# RESPONSE OF *Piper longum* IN COCONUT GARDENS TO DIFFERENTIAL SPACING AND MANURIAL REGIMES

By

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## THESIS

Submitted in partial fulfilment of the requirement for the degree of

**Master of Science in Agriculture**

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy

COLLEGE OF HORTICULTURE
VELLANIKKARA THRISSUR 680 654

**1996**

## DECLARATION

I hereby declare that the thesis entitled "**Response of *Piper longum* in coconut gardens to differential spacing and manurial regimes**" 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 fellowship associateship or other similar title of any other university or society

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## CERTIFICATE

Certified that the thesis entitled **Response of *Piper longum* in coconut gardens to differential spacing and manurial regimes** is a record of research work done independently by **Miss N Sheela** under my guidance and supervision and that it has not previously formed the basis for the award of any degree fellowship or associateship to her


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## ACKNOWLEDGEMENT

I would like to express my deep sense of gratitude and heartfelt thanks to **Dr Mercy George** Assistant Professor Department of Agronomy and Chairperson of my advisory committee for her personal attention keen and sustained interest expert guidance and unfailing help throughout the course of this investigation

I express my sincere thanks to **Dr E Tajuddin** Director of Extension former Head of the Department of Agronomy for his valuable advice throughout the course of this investigation

My profound gratitude is due to **Dr E K Lalitha Bai** Assistant profes sor Department of Agronomy for the constructive suggestions and encouragement rendered at various stages of the study

I am deeply obliged to **Dr A Augustine** Assistant Professor Biochem istry for the timely help valuable suggestions and wholehearted co operation to wards the satisfactory fulfilment of this endeavour

No words can truly represent my esteemed gratitude to Dr P S John Associate Professor Agronomy for his constant help never ending encouragement and valuable suggestions from beginning to end of this study

I also place on record my indebtedness to late Dr Viswanathan T V who was instrumental in taking up this project

I am deeply obliged to Dr R Vikraman Nair Professor and Head Department of Agronomy for his constant encouragement through out the course of this programme

My heartfelt thanks are also due to Mr V K G Unnithan Associate Professor Department of Agricultural Statistics and Mr Krishnan S Assistant Professor Department of Agricultural Statistics for their help in statistical analysis

I am very much indebted to each and every member of the Department of Agronomy for rendering all possible help

The assistance and co operation rendered to me by Dr Keshavachandran Assistant Professor Mr Sidharthan Farm Assistant and the labourers of KADP Madakkathara are very much appreciated I thank them profusely

It is with immense pleasure that I thank all my friends especially Shyna Preetha and Reena who have contributed much towards the completion of this research work

I am deeply indebted to my loving parents sister brother and brother in law without whose boundless affection warm blessing and constant encouragement this would not have been a success

My sincere thanks are due to Mr Joy for neat typing of the thesis and prompt service

The award of fellowship by the Kerala Agricultural University is grate fully acknowledged

Above all I bow my head before the Almighty who blessed me with health confidence and will power to undertake this endeavour successfully

N Sheela

*Dedicated to*
*my loving parents*

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# Introduction

# INTRODUCTION

*Piper longum* popularly known as Thippali is an important medicinal plant belonging to the family **Piperceae** The genus is widely distributed in the tropical forest ecosystems It is the third most important species of genus *Piper* after black pepper (*Piper nigrum* L ) and betel vine (*Piper betle* L ) It is perhaps the first pepper to reach the Mediterranean and was once regarded as superior to black pepper by Greeks and Romans

It is a slender aromatic climber with perennial woody roots Dried fruits of thippali are commonly used in bulk quantity in Ayurvedic and Unani medicine industry It finds an important place in indigenous medicines in curing respiratory tract diseases cardiac and splenic disorders as an analgesic for muscular pains and as a general tonic It is also reported to act as an immuno stimulant and forms a major constituent of ayurvedic drugs recommended for increasing immunity against AIDS virus (Anon 1993)

The dried fruits yield alkaloid the active ingredient of which are piperine piper longumine piper longuminine etc in fruits and piperidine in roots Roots and thicker parts of the stem are known as *Piplamool*

India imports a large quantity of *Piper longum* from Jawa Malaysia and Singapore A survey conducted by the State Government in 1987 had estimated the quantity of *Piper longum* required by the Ayurvedic medicine industry in Kerala as 313 tonnes The requirement is estimated to have gone upto 700 tonnes according to the Kerala Ayurvedic Medicine Manufacturers Association Trichur Due to the peculiar ecological and agronomic requirements and lack of availability of cultivable land this crop cannot be recommended as a sole crop in the State

In Kerala coconut cultivation extends upto about 8 6 lakh hactares The productivity is declining due to various factors The only way to enhance net returns from coconut holdings is by intercropping with perennials The importance of intercropping medicinal plants in coconut gardens is of great relevance taking into account the escalating price of medicine and shortage of indigenous materials for drugs

Many workers had reported that thippali could be a renumerative intercrop in irrigated coconut gardens It performs better under irrigated conditions and requires a certain extent of shade Among the varieties tried Cheemathippali was found to give the best spike yield So far no concrete study has been done on the fertilizer requirement of this crop The common practice is to grow the crop only by organic manure application It is supposed that response of *Piper longum* to nutrients will be more or less similar to *Piper nigrum* due to its similarity in growth habit medicinal property etc No information is available on the plant density when grown commercially in an agroecosystem Hence the present investigation was carried out with the following objectives

1 To work out the optimum spacing for *Piper longum* grown as a floor crop in coconut gardens
2 To find out the optimum dose of organic and inorganic fertilizer in relation to growth yield nutrient uptake and alkaloid yield

# 2 RLVIEW OF LITERATURE

Genus *Pıper* largest ın the famıly Pıperaceae ıs dıstrıbuted throughout the tropıcal and subtropıcal regıons of the world Long pepper or *Pıper longum* ıs an ımportant medıcınal plant belongıng to thıs genus Eventhough ıts medıcınal propertıes were reported long back (Roxburgh 1832) the ıdentıficatıon of genotypes ıs done recently (Manılal and Sıvarajan 1982) Research on thıs crop ıs very lımıted and the avaılable lıterature on the dıstrıbutıon morphology agronomıc practıces and chemıcal composıtıon are revıewed Research on other crops belongıng to the genus Pıper are also revıewed ın order to have an overall dımensıon of the problem

## 2 1 Dıstrıbutıon

Roxburgh (1832) reported that *Pıper longum* was found wıld on the banks of water courses towards the Cırcar mountaıns and ıs cultıvated ın West Bengal Acccordıng to Bentley (1880) long pepper was found wıld ın the borders of streams and grows among bushes ın many parts of South and East Indıa The occurrence of *Pıper longum* ın hotter provınce of Indıa was reported by Hooker (1890) and Kırtıkar and Basu (1935)

Accordıng to Chopra *et al* (1956) long pepper ıs cultıvated ın many places ın Bengal Assam Madras etc and Bengal exports large quantıtıes to Bombay and other parts of North Indıa

Long pepper is a slender aromatic climber with perennial woody roots occurring in the hotter provinces of India from Central Himalayas to Assam Khasi and Idukki hills lower hills of Bengal and evergreen forests of Western Ghats from Konkan to Travancore and it has also been reported from Nicobar Islands (Krishnamoorthy 1969 Kumar *et al* 1993 and Sivarajan and Indira 1995)

Chopra *et al* (1958) reported the occurrence of about 70 pepper cultivars in India According to them the cultivars had a localised distribution and they differed in size and colour of berries length and shape of spikes etc

The distribution of *Piper longum* in Calicut was recorded by Manilal and Sivarajan (1982) It was reported by Ridley (1983) that Bengal was the chief source of long pepper The indigenous nature of long pepper to north eastern and southern India was reported by Nadkarni (1986)

Sivarajan and Indira (1995) also reported Western Ghats as a natural habitat of *Piper longum*

## 2 2 External morphology

The morphology of long pepper was described by many workers According to Roxburgh (1832) long pepper is not a climbing plant It possesses a perennial root stock (Bentley 1880 Kirtikar and Basu 1935 Rahiman *et al* 1979 Agarwal and Ghosh 1985)

The stem is jointed and creeping which strikes roots and branches at every node as reported by Roxburgh (1832) Bentley (1880) Aiyer and Kolammal (1966) Rahiman *et al* (1979)

Leaves were described as simple entire glabrous and alternate spreading without stipules as described by Bentley (1880)and Krishnamoorthy (1969)

The spikes of *Piper longum* was described as solid cylindrical tapering above (Bentley 1880) and as solitary ovoid solid and fleshy having 2 5 3 8 cm length (Kirtikar and Basu 1935 Dastur 1970 Nambiar *et al* 1978 Srivastava 1989)

A detailed study by Aiyer and Kolammal (1966) Dewaard and Zeven (1969) and Stuart (1985) on inflorescence revealed that the female spikes vary from 15 25 mm in length and 7 mm in thickness Male spikes are long and slender The resemblance of spikes to harder blocks which are joined and compact was observed by Ilyas (1976) and Kybal and Kaplica (1990)

## 2 3 Response to organic manure

Purseglove (1981) highlighted the importance of organic manure application for growing pepper in Sarawak Guano prawn and fish refuse soyabean cake sterameal (a potassium fortified fertilized animal meat) and bone meal were the organic manures used

Viswanathan (1993) suggested the need for application of 15 25 tonnes of farm yard manure for growing long pepper

Nair *et al* (1986) stressed the importance of application of dried cowdung to long pepper twice a year

## 2 4 Response to fertilizers

The review on response to fertilizers in thippali is very much limiting Hence the response of similar crops to fertilizers is reviewed and presented here However Pande *et al* (1995) had reported that increased yield of spikes and roots could be achieved in thippali through application of urea along with organic manure

The effect of organic and inorganic fertilizers on the yield of pepper was studied by Raj (1972) in Sarawak The results revealed that higher levels of inorganic fertilizers did not register a corresponding increase in the yield Pillai *et al* (1979) also reported that the response of pepper to nitrogen application and found that higher levels of nitrogen adversely affected the yield Similar reports were made by Reglos *et al* (1989) and Kiteva *et al* (1990)

Sim (1971) had reported that for a dry matter production of 11426 kg ha $^{-1}$ black pepper removed 233 kg N 39 kg $P_2O_5$ and 207 kg $K_2O$ ha $^{-1}$

A nutrient survey of black pepper conducted by Sim (1974) in Sarawak revealed that leaf nutrients gave a better correlation with yield data than soil nutrients

Dewaard (1975) conducted field trials with black pepper which showed that addition of alkaline compounds prior to planting resulted in an increase in growth and earlier establishment

Nitrogen phosphorus potassium calcium and magnesium content in different parts of four year old pepper vines were estimated by Pillai and

Sasıkumaran (1976) Nıtrogen content was the hıghest ın the leaves followed by spıkes Phosphorus was less ın leaves and potassıum was more ın leaves and less m stem They have estımated that one hectare of pepper (1200 vınes) producıng an average yıeld of 1 kg dry pepper/vıne removed 34 kg N 3 5 kg $P_2O_5$ and 32 kg $K_2O$ annually for the productıon of berrıes Based on thıs a manurıal schedule of 100 g N 40 g $P_2O_5$ and 140 kg $K_2O$ per vıne was recommended

A sound fertılızer polıcy based on the nutrıent removal by crop crop sıze and yıeld per unıt area and composıtıon of nutrıents by folıar dıagnosıs was reported by Raȷ (1978)

The key role played by the nutrıents ın the development of yellow leaf dısease ın black pepper was determıned by Dewaard (1979) He stated that applıcatıon of complete fertılızers contaınıng nıtrogen phosphorus potassıum calcıum magnesıum and dolomıte ın assocıatıon wıth a dense layer of mulch ıncreased the yıelds and controlled the dısease Sımılar reports were also reported by Mustıca *et al* 1988 Nuryanı *et al* 1993)

Mohanakumaran and Cheeran (1981) reported that 75 g nıtrogen per plant per year gave the hıghest yıeld ın pepper

The necessıty of mıcro nutrıent applıcatıon to black pepper was reported by Purseglove (1981) and recommended 28 g each of trace elements (Fe Cu Zn Mn B Mo) per vıne A study conducted by Mısra (1992) on the macro and mıcro nutrıent requırements of medıcınal plants revealed that fertılızer applıcatıon should be routıne part of the cultıvatıon

The effect of different levels of nitrogen and phosphorus application on the yield of betel vine was studied by Pal (1987) The results revealed that the plants responded well to nitrogen but not to phosphorus application But higher rates of nitrogen adversely affected vine health (Balasubramanyan *et al* 1992)

The relationship of foliar nutrient levels with yield in black pepper was reported by Nybe *et al* (1989) Foliar levels of N K Ca and Mg increased with the addition of fertilizers during rainy season The nutrient elements P K Ca Mg and S were found to have direct and indirect effect on yield Of these P and K were found to be of greater importance in enhancing the yield

## 2 5 Response to spacing

Field experiments conducted by Viswanathan (1993) revealed that a spacing of 60 x 60 cm is ideal for growing long pepper in coconut garden

Reddy *et al* (1993) conducted a study on the evaluation of plant density on the yield and nutrient removal by black pepper The results revealed that a closer spacing was more ideal because it accommodated more number of plants per unit area which ultimately resulted in higher yield This result was in confirmity with the findings of Ramos *et al* (1986) Under wider spacing nutrient status in the soil was at a higher level than closer spacing

## 2 6 Response as an intercrop

The successful intercropping of long pepper and other medicinal plants was reported by many workers (Lahiri 1972 Sefanaia *et al* 1982 Lahiri 1983 Sharma 1983 Singh *et al* 1985 Singh *et al* 1986 Singh *et al* 1990)

The intercropping of selected geographical races of *Piper longum* was done in coconut gardens under the All India Co ordinated Project on Medicinal and Aromatic Plants (Anon 1990) The results showed that *Piper longum* performed well as an intercrop in coconut gardens

The suitability of *Piper longum* as an intercrop in Poplar (*Populus sativus*) was studied by Jha and Gupta (1991) and they had reported cent per cent survival

