4 41(18 73) | 4 74(21 72) | 4 22(17 30) | NS | | | |
| Pooled | 4 02(15 68) | 4 49(19 46) | 4 28(17 75) | 4 25(17 47) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS - Non significant

initial periods of October and November Thereafter the different planting methods failed to show any significant difference But for the crops grown under partial shade a significantly higher spread was noticed from January onwards for this treatment (flat bed)

4 3 3 Internodal length

The data related to the influence of shade and planting methods on internodal length are presented in Table 8 Internodal length was significantly influenced by the two different growing conditions whereas the planting methods had shown no significant variation with respect to this character The plants under the natural canopy of coconut recorded significantly higher internodal length during all the months except December and March (Fig 6) A sudden increase in internodal length from 3 16 cm to 4 09 cm was noticed during January in the case of plants grown under shade In the case of plants under open a progressive increase in internodal length was recorded upto March which declined during April (2 51 cm)

When different planting methods were considered in combination with the two growing conditions planting in pits recorded a higher internodal length (2 67 cm) during october in the case of plants under full sunlight In the case of plants under the partial sunlight the maximum

Table 8 Effect of shade and planting methods on internodal length (cm)

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (3 23) | (2 03) | S |
| Shade | 2 08(3 39) | 2 17(3 74) | 1 98(2 96) | 1 95(2 83) | 0 24 | | | |
| Open | 1 81(2 28) | 1 56(1 44) | 1 64(1 74) | 1 91(2 67) | | | | |
| Pooled | 1 94(2 83) | 1 86(2 59) | 1 81(2 35) | 1 93(2 75) | NS | | | |
| **November** | | | | | | (3 37) | (2 08) | S |
| Shade | 2 00(3 04) | 2 20(3 84) | 2 14(3 62) | 1 97(2 91) | NS | | | |
| Open | 1 72(1 96) | 1 77(2 17) | 1 77(2 15) | 1 73(2 02) | | | | |
| Pooled | 1 86(2 50) | 1 99(3 03) | 1 95(2 89) | 1 85(2 42) | NS | | | |
| **December** | | | | | | (3 16) | (2 85) | NS |
| Shade | 2 02(3 10) | 2 21(3 94) | 1 98(2 96) | 1 91(2 66) | NS | | | |
| Open | 1 86(2 47) | 1 99(3 00) | 1 99(2 98) | 1 97(2 95) | | | | |
| Pooled | 1 94(2 78) | 2 10(3 47) | 1 99(2 97) | 1 94(2 80) | NS | | | |
| **January** | | | | | | (4 09) | (2 89) | S |
| Shade | 2 18(3 81) | 2 46(5 15) | 2 05(3 29) | 2 24(4 10) | NS | | | |
| Open | 1 91(2 70) | 1 93(2 75) | 2 03(3 12) | 1 98(2 98) | | | | |
| Pooled | 2 50(3 26) | 2 20(3 95) | 2 04(3 20) | 2 11(3 54) | NS | | | |
| **February** | | | | | | (3 98) | (3 09) | S |
| Shade | 2 13(3 58) | 2 44(5 00) | 2 09(3 46) | 2 20(3 88) | NS | | | |
| Open | 1 96(2 88) | 2 02(3 13) | 2 05(3 20) | 2 04(3 18) | | | | |
| Pooled | 2 05(3 23) | 2 23(4 06) | 2 07(3 33) | 2 12(3 53) | NS | | | |
| **March** | | | | | | (3 75) | (3 67) | NS |
| Shade | 2 11(3 50) | 2 36(4 61) | 2 04(3 18) | 2 17(3 71) | 0 20 | | | |
| Open | 2 22(3 94) | 2 04(3 18) | 2 18(3 77) | 2 18(3 80) | | | | |
| Pooled | 2 17(3 72) | 2 20(3 89) | 2 11(3 48) | 2 17(3 75) | NS | | | |
| **April** | | | | | | (4 01) | (2 51) | S |
| Shade | 2 18(3 77) | 2 33(4 42) | 2 17(3 73) | 2 25(4 14) | NS | | | |
| Open | 1 80(2 24) | 1 82(2 32) | 1 93(2 76) | 1 92(2 73) | | | | |
| Pooled | 1 99(3 00) | 2 07(3 37) | 2 05(3 24) | 2 08(3 43) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS - Non significant

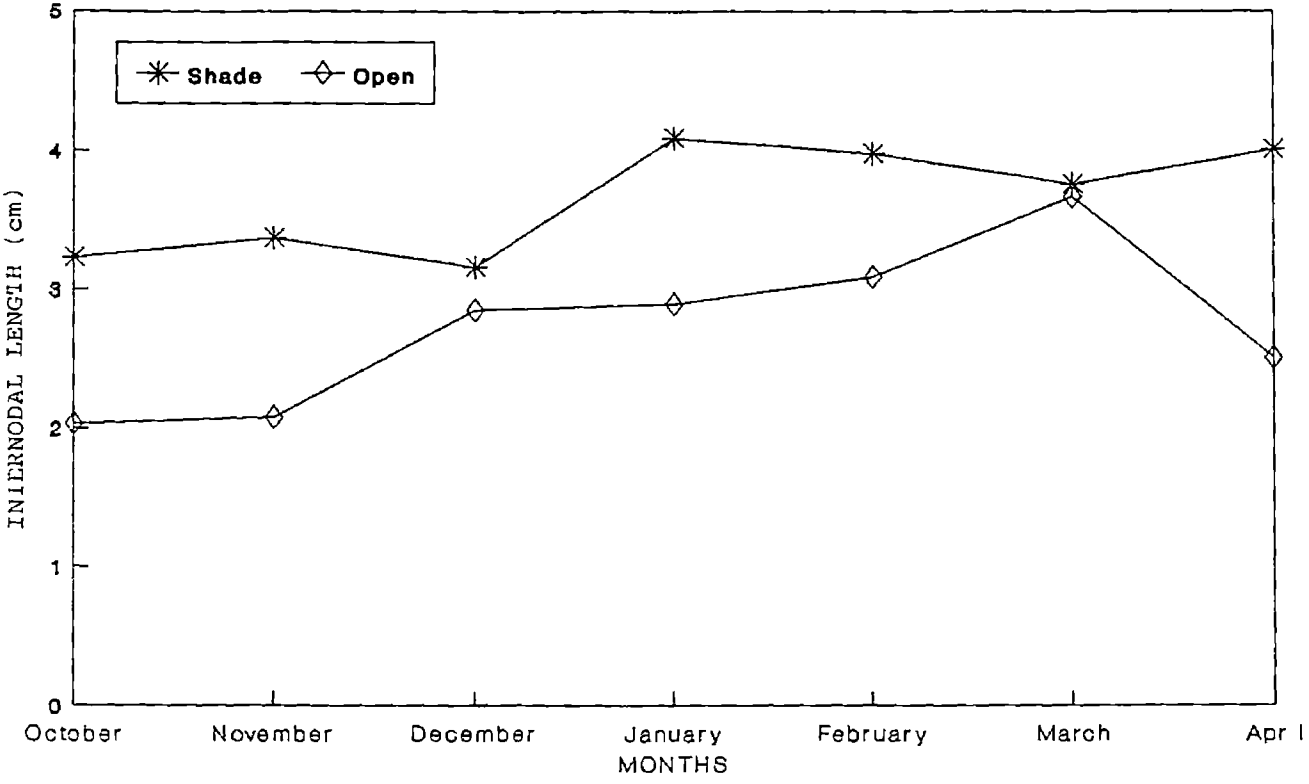



**Fig 6 Effect of shade on internodal length**

internodal length of 4 61 cm was noticed in flat bed planting during March which was on par with the pit followed by mound method under shade

4 3 4 Number of suckers per plant

Data pertaining to the effect of shade and planting methods on sucker production are presented in Table 9 With regard to the number of suckers per plant the different growing conditions had a significant impact The crops grown under the open condition recorded a higher number of suckers per plant though the significant difference was observed only during the initial periods upto November (Fig 7) It is also clear from the table that the rate of increase in sucker production was also higher in the case of plants grown under full sunlight Of the different planting methods tried the flat bed planting contributed for a minimum number of suckers while all the other three treatments form a group

When inidividual analysis was carried out the ridge and furrow planting produced the lower number of suckers under shaded condn

4 3 5 Number of leaves per plant

The influence of methods of planting and shade on total number of leaves per plant could be observed from

Table 9 Effect of shade and planting methods on sucker production (number)

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall Shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (0 45) | (0 71) | S |
| Shade | 1 18(0 40) | 1 17(0 37) | 1 24(0 55) | 1 21(0 48) | NS | | | |
| Open | 1 33(0 79) | 1 22(0 50) | 1 37(0 88) | 1 28(0 66) | | | | |
| Pooled | 1 26(0 59) | 1 19(0 43) | 1 30(0 72) | 1 25(0 57) | 0 08 | | | |
| **November** | | | | | | (0 80) | (1 22) | S |
| Shade | 1 33(0 78) | 1 32(0 76) | 1 34(0 80) | 1 36(0 85) | NS | | | |
| Open | 1 48(1 19) | 1 35(0 83) | 1 52(1 34) | 1 58(1 54) | | | | |
| Pooled | 1 40(0 99) | 1 34(0 79) | 1 43(1 07) | 1 47(1 20) | NS | | | |
| **December** | | | | | | (0 95) | (1 75) | NS |
| Shade | 1 36(0 87) | 1 40(0 98) | 1 39(0 93) | 1 42(1 03) | NS | | | |
| Open | 1 62(1 67) | 1 46(1 18) | 1 68(1 86) | 1 80(2 30) | NS | | | |
| Pooled | 1 49(1 27) | 1 43(1 08) | 1 53(1 40) | 1 61(1 67) | NS | | | |
| **January** | | | | | | (1 05) | (2 15) | NS |
| Shade | 1 36(0 85) | 1 47(1 17) | 1 42(1 02) | 1 47(1 16) | 0 08 | | | |
| Open | 1 67(1 81) | 1 66(1 75) | 1 81(2 33) | 1 91(2 69) | NS | | | |
| Pooled | 1 51(1 33) | 1 56(1 46) | 1 61(1 67) | 1 69(1 92) | NS | | | |
| **February** | | | | | | (1 16) | (3 08) | NS |
| Shade | 1 40(0 97) | 1 50(1 25) | 1 43(1 07) | 1 53(1 34) | 0 09 | | | |
| Open | 1 88(2 61) | 1 93(2 80) | 2 03(3 19) | 2 15(3 71) | NS | | | |
| Pooled | 1 64(1 79) | 1 72(2 03) | 1 73(? 13) | 1 84(2 52) | NS | | | |
| **March** | | | | | | (1 36) | (3 48) | NS |
| Shade | 1 48(1 19) | 1 57(1 48) | 1 49(1 23) | 1 59(1 54) | NS | | | |
| Open | 1 91(2 71) | 2 03(3 15) | 2 10(3 54) | 2 34(4 53) | NS | | | |
| Pooled | 1 69(1 95) | 1 80(2 31) | 1 80(2 39) | 1 97(3 04) | NS | | | |
| **April** | | | | | | (2 79) | (4 71) | NS |
| Shade | 1 80(2 29) | 2 05(3 22) | 1 86(2 53) | 2 02(3 11) | 0 19 | | | |
| Open | 2 10(3 50) | 2 40(4 96) | 2 32(4 54) | 2 59(5 84) | NS | | | |
| Pooled | 1 95(2 89) | 2 23(4 09) | 2 09(3 53) | 2 31(4 48) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS - Non significant

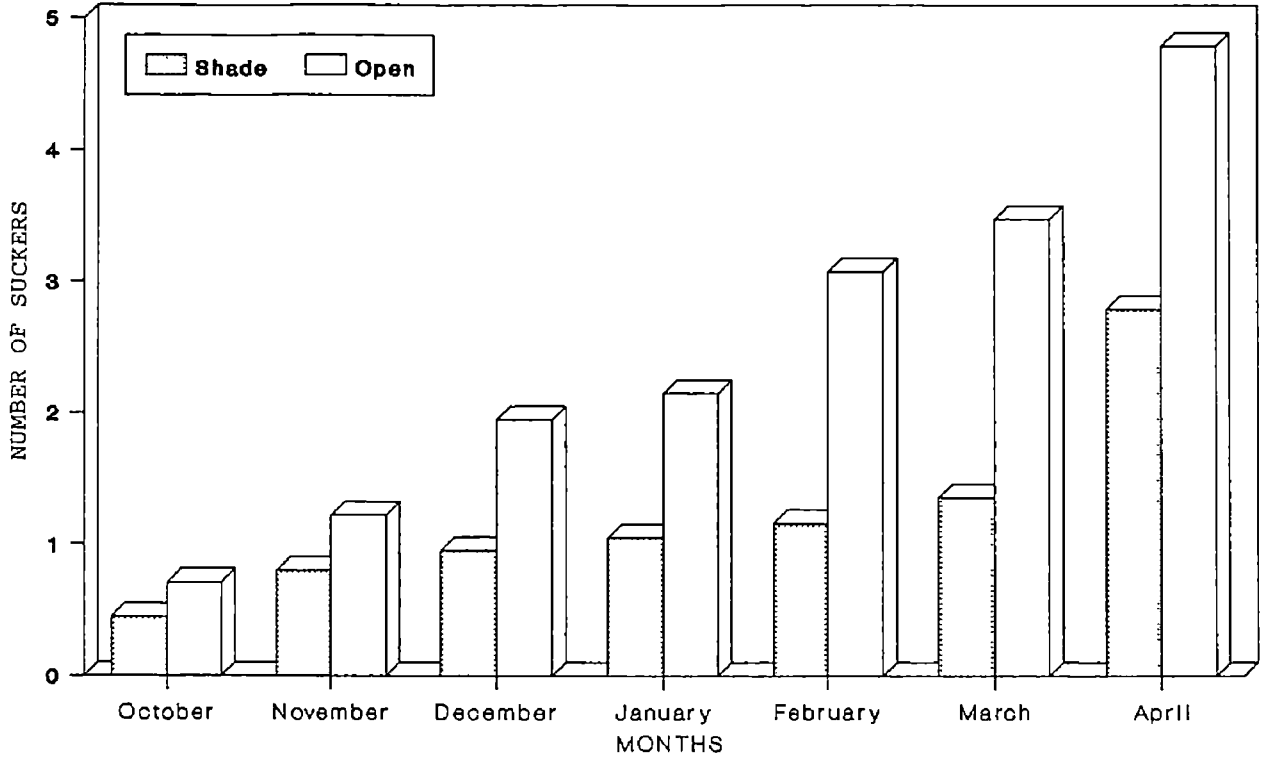



**Fig 7 Effect of shade on sucker production**

the data in Table 10 The growing conditions and four methods of planting significantly influenced the total number of leaves per plant during the initial period of October Maximum leaf production was observed in mound method (9 49) closely followed by pit and ridge methods Flat bed planting recorded a minimum number of leaves (6 74) which was on par with that in ridge and furrow planting (7 96) Irrespective of the planting methods the plants under partial shade recorded higher number of leaves (8 98) as compared to 7 54 in open during October However after October the plants under open registered maximum number of leaves, throughout the growing period though not significant

When individual analysis was carried out from December onwards the different planting methods were found to have significant influence on the number of leaves per plant, in the case of plants grown under the canopy of coconut The flat bed planting recorded the maximum leaf number and the ridge and furrow planting contributed for a minimum number of leaves per plant

4 3 6 Total leaf area per plant

Table 11 clearly indicate the influence of methods of planting and shade on the total leaf area per plant Almost similar trend as observed for total leaf number per

Table 10 Effect of shade and planting methods on the total number of leaves per plant

| | Ridge and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall Shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (8 98) | (7 54) | S |
| Shade | 3 08( 8 55) | 3 03( 8 22) | 3 38 10 53) | 3 10( 8 62) | NS | | | |
| Open | 2 88( 7 37) | 2 50( 5 26) | 3 03( 8 34) | 3 16( 9 18) | | | | |
| Pooled | 2 98( 7 76) | 2 76( 6 74) | 3 20( 9 44) | 3 13( 8 90) | 0 35 | | | |
| **November** | | | | | | (11 80) | (12 20) | NS |
| Shade | 3 47(11 05) | 3 61(11 97) | 3 80(13 71) | 3 38(10 47) | NS | | | |
| Open | 3 36(10 42) | 3 00( 8 02) | 3 83(14 53) | 4 00(15 80) | NS | | | |
| Pooled | 3 41(10 74) | 3 30( 9 99) | 3 82(14 13) | 3 69(13 14) | NS | | | |
| **December** | | | | | | (13 38) | (24 46) | NS |
| Shade | 3 74(13 05) | 4 02(15 32) | 3 89(14 33) | 3 43(10 80) | 0 37 | | | |
| Open | 4 34(18 34) | 3 99(15 12) | 5 43(30 06) | 5 73(34 32) | NS | | | |
| Pooled | 4 04(15 70) | 4 01(15 22) | 4 16(22 20) | 4 58(22 56) | NS | | | |
| **January** | | | | | | (16 13) | (32 96) | NS |
| Shade | 3 74(12 98) | 4 43(18 72) | 4 23(17 15) | 4 07(15 65) | 0 38 | | | |
| Open | 5 82(35 18) | 4 53(19 64) | 6 18(38 49) | 6 15(38 51) | NS | | | |
| Pool | 4 78(24 00) | 4 48(19 18) | 5 20(27 82) | 5 11(27 07) | NS | | | |
| **February** | | | | | | (21 23) | (42 43) | NS |
| Shaded | 4 12(16 14) | 4 94(23 48) | 4 76(22 32) | 4 88(22 97) | 0 59 | | | |
| Open | 6 05(36 97) | 5 56(30 51) | 7 11(51 84) | 6 99(50 40) | NS | | | |
| Pooled | 5 09(26 56) | 5 28(26 99) | 5 93(37 08) | 5 93(36 69) | NS | | | |
| **March** | | | | | | (26 56) | (54 30) | NS |
| Shade | 4 71(21 31) | 5 52(29 53) | 5 15(26 31) | 5 44(29 09) | NS | | | |
| Open | 6 99(49 78) | 6 29(38 75) | 7 32(63 55) | 7 99(65 11) | NS | | | |
| Pooled | 5 86(35 55) | 5 91(34 14) | 6 24(44 93) | 6 72(47 10) | NS | | | |
| **April** | | | | | | (31 56) | (50 50) | NS |
| Shade | 4 94(23 57) | 6 20(37 68) | 5 32(27 96) | 6 14(37 03) | 0 59 | | | |
| Open | 6 19(39 89) | 6 91(47 34) | 7 24(52 67) | 7 74(62 08) | NS | | | |
| Pooled | 5 57(31 73) | 6 56(42 51) | 6 28(40 32) | 6 94(49 56) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS Non significant

Table 11 Effect of shade and planting methods on total leaf area/plant (cm²)

| | Ridged and furrow | Flat bed | Mound | Pit followed by mound | CD (0 05) | Overall Shade | Overall Open | |
|---|---|---|---|---|---|---|---|---|
| **October** | | | | | | (150 99) | (69 13) | S |
| Shade | 11 38(130 50) | 12 69(165 22) | 13 02(171 86) | 11 49(136 36) | NS | | | |
| Open | 7 21( 53 91) | 5 27( 27 14) | 8 84( 79 61) | 10 04(115 87) | | | | |
| Pooled | 9 30( 92 21) | 8 98( 96 18) | 10 93(125 74) | 10 77(126 12) | 1 81 | | | |
| **November** | | | | | | (139 53) | (66 71) | NS |
| Shade | 10 80(118 42) | 13 07(170 46) | 11 68(137 92) | 11 35(131 32) | NS | | | |
| Open | 8 04( 66 85) | 7 87( 62 41) | 11 19(145 81) | 10 60(125 18) | | | | |
| Pooled | 9 42( 92 64) | 10 47(116 44) | 11 43(141 87) | 10 97(128 25) | NS | | | |
| **December** | | | | | | (124 11) | (217 21) | NS |
| Shade | 10 63(112 93) | 12 79(167 26) | 10 71(114 54) | 9 98(101 73) | 1 59 | | | |
| Open | 11 70(146 46) | 10 37(110 34) | 15 48(257 81) | 17 81(334 23) | 5 60 | | | |
| Pooled | 11 17(129 70) | 11 58(138 80) | 13 10(186 18) | 13 90(217 98) | NS | | | |
| **January** | | | | | | (198 51) | (301 36) | NS |
| Shade | 13 00(172 17) | 16 02(261 61) | 13 51(184 90) | 13 12(175 35) | 1 87 | | | |
| Open | 16 58(339 08) | 13 48(187 97) | 16 74(298 32) | 18 06(380 08) | NS | | | |
| Pooled | 14 79(255 63) | 14 75(224 79) | 15 13(241 61) | 15 59(277 72) | NS | | | |
| **February** | | | | | | (281 05) | (296 95) | NS |
| Shade | 12 94(169 08) | 20 07(417 57) | 15 88(260 32) | 16 42(277 24) | 3 50 | | | |
| Open | 17 05(312 06) | 14 58(224 11) | 18 40(361 04) | 16 53(290 53) | NS | | | |
| Pooled | 15 00(240 57) | 17 32(320 84) | 17 14(310 68) | 16 48(283 92) | NS | | | |
| **March** | | | | | | (274 30) | (446 63) | NS |
| Shade | 14 29(205 41) | 20 09(413 28) | 14 21(205 96) | 16 36(272 87) | 0 41 | | | |
| Open | 18 40(368 56) | 19 29(379 87) | 21 34(497 93) | 21 70(540 18) | NS | | | |
| Pooled | 16 35(286 99) | 19 69(396 58) | 17 78(351 95) | 19 03(406 53) | NS | | | |
| **April** | | | | | | (482 47) | (713 44) | NS |
| Shade | 18 61(353 99) | 26 90(737 81) | 16 76(293 69) | 22 98(539 39) | 3 88 | | | |
| Open | 21 03(542 35) | 24 87(657 73) | 24 22(623 14) | 29 79(1030 53) | NS | | | |
| Pooled | 19 82(448 17) | 25 88(697 77) | 20 49(458 42) | 26 38(784 96) | NS | | | |

Figures in parenthesis are original values and others are square root transformed ones
S - Significant NS - Non significant

plant was noticed in this case also The different planting methods and shade had significantly influenced the total leaf area per plant during the initial period of October (Fig 8) A higher leaf area of 150 99 $cm^2$ was noticed in the plants grown under partial sunlight whereas it was only 69 13 $cm^2$ for the plants under open condition Again, the flat bed method of planting itself recorded the lowest leaf area of 96 18 $cm^2$ From December onwards the plants grown under the open condition contributed for a higher leaf area per plant, though not significant

The individual analysis results show that the different planting methods differ significantly with regard to the total leaf area per plant especially in the case of plants grown under partial sunlight (Fig 9) The flat bed planting registered a higher leaf area and the ridge and furrow method the minimum value

4 3 7 Chlorophyll content in the leaves

The chlorophyll content in the leaves was estimated at three different phases of growth, ie during preflowering flowering and post flowering (Table 12) It could be observed that the chlorophyll content was considerably reduced as flowering advanced There was not much variation in the total chlorophyll content of plants grown under full and partial sunlight and also the chlo