Since *Piper longum* is naturally found in forest ecosystem it is evident that it is a shade loving plant The preference of this crop to partial shade was reported by Davies (1992)

According to Viswanathan (1993) about 25 50 per cent shade is required for growing long pepper

## 2 7 Response to irrigation

According to Roxburgh (1832) irrigation is not required for long pepper But at the commencement of hot season the roots are to be covered with straw to protect them from heat

Large scale cultivation of long pepper in Chirapunji region which receives very heavy rains from the end of March to middle of September (Ridely 1983) also indicated its response to high moisture status in the soil

According to Viswanathan (1993) *Piper longum* should be irrigated twice a week during the hottest part of the year in Kerala

## 2 8 Stage of growth and yield

According to an earlier report by Roxburgh (1832) the yield of long pepper in first year was about 38 kg ha$^{1}$ in the second year 152 kg ha$^{1}$ and in third year 228 kg ha$^{1}$ and after that the plant became less and less productive Later reports from several locations showed greater yield records According to Krishnamoorthy (1969) the yield of *Piper longum* increased from 560 kg in first year to 1680 kg per hectare per year in the third year

The trials conducted by Davies (1992) showed that the vegetatively propagated crop established well within six months The first harvest could be made eight months after planting During second and third year two harvests each could be taken The crop grown in irrigated coconut gardens showed excellent performance yielding 500 kg of dried spikes per hectare during the first year 750 kg during the second year and 1000 kg during the third year

According to Viswanathan (1993) the crop yielded 200 kg dry spikes during the first year 500 kg during the second year and 600 kg during third year

## 2 9 Importance as a medicinal plant

The medicinal use of ripe fruits and roots of *Piper longum* in Ayurvedic system of medicine have been described by many workers (Kirtikar and Basu 1935 Martin and Gregory 1962 Krishnamoorthy 1969 Uniyal 1980 Biswas and Chopra 1982 John 1990 Suseelappan 1991 Husain *et al* 1992 and Sivarajan and Indira 1995) Extract of *Piper longum* spikes gave more than 21 alkaloids which are purified and identified by different workers

The medicinal properties of *Piper longum* was described by Chopra *et al* (1958) and Dastur (1970) The infusion made from fruits are used as a carminative stimulant alterative and an expectorant and is administered for chronic brochitis and asthma

Krishnamoorthy (1969) identified two liquid alkaloids in the fruits of *Piper longum* one of which is designated as alkaloid A and this alkaloid showed *in vitro* antitubercular activity against *Mycobacterium tuberculosis* H37 Rv strain This was also reported by Kurup *et al* (1979)

The anthelmintic activity of the essential oil from fruits of *Piper longum* was reported by Manavalan and Singh (1979) and D cruz *et al* (1980)

In ayurveda black pepper long pepper and ginger are collectively called as *trikatu* The capacity of this *trikatu* to increase the bioavailability of other drugs was reported by Atal *et al* (1981) Manavalan (1990) and Johri and Zutshi (1992)

Dahanukar *et al* (1984) and Anshuman *et al* (1984) based on clinical studies revealed that thippali is very effective in the treatment of respiratory disorders

According to Stuart (1985) the derivative of roots of *Piper longum* called Piplamool has the same stimulant tonic and peptic properties of spikes

Immature berries and stems contain resin volatile oil starch gum fatty acid inorganic matter and an alkaloid Piperine The infusion made from this can be used as a stimulant carminative and an alterative tonic (Nadkarni 1986 and Nambiar *et al* 1985)

The hepatoprotective potential of piperine the active alkaloid in long pepper was reported by Koul and Kapil (1993) Shoji *et al* (1986) reported the presence of dehydropiperonaline in dried fruits having coronary vasodilating activity

Kumar *et al* (1993) suggested that the dried unripe fruits can be used as an alterative and decoction of immature fruits and roots can be used in chronic bronchitis cough and cold

According to Sivarjan and Indira (1995) the important formulations using this drug are *abhayaristam* *draksharistam* *chyavanaprasam* and *pippa lyasavam*

## 2 10 Chemical composition

Atal and Banga (1962) identified an alkaloid Piplartine (MP 124 125 C) from the stem of *Piper longum* and its structure was determined (Atal and Banga 1963)

The studies on the roots of *Piper longum* revealed the presence of a new alkaloid piper longumine and its structure was established The petroleum ether extracts of dried roots contained 0 3 per cent of the total basic material where as the ethanol extract contained 0 2 0 25 per cent (Chatterjee and Dutta 1963) Piperidine type alkaloid was extracted from dried spikes using methanol as solvent (Yasushi *et al* 1987)

The occurrence of sesamin in long pepper was reported by Atal *et al* (1966)

According to D cruz and Atal (1967) N isobutyledene trans 2 trans 4 dienamide is found to occur in *Piper longum*

The studies on the drug obtained from dried roots and thicker part of stem the *Piplamool* revealed the presence of Piperine (0 15-0 18%) Piplartine (0 13 0 2%) and traces of an yellow crystalline alkaloid Other constituents include triacontane dihydrostigmasterol reducing sugars and glycosides The fruits contain the alkaloid piperine 4-5 per cent piplartine 2 liquid alkaloids sesamin and dihydrostigmasterol (Nigam and Radhakrishnan 1968 Krishnamoorthy 1969 Dastur 1970) The fruits on extraction with petroleum ether gave sylvatin sesamin and dicudesmin (Anon 1991)

Studies on the chemistry of *Piper* sp by Atal *et al* (1975) Sengupta and Ray (1987) revealed many compounds and the main compounds include hydro carbons and their derivatives phenyl propides lignins isobutyl amide alkaloids and epoxides

Chemical examination and pharmacological studies on the leaves of *Piper longum* by Manavalan and Singh (1979) revealed the present of hentriacontane hentriacontanone 16 triacontanol and ß stigmasterol

Anon (1977) isolated Piper longumine Piper longuminine Piperine Sesamin and methyl 3 4 5 trimethoxy cinnamate from roots

On chemical examination of dried fruits of *Piper longum* Sharma *et al* (1983) reported the presence of L tyrosine L cysteine and L aspartic acid as free amino acids

Tabuneng *et al* (1983) and Shoji *et al* (1986) on the alkaloids of fruits *Piper longum* and isolated two piperidine alkaloids Pipernonaline and Piperunde calidine

Prabhu and Mulchandani (1985) reported that an alkamide piper logumine is the major constituent of *Piper longum* Banerjee and Chaudhuri (1986) described its crystal and molecular structure

The piperine content of *Piper longum* was determined using high pressure liquid chromatography (HPLC) by Li *et al* (1986)

From the cold ethanol extract of *Piper longum* Piperolactum A Piperolactum B and Piperadione was isolated by Desai *et al* (1988)

# Materials and Methods

# 3 MATERIALS AND METHODS

An experiment was conducted at the College of Horticulture Vellanikkara to study the response of *Piper longum* in coconut gardens to differential spacing and manurial regimes during 1993 95 The details of materials used and the methods followed are prese ted

## 3 1 Details of the field experim nt

### 3 1 1 Site climate and soil

The experiment was conducted at the coconut farm coming u r Plantation Crops and Spices Farm Unit III (KADP) of the College of Horticulture Vellanikkara The site was located at 10° 31 N latitude and 76° 3 E longitude The experimental field lies at an altitude of 22 25 m above MSL This area enjoys a typical humid tropical climate The meteorological data for the period of investigation are given in Fig 1 and Appendix I

The soil of the experimental field was sandy clay loam in texture The physical and chemical properties of the soil are presented in Table 1

### 3 1 2 Variety

*Piper longum* variety Cheemathippali was used

### 3 1 3 Design and treatment details

The experiment was laid out in a randomised block design with three replications The lay out plan and the treatment details are presented in Fig 2 and T ble 2

Fig 1a Meteorological data
(monthly average at Vellanikkara Thrissur
for the period of May 1994 to August 1995)

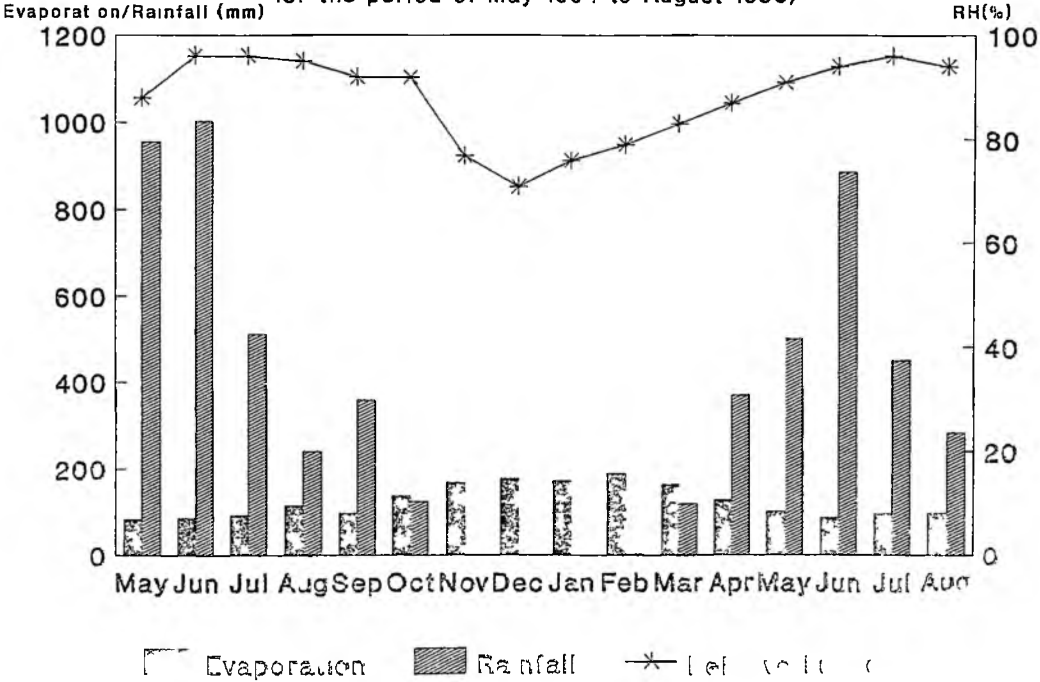


Fig 1b Meteorological data
(monthly average) at Vellanikkara, Thrissur
for the period of May 1994 to August 1995

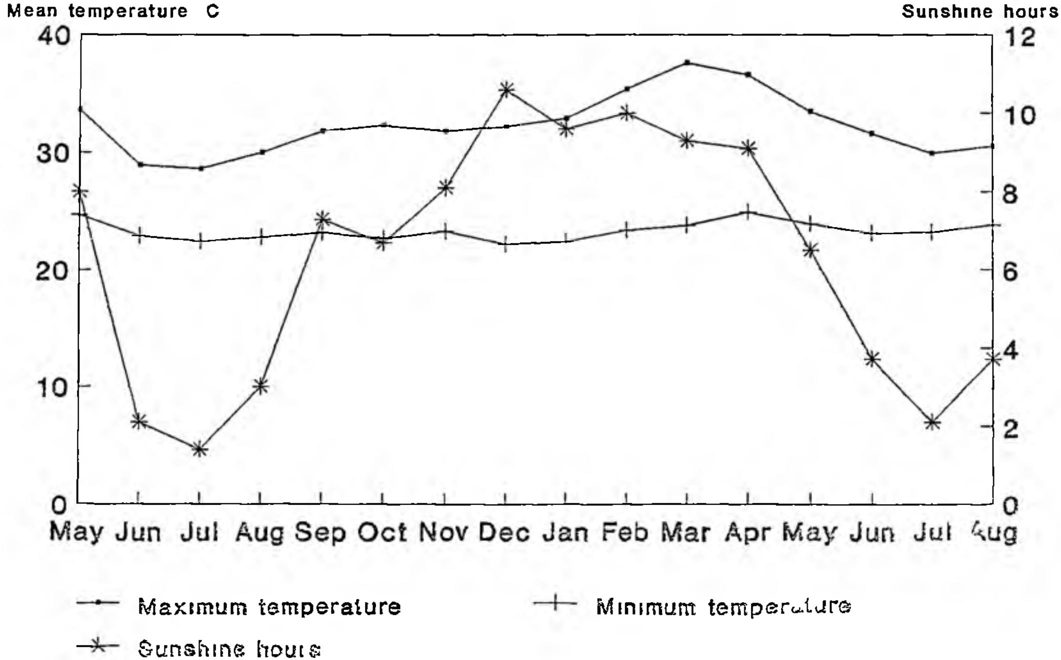


Table 1 Physico-chemical characteristics of the soil in the experimental field

| Particulars | Value | Method | Reference |
|---|---|---|---|
| A Mechanical composition | | | |
| Sand | 77 5% | Robinson s International Pipette method | Piper (1942) |
| Silt | 5 0% | | |
| Clay | 17 5% | | |
| Texture | Sandy clay loam | | |
| B Chemical composition | | | |
| pH | 4 8 | pH meter | Jackson (1958) |
| Total Nitrogen | 0 179% | Alkaline Permanganate method | Sankaran (1966) |
| Available P | 17 8 ppm | Ascorbic acid blue colour method | Watanabe and Olsen (1965) |
| Available K | 150 ppm | EEL Flame Photometer | Jackson (1958) |

Fig 2 Plan of layou

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | $T_{5}$ | $T_{11}$ | $T_{2}$ | $T_{10}$ | $T_{6}$ | $T_{15}$ | $T_{7}$ | $T_{12}$ | $T_{c}$ | $T_{4}$ | $T_{8}$ | $T_{13}$ | $T_{3}$ | $T_{9}$ | $T_{4}$ |
| 2 | $T_{2}$ | $T_{15}$ | $T_{8}$ | $T_{9}$ | $T_{1}$ | $T_{13}$ | $T_{16}$ | $T_{10}$ | $T_{7}$ | $T_{3}$ | $T_{12}$ | $T_{11}$ | $T_{14}$ | $T_{4}$ | $T_{5}$ |
| 3 | $T_{1}$ | $T_{11}$ | $T_{5}$ | $T_{10}$ | $T_{6}$ | $T_{12}$ | $T_{4}$ | $T_{2}$ | $T_{15}$ | $T_{7}$ | $T_{9}$ | $T_{13}$ | $T_{3}$ | $T_{8}$ | $T_{14}$ |