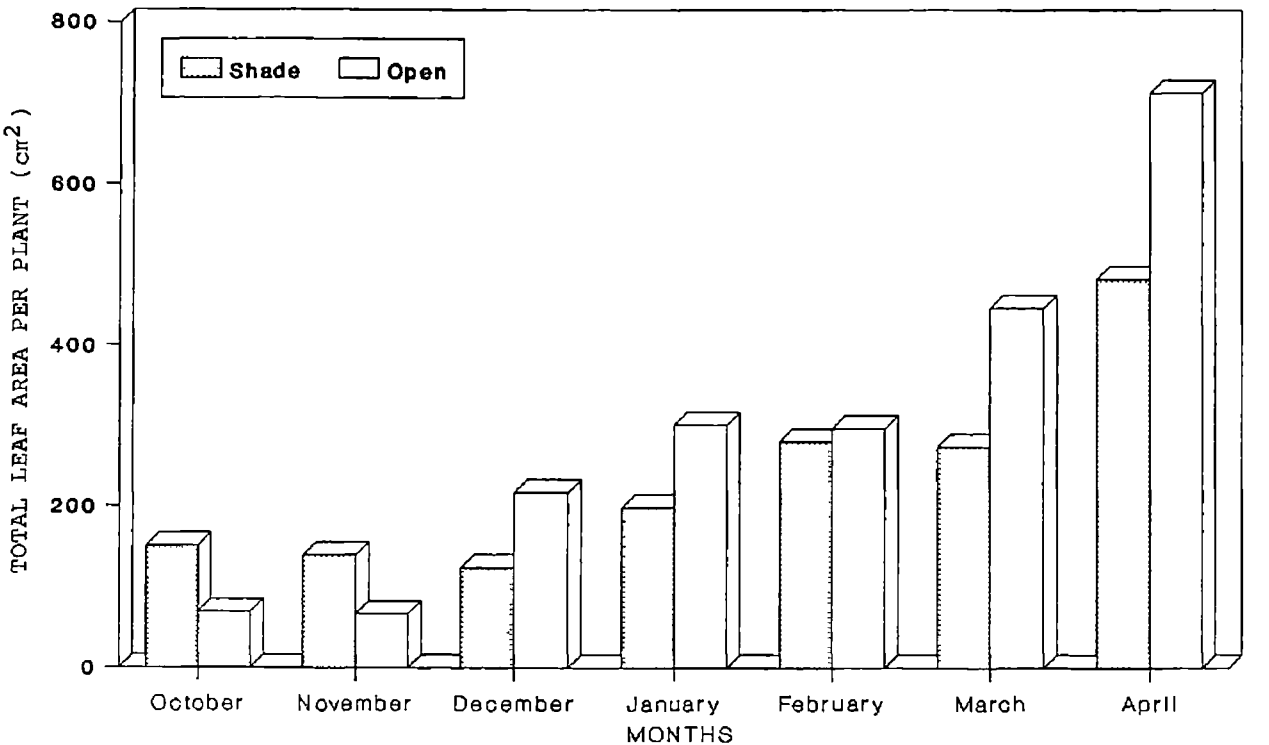



**Fig 8 Effect of shade on total leaf area per plant**

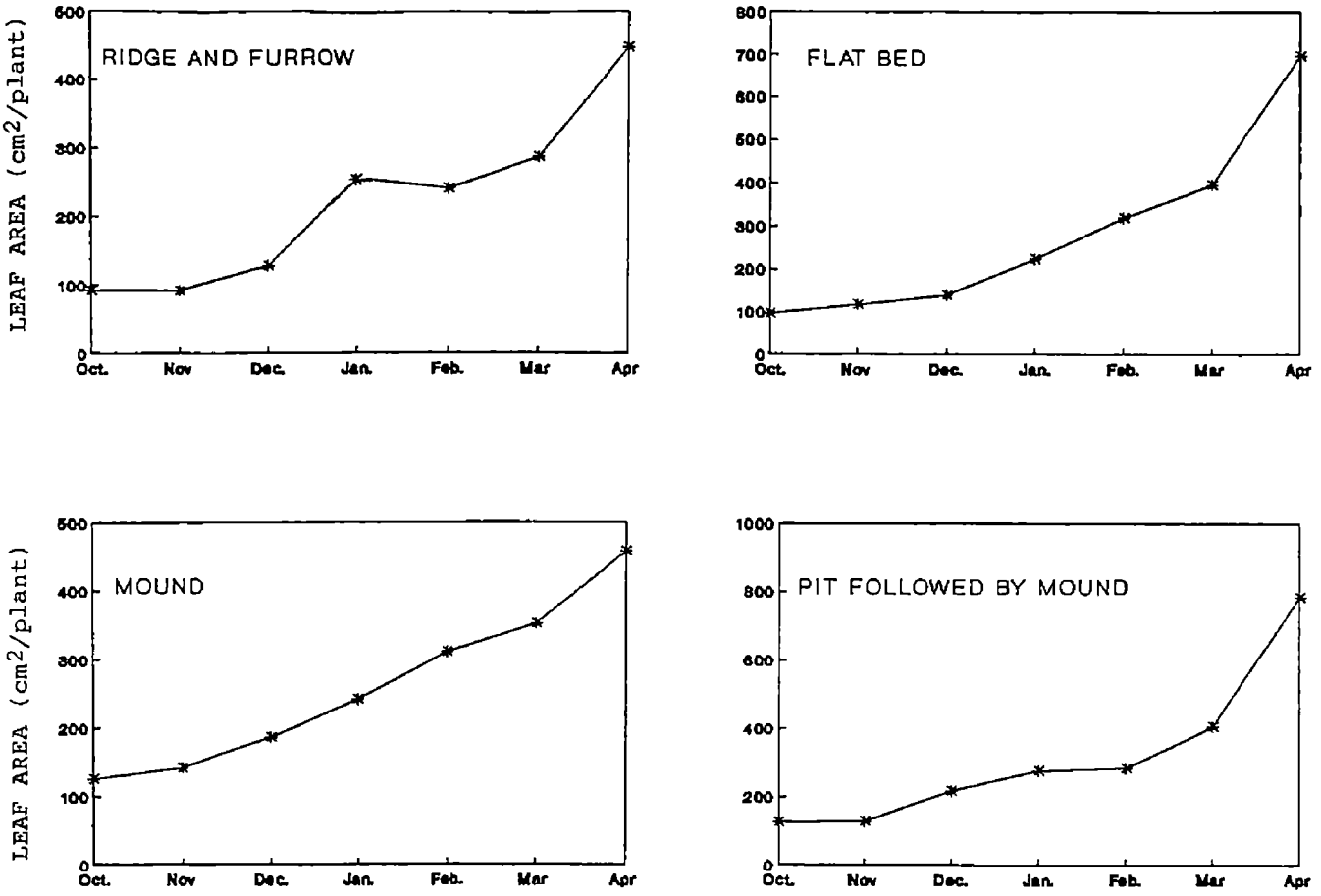



Fig.9 Effect of planting methods on total leaf area per plant

Table 12 Effect of shade on the chlorophyll content of leaves

| | Chlorophyll a g/cm² | | Chlorophyll b g/cm² | | Chlorophyll a/b ratios | | Total chlorophyll g/cm² | | Total chlorophyll g/l | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Shade | Open | Shade | Open | Shade | Open | Shade | Open | Shade | Open |
| Pre flowering | 0 0008 | 0 0052 | 0 0017 | 0 0023 | 0 50 | 0 55 | 0 0025 | 0 0035 | 0 0504 | 0 0707 |
| Flowering | 0 0006 | 0 0007 | 0 0014 | 0 0015 | 0 44 | 0 49 | 0 0020 | 0 0022 | 0 0398 | 0 0443 |
| Post flowering | 0 0004 | 0 0004 | 0 0006 | 0 0005 | 0 72 | 0 64 | 0 0010 | 0 0009 | 0 0194 | 0 0180 |
| Mean | 0 0006 | 0 0021 | 0 0012 | 0 0014 | 0 55 | 0 56 | 0 0018 | 0 0022 | 0 0365 | 0 0443 |

rophyll a/b ratio remained almost the same for both conditions Under both conditions the a/b ratios of chlorophyll varied during the three phases of pre-flowering, flowering and post-flowering During flowering the a/b ratio had reduced and thereafter showed an increasing trend at the post flowering stage under both the conditions

## 4 4 Post harvest observations

### 4 4 1 Fresh weight of shoot

The data on the impact of different planting methods and shade on the fresh shoot weight of plants are presented in Table 13 It could be explicitly read out from the table that the four different planting methods and the two growing conditions had a significant influence on the fresh shoot weight of the plant The natural shade of coconut had significantly reduced fresh weight of shoot (19 03 g) as compared to those under open condition (31 93 g) (Fig 10) With regard to different planting methods the highest shoot weight of 34 59 g was recorded in pit followed by mound method of planting which was on par with the flat bed and mound methods of planting the respective values being 28 69 g and 23 03 g But the lowest shoot weight of 15 59 g was recorded in the case of ridge and furrow method of planting (Fig 11)

Table 13 Effect of shade and planting methods on fresh weight of shoot and root and volume of root

| | Shoot weight (g/plant) | | | Root weight (g/plant) | | | Root volume (ml/plant) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shade | Open | Pooled | Shade | Open | Pooled | Shade | Open | Pooled |
| Ridge and furrow | 3 46 (11 23) | 4 53 (19 96) | 3 99 (15 59) | 4 60 (20 30) | 6 50 (41 49) | 5 55 (30 90) | 4 76 (21 73) | 6 06 (35 74) | 5 41 (28 74) |
| Flat bed | 5 11 (26 27) | 5 59 (31 11) | 5 35 (28 69) | 5 91 (34 62) | 6 07 (36 25) | 5 99 (35 43) | 6 11 (36 80) | 6 07 (36 18) | 6 09 (36 49) |
| Mound | 4 24 (17 74) | 5 29 (28 33) | 4 77 (23 03) | 4 97 (23 78) | 6 68 (45 65) | 5 83 (34 71) | 5 38 (28 07) | 6 72 (45 90) | 6 05 (36 98) |
| Pit followed by mound | 4 63 (20 88) | 6 71 (48 30) | 5 67 (34 59) | 5 09 (25 32) | 6 44 (43 78) | 5 76 (34 55) | 4 91 (23 45) | 6 21 (41 62) | 5 56 (32 53) |
| CD (0 05) | NS | | 0 90 | 0 70 | NS | NS | 0 63 | NS | NS |
| Overall | 4 36 (19 03) | 5 53 (31 93) | | 5 14 (26 00) | 6 42 (41 79) | | 5 29 (27 51) | 6 27 (39 86) | |
| | S | | | NS | | | NS | | |

Note Figures in paranthesis are original values and others are square root transformed ones
NS - Not significant
S - Significant

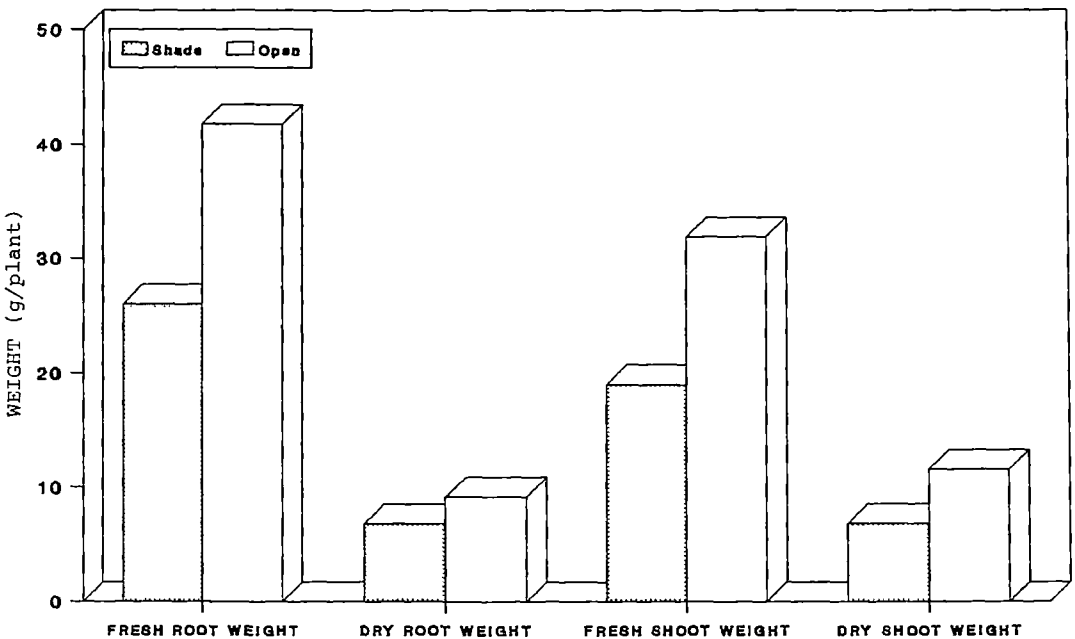



Fig 10 Influence of shade on fresh and dry weight of shoot and root

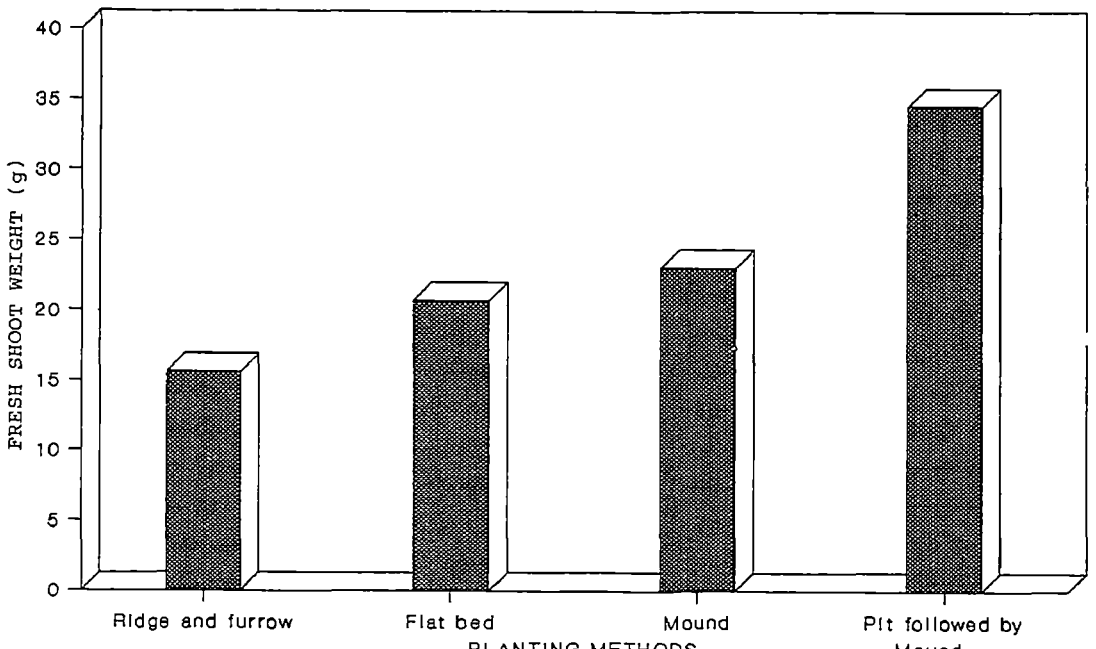



**Fig 11 Effect of planting methods on fresh shoot weight**

4 4 2 Fresh weight of root

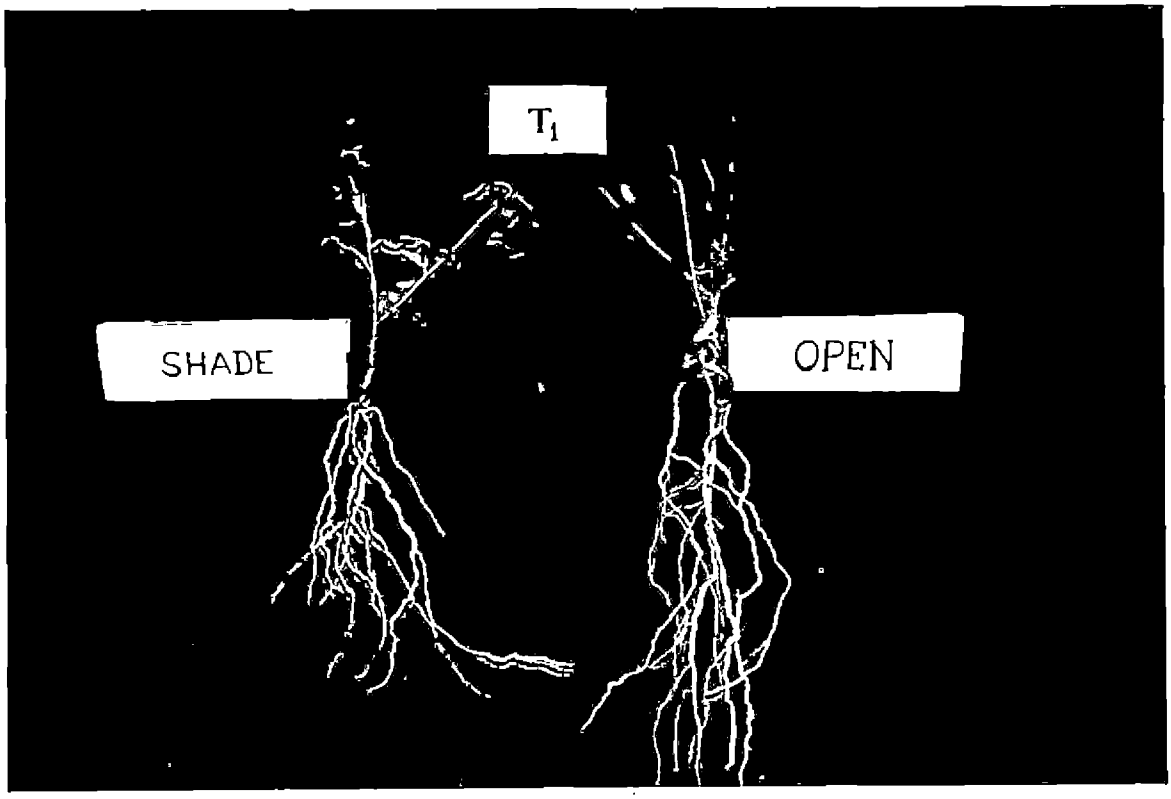
The different planting methods and shade failed to project any significant influence on the fresh weight of root (Table 13) It could be seen from Table 13 and Fig 10 that the plants grown under full sunlight recorded much higher yield of (41 79 g) than the plants grown under natural shade of coconut (26 00 g) though not significant (Plates 7, 8, 9 and 10) But when individual analysis was carried out, the different planting methods exerted a significant influence on the fresh root yield of plant grown under shade The flat bed planting method recorded the maximum yield of 34 62 g followed by pit planting (25 3 g) which was on par with mound and ridge methods

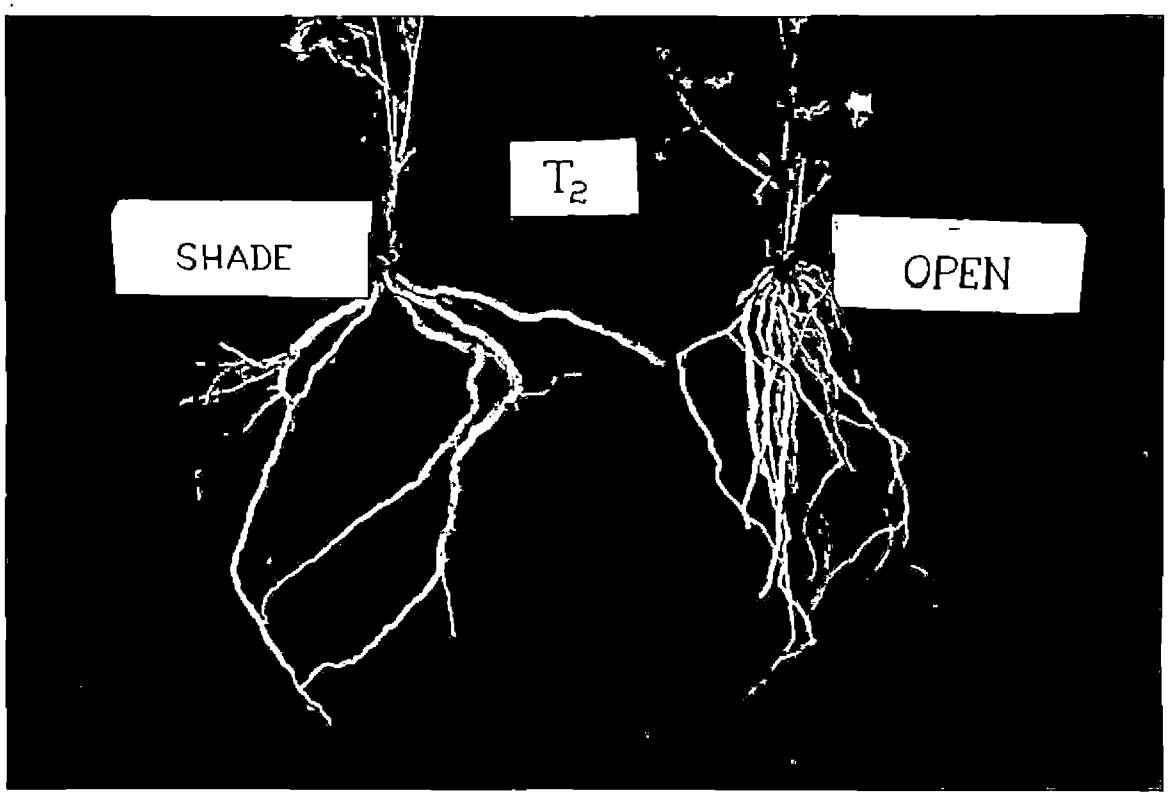
4 4 3 Fresh root volume

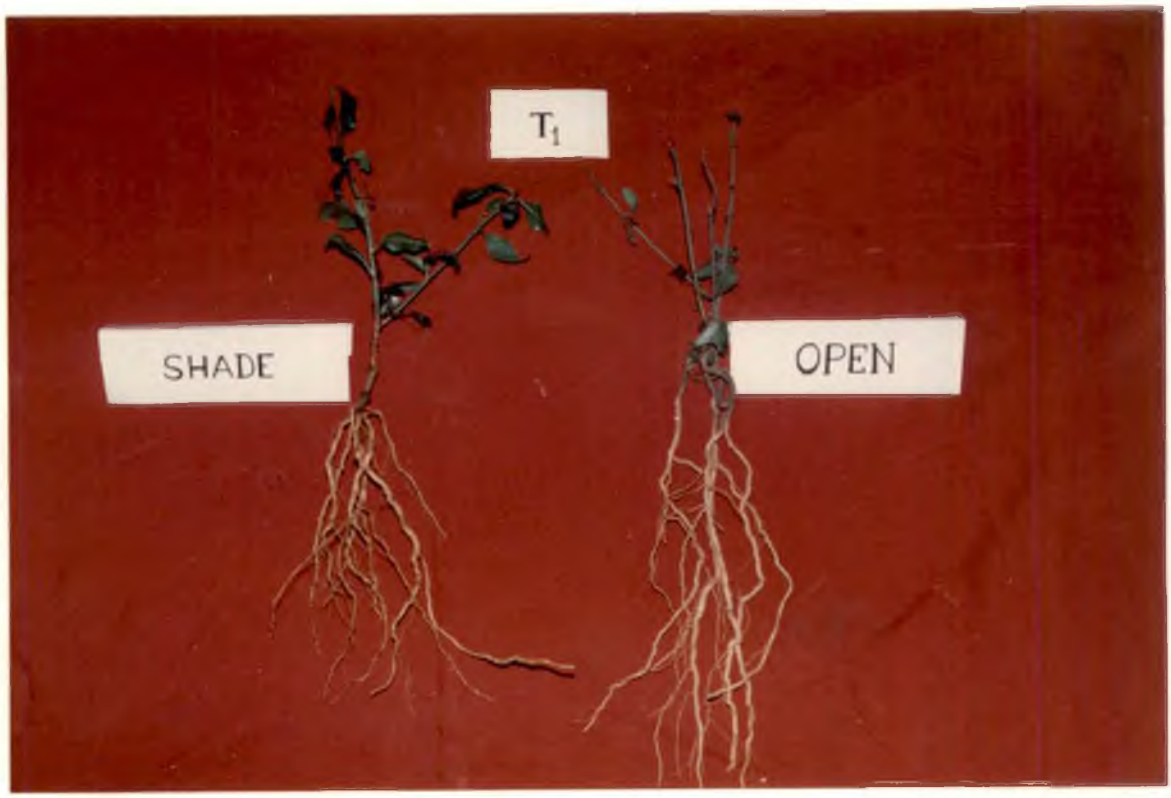
From Table 13 it could be seen that the different planting methods and shade had not significantly influenced the fresh root volume However when individual analysis was carried out the different planting methods were found to vary significantly with respect to volume of fresh root under shaded condition The plants under the ridge method of planting showed the lowest root volume of 21 73 ml which was on par with the pit followed by mound method (23 45 ml) As in the case of fresh root weight

Plate 7 Root growth under open and shaded condition in ridge and furrow method of planting

Plate 8 Root growth under open and shaded condition in flat bed method of planting