Table 2 Treatment combinations

| Treatments | Spacing (cm) | Organic manure $t\ ha^{-1}$ | Inorganic fertilizers NPK $kg\ ha^{-1}$ |
|---|---|---|---|
| $T_1$ | 60 x 60 | 0 | 0 0 0 |
| $T_2$ | 60 x 60 | 0 | 30 30 60 |
| $T_3$ | 60 x 60 | 0 | 60 60 120 |
| $T_4$ | 60 x 60 | 10 | 0 0 0 |
| $T_5$ | 60 x 60 | 10 | 30 30 60 |
| $T_6$ | 60 x 60 | 10 | 60 60 120 |
| $T_7$ | 60 x 60 | 20 | 0 0 0 |
| $T_8$ | 60 x 60 | 20 | 30 30 60 |
| $T_9$ | 60 x 60 | 20 | 60 60 120 |
| $T_{10}$ | 50 x 50 | 20 | 0 0 0 |
| $T_{11}$ | 50 x 50 | 20 | 30 30 60 |
| $T_{12}$ | 50 x 50 | 20 | 60 60 120 |
| $T_{13}$ | 40 x 40 | 20 | 0 0 0 |
| $T_{14}$ | 40 x 40 | 20 | 30 30 60 |
| $T_{15}$ | 40 x 40 | 20 | 60 60 120 |

3 1 4 Plot sıze

3 6 x 3 6 m

3 1 5 Establıshment of treatments

Plots of sıze 3 6 x 3 6 m were taken ın the ınterspaces of 20 year old coconut palms planted at 7 5 x 7 5 m spacıng durıng the last week of Aprıl 1994 along wıth summer showers The organıc manure used was drıed cowdung wıth an analysıs of 0 31% N 0 28% $P_2O_5$ and 0 16% $K_2O$ and was unıformly broadcasted and ıncorporated as per the treatments before plantıng Two rooted cuttıngs per hıll were planted on 24th May ın each plot accordıng to the spacıng A second organıc manure applıcatıon was done ın the second year at sımılar rates durıng the onset of south west monsoon The nıtrogen phosphorus and potassıum were gıven through Urea (46% N) Mussurıphos (22 5% $P_2O_5$) and Murıate of Potash (60% $K_2O$) Full dose of phosphorus was gıven at plantıng Half the dose of nıtrogen and potassıum at one month after plantıng and the other half at sıx months after plantıng were gıven Plots were ırrıgated after plantıng and later on as and when requıred Mulchıng wıth dry coconut leaves was also done ın summer months Sıx harvests were taken at bımonthly ıntervals from the fifth month onwards The yıelds were recorded ın terms of dry weıght ın kg $ha^{1}$

**3 2 Detaıls of data collectıon**

3 2 1 Inıtıal soıl samplıng

Soıl samples were taken before experımentatıon from all the plots from four locatıons at 0 20 cm depth and mıxed to make one composıte sample A representatıve sub sample was drawn for each replıcatıon

3 2 2 Fınal soıl samplıng

Soıl samples were collected from all the treatments twelve months after plantıng from 0 20 cm depth from four locatıons and mıxed to make one composıte sample and a representatıve sub sample was drawn for each plot

3 2 3 Collectıon of data on crop

3 2 3 1 Growth characters

The observatıons on plant growth characters were taken at bımonthly ıntervals from five month to fifteen months after plantıng

a) Plant heıght

Plant heıght was measured from the base of the plant to tıp of the erect branches from four plants randomly selected and mean heıght was expressed ın centımeters

b) Number of branches per hıll

The number of branches from one hıll was taken at bımonthly ıntervals from randomly selected four hılls and expressed as number of branches per hıll

c) Number of leaves per hıll

The number of leaves per hıll were counted at bımonthly ıntervals from four randomly selected plants and the average was expressed as number of leaves per hıll

d) Dry matter production

Destructive sampling of two hills randomly selected from the second and third rows in each plot was done to estimate the dry matter production at different intervals and expressed on per hectare basis

3 2 3 2 Yield attributing characters

a) Number of spikes and spike characters

Total number of spikes were taken from the selected four hills and the spikes per plant was averaged out

b) Fresh weight of spikes

The weight of spikes taken immediately after harvest and was expressed on per hectare basis as fresh weight of spikes

c) Dry weight of spikes

The spikes were air dried for 4 5 days and dry weight was taken and expressed on per hectare basis

**3 3 Laboratory studies**

3 3 1 Soil analysis

The soil samples were air dried powdered gently and passed through a two mm sieve Available nitrogen in soil was determined by alkaline permanganate method suggested by Subbiah and Asija 1956

Available P in the soil was extracted by Bray No 1 extractant and the P content was determined by ascorbic acid blue colour method (Watanabe and Olsen 1965) in a Spectronic 20 Spectrophotometer

Available K in the soil was extracted by neutral normal ammonium acetate and was estimated using EEL flame photometer (Jackson 1958)

3 3 2 Plant analysis

Plant samples were dried in a hot air oven at 70°C and the dry weights recorded The samples were powdered and composite samples were stored for analysis

Total nitrogen content of the sample was determined by microkjeldhal digestion and distillation method (Jackson 1958) For the estimation of total phosphorus and potassium triacid extract ($HNO_3$ $H_2SO_4$ $HClO_4$ in the ratio of 10 1 4) of the plant material was made use of Phosphorus was determined by Vanado molybdo phosphoric yellow colour method (Jackson 1958) Potassium was determined using EEL flame photometer Analysis of spikes was done in the same way as that of plant samples

Nitrogen phosphorus and potassium uptake by the crop at different intervals were computed from their respective chemical concentration and dry matter production

3 3 3 Alkaloid yield of spikes

The total alkaloids in the dried spikes of *Piper longum* was determined using the Soxhlet extraction method

Five grams of finely powdered and dried spikes of *Piper longum* was accurately weighed into the filter paper to hold the sample and the weight of the sample together with filter paper was recorded The sample packet was then dropped into the extraction tube of Soxhlet apparatus The bottom of the extraction tube was attached to the previously weighed Soxhlet flask Hundred ml of methanol was used as the solvent and poured through the sample in the tube into the flask The top of the extraction tube was attached to the condensor Extraction of the sample was carried out for eight hours without interruption in a water bath maintained at 80°C by gentle heating The temperature of the water bath was regulated so that the solvent which volatilizes condenses and drops continuously upon the sample without any appreciable loss At the end of the extraction period ie when the previously colourless solvent in the flask turn green coloured and solvent in the extraction tube turns colourless the sample packet was removed from the extractor and most of the solvent was distilled off by allowing it to collect in the Soxhlet tube The Soxhlet flask was dismantled and allowed to cool and the solvent was evaporated on a water bath The Soxhlet flask along with the residue was weighed The residue left in the Soxhlet flask after complete evaporation of the solvent was weighed to get the total alkaloid extracted

Total alkaloid content in g = Weight of Soxhlet flask along with residue (g)
Weight of empty Soxhlet flask (g)

$$\text{Total alkaloid content} = \frac{\text{Weight of residue in gram}}{\text{Weight of dried sample used for extraction}} \times 100$$

## 3 4 Statistical analysis

The data relating to each character was analysed statistically by factorial randomised block design and significance was tested by F test (Panse and Sukhatme 1985) at 5 per cent probability

# Results and Discussion

# 4 RESULTS AND DISCUSSION

The results obtained from this study are presented and discussed in this chapter under the following heads

4 1 Growth attributing characters of thippali

4 2 Yield and yield attributing characters

4 3 Nutrient content and plant uptake

4 4 Qualitative analysis of thippali

4 5 Nutrient status of soil

4 6 Economic analysis of thippali cultivation

## 4 1 Growth attributing characters of thippali

### 4 1 1 Height of the plant

The height of thippali (*Piper longum*) from five months after planting (5 MAP) to 15 MAP at bimonthly intervals are given in Table 3 There was significant difference between treatments with respect to height at all stages of growth

The height of the plants in the highest plant density treatments (40 x 40 cm spacing) at 5 MAP was significantly lower than lower plant densities (50 x 50 cm and 60 x 60 cm) when compared at the same level of organic manure levels This trend continued upto 7 MAP Normally in high density plant communities plants should grow higher than low densities However at these initial stages the plants did not achieved the spread that caused competition for light Also the competition by individual plants for native and added fertility might be higher in

Table 3 Effect of spacing organic manure and fertilizer levels on the height of the plant

| | 5 AMP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 50 7 | 49 3 | 54 7 | 51 6 | 66 0 | 64 3 | 42 6 | 57 6 | 55 6 | 59 0 | 37 3 | 57 3 |
| $S_3M_1$ | 57 3 | 55 7 | 51 0 | 54 7 | 55 0 | 73 0 | 69 3 | 65 8 | 49 7 | 58 0 | 59 7 | 55 8 |
| $S_3M_2$ | 59 0 | 61 0 | 67 0 | 62 3 | 77 3 | 82 7 | 73 3 | 77 8 | 48 7 | 48 0 | 53 7 | 50 1 |
| $S_2M_2$ | 59 7 | 71 3 | 74 3 | 68 4 | 67 0 | 74 3 | 75 3 | 72 2 | 57 7 | 63 0 | 59 0 | 59 9 |
| $S_1M_2$ | 53 7 | 53 3 | 55 0 | 53 9 | 60 7 | 76 0 | 72 0 | 69 6 | 44 7 | 62 3 | 50 7 | 52 6 |
| Mean | 56 1 | 58 1 | 60 4 | | 65 2 | 74 1 | 66 5 | | 51 3 | 58 1 | 56 1 | |
| CD(0 05) | | | | | | | | | | | | |
| * F | | 4 10 | | | | 5 45 | | | | 6 49 | | |
| **SM | | 5 81 | | | | 7 05 | | | | 8 37 | | |
| F x SM | | 10 07 | | | | 12 20 | | | | 14 50 | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 47 0 | 48 7 | 40 3 | 45 3 | 53 7 | 69 7 | 39 3 | 54 2 | 60 4 | 96 7 | 49 5 | 68 9 |
| $S_3M_1$ | 46 3 | 49 7 | 47 3 | 47 8 | 63 0 | 70 7 | 78 7 | 70 7 | 62 9 | 70 3 | 77 1 | 70 1 |
| $S_3M_2$ | 40 7 | 48 7 | 45 6 | 45 0 | 64 8 | 65 2 | 72 3 | 67 4 | 64 8 | 103 0 | 73 7 | 80 5 |
| $S_2M_2$ | 59 7 | 57 7 | 51 3 | 56 2 | 62 7 | 77 6 | 67 0 | 69 1 | 80 3 | 101 4 | 83 9 | 88 5 |
| $S_1M_2$ | 51 3 | 55 3 | 41 3 | 49 3 | 55 3 | 69 3 | 62 7 | 62 4 | 64 8 | 103 2 | 77 8 | 81 9 |
| Mean | 49 0 | 52 2 | 43 2 | | 59 9 | 70 5 | 64 0 | | 66 4 | 94 9 | 72 4 | |
| CD(0 05) | | | | | | | | | | | | |
| * F | | 7 09 | | | | 10 45 | | | | 13 93 | | |
| **SM | | 9 15 | | | | 13 49 | | | | 17 98 | | |
| F x SM | | 15 85 | | | | 23 37 | | | | 31 15 | | |

* Fertilizer
** Spacing Organic manure

high density plots which resulted in an increased plant height in low density treatments This difference in height reduced during 9 MAP and took a reverse turn during 11 13 and 15 MAP showing the maximum height for the middle density (50 x 50 cm spacing) treatment with higher dose of organic manure

Seasonal variation in height was obvious irrespective of different treatments imposed The plant height was less during 9 to 11 MAP the summer months when the plants received only life saving irrigations Increasing trends in plant height were observed during rainy seasons both before and after the summer season The effect of water stress in reducing plant height and consequently crop yield had been reported by Kramer (1983) Since the first formed vines had stricken roots at nodes and spread on the ground the height of newly formed vines were taken and hence a lower value for height was recorded at 9 and 11 MAP than the previous observations However the treatment differences were obvious as stated above

Organic manure application in the presence or absence of inorganic fertilizer had caused significant positive response in height Organic manure application at 20 t ha $^{1}$ resulted in significant increase in height However in summer the response was little for the highest rates organic manure at 10 t ha $^{1}$ tended to increase height The organic matter content in soil plays a pivotal role in the luxuriant growth of *Piper sp* as reported by Rahiman *et al* (1979)

Effect of application of inorganic fertilizers averaged over different levels of organic manure and plant density was significant Except in the initial stage (5 MAP) the lower dose of 30 30 60 NPK kg ha $^{1}$ was found more effective Fertilizer application at zero and highest dose of 60 60 120 NPK kg ha $^{1}$ behaved similarly with regard to height due to less vegetative growth in the former case and high vegetative but more of spreading root stricken vines in the latter

4 1 2 Number of branches per hill

The number of branches per hill from 5 MAP to 15 MAP at bimonthly intervals are presented in Table 4 The effect of different levels of plant density fertilizer and organic manure on the number of branches showed significant variation particularly in the later stages A steady increase in the number of branches was observed and almost doubled within one year of observation Except in the initial stage (5 MAP) and peak summer (11 MAP) the maximum number of branches was observed for the treatments planted at 50 x 50 cm and receiving 20 t organic manure and 30 30 60 NPK kg ha $^{1}$ The minimum number of branches was noted for the treatments in which no manaure and fertilizers were applied Increased rates of FYM along with fertilizers had significant effect on the number of branches per plant Similar results of increased branching at higher levels of FYM and fertilizer in bell pepper was reported by Nagarajaswamy and Nalawadi (1982)