T1
SHADE
OPEN


T2
SHADE
OPEN


T1
SHADE
OPEN

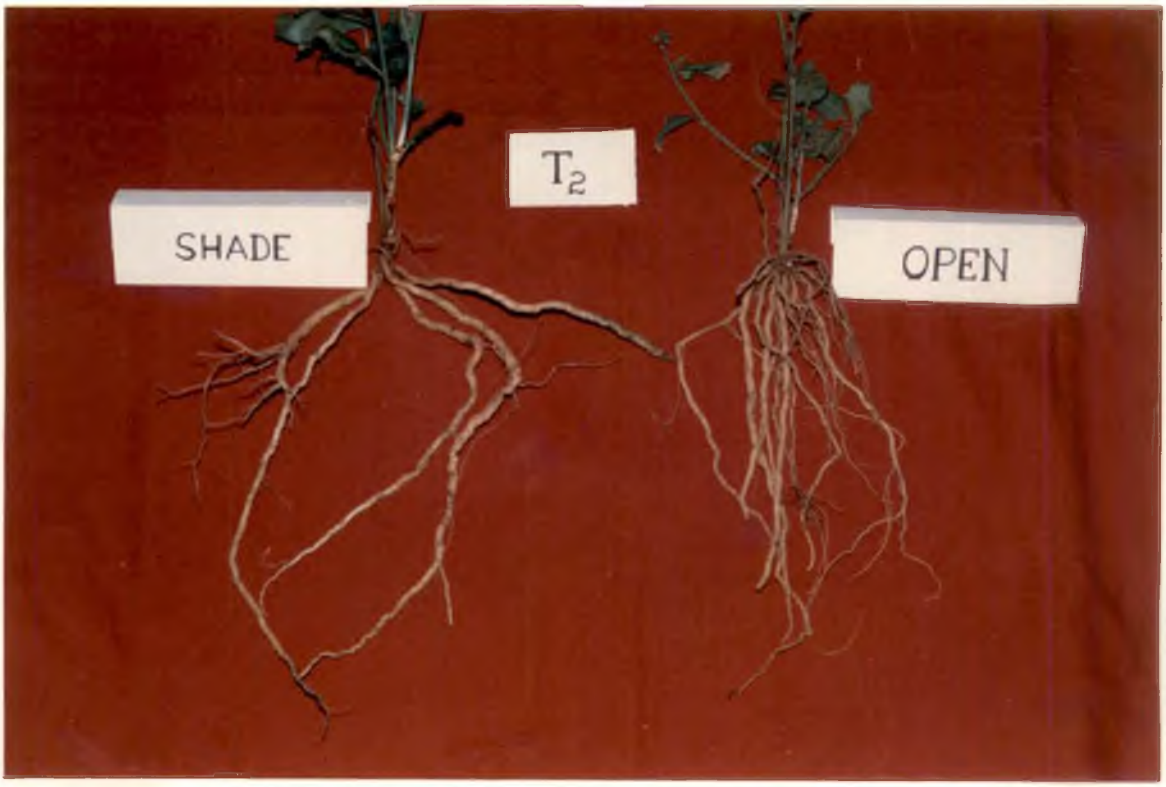
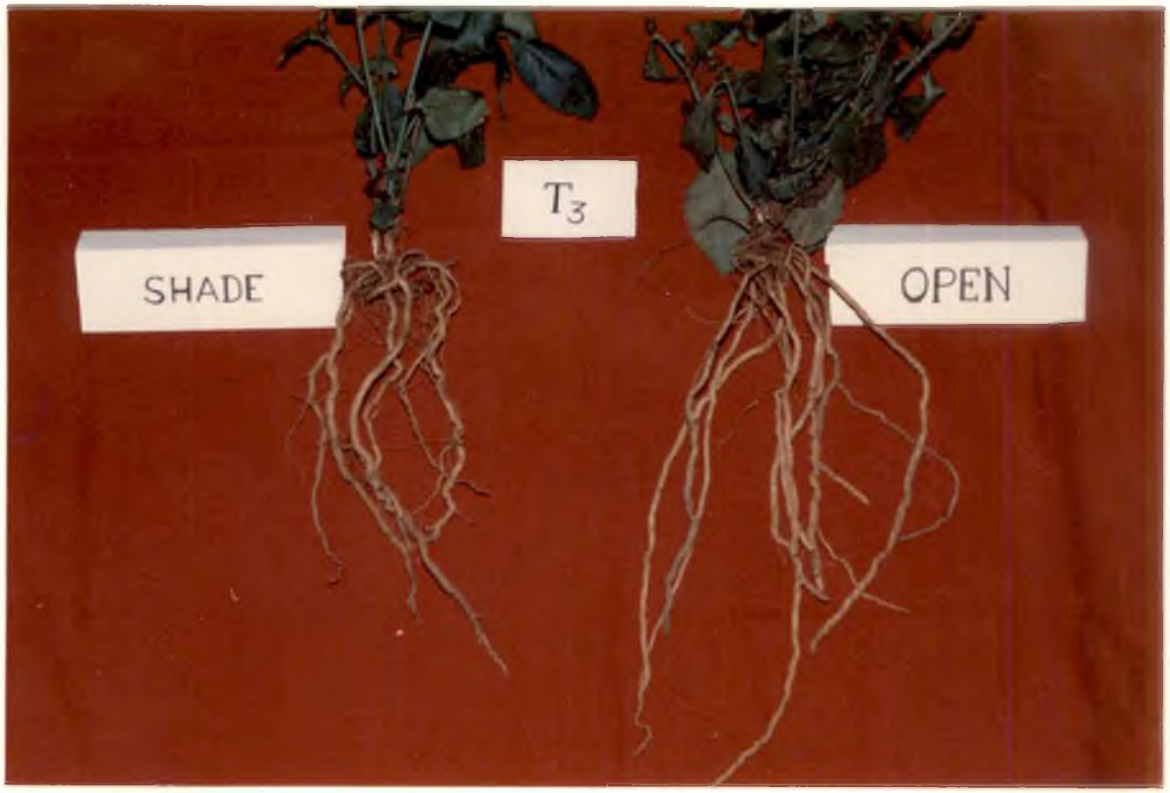

T2
SHADE
OPEN

Plate 9 Root growth under open and shaded condition in mound method of planting

Plate 10 Root growth under open and shaded condition in pit followed by mound method of planting


T3
SHADE
OPEN


T4
SHADE
OPEN

the flat bed method recorded the maximum root volume of 36 80 ml which was on par with root volume noticed under mound method of planting (28 07 ml)

4 4 4 Number of roots per plant

From the data presented in Table 14 it could be seen that the two growing conditions had a significant influence on number of roots per plant while the different planting methods had no significant influence The maximum number of 10 96 was noticed for the plants grown under open condition and in the case of plants under partial shade the number of roots noticed was only 7 30 which was significantly lower (Fig 12) Results of the individual analysis had indicated that under the partial sunlight condition, the different planting methods had significantly influenced the number of roots per plant and the maximum being noticed under mound planting, 9 33 followed by the plants under pit followed by mound method of planting (7 13)

4 4 5 Length of roots

Data relating to the effect of shade and planting methods on root length of plant are presented in Table 14 The different planting methods under consideration and the two growing conditions had significantly influenced the

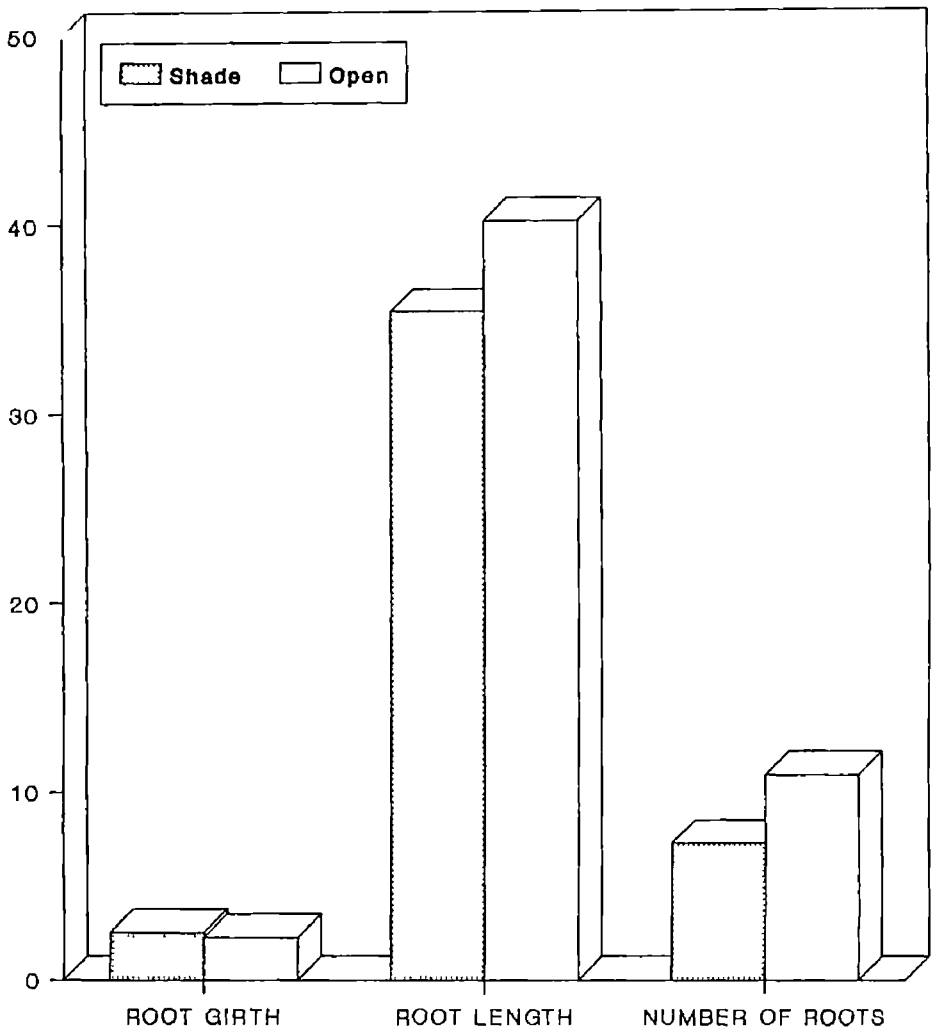



**Fig 12 Effect of shade on root characters**

Table 14 Effect of shade and planting methods on root character (per plant)

| | Number of roots | | | Length of roots (cm) | | | Girth of roots (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shade | Open | Pooled | Shade | Open | Pooled | Shade | Open | Pooled |
| Ridge and furrow | 2 58 (5 67) | 3 58 (11 83) | 3 08 (8 75) | 6 02 (35 28) | 6 68 (43 70) | 6 35 (39 49) | 1 89 (2 59) | 1 79 (2 22) | 1 84 (2 41) |
| Flat bed | 2 82 (7 07) | 3 44 (10 98) | 3 13 (9 02) | 6 21 (37 70) | 6 58 (42 43) | 6 40 (40 07) | 1 92 (2 68) | 1 78 (2 17) | 1 85 (2 43) |
| Mound | 3 20 (9 33) | 3 36 (10 42) | 3 28 (9 88) | 6 13 (36 63) | 6 46 (40 78) | 6 30 (38 71) | 1 81 (2 27) | 1 81 (2 27) | 1 81 (2 27) |
| Pit follo wed by mound | 2 84 (7 13) | 3 38 (10 62) | 3 11 (8 88) | 5 71 (31 98) | 5 89 (33 95) | 5 89 (32 96) | 1 84 (2 38) | 1 80 (2 27) | 1 82 (2 33) |
| CD (0 05) | 0 39 | | NS | NS | | 0 33 | NS | | NS |
| Overall | 2 86 (7 30) | 3 44 (10 96) | | 6 02 (35 40) | 6 40 (40 22) | | 1 86 (2 48) | 1 80 (2 23) | |
| | S | | | S | | | NS | | |

Note Figures in paranthesis are original value and others are square root transformed ones
S - Significant NS - Non significant

root length The plants under full sunlight recorded a significantly higher root length of 40 22 cm compared to the plants under shade conditions (35 40 cm) (Fig 12) The plants under pit followed by mound planting showed significantly lower length of 32 96 cm while all the other three treatments formed a group (Fig 13) Maximum root length (40 07 cm) was recorded for the flat bed method

4 4 6 Girth of roots

Neither the different planting methods nor the growing conditions had significantly influenced the root girth (Table 14) However, the root girth was found to be slightly higher under shade condition (2 48 cm) as compared to open (2 23 cm) (Fig 12) Of the different planting methods studied, flat bed planting contributed for the highest root girth of 2 43 cm and the lowest by mound method (2 27 cm)

4 4 7 Dry weight of shoot

The dry weight of shoot was not significantly influenced by planting methods or shade conditions (Table 15) Individual analysis data revealed that the flat bed planting contributed a significantly higher dry weight of shoot which was on par with that of pit followed by mound

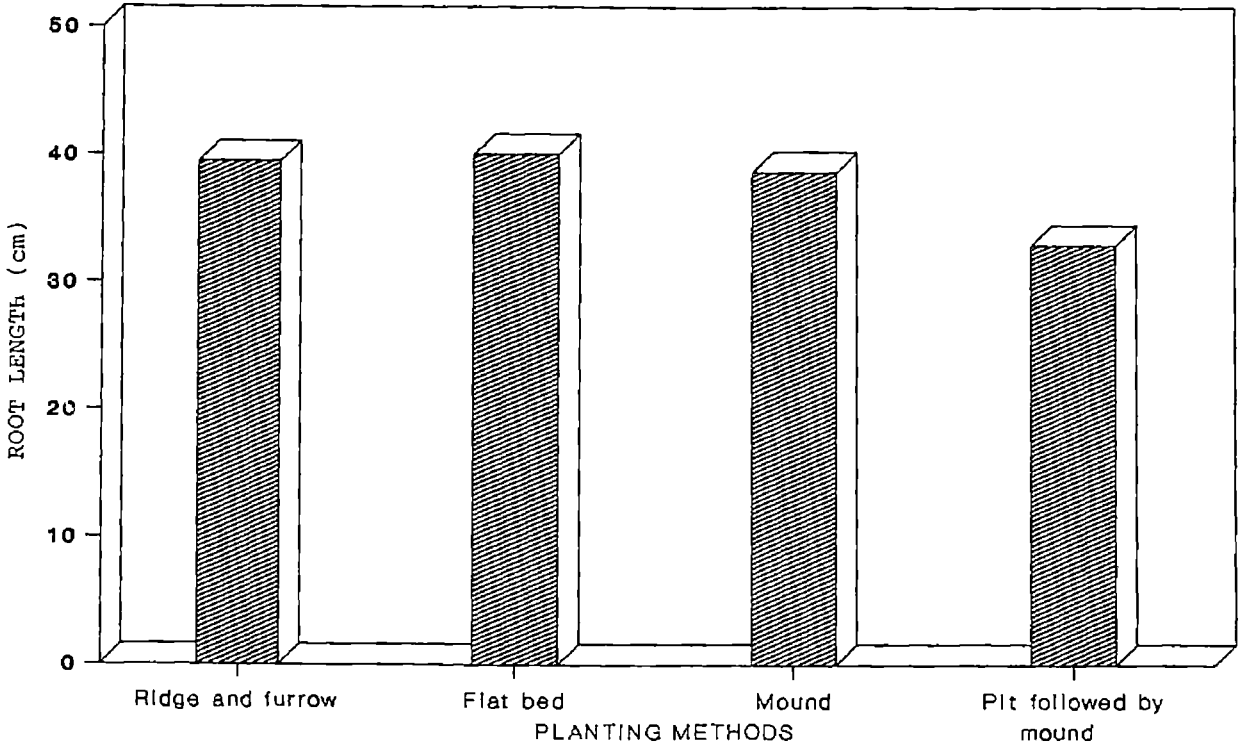



**Fig 13 Effect of planting methods on root length**

Table 15 Effect of shade and planting methods on dry weight of shoot and root and shoot root ratio *[per plant]*

| | Dry shoot weight (g) | | | Dry root weight (g) | | | Shoot/root ratio | | |
|---|---|---|---|---|---|---|---|---|---|
| | Shade | Open | Pooled | Shade | Open | Pooled | Shade | Open | Pooled |
| Ridge and furrow | 4 46 | 8 02 | 6 24 | 5 44 | 10 08 | 7 76 | 0 85 | 0 °0 | 0 82 |
| Flat bed | 9 18 | 10 94 | 10 06 | 8 79 | 8 63 | 8 71 | 1 05 | 1 23 | 1 14 |
| Mound | 5 83 | 11 39 | 8 61 | 6 66 | 9 71 | 8 18 | 0 88 | 1 24 | 1 06 |
| Pit followed by mound | 7 37 | 15 80 | 11 77 | 6 38 | 8 16 | 7 27 | 1 21 | 1 77 | 1 49 |
| CD (0 05) | 2 50 | NS | NS | 1 92 | NS | NS | NS | 0 53 | NS |
| Overall | 6 80 | 11 54 | | 6 81 | 9 14 | | 1 00 | 1 26 | |
| | NS | | | NS | | | NS | | |

NS Non significant

planting under shade conditions

4 4 8 Dry weight of root

Data furnished in Table 15 clearly indicate that the different planting methods and shade had not significantly influenced the dry weight of root Though not significant the plants under open condition recorded a higher dry weight of root (9 14 g) than those under shade (6 81 g) From individual analysis data it could be seen that the flat bed planting contributed maximum dry weight of roots (8 79 g) which was significantly higher than all other treatments

4 4 9 Shoot root ratio

The data relating to the effect of different planting methods and shade on the dry shoot root ratio are furnished in Table 15 Both the growing conditions and planting methods had not significantly influenced the shoot root ratio From individual analysis it is clear that the different planting methods had a significant influence on the shoot root ratio of the plants grown under the full sunlight and the maximum being recorded under pit followed by mound planting (1 77) which was on par with that under mound planting (1 24)

4 4 10 Plumbagin content in the roots

Data pertaining to the effect of shade and different planting methods on the total alkaloid content and purified plumbagin content are presented in Table 16 (Plates 11 and 12) It could be seen that the different planting methods had no profound influence on the alkaloid content of the roots There was a slight difference in crude plumbagin under open and shade conditions the maximum of 0 88 per cent being noticed under shade condition while the plants under full sunlight condition recorded 0 74 per cent But when purified there was no variation in the plumbagin content between open and shade (0 32 %)

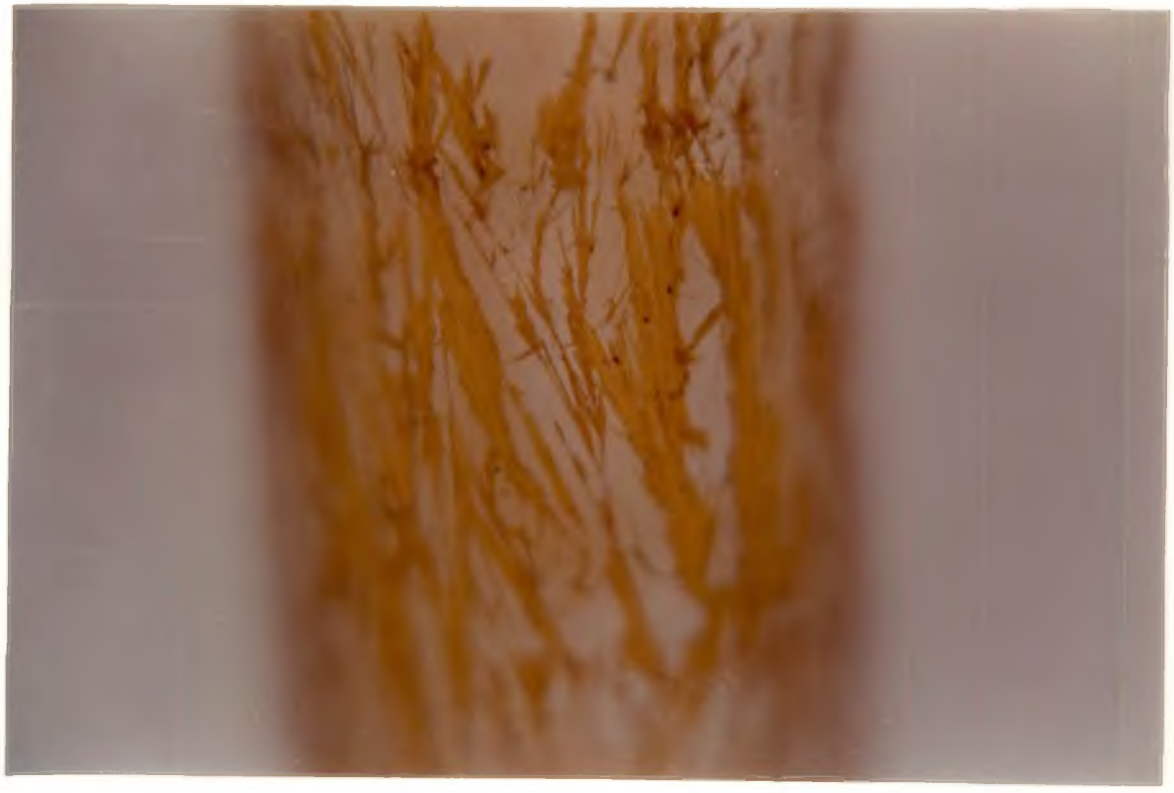
Table 16 Effect of shade and planting methods on plumbagin content of the roots [fresh weight basis]

| | Crude plumbagin (%) | | Purified plumbagin (%) | |
|---|---|---|---|---|
| | Shade | Open | Shade | Open |
| Ridge and furrow | 0 79 | 0 71 | 0 23 | 0 35 |
| Flat bed | 0 94 | 0 71 | 0 33 | 0 34 |
| Mound | 0 89 | 0 85 | 0 36 | 0 35 |
| Pit followed by mound | 0 88 | 0 67 | 0 37 | 0 27 |
| Mean | 0 88 | 0 74 | 0 32 | 0 32 |

Plate 11 Crude and purified plumbagin


PLUMBAGIN
CRUDE
CRYSTAL

Plate 12 A close up view of purified plumbagin (needle shaped crystals)



# Discussion

# DISCUSSION

'Chethikoduveli' (*Plumbago rosea* L ) is an economically important medicinal plant of Kerala which finds immense use in multitudes of ayurvedic formulations The plant is valued for the alkaloid plumbagin the content and quality of which are likely to be influenced by different growing conditions especially by shade However no systematic investigations have so far been conducted in this line Hence the present study has been undertaken with the main objectives to find out the effect of shade and planting methods on growth yield and plumbagin content The results of the investigations are critically discussed in this chapter based on the works done elsewhere

## 5 1 Effect of IBA on rooting of cuttings

The best use of rooting hormones is with plants whose cuttings will root but only with difficulty The purpose of treating cuttings with auxin type growth regulators is to increase the percentage of cuttings that form roots, to hasten root initiation to increase the number and quality of roots produced per cutting and to increase uniformity of rooting (Hartman and Kester 1989)

A quick dip treatment of IBA was found to have significant influence on percentage survival bud break and rooting of plumbago albeit it had no influence on shoot growth and leaf number

The highest number of roots per cutting was recorded when the cuttings were treated with IBA 500 ppm for 60 seconds and it was on par with other treatment at the same concentration but for lesser period (Table 1) The root length recorded was also maximum at this concentration An increase in root number and root length by IBA treatment was reported on *Vitex negundo* and *Sida retusa* by Philip *et al* 1990 The superiority of these treatments over others is again justified by the fact that the time taken for sprouting was the least (seven days) at 500 ppm IBA A pronounced relationship between bud activity and rooting of cuttings has already been established in other crops (Roberts and Fuchi Gami 1973)

A higher percentage survival (84%) was recorded in the treatment IBA 500 ppm for 30 seconds as compared to 60 per cent in the control It was also found that in general IBA 500 ppm gave 78 per cent survival against 68 per cent at 1000 ppm suggesting a lower concentration for better survival The increased survival percentage by IBA treatment had also been reported in some other crops In

*Solanum hispidum* 100 per cent survival was noticed in the case of IBA treated cuttings whereas it was only 70 per cent in the control (Badola *et al* 1991) The results of IBA treatment on rootings of cutting of patchouli under mist condition also support this finding wherein a cent per cent survival was obtained as against 56 per cent in the control (Selvarajan and Rao 1991)

5 2 General observations

5 2 1 Percentage survival in the field

The plants under natural shade of coconut recorded a higher percentage survival than that in the open The coconut plantation under study on an average imparted 65 73 per cent shade This high percentage of shade might have contributed for a better survival in the coconut garden The lowest establishment of cuttings was recorded in the case of flat bed method of planting both under open and shaded conditions

5 2 2 Soil nutrient status

The plant nutrients released in the soil either by weathering or by decomposition of organic material or by addition of fertilizers are lost by crop removal erosion volatalization denitrifiacation fixation or by combination of two or more of these processes (Gupta and

Kaleem 1991) The loss of nutrients are balanced by addition of fertilizers Ideally the nutrients added should supplement the nutrient loss by soil to restore the fertility In the present study a marked reduction in the major soil nutrients could be observed at the stage of harvest as compared to that at the time of planting even after sufficiently manuring the crop This indicates that the nutrient requirement of the crop may be much higher than the dose actually applied It was also noticed that among the nutrients studied phosphorus showed a higher soil depletion both under shade (48%) and open (37%) followed by potassium Organic carbon showed the least reduction Pillai (1990) observed a higher phosphorus and potassium content and low nitrogen content in the herbage of clocimum grown under open Phosphorus is a nutrient element which is highly essential for the growth and development of roots Plumbago being a root crop the higher requirement of phosphorus is quite natural

5 2 3 Incidence of diseases and pests

High incidence of leaf blight and nematode might have contributed for the lower yield observed in the study Serious yield losses due to root knot nematode damage had been reported in several important crops The incidence of nematode was high in open and this might have

the reason for higher number of roots under full sunlight These endoparasitic nematodes secrete enzymes in the plant tissues during feeding and plants show abnormal growth responses deprive host of its nutrients and also causes mechanical injury which might have reflected in the higher number of tiny roots This is true in the present study as well

5 2 4 Light infiltration in coconut plantation

The percentage light infiltration in the coconut plantation varied from 27 per cent to 35 per cent It could be observed from the Figure 1 that during all the months under consideration the maximum infiltration was at 12 noon The natural shade of coconut accounted for about 65-73 per cent shade and even under this high percentage of shade there was no significant difference in root yield but there was a significant difference in the shoot yield the open crop recorded a higher fresh shoot weight

5 2 5 Flowering

In general it was observed that the flower initiation was comparatively earlier in open as compared to shade In clocimum a reduction in the number of days required for the emergence of inflorescence under open

condition was observed by Pillai (1990) She had also observed a higher number of flowering shoots and a greater length under open condition In plumbago also the flowering intensity in terms of number of plants flowered as well as number of flowers per plant was higher in the case of plants grown under open condition This may be due to the fact that the optimum light requirement for the production of flower is relatively high as compared to vegetative growth

## 5 3 Preharvest observations

### 5 3 1 Plant height

The two different growing conditions had a significant influence on plant height only during the initial period of growth ie October The plant height was significantly higher under shaded condition (14 77 cm) as compared to open condition (8 92 cm) After Oct there was no significant difference The plant height was taken upto the tip of the inflorescence after the flowering had initiated The increased inflorescence length observed under open condition might have contributed to the increasing trend in plant height during post flowering period Pillai (1990) had also observed significant variation in length of inflorescence in clocimum under varying intensity of shade the minimum length recorded was under