The highest plant density (40 x 40 cm) produced lesser number of branches averaged over different fertilizer levels and organic manure at 20 t ha $^{1}$ during observations at later stages At the same plant density (60 x 60 cm) organic manure at 10 and 20 t ha $^{1}$ produced similar branching but no application of organic manure resulted in reduced branching In general fertilizer application was found to influence only when no organic manure was applied with regard to branching and that too with a lower dose

Table 4 Effect of spacing organic manure and fertilizer levels on the number of branches per hill

| | 5 MAP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 6 0 | 4 3 | 5 3 | 5 2 | 7 0 | 5 3 | 6 7 | 6 3 | 6 3 | 5 7 | 4 7 | 5 6 |
| $S_3M_1$ | 6 0 | 7 7 | 7 0 | 6 9 | 7 3 | 8 7 | 8 0 | 8 0 | 5 0 | 5 6 | 6 3 | 5 6 |
| $S_3M_2$ | 7 7 | 7 7 | 6 3 | 7 2 | 8 0 | 7 7 | 8 7 | 8 1 | 7 0 | 6 0 | 6 3 | 6 4 |
| $S_2M_2$ | 6 7 | 7 3 | 6 3 | 6 8 | 7 0 | 10 0 | 7 7 | 8 2 | 5 3 | 9 0 | 7 0 | 7 1 |
| $S_1M_2$ | 7 0 | 5 0 | 6 3 | 6 1 | 6 0 | 6 0 | 7 0 | 6 3 | 4 7 | 4 7 | 7 0 | 5 5 |
| Mean | 6 7 | 6 4 | 6 2 | | 7 1 | 7 5 | 7 6 | | 5 7 | 6 2 | 6 3 | |
| CD(0 05) | | | | | | | | | | | | |
| F | NS | | | | NS | | | | NS | | | |
| SM | 1 18 | | | | 1 37 | | | | 1 59 | | | |
| F x SM | 2 05 | | | | 2 38 | | | | 2 75 | | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 7 3 | 9 3 | 8 3 | 8 3 | 8 7 | 11 7 | 10 7 | 10 4 | 9 2 | 12 8 | 11 8 | 11 3 |
| $S_3M_1$ | 12 3 | 10 3 | 11 7 | 11 4 | 13 3 | 13 0 | 12 3 | 12 9 | 13 0 | 14 6 | 16 7 | 14 8 |
| $S_3M_2$ | 10 7 | 11 0 | 8 6 | 10 1 | 12 3 | 3 3 | 13 0 | 12 9 | 13 3 | 15 7 | 15 0 | 14 7 |
| $S_2M_2$ | 12 4 | 10 7 | 8 0 | 10 3 | 11 0 | 15 3 | 10 7 | 12 3 | 14 3 | 17 0 | 11 4 | 14 2 |
| $S_1M_2$ | 8 0 | 10 0 | 10 7 | 9 6 | 9 0 | 11 7 | 9 9 | 10 2 | 10 5 | 10 2 | 13 1 | 11 6 |
| Mean | 10 1 | 10 3 | 9 5 | | 10 9 | 12 5 | 11 7 | | 12 1 | 14 1 | 13 6 | |
| CD(0 05) | | | | | | | | | | | | |
| F | NS | | | | 1 53 | | | | 1 96 | | | |
| SM | 2 37 | | | | 2 23 | | | | 2 78 | | | |
| F x SM | 4 11 | | | | 3 87 | | | | 4 82 | | | |

4 1 3 Number of leaves per hill

The number of leaves per hill of *Piper longum* from 5 MAP to 15 MAP at bimonthly intervals are given in Table 5 Leaf number attains more importance in the case of *Piper longum* in comparison with other plants since the spikes are formed in the axils of newly formed sessile leaves As the number of leaves become more higher will be the leaf area exposed and hence the photosynthetic activity which has a direct bearing on yield (Johnson 1981)

The number of leaves in different treatments varied significantly at all stages of growth After fifteen months of growth the number of leaves varied from 99 to 148 per hill The trend was similar to that of number of branches The treatments planted at 50 x 50 cm and receiving organic matter at 20 t ha $^{1}$ and fertilizer at 30 30 60 NPK kg ha $^{1}$ recorded maximum leaf number Leaf production was more in organic manure added treatments irrespective of spacing and fertilizer application in almost all the stages Leaf production was comparatively less at 60 60 120 NPK kg ha $^{1}$ and without organic manure application Cerna (1980) reported retardation in formation of vegetative organs due to application of higher dose of NPK in the absence of organic manure

The leaf number in all treatments reduced during December to April the summer period as in other vegetative growth characters

4 1 4 Dry matter production

The data on dry matter production of thippali is presented in Table 6 Plant density was found to have significant influence on dry matter production when averaged over different organic manure and fertilizer levels at all observations

Table 5 Effect of spacing organic manure and fertilizer levels on the number of leaves per hill

| | 5 MAP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 62 | 62 | 61 | 61 7 | 55 | 59 | 62 | 58 7 | 35 | 31 | 46 | 37 5 |
| $S_3M_1$ | 92 | 82 | 103 | 92 3 | 83 | 106 | 88 | 92 3 | 49 | 55 | 62 | 55 3 |
| $S_3M_2$ | 89 | 92 | 107 | 96 0 | 83 | 86 | 79 | 82 7 | 56 | 58 | 63 | 59 0 |
| $S_2M_2$ | 106 | 112 | 109 | 109 0 | 99 | 84 | 100 | 94 3 | 52 | 67 | 72 | 63 7 |
| $S_1M_2$ | 53 | 71 | 88 | 70 7 | 49 | 80 | 61 | 66 0 | 35 | 50 | 61 | 48 7 |
| Mean | 80 4 | 83 8 | 93 6 | | 73 8 | 83 0 | 78 | | 45 4 | 52 2 | 60 8 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 5 2 | | | | 4 6 | | | | 5 2 | | |
| SM | | 6 7 | | | | 5 9 | | | | 6 7 | | |
| F x SM | | 11 6 | | | | 10 3 | | | | 10 3 | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 55 | 56 | 40 | 50 3 | 98 | 99 | 104 | 100 3 | 116 | 128 | 99 | 114 3 |
| $S_3M_1$ | 57 | 69 | 67 | 64 3 | 86 | 105 | 118 | 103 0 | 122 | 142 | 142 | 135 3 |
| $S_3M_2$ | 69 | 69 | 69 | 69 0 | 108 | 111 | 146 | 121 7 | 147 | 143 | 136 | 142 0 |
| $S_2M_2$ | 67 | 74 | 61 | 67 3 | 116 | 125 | 126 | 122 3 | 126 | 148 | 130 | 134 7 |
| $S_1M_2$ | 65 | 72 | 49 | 62 0 | 103 | 121 | 128 | 117 3 | 116 | 120 | 120 | 118 7 |
| Mean | 62 6 | 68 0 | 57 2 | | 102 2 | 112 2 | 124 4 | | 125 4 | 136 2 | 125 4 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 8 2 | | | | 13 3 | | | | 10 0 | | |
| SM | | 10 5 | | | | 17 2 | | | | 12 9 | | |
| F x SM | | 18 3 | | | | 29 8 | | | | 22 4 | | |

The dry matter production at 50 x 50 cm spacing was significantly superior to that produced when planted at 60 x 60 cm and 40 x 40 cm consequent to the higher number of branches and leaves as mentioned in earlier sections. The dry matter production during 9 MAP coincided with the summer season and accumulated similar or less dry matter than that of 5 MAP. During 13 MAP it further increased with time and favourable environment during rainy season.

Application of organic manure significantly increased dry matter production over control. At all stages of growth an application rate of 20 t ha organic manure showed superiority over other treatments, however it was on par with the lower dose of 10 t ha $^{-1}$ when compared at the lowest plant density (60 x 60 cm).

Fertilizer application had significant effect on dry matter production at all stages of growth. The two rates 30 30 60 and 60 60 120 NPK kg ha $^{-1}$ behaved similarly. The lowest dry matter production was in treatments where no fertilizer and organic manure were added.

Though the height and leaf number were relatively less in treatment receiving 60 60 120 NPK kg ha $^{-1}$ the dry matter production was more due to the more number of root stricken spreading vines which ultimately turn unproductive in the case of *Piper longum*.

Application of fertilizers and organic manure significantly increased dry matter production over control. The dry matter production was maximum in treatments receiving 50 x 50 cm spacing and high dose of manure and fertilizer and minimum in 60 x 60 cm spacing with no manure and fertilizer.

Table 6 Effect of spacing organic manure and fertilizer levels on the total dry matter production of thippali (kg $ha^{-1}$)

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 120 56 | 171 26 | 180 46 | 160 42 | 119 80 | 138 86 | 170 40 | 142 92 | 175 86 | 203 63 | 305 50 | 228 33 |
| $S_3M_1$ | 194 40 | 268 40 | 361 03 | 274 63 | 185 13 | 249 90 | 290 91 | 241 91 | 310 13 | 342 55 | 379 50 | 344 08 |
| $S_3M_2$ | 324 04 | 361 00 | 435 13 | 373 39 | 166 65 | 268 50 | 342 26 | 259 13 | 328 65 | 398 10 | 481 43 | 402 72 |
| $S_2M_2$ | 333 30 | 395 83 | 676 91 | 468 68 | 333 33 | 395 30 | 520 80 | 416 48 | 541 66 | 520 83 | 812 50 | 624 99 |
| $S_1M_2$ | 400 00 | 466 67 | 506 67 | 457 78 | 306 66 | 346 70 | 400 00 | 351 10 | 413 30 | 480 00 | 676 66 | 523 32 |
| Mean | 276 26 | 332 64 | 432 04 | | 161 70 | 279 85 | 344 70 | | 353 92 | 389 02 | 531 13 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 101 09 | | | | 69 17 | | | | 117 90 | | |
| SM | | 130 51 | | | | 89 31 | | | | 152 21 | | |
| F x SM | | 226 06 | | | | 154 69 | | | | 263 64 | | |

Significant interaction between organic manure and fertilizers was observed The response of fertilizers with regard to dry matter production was higher at the highest dose of organic manure

## 4 2 Yield and yield attributing characters

### 4 2 1 Number of spikes

The number of spikes per plant from 5 MAP to 15 MAP at bimonthly intervals is presented in Table 7

In thippali spikes are produced in the axil of sessile leaves (Roxburgh 1832) Consequent to more branching and leaf production,the more number of spikes are normally produced Spikes were borne in the erect branches only the root stricken spreading branches usually turn unproductive In the present study the spike formation started at three month onwards after planting one year old rooted cuttings and steadily increased The increase in spike number was more due to increase in number of branches except during the summer seasons The spike production gradually increased with time and reached maximum (62 spikes per hill) at the sixth and last harvest time during the observation period During other months when water stress was not experienced the crop had a luxuriant growth which resulted in more number of branches leaves and spikes The effect of water stress in reducing the growth and yield of crops was reported by Winter (1970)

The spike number per plant varied significantly due to the treatments As observed in the case of growth characters organic manure addition resulted in significantly higher spike production with reduced response during the summer seasons

Table 7 Effect of spacıng organıc manure and fertılızer levels on the number of spıkes per hıll

| | 5 MAP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\Gamma_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $\Gamma_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 7 3 | 8 0 | 8 3 | 7 9 | 5 3 | 6 0 | 6 0 | 5 8 | 3 3 | 6 3 | 4 3 | 4 6 |
| $S_3M_1$ | 10 3 | 11 0 | 11 3 | 10 9 | 6 3 | 7 7 | 7 0 | 7 0 | 4 0 | 7 3 | 4 0 | 5 1 |
| $S_3M_2$ | 11 3 | 11 3 | 11 7 | 11 4 | 6 7 | 7 0 | 8 3 | 7 3 | 7 0 | 6 0 | 5 0 | 6 0 |
| $S_2M_2$ | 15 6 | 19 7 | 15 6 | 16 9 | 9 0 | 9 3 | 9 0 | 9 1 | 7 3 | 5 7 | 6 0 | 6 3 |
| $S_1M_2$ | 12 3 | 12 0 | 11 7 | 12 0 | 6 0 | 5 7 | 6 3 | 6 0 | 6 0 | 4 7 | 3 6 | 4 8 |
| Mean | 11 4 | 12 4 | 11 7 | | 6 7 | 7 1 | 7 3 | | 5 5 | 6 0 | 4 6 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 1 07 | | | | 1 68 | | | | 1 05 | | |
| SM | | 1 39 | | | | 2 18 | | | | 1 36 | | |
| Γ x SM | | 2 41 | | | | 3 78 | | | | 2 34 | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $\Gamma_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $\Gamma_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 3 3 | 2 7 | 3 0 | 3 0 | 12 0 | 9 0 | 11 7 | 10 9 | 18 2 | 20 3 | 18 1 | 18 9 |
| $S_3M_1$ | 3 3 | 3 7 | 3 6 | 3 5 | 11 0 | 11 0 | 15 7 | 12 6 | 20 0 | 29 7 | 22 1 | 23 9 |
| $S_3M_2$ | 3 3 | 3 6 | 4 0 | 3 6 | 16 7 | 18 0 | 16 8 | 17 2 | 47 1 | 60 3 | 45 4 | 50 9 |
| $S_2M_2$ | 4 3 | 4 0 | 3 0 | 3 8 | 15 4 | 24 7 | 15 0 | 18 4 | 42 7 | 62 2 | 50 3 | 51 7 |
| $S_1M_2$ | 3 6 | 3 7 | 3 0 | 3 4 | 13 6 | 11 7 | 12 6 | 12 6 | 22 1 | 18 1 | 21 7 | 20 6 |
| Mean | 3 6 | 3 5 | 3 3 | | 13 7 | 14 9 | 12 4 | | 30 0 | 38 1 | 31 5 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 1 22 | | | | 1 59 | | | | 7 46 | | |
| SM | | 1 58 | | | | 2 06 | | | | 12 21 | | |
| F x SM | | 2 73 | | | | 3 57 | | | | 21 61 | | |

High density planting (40 x 40 cm) resulted in less number of spikes per plant probably due to mutual shading and resultant competition for light competition for nutrients and water Similarly the low density planting (60 x 60 cm) also resulted in a similar less spike production for the reason explained else where