75 per cent shade the higher plant height observed under shaded condition could be again substantiated by the significantly higher internodal length Theoritically photodestruction of auxin is less in shaded stands shading tends to increase auxin levels which could increase the internodal length (Evans 1973) The favourable effect of shade on plant height is also believed to be due to auxin enhancement probably acting synergestically with gibberillic acid (Leopold 1964) But in *Mentha arvensis* Duriyaprapan and Brittin (1982) had failed to record any influence of shade on plant height Bai and Nair (1982) and George (1982) were of the opinion that plant height was unaffected by shading in cowpea blackgram and colocasia

Height of the plant was not influenced by any of the planting methods (Table 4) This was supported by the findings of Ramachandran and Muthuswami (1984) in turmeric This may be due to the similar growth pattern of the plant under different conditions However flat bed was found to be superior to all others under shaded condition The quantum of light infiltered to each plot had also showed high variation which may explain the above result

When the monthly increase in plant height was considered it was found to be high during December

January, the period which of course coincided with flowering The plants under full sunlight recorded 10 46 cm growth in height as compared to 7 72 cm in the case of plants under partial sunlight But both the conditions recorded almost same quantum of increase in height during initial periods of October and November The length of inflorescence observed was high under open condition which could have accounted for higher increase in plant height

5 3 2 Plant spread

The different growing conditions had not influenced the plant spread However during the initial periods the plant spread both NS and EW spread was comparatively high under shaded condition A slight decrease in spread during December - January could be attributed to the flowering which occurred during that period During flowering the nutrients may get translocated to the developing inflorescence and as such the number of new branches produced will be less which could be noticed from the decreased spread The growth of inflorescence in general is at a faster rate than the vegetative shoots and the indeterminate growth of inflorescence will change to a determinate stage after sometime then more side branches will arise and hence the spread regains after a period During the time of initiation of

inflorescence the flowering branches may get oriented towards the sunlight thereby the plants tend to be more erect than spreading

The different planting methods had no significant influence on the plant spread which may be due to the uniform population density under different methods However, under shaded condition ridge and furrow method recorded the minimum spread and the maximum was in the case of flat bed

5 3 3 Internodal length

The natural shade imparted by coconut had significantly increased the internodal length This was in conformity with the results obtained by Sreekumari *et al* (1988) in cassava Shading tend to increase the auxin level due to the reduced photodestruction of the same which could increase the internodal length A sudden increase in internodal length was noticed during December January period under shaded condition whereas it was observed during November - December in the case of plants under open This suggests the occurrence of early flowering in plants grown under full sunlight The different planting methods in general had not influenced the internodal length Under shaded condition, the plants on flat bed recorded a comparatively higher internodal length

which was on par with the pit planting

5 3 4 Number of suckers per plants

The plants grown under full sunlight contributed for a greater number of suckers per plant In a root crop like Plumbago the number of suckers is a major yield contributing character Under uniform agroclimatic and management conditions solar energy will be a factor deciding the sucker production unless the plant is a shade loving one The increased sucker production under open condition may be due to the increased receipt of solar energy

5 3 5 Number of leaves per plant

The different planting methods or shade had not significantly influenced the number of leaves per plant Even though the internodal length was low under open condition the total leaf number remained more or less same as compared to shaded condition This could be at tributed to the higher sucker production per plant under open condition

As in the case of other parameters the minimum number of leaf per plant was noticed under ridge and furrow planting The present finding is in conformity with the results obtained by Prameela (1990) who had observed

no significant impact of shade on number of leaves in colocasia Similar reports were obtained by Sennamarappa and Shanker (1988) in turmeric

5 3 6 Total leaf area per plant

Shade had no differential influence on the total leaf area per plant (Table 11) However comparatively higher leaf area was observed in plants grown under open condition Pillai (1989) had also observed a higher leaf area under open condition But the results of the present study is in contradiction with that obtained by Duriyaprapan and Britten (1982) in *Mentha arvensis* wherein they had recorded an increased leaf area in plants grown under shaded condition

Under partial sunlight condition the ridge and furrow method registered the lowest leaf area and flat bed method the maximum value

5 3 7 Chlorophyll content in the leaves

The total chlorophyll content in the leaves remained almost same both under open and shade conditions It was also observed that the chlorophyll content had considerably decreased as flowering advanced Lower chlorophyll a/b ratio are typical of shade ecotypes and may enable more efficient absorption of light under shaded

condition (Boardman 1977 Young and Smith 1980) Also the ratio of chlorophyll a to b is higher in photosystem I than photosystem II A higher a/b ratio during post flowering period suggests that in plumbago the photosystem I is more efficient during post flowering period which may favourably influence the yield parameters The lack of variation in chlorophyll content of plants grown under shade and open condition reveal the ability of the plant to utilize effectively higher percentage of solar energy even under limited light regimes A higher photosynthetic efficiency even under infiltered light condition is really advantageous

5 4 Post harvest observations

5 4 1 Fresh and dry weights of shoot

Sunlight had a favourable effect on the shoot growth of plant (Table 13 and 15) A higher shoot weight recorded under full sunlight condition can be further substantiated by the higher number of suckers leaves a higher leaf area and a lower internodal length under open conditions

The three planting methods flat bed mound and pit followed by mound recorded almost the same shoot weight while ridge and furrow method the lowest The ridge method also recorded the lowest values for all other

biometric characters A ridge of 30 cm height and 30 cm width may not contribute a congenial condition for growth of plant and probably a bigger ridge might be more benefi cial

5 4 2 Fresh and dry weights of root

Shade and different planting methods had no significant influence on yield (Table 13 and 15) Eventhough open condition had favoured the shoot production (fresh) the filtered light was sufficient enough to register root growth on par with that under open This can be again substantiated by the production of same quantum of chlorophyll even under partial sunlight The results are in agreement with the findings of Nair *et al* (1991) and Rajagopalan *et al* (1992) in medicinal plants But there was no significant difference in the dry weight of root according to different planting methods and growing condi tions When different planting methods are considered the ridge and furrow method recorded the lowest root yield (30 90 g) and shoot yield (15 59 g) whereas the maximum root yield (34 62 g) was recorded by bed method The results elucidate the suitability of growing plumbago in the partially shaded conditions like that of coconut plantation

5 4 3 Root characters

The plants grown under full sunlight recorded a significantly higher root number and length even though there was no significant difference in root girth The increased length or number of roots was not reflected in the root yield So it may be presumed that the girth of the root may have a decisive role in determining the total root yield The dry weight of root was also not influenced by different growing conditions and planting methods

5 4 4 Plumbagin content in the roots

The different planting methods had no profound influence on the alkaloid content in the roots There was a slight variation in the crude plumbagin under open and shade conditions However there was not much difference in the purified plumbagin under two experimental conditions The higher content of crude plumbagin under shaded condition can be accounted for the accumulation of other analogues of plumbagin in the plants under shaded condition It may also be due to the adaptation of plant under shaded condition where nematode attack was less when compared with the observations under open conditions The higher degree of tolerance imparted against nematode infestation by the plants under shade may be due to the production of some constituents other than pure plumbagin under shaded condition

# Summary

## SUMMARY

The investigations were undertaken with the main objectives of identifying suitable method of planting and effect of shade on growth, root yield and plumbagin content of *Plumbago rosea* L The assessment of the suitability of growing plumbago as intercrop in young coconut plantation has also been envisaged in the study Two field experiments were laid out one under open condition and another under natural shade in coconut plantation in randomised block design at the College of Horticulture Vellanikkara Thrissur Kerala during the year 1993 94

A Preliminary trial was carried out in order to study the influence of rooting hormone on rooting of plumbago cuttings It was found that the growth regulator IBA had a favourable effect on rooting of cutting Dipping of cuttings in IBA at 500 ppm for 30 seconds was found to give a higher survival percentage higher root number and root length and recorded a lesser time for bud break

When the two growing conditions were compared a higher field establishment could be observed under natural shade of coconut The percentage of light infiltration in the coconut plantation ranged from 27 per cent to 35 per cent Maximum infiltration was noticed at 12 00 noon

When different planting methods were considered irrespective of shade and open conditions the four methods studied viz ridge and furrow flat bed mound and pit followed by mound had no significant influence on biometric characters of the crop such as plant height internodal length plant spread leaf number total leaf area per plant, number of suckers per plant and root yield However the ridge and furrow method recorded a negative influence on biometric and yield characters though not significant

The leaf blight incidence mite damage and nematode attack were more under open condition The intensity of flowering in terms of number of plants flowered and number of flowers per plant was also high in the plants grown under full sunlight

When nutrient status of the soil was analysed before planting and after harvest it was observed that all the major nutrients showed a reducing trend the percentage of reduction being very high (upto 47 58%) in the case of phosphorus

Among the biometric characters studied shade had a positive influence on the internodal length of plants in almost all months and on plant height during the initial

periods only There was no variation in plant spread under shade and open conditions Total number of leaves and total leaf area per plant were high under partial shade condition during the initial period of October and there after the crops under open condition recorded maximum values though not significant Shade had a negative influence on the number of suckers per plant

There was not much variation in the total chlorophyll and ratio of chlorophyll a to b under partial and full sunlight Under both conditions there was a reduction in chlorophyll content and a/b ratio during flowering stage the maximum values being recorded during the post flowering period

Growing condition and planting methods had a significant influence on the fresh shoot weight the maximum values being recorded under full sunlight and in pit followed by mound planting

Fresh root yield dry yield of shoot and root root volume and root girth were not influenced by the partial shade imparted by coconut canopy However the root length and root number were significantly high under open condition

The crude plumbagin was slightly high under partial shade of coconut but there was no variation in the purified plumbagin content

Based on the results of the present investigations it could be concluded that *Plumbago rosea* L is a suitable intercrop in the coconut gardens of Kerala homesteads and the crop can be grown by adopting any method of planting such as ridge and furrow mound, flat bed and pit followed by mound method according to the locality

# References

## REFERENCES


*Aclan, F and Quisumbing, E C 1976 Fertilizer requirement mulch and light attenuation on the yield and quality of ginger *Philipp agric* 60(5/6) 183-191

Ahluwalia K S 1963 Observations on cultivation and alkaloid content of *Rauwolfia serpentina* (C ) *Indian Forester* 89 373-379

Amma, M K 1989 *Plant and soil analysis* Rubber Research Institute Kottayam p 70 95

Anjaneyulu, V S R and Krishnamoorthy 1979 The efficiency of broad-ridge method of planting turmeric *Indian Arecanut Spices and Cocoa Journal* 2 116-118

Badola, K C , Pal, M and Bhandari H C S 1991 Rooting branch cuttings of *Solanum hispidum* for raising clonal crops *Indian J forestry* 14(4) 290-291

Bai, E K L 1981 Shade response of common rainfed intercrops of coconut M Sc (Ag ) thesis Kerala AGricultural University, Vellanikkara Thrissur Kerala

Bai, E K L and Nair R V 1982 Shade response of some common rainfed intercrops *proceedings of fifth annual symposium on plantation crops* Indian society for plantation crops Kasargod p 394 401

Balashanmugam P V and Veeramuthu P G 1989 Effect of planting technique and intercropping in turmeric (*Cucuma longa*) *South Indian Hort* 37(3) 189-190

Balyan S S Sobti S N , Pushpangadan, P Singh A and Atal, C K 1982 *Cultivation and utilization of aromatic plants* Atal C K and Kapur B M (eds ) Regional Research Lab , Jammu p 481-486

Bhaumik, S K , Sen H and Bhattacharya S P 1988 Effect of herbicides and planting methods on the yield of elephant foot yam (*Amorphophalus campanulatus* Blume ) *J Root Crops* 14(1) 23-26

Biswas, K 1955 Cultivation of *Rauwolfia serpentina* in West Bengal *Indian J Pharm Sci* 18(6) 227-232

Biswas P K and Bhaduri P N 1975 Induced tetraploidy in *Rauwolfia serpentina* Benth and its propaga tion *Abstract paper of National Symposium on Advanced Development, Production and Utilisation of Medicinal and Aromatic Plants* CIMPO, Lucknow

Biswas S , Sen H and Mukhopadhyay S K 1990 Effect of light intensity on shoot growth and tuber development in sweet potato *J Root Crops* 16(1) 1-3

Boardman N K 1977 Comparative photosynthesis of sun and shade plants *Annual Rev Pl Physiol* 28 355 377

Duriyaprapan S and Britten, E J 1982 The effect of radiation on plant growth and oil quality of Japnese mint *J Exp Bot* 33 1317 1324

Edmond J B , Senn T L Andrews F S and Halfacre R G 1985 *Fundamentals of Horticulture* Tata Mcgraw Hill Publishing Company Ltd New Delhi p 206

Evans L T 1973 The physiological basis of crop yield *Crop Physiology* Evans L T (ed ) Camb p 333

*Fing, Y Z 1982 Cultivated multistorey and multispecific association of tropical crop plants and beneficial effeect of these communities on light intensity, soil fertility and soil moisture In collected research papers on tropical botany *Academia Sinica* 42-45