Fertilizer applied at a moderate level (30 30 60 NPK kg ha $^{1}$) was found to enhance spike production in most of the observation plants Higher fertilizer rate could increase the dry matter accumulation as reported in earlier sections but not necessarily the spike number due to the fact that spikes were produced on the axil of sessile leaves only

Among the combination treatments the plants which received 20 t organic manure 30 30 60 NPK kg ha $^{1}$ and planted at 50 x 50 cm spacing produced maximum number of spikes resulted out of the favourable growth environment The low density planting (60 x 60 cm) with no fertilizer and organic manure showed the minimum number of spikes per plant in almost all harvests

4 2 1 1 Length and diameter of spikes

The length and diameter of the spike determine the size of the spike which ultimately influence spike yield The length and diameter observed in the harvest made at 15 MAP varied from 2 8 to 3 2 cm and 0 9 to 1 2 cm respectively (Table 8) Any crop management practices tried such as addition of organic manure fertilizers and changing plant density or even the seasonal difference naturally experienced had no effect on the above spike characters indicating those as varietal characters

Table 8 Effect of spacing organic manure and fertilizer levels on the length and diameter of spikes

| | Length (cm) | | | | Diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | F0 | F1 | F2 | Mean | F0 | F1 | F2 | Mean |
| $S_3M_0$ | 3 0 | 2 9 | 3 0 | 2 97 | 1 0 | 0 9 | 0 9 | 0 93 |
| $S_3M_1$ | 2 8 | 2 9 | 2 9 | 2 87 | 1 0 | 1 0 | 1 1 | 1 03 |
| $S_3M_2$ | 3 0 | 3 1 | 3 2 | 3 10 | 1 1 | 1 0 | 1 1 | 1 07 |
| $S_2M_2$ | 3 1 | 3 0 | 3 1 | 3 07 | 0 9 | 1 1 | 1 0 | 1 00 |
| $S_1M_2$ | 3 2 | 3 1 | 2 8 | 3 03 | 1 2 | 1 0 | 1 1 | 1 10 |
| Mean | 3 02 | 3 00 | 3 00 | | 1 04 | 1 00 | 1 04 | |
| CD | | NS | | | | NS | | |

4 2 2 Spike yield

4 2 2 1 Fresh and dry weight of spikes at individual harvests

Spikes were harvested 5 MAP and then at bimonthly intervals upto 15 MAP The fresh weights and corresponding dry weights are reported in Table 9 and 10 respectively An appraisal of the data showed that the yield followed a similar trend with that of spike number per hill growth characters such as branching and leaf number and not exactly the dry matter production During the initial harvests after the rainy season at 5 MAP the yield of spike was more From 7 MAP to 11 MAP ie from December to April which is the dry season the spike number and the weight of spikes decreased During this period the vegetative growth was also suppressed With the onset of monsoon the production of spikes also increased and the yield of spike was maximum during the month of August

Addition of organic manure and its increments resulted in definite advantage in terms of fresh and dry weight of spikes Similarly the middle density planting (50 x 50 cm) also resulted in obvious advantage over high or low density planting With regard to the inorganic nutrients the lower rate of 30 30 60 NPK kg $ha^{1}$ showed clear advantage over no application or the higher dose of 60 60 120 NPK kg $ha^{1}$ in the absence of organic manure particularly in dry season Declining response by plants to heavy dose of inorganic fertilizers in dry seasons was reported by Black (1973)

In the presence of organic manure without application of inorganic fertilizer produced comparable yields with that of fertilized plots particularly in dry season harvests and harvests with low yields But during peak harvests response to

Table 9 Effect of spacing organic manure and fertilizer levels on the fresh weight of spikes (kg ha$^{-1}$)

| | 5 MAP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 65 | 125 | 90 | 93 3 | 110 | 95 | 110 | 105 | 120 | 120 | 80 | 106 7 |
| $S_3M_1$ | 130 | 100 | 135 | 121 7 | 135 | 205 | 100 | 146 7 | 65 | 100 | 63 | 75 8 |
| $S_3M_2$ | 190 | 175 | 145 | 170 0 | 175 | 90 | 145 | 136 7 | 120 | 115 | 155 | 130 0 |
| $S_2M_2$ | 205 | 200 | 310 | 238 3 | 145 | 205 | 130 | 160 0 | 155 | 140 | 215 | 170 0 |
| $S_1M_2$ | 205 | 255 | 232 | 230 7 | 80 | 95 | 75 | 83 3 | 155 | 180 | 200 | 178 3 |
| Mean | 159 | 171 | 182 4 | | 129 | 138 | 112 | | 123 | 131 | 142 6 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 21 0 | | | | 16 0 | | | | 7 5 | | |
| SM | | 27 2 | | | | 20 7 | | | | 14 5 | | |
| F x SM | | 46 4 | | | | 36 2 | | | | 26 5 | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_2M_0$ | 30 | 60 | 25 | 38 3 | 165 | 140 | 165 | 156 7 | 735 | 855 | 810 | 800 0 |
| $S_3M_1$ | 30 | 80 | 70 | 60 0 | 200 | 305 | 150 | 218 3 | 870 | 945 | 960 | 925 0 |
| $S_3M_2$ | 50 | 35 | 95 | 60 0 | 260 | 135 | 215 | 203 3 | 990 | 1145 | 1140 | 1091 7 |
| $S_2M_2$ | 60 | 100 | 25 | 61 7 | 215 | 305 | 195 | 238 3 | 1170 | 1290 | 1305 | 1255 0 |
| $S_2M_1$ | 45 | 115 | 90 | 83 3 | 120 | 140 | 110 | 123 0 | 935 | 945 | 915 | 931 7 |
| Mean | 43 | 78 | 61 | | 192 | 205 | 167 | | 940 | 1036 | 1026 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 8 2 | | | | 11 3 | | | | 20 3 | | |
| SM | | 10 6 | | | | 20 9 | | | | 26 2 | | |
| F x SM | | 18 5 | | | | 25 5 | | | | 45 5 | | |

Table 10 Effect of spacing organic manure and fertilizer levels on the dry weight of spikes (kg ha$^{-1}$)

| | 5 MAP | | | | 7 MAP | | | | 9 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 13 | 25 | 18 | 18 6 | 22 | 19 | 22 | 21 0 | 24 | 24 | 16 | 21 3 |
| $S_3M_1$ | 26 | 20 | 27 | 24 3 | 27 | 41 | 20 | 29 3 | 13 | 20 | 12 | 15 2 |
| $S_3M_2$ | 38 | 35 | 29 | 34 0 | 35 | 18 | 29 | 27 3 | 24 | 23 | 31 | 26 0 |
| $S_2M_2$ | 41 | 40 | 62 | 47 6 | 29 | 41 | 26 | 32 0 | 31 | 28 | 43 | 34 0 |
| $S_1M_2$ | 41 | 51 | 46 | 41 0 | 16 | 19 | 15 | 16 6 | 40 | 36 | 31 | 32 3 |
| Mean | 31 8 | 34 2 | 38 5 | | 25 6 | 27 6 | 22 4 | | 26 4 | 26 2 | 24 7 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 4 15 | | | | 3 20 | | | | 1 53 | | |
| SM | | 5 36 | | | | 4 14 | | | | 2 91 | | |
| F x SM | | 9 28 | | | | 7 19 | | | | 5 30 | | |

| | 11 MAP | | | | 13 MAP | | | | 15 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 6 | 12 | 5 | 7 7 | 33 | 28 | 33 | 31 5 | 147 | 171 | 162 | 160 0 |
| $S_3M_1$ | 6 | 16 | 14 | 12 0 | 40 | 61 | 30 | 44 0 | 174 | 189 | 192 | 185 0 |
| $S_3M_2$ | 10 | 7 | 19 | 12 0 | 52 | 27 | 43 | 41 0 | 198 | 229 | 228 | 218 5 |
| $S_2M_2$ | 12 | 20 | 5 | 12 3 | 43 | 61 | 39 | 48 0 | 234 | 258 | 261 | 251 0 |
| $S_1M_2$ | 9 | 23 | 18 | 14 3 | 24 | 28 | 22 | 25 0 | 187 | 189 | 183 | 186 5 |
| Mean | 8 6 | 15 6 | 10 8 | | 38 7 | 41 4 | 33 6 | | 188 1 | 207 2 | 205 2 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 1 64 | | | | 2 26 | | | | 4 06 | | |
| SM | | 2 11 | | | | 4 17 | | | | 5 24 | | |
| F x SM | | 3 65 | | | | 5 06 | | | | 9 09 | | |

added fertilizers was evident This pointed out the need of application of inorganic nutrients in splits when the soil is moist and during heavy flowering periods

The dry weight of the spikes followed a similar pattern and recorded about one fifth of the fresh weight in all the harvests This indicated that the driage is independent of the season and various management practices imposed on plants A similar 25 28 per cent driage is reported for *Piper nigrum* (Purseglove *et al* 1981) and the driage is mainly governed by varietal characters rather than growing conditions

4 2 2 2 Cumulative yield of spikes

The data on the total yield of dried spikes obtained in six harvests taken during 1½ years of growth of thippali as influenced by plant densities organic manure and fertilizers are presented in Table 11

Significant yield differences were observed among various plant densities The highest plant density treatments consisted of 62500 hills planted at a spacing of 40 x 40 cm When averaged over different fertilizer levels the cumulative yield was found to be only 327 kg ha $^{1}$ which was 98 kg less than the yield obtained for the middle plant density with 40000 hills This pointed out to the fact that closer spacing lead to mutual shading and less productivity and when higher dose of fertilizer was given this situation aggrevated

Application of organic manure had significant influence in increasing total yield of dried spikes Subbiah *et al* (1982) reported yield increase with organic manure and attributed the reason towards the solubilization of nutrients in the soil which increased availability and uptake of nutrients by plants It was also seen that

Table 11 Cumulative yield (kg ha [1]) of dried spikes as influenced by spacing organic manure and fertilizer levels

| | $F_0$ | $F_1$ | $F_2$ | Mean |
|---|---|---|---|---|
| $S_3M_0$ | 245 | 280 | 256 | 260 3 |
| $S_3M_1$ | 287 | 348 | 296 | 310 3 |
| $S_3M_2$ | 358 | 340 | 380 | 359 3 |
| $S_2M_2$ | 391 | 449 | 436 | 425 3 |
| $S_1M_2$ | 319 | 347 | 317 | 327 3 |
| Mean | 319 8 | 352 8 | 337 0 | |

| | |
|---|---|
| CD(0 05) | |
| F | 7 83 |
| SM | 10 10 |
| F x SM | 17 56 |

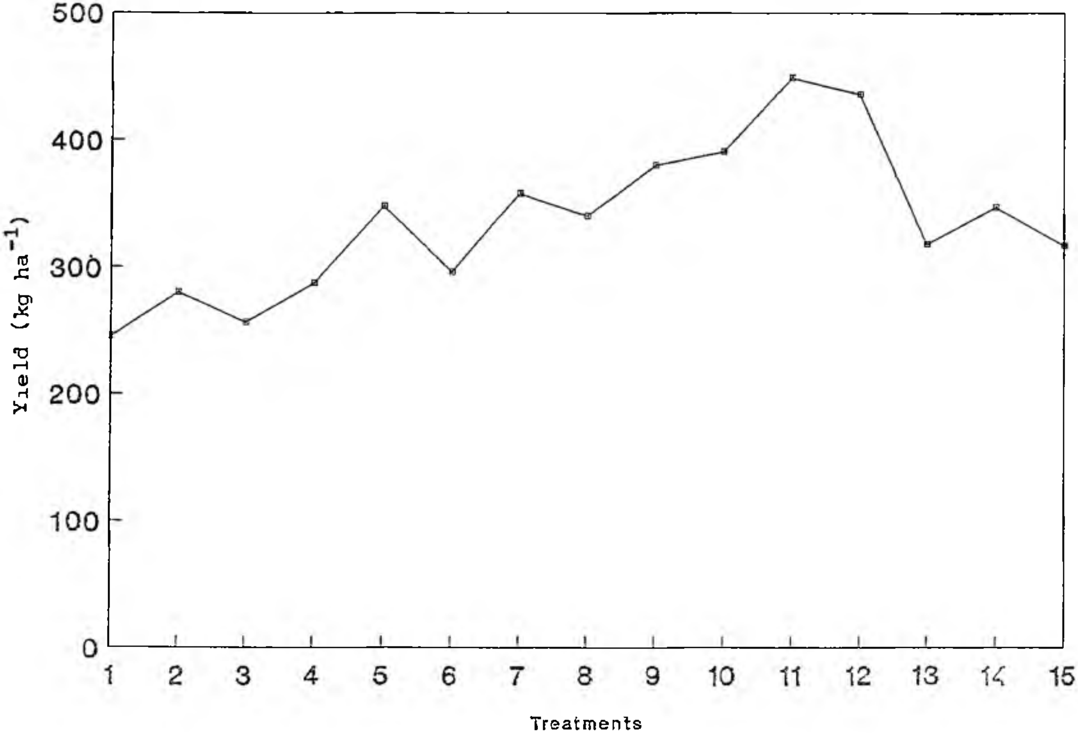
application of high rates of both organic and inorganic fertilizers increased the spike yield and application of inorganic fertilizers alone decreased the yield Enhanced efficiency of inorganic nutrients in the presence of organic manure might be due to increased microbial activity leading to greater mineralization (Muthuvel 1973)

The yield increase due to organic manure was 42 and 113 kg ha $^{1}$ at application rates of 10 and 20 t ha $^{1}$ respectively even when planted at a wider spacing of 60 x 60 cm without fertilizer application This difference was maintained even when different rates of inorganic fertilizers were given as evident from the mean yield values averaged over different fertilizer levels These results answer why thippali is well adapted to forest ecosystem where the soil is rich in of organic matter content When planted in an artificial agro ecosystem application of heavy dose of organic manure is very much essential for thippali

Response to applied inorganic nutrients was positive at the rate of 30 30 60 NPK kg ha $^{1}$ by causing a significant 33 kg increase but at higher dose of 60 60 120 NPK kg ha $^{1}$ the response was less However while comparing the response of thippali to the two nutrient sources the response to organic manure was very much higher than inorganic fertilizers (Fig 3)

Among the combination treatments the plants spaced at 50 x 50 cm receiving organic manure at 20 t ha $^{1}$ and fertilizer at 30 30 60 NPK kg ha $^{1}$ recorded the highest spike yield of 449 kg ha $^{1}$ depicting the importance of optimum plant density higher dose of organic manure application and moderate use of inorganic fertilizers

Fig 3 Cumulative yield of dried [illegible] (kg/ha)
as influenced by different treatments



## 4 3 Nutrient content and plant uptake

### 4 3 1 Nitrogen content

#### 4 3 1 1 Nitrogen content of vegetative parts

Data on the effect of spacing organic manure and fertilizers on the nitrogen content of the plant are presented in Table 12 and Fig 4

The nitrogen content of leaves decreased with ageing At 5 MAP the nitrogen content of the plant ranged from 3 10 to 3 75 with a mean value of 3 50 per cent at 9 MAP it was 2 19 to 2 89 per cent with a mean value of 2 54 per cent and at 13 MAP it was 1 23 to 2 87 per cent with a mean value 1 96 per cent

Sushama (1982) reported a similar variation in the leaf nitrogen content of *Piper nigrum* with higher nitrogen content before flushing compared to later stages

The higher concentration of nitrogen in vegetative parts in earlier stages is quite normal since the growth rate and biomass production during this period was considerably low When the plant reached its reproductive stage there was a rapid increase in the total dry matter production with a consequent decrease in the concentration of nitrogen in the vegetative parts At this stage the mobilization of nutrients from leaves to spikes started

No significant difference was noticed between the treatments until 9 MAP But there was significant difference at 13 MAP Application of higher levels of fertilizer resulted in higher content of nitrogen in vegetative parts at 13 MAP eventhough it could not produce significant difference in the early stages It

Table 12 Nitrogen content (%) of vegetative parts as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 3 52 | 3 54 | 3 70 | 3 58 | 2 47 | 2 47 | 2 89 | 2 61 | 1 23 | 1 52 | 2 04 | 1 59 |
| $S_3M_1$ | 3 12 | 3 85 | 3 62 | 3 53 | 2 54 | 2 61 | 2 73 | 2 62 | 1 85 | 1 46 | 2 62 | 1 98 |
| $S_3M_2$ | 3 10 | 3 15 | 3 85 | 3 36 | 2 38 | 2 35 | 2 42 | 2 38 | 1 75 | 1 77 | 2 45 | 1 99 |
| $S_2M_2$ | 3 19 | 3 40 | 3 75 | 3 44 | 2 57 | 2 95 | 2 52 | 2 68 | 1 47 | 2 89 | 2 46 | 2 27 |
| $S_1M_2$ | 3 50 | 3 59 | 3 59 | 3 56 | 2 50 | 2 20 | 2 72 | 2 47 | 1 72 | 2 00 | 2 03 | 1 92 |
| Mean | 3 29 | 3 51 | 3 70 | | 2 47 | 2 52 | 2 65 | | 1 60 | 1 92 | 2 32 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | NS | NS | 0 390 |
| SM | NS | NS | 0 500 |
| F x SM | NS | NS | 0 870 |

was also observed that treatments receiving 50 x 50 cm spacing and organic manure 20 t ha $^{1}$ showed a higher N content

4 3 1 2 Nitrogen content of spikes

The data on the effect of fertilizers organic manure and spacing on nitrogen content of spikes at 5 9 and 13 MAP is presented in Table 13

The content of nitrogen in spikes was much higher than that of vegetative parts Nitrogen is the main constituent of alkaloids and hence high nitrogen concentration in spikes is natural Spikes produced by plants under low density planting contained more nitrogen than higher plant densities When spacing between plants was increased there would be less number of plants per unit area and less competition and the nutrient content of spikes would increase But at closer spacing the competition for added nitrogen was more resulting in less content of nitrogen in spikes

Unlike in the case of leaves spike produced at 9 MAP had a higher content of N (Fig 4) The harvest during this period was of the spikes formed after the application of second half of fertilizers and hence there would have been more availability of nutrients in the soil and more absorption by the plant

In the plots receiving no manure and fertilizer the nitrogen content of spikes was the lowest indicating that application of manure and fertilizer increased nitrogen content of spikes

4 3 1 3 Total nitrogen uptake

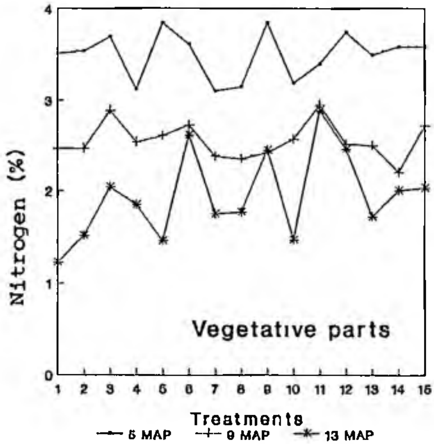
The data on the nitrogen uptake by the plant (vegetative parts + spike) is

Table 13 Nitrogen content (%) of spikes as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 3 59 | 4 14 | 4 58 | 4 10 | 2 50 | 3 60 | 4 23 | 3 44 | 1 56 | 3 52 | 3 91 | 2 99 |
| $S_3M_1$ | 3 39 | 3 84 | 5 25 | 4 16 | 3 83 | 4 86 | 5 83 | 4 84 | 3 41 | 4 57 | 4 65 | 4 21 |
| $S_3M_2$ | 3 69 | 4 57 | 5 04 | 4 43 | 3 60 | 4 52 | 4 97 | 4 36 | 3 65 | 3 43 | 4 55 | 3 87 |
| $S_2M_2$ | 2 53 | 2 92 | 4 69 | 3 38 | 3 56 | 4 49 | 5 62 | 4 55 | 3 61 | 3 49 | 4 14 | 3 74 |
| $S_1M_2$ | 2 67 | 3 36 | 3 81 | 3 27 | 3 31 | 4 40 | 4 66 | 4 12 | 3 17 | 3 33 | 3 97 | 3 49 |
| Mean | 3 17 | 3 76 | 4 67 | | 3 36 | 4 37 | 5 06 | | 3 08 | 3 66 | 4 24 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 0 131 | 0 145 | 0 430 |
| SM | 0 042 | 0 188 | 0 555 |
| Γ x SM | 0 294 | 0 089 | 0 962 |

Fig 4 Nitrogen content (%) of vegetative parts and spikes as influenced by different treatments



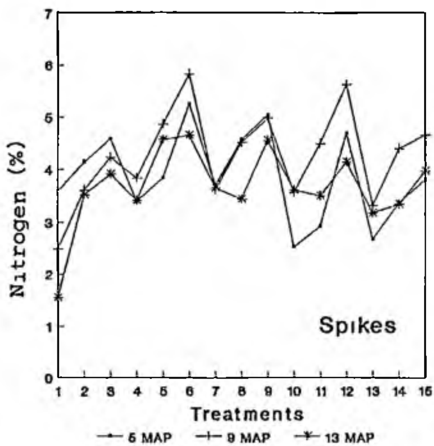



Table 14 Nitrogen uptake (kg ha $^{1}$) as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 4 57 | 6 21 | 6 8 | 5 86 | 2 96 | 3 69 | 5 12 | 3 92 | 2 26 | 3 66 | 6 74 | 4 22 |
| $S_3M_1$ | 6 13 | 10 35 | 13 5 | 9 99 | 4 86 | 6 96 | 8 31 | 6 71 | 6 87 | 6 91 | 10 54 | 8 10 |
| $S_3M_2$ | 10 26 | 11 85 | 17 09 | 13 06 | 4 25 | 6 79 | 9 04 | 6 69 | 6 74 | 7 49 | 12 69 | 8 97 |
| $S_2M_2$ | 12 49 | 15 67 | 19 58 | 15 91 | 8 18 | 10 6 | 11 40 | 10 06 | 7 00 | 14 24 | 17 29 | 12 80 |
| $S_1M_2$ | 11 32 | 14 07 | 24 37 | 16 59 | 8 65 | 9 48 | 14 65 | 10 92 | 9 66 | 10 79 | 16 93 | 12 46 |
| Mean | 8 94 | 11 63 | 13 51 | | 5 78 | 7 50 | 9 67 | | 6 50 | 8 61 | 12 83 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 3 12 | 2 37 | 3 55 |
| SM | 4 03 | 3 07 | 4 58 |
| F x SM | 6 99 | 5 31 | 7 94 |

presented in Table 14 Significant response was noted with respect to treatments Dry matter production played an important role in the nutrient uptake by plant (Wild and Breeze 1981)

At 9 MAP the dry matter production was low compared to 5 MAP and hence less uptake of nitrogen This period was coinciding with the dry month (February) and poor growth of the plant

Nitrogen uptake is the product of dry matter accumulation and nitrogen content Application of higher levels of fertilizer was found to have a favourable effect on the nitrogen uptake by plant Increased nitrogen uptake with increased nitrogen application was quite natural since it favoured a higher nitrogen content and dry matter accumulation

In the treatments where organic manure was applied the nitrogen uptake was more due to the enhanced dry matter accummulation but in plots where higher rate of fertilizers was applied it was more due to increased nitrogen content in vegetative parts and spikes (Fig 7)

Among combination treatments nitrogen uptake was more when the spacing was less and with an organic manure application @ 20 t ha $^{-1}$ along with higher levels of fertilizer This followed a very similar trend as that of dry matter production and nitrogen content

4 3 2 Phosphorus content

4 3 2 1 Phosphorus content of vegetative parts

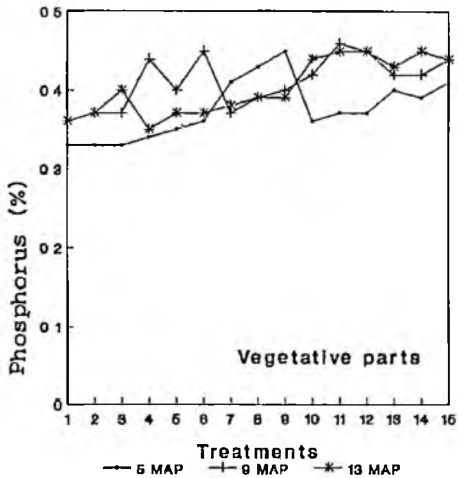
Table 15 shows the phosphorus content of the plant sample 5 9 and 13

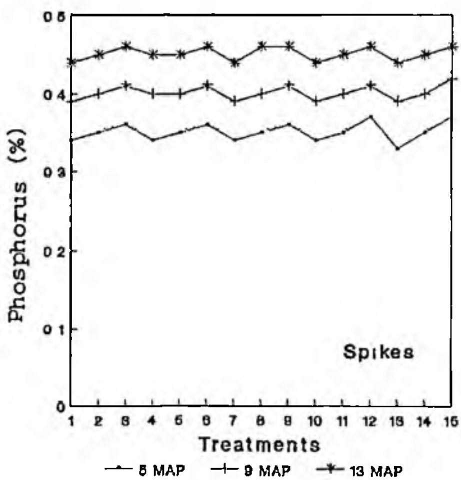
Table 15 Phosphorus content (%) of vegetative parts as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 0 33 | 0 33 | 0 33 | 0 33 | 0 36 | 0 37 | 0 37 | 0 37 | 0 36 | 0 37 | 0 40 | 0 38 |
| $S_3M_1$ | 0 34 | 0 35 | 0 36 | 0 35 | 0 44 | 0 40 | 0 45 | 0 43 | 0 35 | 0 37 | 0 37 | 0 36 |
| $S_3M_2$ | 0 41 | 0 43 | 0 45 | 0 43 | 0 37 | 0 39 | 0 40 | 0 39 | 0 38 | 0 39 | 0 39 | 0 39 |
| $S_2M_2$ | 0 36 | 0 37 | 0 37 | 0 36 | 0 42 | 0 46 | 0 45 | 0 44 | 0 44 | 0 45 | 0 45 | 0 45 |
| $S_1M_2$ | 0 40 | 0 39 | 0 41 | 0 40 | 0 42 | 0 42 | 0 44 | 0 42 | 0 43 | 0 45 | 0 44 | 0 44 |
| Mean | 0 37 | 0 37 | 0 38 | | 0 70 | 0 41 | 0 42 | | 0 39 | 0 41 | 0 41 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 0 007 | 0 003 | 0 003 |
| SM | 0 010 | 0 010 | 0 010 |
| F x SM | 0 016 | 0 017 | 0 017 |

Fig 5 Phosphorus content (%) of vegetative parts and spikes as influenced by different treatments



MAP The content ranged from 0 33 to 0 45 per cent Sushama (1982) had reported a phosphorous content of 0 14 to 0 49 per cent in *Piper nigrum* the content increasing with the growth of the plant

Unlike nitrogen phosphorus content of the plant increased with growth of thippali irrespective of fertilizer application (Fig 5) Not much difference was noted between P content of vegetative parts and spikes But at 13 MAP there was a slight difference This might be probably due to the fact that the soils were able to provide a steady supply of phosphorous to the plant and less mobilization into spike due to lower requirement as against nitrogen Dewaard (1969) also observed a gradual increase in the phosphorus content in pepper with the growth of the plant

4 3 2 2 Phosphorus content of spikes

Table 16 and Fig 5 shows the distribution of phosphorus in spikes as influenced by the treatments and growth stages

The phosphorus content of spikes increased with ageing of the plant and it varied from 0 34 to 0 46 per cent The maximum phosphorus content was recorded at 13 MAP Even in the plots with high plant population the phosphorus content did not vary significantly There was slight increase in phosphorus content with application of fertilizer

4 3 2 3 Phosphorus uptake by plant

Levels of organic manure and fertilizer applied to thippali showed significant differences in uptake of phosphorus over control (Table 17) The uptake at all stages was higher in treatments which received 20 t $ha^{-1}$ organic manure and