Fukai, S Alcay A B Liamela A B and Patterson R P 1984 Effect of solar radiation on growth of cassava 1 Canopy development and dry matter production *Fld Crops Res* 347-360

George, E B 1992 *Evaluation of ginger cultivars for shade tolerance* M Sc (Ag ) thesis Kerala Agricultural University Vellanikkara Thrissur, Kerala

George S 1982 Shade response of common rainfed intercrops of coconut Part III Legume M Sc (Ag ) thesis Kerala Agricultural University Vellanikkara, Thrissur Kerala

Gupta, A K and Kareem M 1993 Manures and Fertilizers *Handbook of Agricultural Science* Kalyani Publishers N Delhi p 39-50

Hartman H T and Kester, D E 1983 *Plant Propagation Principles and Practices* 2nd ed Prentice Hall Eaglewood cliffs N Z

*Kan S 1991 Cultivation and breeding of *Geranium thunbergis* (1) Effect of planting density and light intensity on yield and tanin content *Shoyakugaku Zasshi* 45(1) 1-5

*Kesahara Y and Hikino H 1983 Cultivation conditions and antiemetic activity of *Pinellia ternata Hort Abstr* 1986 56(1) 62

Krishnamoorthy H N 1981 *Plant Growth Substances Including applications in Agriculture* Tata McGraw Hill Publishing Co Ltd , New Delhi p 163

Leopold A C 1964 *Plant Growth and Development* McGraw Hill Book Company New York p 329-347

*Lewandowska M , Hart J W and Jarvis, P G 1976 Photosynthetic electron transport in plants of sitka spruce - subjected to different light environments during growth *Physiol Plant* 37 269 274

Mohanty D C and Sarma, Y N 1978 Performance of ginger in tribal areas of Orissa, India, as influenced by method of planting seed treatment manuring and mulching *J Pln Crops* 6(1) 14-16

Nalawadi U G Narayanaswamy P and Ratnam B P 1988 Studies on the effect of light intensity on flowering in *Ixora singaporensis Hort S Indian Hort* 36(182) 94-95

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 Spices Pl* Today and Tomorrow Printers and Publishers New Delhi 5 p 163-165

Nigam, A K and Gupta V K 1971 *Handbook on Analysis of Agricultural Experiments* IASRI Library Avenue New Delhi p 293-307

Nigam K B Rawat G S and Prasad B 1984 Effect of methods of sowing, plant density and fertility level on Aswagandha (*Withania somnifera*) *South Indian Hort* 32(6) 356-359

Okoli, P S U and Wilson G F 1986 Response of cassava (*Manihot esculenta* Grants) to shade under field condition *Fld Crops Res* 14 349-350

Pal, M Goel C L and Bhandari H C S 1993a Effect of auxins on rooting branch cuttings of Antamul (*Tylophora indica*) *Indian J Forestry* 16(3) 243-245

Pal M , Mishra M and Bhandari H C S 1993b Promotion of rooting of shoot cuttings of *Datura stramonium* L by IBA *Indian J Forestry* 16(4) 336 338

Panda, J M and Mohanty B K 1990 Studies on rapid rooting of betelvine cuttings treated with growth regulators *Science Culture* 56(5) 212-214

Philip J Nair G S Premalatha T and Sudhadevi P K 1990 Standardisation of vegetative propagation techniques in some of the medicinal plants grown in Kerala *Indian Cocoa Arecanut and Spices Journal*

Pillai R R 1990 *Quality of oil of clocimum (Ocimum gratissimum Linn ) as influenced by stages of harvest and shade* M Sc (Ag ) thesis Kerala Agricultural University Vellanikkara Thrissur Kerala

Prameela P 1990 *Screening different morphotypes of colocasia (Colocasia esculanta L Schatt ) for shade tolerance* M Sc (Ag ) thesis Kerala Agricultural University Vellanikkara Thrissur Kerala

Prasad M 1988 Yield of sweet potato as affected by planting method and vine length *J Root Crops* 15(1) 63 64

Radakrishnan V V Viswanathan T V Cheriyan S and Regunath B R 1991 Shade tolerance studies on Patchouli *South Indian Hort* 39(1) 388-389

Raghavan K K 1992 Cataloguing of medicinal plants in Vellanikkara rubber estate Dissertation for P G Diploma in Natural Rubber Production Kerala Agricultural University Vellanikkara Thrissur Kerala

Rajagopalan A Viswanathan T V and Devi S N 1992 Medicinal plants as intercrops in coconut gardens - A preliminary study *J Pln Crops* 20(supplement) 50-51

Ramachandran N and Muthuswami S 1984 Studies on the influence of method of planting and spacing on yield and quality of turmeric (*Curcuma longa* L ) *S Indian Hort* 32(3) 143 145

Ramadasan A and Satheesan K V 1980 *Annual Report - 1980* CPCRI Kasargod p 813

Ramadasan A and Satheesan K V 1987 Curcumin and essential oil content of three turmeric cultivars grown in monculture and as intercrop in coconut garden *J Pln Crops* 16(1) 1-72

* Ramanujan T Nair M G and Indira P 1984 Growth and development of cassava genotypes under shade in coconut garden *Turrialba* 34 267 214

Ravisankar C and Muthuswamy S 1986 Dry matter production and recovery of dry ginger in relation to light intensity *Indian Cocoa Arecanut & Spices Journal* 19 4 6

Ravisankar C and Muthuswamy S 1987 Study on the quality of ginger (*Zingiber officinale* Rosc ) grown in different light intensities *South Indian Hort* 35 226-231

* Roberts A N and Fuchigami L H 1973 Seasonal changes in auxin effect on rooting of Douglas-fir stem cuttings as related to bud activity *Phys Plant* 28 215-221

RRII 1989 Annual Report 1987 88 Rubber Research Institute of India Kottayam Kerala

Sahu, B N 1970 Intercropping *Rauwolfia serpentina* Benth *ex kurz Indian J Agron* 15(3) 229 235

*Samuel, S Nair E V G Kumar D K V and John R 1993 Domestication of high value medicinal plants for ayurvedic formulations - needs of society *Traditional Medical Systems* 3(3) 17-21

Santhakumari G Sarasamma P G and Radakrishnan V 1980 Effect of plumbagin on cell growth and mitosis *Indian J Exp Biol* 18(3) 215-218

Satheesan K V and Ramadasan A 1992 Leaf physiological characters as shade tolerance indicators in turmeric cultivars grown as intercrop in coconut garden Proceedings of PLACROSYM IX *J Pln Crops* 20 284 287

Selvarajan M and Rao V N M 1991 Studies on rooting of patchouli cuttings under different environment *S Indian Hort 39(6) 388 389*

Sennamarappa M and Shankar K 1988 Performance of turmeric and sweet potato cowpea planted as intercrop at two crop intensities under four different densities of arecanut *J Pln Crops* 16(1) 19-25

*Shibata T Hatakeyama Y Anetai M Kaneshima H 1992 The trial cultivation of *Captis japonica* Makhino on unshaded (open) condition in NOrthern Hokkaido *Shoyokugaku zasshi* 46(4) 317-321

Sreekumari, N T Abraham K and Ramanujan T 1988 The performance of cassava under shade *J Root Crops* 14(1) 43-52

Subha S 1990 *Effect of spacing and planting materials on the growth yield and active principle of Plumbago rosea Linn* M Sc (Hort ) thesis Kerala Agricultural University Vellanikkara Thrissur Kerala

Thumininkatti and Patwardhan, V N 1932 *Wealth of India - Raw materials* Vol VIII Publication Information Directorate C S I R New Delhi p 162-163

* Tikhomirov, A A , Zolutukhin J C and Yasid'ko F 1976 Effect of light regime on productivity and quality of the harvest of reddish *Soviet Pl Physiol* 23 27-31

Varughese S 1989 *Screening of varieties of ginger and turmeric for shade tolerance* M Sc (Ag ) thesis Kerala Agricultural University Vellanikkara Thrissur, Kerala

Vijayakumar, K R Rao, P S and Sethuraj M R 1989 Natural Rubber - A commercially important forest species *Rubber Board Bulletin* 24(3) 21-23

Yadav, R L , Anwar M Singh R and Singh, D 1983 Response of *Costus speciosus* to Nitrogen Phosphorus and Pottasium fertilizers *J Agri Sci* 101(3) 755-776

* Young, D R and Smith W K 1980 Influence of sunlight on photosynthesis water relations and leaf structure in the under storey species *Arnica cordifolia* Ecology, 61 1380 1390

* Originals not seen

# Appendix

Appendix
Weather data of Vellanikkara
Rain in mm and Sunshine in hours

| Element | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year 1992 | | | | | | | * | | | | | |
| Rain | 0 0 | 0 0 | 0 0 | 48 6 | 90 6 | 979 8 | 874 5 | 562 9 | 302 9 | 386 7 | 376 7 | 2 0 |
| Mean RH(%) | 53 | 65 | 61 | 65 | 73 | 84 | 87 | 88 | 82 | 82 | 77 | 61 |
| Sunshine | 9 0 | 9 2 | 9 2 | 8 8 | 7 4 | 3 3 | 2 1 | 2 7 | 4 1 | 4 6 | 5 5 | 8 9 |
| Year 1993 | | | | | | | | | | | | |
| Rain | 0 0 | 6 6 | 0 0 | 32 1 | 131 1 | 700 3 | 661 6 | 276 7 | 85 3 | 519 0 | 74 6 | 18 0 |
| Mean RH (%) | 53 | 62 | 63 | 69 | 74 | 86 | 87 | 87 | 81 | 83 | 73 | 66 |
| Sunshine | 8 1 | 9 4 | 9 0 | 9 1 | 6 5 | 3 3 | 2 4 | 4 8 | 6 4 | 4 8 | 5 8 | 7 5 |
| Year 1994 | | | | | | | | | | | | |
| Rain | 19 4 | 1 7 | 21 0 | 165 2 | 124 2 | 955 1 | 1002 1 | 509 2 | 240 5 | 358 2 | | |
| Mean RH (%) | 58 | 59 | 59 | 74 | 75 | 90 | 91 | 85 | 78 | 80 | | |
| Sunshine | 9 1 | 8 7 | 9 3 | 8 0 | 8 0 | 2 1 | 1 4 | 3 0 | 7 3 | 7 3 | | |

Source Agrometeorological Observatory
College of Horticulture Vellanikkara

# INFLUENCE OF METHODS OF PLANTING AND SHADE ON GROWTH, YIELD AND PLUMBAGIN CONTENT OF 'CHETHIKODUVELI' (*Plumbago rosea* Linn)

By

**JALAJA S. MENON**

## ABSTRACT OF A 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 Plantation Crops and Spices
COLLEGE OF HORTICULTURE
Vellanikkara Thrissur

**1994**

## ABSTRACT

Investigations on "Influence of methods of planting and shade on growth, yield and plumbagin content of 'Chethikoduveli' (*Plumbago rosea* Linn )" was conducted at the Department of Plantation Crops and Spices, College of Horticulture Vellanikkara during 1993-'94

The study was undertaken with the main objectives of identifying suitable method of planting for better growth, root yield and plumbagin content and to assess the effect of shade on growth, yield and quality of plumbago The investigation was also aimed at gathering information regarding the suitability of growing plumbago an intercrop in young coconut garden

A preliminary trial was carried out in order to study the influence of rooting hormone on rooting of plumbago cuttings Dipping the cuttings in 500 ppm IBA for 30 seconds was found to give a higher survival percentage, higher root number and root length and recorded a lesser time for bud break

Two sets of experiments, one under full sunlight and another under the natural shade of coconut were laid

out The four planting methods tried were ridge and furrow, flat bed, mound and pit followed by mound

The morphological characters studied in the present investigations were the height spread, number of suckers total number of leaves, leaf area per plant and internodal length The yield parameters such as number length, girth and volume of root and fresh and dry weights of shoot and root per plant shoot root ratio and chlorophyll content were also studied The plumbagin content in the root was also studied

When the two growing conditions were compared, a higher field establishment could be observed under natural shade of coconut Among the biometric characters studied shade had a positive influence on internodal length during the entire period of growth However the favourable effect of shade on plant height could be observed only during the initial periods of growth

There was not much variation in the total chlorophyll and ratio of chlorophyll a to b under partial and full sunlight

There was no significant difference in the root yield under open and shade conditions But the crops under partial sunlight recorded a higher shoot weight

Eventhough the crude plumbagin was higher under shade condition, there was no marked difference in the purified plumbagin

The intensity of flowering was found to be high under open condition The leaf blight incidence mite damage and nematode attack were also more under open condition

When different planting methods were considered irrespective of shade and open conditions, the four methods studied viz ridge and furrow flat bed mound and pit followed by mound had no significant influence on biometric character, root yield and plumbagin content

The study revealed the possibility of successfully cultivating plumbago as an intercrop in young coconut plantation adopting any method of planting such as ridge and furrow flat bed, mound and pit followed by mound