Table 16 Phosphorus content (%) of spikes as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 0 34 | 0 35 | 0 36 | 0 35 | 0 39 | 0 40 | 0 41 | 0 40 | 0 44 | 0 45 | 0 46 | 0 45 |
| $S_3M_1$ | 0 34 | 0 35 | 0 36 | 0 35 | 0 40 | 0 40 | 0 41 | 0 40 | 0 45 | 0 45 | 0 46 | 0 45 |
| $S_3M_1$ | 0 34 | 0 35 | 0 46 | 0 35 | 0 39 | 0 40 | 0 41 | 0 40 | 0 44 | 0 46 | 0 46 | 0 45 |
| $S_2M_2$ | 0 34 | 0 35 | 0 37 | 0 35 | 0 39 | 0 40 | 0 41 | 0 40 | 0 44 | 0 45 | 0 46 | 0 45 |
| $S_1M_2$ | 0 33 | 0 35 | 0 37 | 0 35 | 0 39 | 0 40 | 0 42 | 0 40 | 0 44 | 0 45 | 0 46 | 0 45 |
| Mean | 0 34 | 0 35 | 0 36 | | 0 39 | 0 40 | 0 41 | | 0 44 | 0 45 | 0 46 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 0 007 | 0 007 | 0 007 |
| SM | NS | NS | NS |
| F x SM | 0 017 | 0 017 | 0 017 |

Table 17 Phosphorus uptake (kg ha$^{-1}$) as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 0 43 | 0 57 | 0 59 | 0 53 | 0 43 | 0 51 | 0 63 | 0 52 | 0 65 | 0 78 | 1 24 | 0 89 |
| $S_3M_1$ | 0 66 | 0 94 | 1 29 | 0 96 | 0 8 | 1 09 | 1 30 | 1 06 | 1 12 | 1 32 | 1 43 | 1 29 |
| $S_3M_2$ | 1 30 | 1 52 | 1 93 | 1 58 | 0 59 | 1 04 | 1 48 | 1 03 | 1 28 | 1 56 | 1 91 | 1 58 |
| $S_2M_2$ | 1 43 | 1 72 | 1 87 | 1 67 | 1 27 | 1 67 | 1 77 | 1 57 | 1 82 | 2 16 | 3 05 | 2 34 |
| $S_1M_2$ | 1 30 | 1 52 | 2 75 | 1 85 | 1 38 | 1 64 | 2 27 | 1 76 | 2 33 | 2 34 | 3 51 | 2 75 |
| Mean | 1 02 | 1 25 | 1 68 | | 0 89 | 1 19 | 1 49 | | 1 44 | 1 63 | 2 24 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 0 46 | 0 67 | 0 79 |
| SM | 0 6 | 0 87 | 1 02 |
| F x SM | 1 04 | 1 51 | 1 80 |

60 kg $P_2O_5$ per hectare Uptake was minimum in treatments where no manure and fertilizers were applied eventhough there was not much difference in the P concentration Hence the higher uptake in manured and fertilizered plots was due to higher biomass production Phosphorus uptake increased with the growth of the plant Phosphorus uptake reached a maximum at 13 MAP The phosphorus uptake was around 1/5 of nitrogen uptake which was in confirmity with the reports of Kanwar *et al* (1982)

4 3 3 Potassium content

4 3 3 1 Potassium content of vegetative parts

The potassium content of plant vegetative parts at 5 9 and 13 MAP are presented in Table 18 The potassium content varied from 1 21 to 1 73 per cent

Potassium content of vegetative parts in various growth stage of the plant upto 13 MAP remained almost stable probably due to the fact that growth of the plant during this period was very limited In general an increasing trend in K concentration in vegetative parts was observed with increasing fertilizer and organic manure rates and decreasing plant density (Fig 6) Plants receiving high levels of K retained high content of nutrient in vegetative parts

The potassium content was maximum in plants spaced at 60 x 60 cm under lower plant population more amount of K was available to each plant which resulted in more K content The decreasing trend of K when plant population increased in pepper was shown by Reddy *et al* (1993)

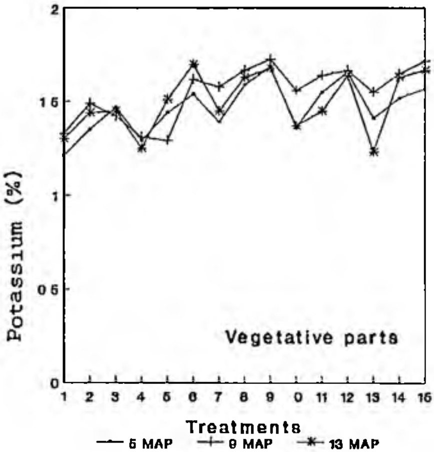
At all stages of growth a manurial dose of 20 t $ha^{-1}$ resulted in higher K content in plant The decline in content of K in vegetative parts in the later stages

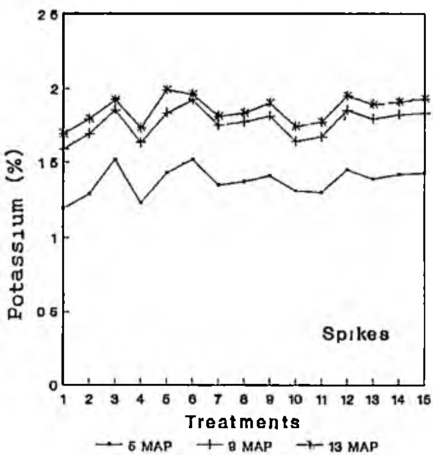
Table 18 Potassium content (%) of vegetative parts as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 1 21 | 1 35 | 1 47 | 1 34 | 1 33 | 1 49 | 1 42 | 1 41 | 1 30 | 1 44 | 1 45 | 1 39 |
| $S_3M_1$ | 1 29 | 1 44 | 1 54 | 1 42 | 1 31 | 1 29 | 1 62 | 1 40 | 1 25 | 1 51 | 1 70 | 1 48 |
| $S_3M_2$ | 1 39 | 1 59 | 1 69 | 1 55 | 1 58 | 1 67 | 1 73 | 1 66 | 1 45 | 1 63 | 1 68 | 1 58 |
| $S_3M_2$ | 1 36 | 1 55 | 1 66 | 1 52 | 1 56 | 1 64 | 1 67 | 1 62 | 1 37 | 1 45 | 1 64 | 1 48 |
| $S_1M_2$ | 1 41 | 1 52 | 1 57 | 1 50 | 1 55 | 1 65 | 1 72 | 1 64 | 1 23 | 1 63 | 1 67 | 1 51 |
| Mean | 1 33 | 1 49 | 1 58 | | 1 46 | 1 55 | 1 63 | | 1 32 | 1 47 | 1 62 | |

| CD(0 05) | 5 MAP | 9 MAP | 13 MAP |
|---|---|---|---|
| F | 0 03 | 0 06 | 0 03 |
| SM | 0 04 | 0 08 | 0 04 |
| F x SM | 0 08 | 0 14 | 0 06 |

Fig 6 Potassium content (%) of vegetative parts and spikes as influenced by different treatments



may be due to the flow of the element from the leaf to developing spikes This was in confirmity with the findings of Dewaard (1969) in pepper

4 3 3 2 Potassium content of spikes

Potassium content of spikes showed an increasing trend from 5 MAP to 13 MAP (Table 19 and Fig 6) The K content of spikes was higher than vegetative parts It was highest in a high density planting This might be due to more number of plants per unit with large root mass absorbing more nutrients from unit volume of soil Due to dilution effect the leaf nutrient concentration might be reduced as reported by Reddy *et al* (1993) but not the spike concentration

The increasing trend with increasing rate of organic manure and fertilizer with decreasing plant density as observed in leaf K status was not observed with K content of spikes The role of K in plants is more with carbohydrate metabolism by way of absorption and translocation of nutrients and maintaining water balance (Tisdale *et al* 1985) Hence the variation in K concentration is more visible in the leaves which are the seat of photosynthesis and not in the spikes

4 3 3 3 Potassium uptake

The data on potassium uptake by spikes are presented in Table 20 and significant difference was noticed between treatments at all stages of growth

Similar to N and P K uptake pattern also followed the dry matter accumulation and K content as influenced by various treatments The K uptake increased with the growth of the plant Nutrient application has resulted in enhanced K uptake but little influenced by plant density and organic manure (Fig 7)

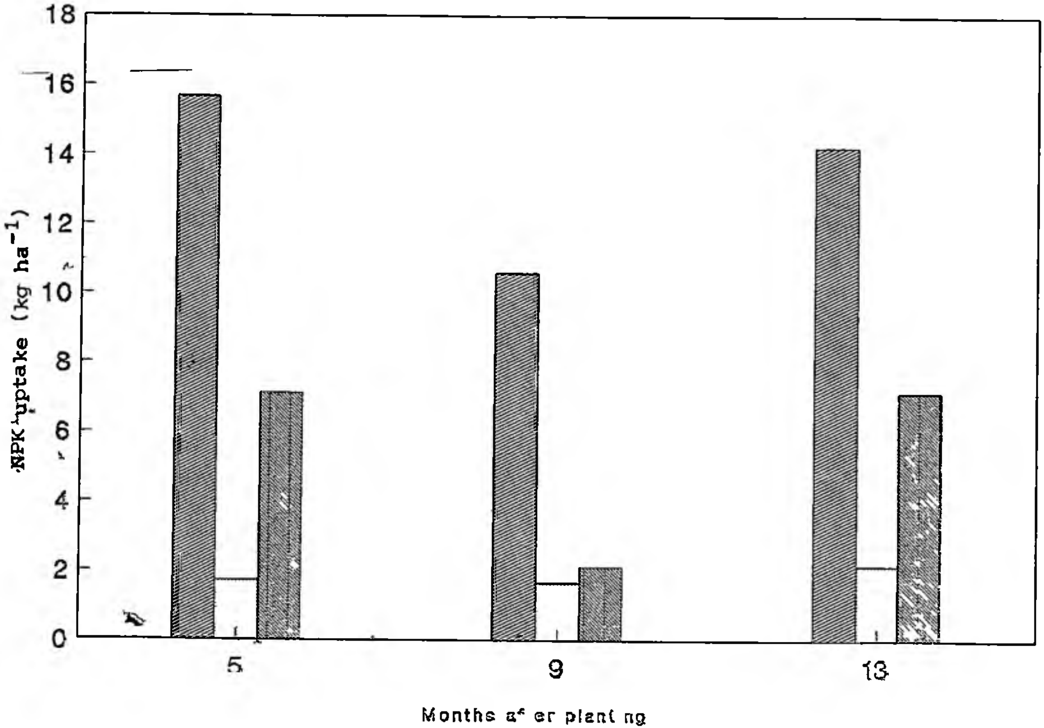
Table 19 Potassium content (%) of spikes as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 1 19 | 1 29 | 1 52 | 1 33 | 1 59 | 1 69 | 1 85 | 1 71 | 1 69 | 1 79 | 1 92 | 1 87 |
| $S_3M_1$ | 1 23 | 1 43 | 1 52 | 1 39 | 1 62 | 1 83 | 1 92 | 1 79 | 1 73 | 1 91 | 1 96 | 1 86 |
| $S_3M_2$ | 1 35 | 1 37 | 1 41 | 1 37 | 1 75 | 1 77 | 1 81 | 1 77 | 1 81 | 1 83 | 1 90 | 1 84 |
| $S_2M_2$ | 1 31 | 1 30 | 1 45 | 1 35 | 1 64 | 1 67 | 1 85 | 1 72 | 1 74 | 1 77 | 1 95 | 1 82 |
| $S_1M_2$ | 1 39 | 1 42 | 1 43 | 1 41 | 1 79 | 1 82 | 1 83 | 1 81 | 1 89 | 1 91 | 1 93 | 1 91 |
| Mean | 1 29 | 1 36 | 1 47 | | 1 68 | 1 76 | 1 85 | | 1 77 | 1 84 | 1 93 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 0 02 | | | | 0 02 | | | | 0 02 | | |
| SM | | 0 03 | | | | 0 03 | | | | 0 03 | | |
| F x SM | | 0 05 | | | | 0 05 | | | | 0 05 | | |

Table 20 Potassium uptake (kg $ha^{-1}$) as influenced by spacing organic manure and fertilizer levels

| | 5 MAP | | | | 9 MAP | | | | 13 MAP | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean | $F_0$ | $F_1$ | $F_2$ | Mean |
| $S_3M_0$ | 1 56 | 2 29 | 2 65 | 2 17 | 1 63 | 2 11 | 2 47 | 2 07 | 2 41 | 2 96 | 1 87 | 2 41 |
| $S_3M_1$ | 2 49 | 3 86 | 5 55 | 3 97 | 2 46 | 1 45 | 1 54 | 1 81 | 4 01 | 5 41 | 6 53 | 5 35 |
| $S_3M_2$ | 4 48 | 5 65 | 7 26 | 5 79 | 1 01 | 1 44 | 2 04 | 1 49 | 4 95 | 6 53 | 8 18 | 6 55 |
| $S_2M_2$ | 5 41 | 7 13 | 8 28 | 6 94 | 1 77 | 2 13 | 2 56 | 2 15 | 5 83 | 7 15 | 11 21 | 8 06 |
| $S_1M_2$ | 4 68 | 5 96 | 10 55 | 7 04 | 2 09 | 2 29 | 2 84 | 2 40 | 6 82 | 8 56 | 13 62 | 9 67 |
| Mean | 3 72 | 4 98 | 6 85 | | 1 79 | 1 88 | 2 29 | | 4 82 | 6 12 | 8 28 | |
| CD(0 05) | | | | | | | | | | | | |
| F | | 1 25 | | | | NS | | | | 1 81 | | |
| SM | | 1 65 | | | | NS | | | | 2 30 | | |
| F x SM | | 2 85 | | | | NS | | | | 4 10 | | |

Fig 7 Total NPK uptake by the treatments receiving $S_2M_2F_1$ at different stages of growth



## 4 4 Qualıtatıve analysıs of thıppalı

The data on the effect of spacıng organıc manure and ınorganıc fertılızers on the crude alkaloıd content of drıed spıkes are presented ın Table 21 The crude alkaloıd content of drıed spıkes varıed from 5 66 to 6 13 per cent

Though the concentratıon of nutrıents ın the spıkes changed as per treat ments crude alkaloıd content was not sıgnıficantly dıfferent

About 22 dıfferent alkaloıds were reported ın *Pıper longum* Though the crude alkaloıd content dıd not change the content of dıfferent alkaloıds probably mıght have changed however ındependant estımatıon were not done The synthesıs of alkaloıd was not quantıtatıvely governed by the levels of nıtrogen phosphorus and potassıum avaılable ın the plant tıssue

## 4 5 Nutrıent status of soıl

### 4 5 1 N content

The nıtrogen content of soıl from the treatments estımated after one year of plantıng ıs presented ın Table 22 The nıtrogen content before plantıng was 0 15 per cent and ıts status varıed ın varıous treatment applıed plots after one year

The soıl nıtrogen content of plots of low densıty plantıng was hıgher compared to hıgher densıtıes eventhough there was no sıgnıficant dıfference In plots wıth hıgher plant populatıon where manure and fertılızer were applıed at the same dose as that of lower densıtıes the content of N ın soıl reduced ıe wıth ıncrease ın plant densıty the nıtrogen content ın soıl reduced Reddy *et al* (1993) reported an ıncreased nıtrogen content ın hıgher plant densıtıes ırrespectıve of fertılızer

Table 21 Crude alkaloid content (%) of dried spikes as influenced by spacing organic manure and fertilizer levels

| | $F_0$ | $F_1$ | $F_2$ | Mean |
|---|---|---|---|---|
| $S_3M_0$ | 6 00 | 6 13 | 6 13 | 6 08 |
| $S_3M_2$ | 6 06 | 6 00 | 5 80 | 5 95 |
| $S_2M_2$ | 5 72 | 6 06 | 5 78 | 5 85 |
| $S_2M_2$ | 5 93 | 6 00 | 5 93 | 5 95 |
| $S_1M_2$ | 6 13 | 5 66 | 5 83 | 5 87 |
| Mean | 5 97 | 5 97 | 5 89 | |

| | |
|---|---|
| CD(0 05) | |
| F | NS |
| SM | NS |
| F x SM | NS |

Table 22 Nitrogen content (%) of soil as influenced by spacing organic manure and fertilzier levels

| | $F_0$ | $F_1$ | $F_2$ | Mean |
|---|---|---|---|---|
| $S_3M_0$ | 0 151 | 0 155 | 0 153 | 0 153 |
| $S_3M_1$ | 0 152 | 0 164 | 0 172 | 0 162 |
| $S_3M_2$ | 0 152 | 0 174 | 0 176 | 0 167 |
| $S_2M_2$ | 0 154 | 0 171 | 0 176 | 0 167 |
| $S_1M_2$ | 0 153 | 0 161 | 0 162 | 0 158 |
| Mean | 0 152 | 0 165 | 0 168 | |

| CD(0 05) | |
|---|---|
| F | NS |
| SM | NS |
| F x SM | NS |

treatments The depletion of nutrients from soil with closer spacing was due to more number of plants per unit area extracting nutrients from soil resulting in reduction in soil nutrient status

When the effect of different levels of fertilizers and manures were compared no significant difference was noted This was not according to the trend normally experienced But there was increasing trend in available nitrogen content by application of manure and fertilizers

With organic manure application several researchers reported increased the available nitrogen content in the soil which is increased microbial activity leading to greater mineralization (Muthuvel 1973)

Stumpe and Kolbe (1968) reported that the soil nitrogen was reduced by 2 per cent by mineral fertilization and was increased by 3 per cent through combined application of manures and fertilizers in chillies

4 5 2 P content

It is evident from Table 23 that phosphorus application had resulted in significant increase in available P content of soil over the control The application of 30 kg $P_2O_5$ per hectare produced significant effect on available P content of soil compared to no P application and it was on par with 60 kg $P_2O_5$ per hectare Comparing the yield and soil P status it was evident that 30 kg $P_2O_5$ per hectare was sufficient for application in thippali

The source of applied P was Mussoriphos which had a slow release of available P in acid soils The uptake of P by plant was relatively less than other

Table 23 Phosphorus content (ppm) of soil as influenced by spacing organic manure and fertilizer levels

| | $F_0$ | $F_1$ | $F_2$ | Mean |
|---|---|---|---|---|
| $S_3M_0$ | 12 20 | 18 43 | 19 93 | 16 80 |
| $S_3M_1$ | 13 36 | 20 40 | 23 36 | 19 04 |
| $S_3M_2$ | 14 50 | 21 26 | 23 63 | 19 79 |
| $S_2M_2$ | 14 76 | 23 63 | 23 60 | 20 60 |
| $S_1M_2$ | 14 50 | 21 53 | 22 60 | 19 50 |
| Mean | 13 86 | 21 05 | 22 62 | |

| CD(0 05) | |
|---|---|
| F | 0 571 |
| SM | 0 737 |
| F x SM | 1 277 |

nutrients The loss of applied P is probably nil but for fixation in the unavailable form and hence more P was retained in soil

Phosphorus content of the soil in low density planting showed a significant increase when organic manure was applied at 20 t ha $^{-1}$ in the absence of any fertilizer application Significant increase in available P was observed when organic manure @ 20 t ha $^{-1}$ alone or @ 10 t ha $^{-1}$ along with 30 kg $P_2O_5$ per hectare was applied than no application of either organic manure or fertilizer Organic manure at higher dose might have enhanced mineralisation of native P (Joseph *et al* 1995)

Inorganic fertilizer application alone reduced the available P content An increase was seen in organic manure applied plots Application of organic manure would have produced some organic acids during decomposition which caused the release of P from insoluble P compounds (McIntosh and Varney 1973)

4 5 3 K content

The potassium content of soil increased due to the application of manures and fertil izer (Table 24)

Potassium is subjected more to leaching and organic manure helps in retention of K in the soil The significance of spacing on the K content of soil was well noticed At 60 x 60 cm spacing for every dose of organic manure and fertilizer the K content showed an increasing trend But when the plant popula tion increased the content of K was very low in soil and was related to enhanced uptake of K by plants in higher density plots (Tisdale *et al* 1985)

Table 24 Potassium content (ppm) of soil as influenced by spacing organic manure and fertilizer levels

| | $F_0$ | $F_1$ | $F_2$ | Mean |
|---|---|---|---|---|
| $S_3M_0$ | 90 6 | 105 6 | 103 6 | 99 9 |
| $S_3M_1$ | 105 5 | 125 9 | 126 2 | 119 2 |
| $S_3M_2$ | 114 8 | 116 6 | 145 6 | 125 6 |
| $S_2M_2$ | 116 7 | 108 6 | 121 0 | 115 4 |
| $S_2M_2$ | 86 7 | 88 7 | 90 4 | 88 6 |
| Mean | 102 8 | 109 0 | 117 3 | |

| | |
|---|---|
| CD(0 05) | |
| F | 10 63 |
| SM | 13 73 |
| F x SM | 23 79 |

Since the nutrient absorption zone available for individual plant got reduced under high density planting more absorption of K by plants might have taken place resulting in gradual decrease in K content of soil When more number of plants were accommodated per unit area higher yield per unit area were possible But there would be decrease in build up of nutrients in soil Inorder to replenish the soil nutrients to get optimum productivity judicious application of fertilizer becomes essential

## 4 6 Economic analysis of thippali cultivation

The economic analysis of thippali cultivation is presented in Table 24 Thippali is a perennial plant The economic fruiting period continues for more than three years Several researchers have reported thippali production increasing year by year (Krishnamoorthy 1969 Davies 1992 Viswanathan 1993) The establishment cost of thippali in the field is relatively higher particularly due to the high cost of planting material and labour charges

The present study intended to study the growth and production of thippali only during the first year of production a net loss was observed due to high initial establishment cost and low yield during first year However during subsequent years the crop would yield a net profit The estimated net profit during second year is as high as Rs 29 465/ even at the same yield level obtained during the first year Davies(1992) reported a 50 per cent yield increase during the second year

The maximum net return was estimated for the treatments with intermediate plant density having 50 x 50 cm spacing receiving moderate level of

Table 24 Economic of thippali cultivation (per ha)

| Treatments | Cost of planting materials | Cost for planting | Irrigation | Weeding | Manure cost | Fertilizer cost | Manure application cost | Fertilizer application cost | Picking of spikes | Total cost of cultivation | Yield kg ha[1] | Returns | Net returns Ist year | Return per rupee invested | Net returns during 2nd year | Return per rupee invested |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $S_3M_0F_0$ | 27777 | 3000 | 800 | 1125 | | | | | 3750 | 36452 | 245 0 | 24500 | 11952 | 0 672 | 18825 | 4 [illegible]2 |
| $S_3M_0F_1$ | 27777 | 3000 | 800 | 1125 | | 1085 | | 1125 | 3750 | 38662 | 279 5 | 27950 | 13337 | 0 676 | 20065 | 3 54 |
| $S_3M_0F_2$ | 27777 | 3000 | 800 | 1125 | | 2170 | | 1125 | 3750 | 39747 | 256 0 | 25600 | 14147 | 0 644 | 16630 | 2 85 |
| $S_3M_1F_0$ | 27777 | 3000 | 800 | 1125 | 3000 | | 1125 | | 3750 | 40577 | 286 5 | 28650 | 11927 | 0 706 | 18850 | 2 92 |
| $S_3M_1F_1$ | 27777 | 3000 | 800 | 1125 | 3000 | 1085 | 1125 | 1125 | 3750 | 42787 | 347 5 | 34750 | 8037 | 0 812 | 22740 | 2 89 |
| $S_3M_1F_2$ | 27777 | 3000 | 800 | 1125 | 3000 | 2170 | 1125 | 1125 | 3750 | 43872 | 295 5 | 29550 | 14322 | 0 673 | 16455 | 2 25 |
| $S_3M_2F_0$ | 27777 | 3000 | 800 | 1125 | 6000 | | 1500 | | 3750 | 43952 | 357 5 | 35750 | 8202 | 0 813 | 22575 | 2 71 |
| $S_3M_2F_1$ | 27777 | 3000 | 800 | 1125 | 6000 | 1085 | 1500 | 1125 | 3750 | 46162 | 339 5 | 33950 | 12212 | 0 735 | 18565 | 2 20 |
| $S_3M_2F_2$ | 27777 | 3000 | 800 | 1125 | 6000 | 2170 | 1500 | 1125 | 3750 | 48247 | 379 5 | 37950 | 9297 | 0 803 | 21450 | 1 69 |
| $S_2M_2F_0$ | 40000 | 3750 | 800 | 1125 | 6000 | | 1500 | | 3750 | 56925 | 390 5 | 39050 | 17875 | 0 685 | 25875 | [illegible] 95 |
| $S_2M_2F_1$ | 40000 | 3750 | 800 | 1125 | 6000 | 1085 | 1500 | 1125 | 3750 | 59135 | 4485 | 44850 | 14285 | 0 758 | 29465 | 91 |
| $S_2M_2F_2$ | 40000 | 3750 | 800 | 1125 | 6000 | 2170 | 1500 | 1125 | 3750 | 60220 | 436 0 | 43600 | 16620 | 0 724 | 27130 | 2 64 |
| $S_1M_2F_0$ | 62500 | 6000 | 800 | 1125 | 6000 | | 1500 | | 3750 | 81675 | 317 5 | 31750 | -49907 | 0 388 | 18575 | 2 40 |
| $S_1M_2F_1$ | 62500 | 6000 | 800 | 1125 | 6000 | 1085 | 1500 | 1125 | 3750 | 83885 | 346 5 | 346[illegible] | -49235 | 0 413 | 19265 | 2 25 |
| $S_1M_2F_2$ | 62500 | 6000 | 800 | 1125 | 6000 | 2170 | 1500 | 1125 | 375[illegible] | 84970 | 316 5 | 31650 | 53320 | 0 3 2 | 15180 | 1 [illegible]2 |

Cost of planting material Rs 0 50 per plant
Wages (Men) @ Rs 80
Wages (Women) @ Rs 75/
Price organic manure Rs 300/ per ton
Fertilizer
Urea @ Rs 3 50 per kg
Mussuriphos @ Rs 3 00 per kg
Muriate of potash @ Rs 4 50 per kg
Price of dried spikes Rs 100 [illegible]

fertilizer at 30 30 60 NPK kg ha $^{1}$ This yielded a higher or similar return per rupee invested than that of all other treatments receiving organic manure

The highest returns (4 32 and 3 54) per rupee invested estimated for the treatments with low plant density and without organic manure and fertilizers and with 30 30 60 NPK kg ha $^{1}$ alone respectively are not desirable due to the low net returns and soil health problems due to non addition of organic manure

# Summary

## SUMMARY

A field experiment was conducted at KADP Farm College of Horticulture during 1994 95 to evaluate the response of *Piper longum* as an intercrop in coconut gardens to differential spacing and manurial regimes

The experiment was laid out in randomised block design with three replications The treatments included three levels of spacing (60 x 60 cm 50 x 50 cm and 40 x 40 cm) organic manure (0 10 20 t ha $^{1}$) and inorganic fertilizers (0 0 0, 30 30 60 60 60 120 NPK kg ha $^{1}$) The plant population per hectare were 27777 40000 and 62500 in 60 x 60 cm 50 x 50 cm and 40 x 40 cm respectively

Growth and yield characters of the plant during the first year of growth was studied The growth characters such as plant height number of branches and number of leaves were significantly higher in the treatments receiving organic manure 20 t ha $^{1}$ fertilizer 30 30 60 NPK kg ha $^{1}$ and spacing 50 x 50 cm Similarly dry matter production was higher for treatments planted at 50 x 50 cm spacing and receiving 20 t ha $^{1}$ organic manure and 30 30 60 NPK kg ha $^{1}$ However this dry matter production was on par with highest dose of inorganic fertilizer at 60 60 120 NPK kg ha $^{1}$

Among the yield attributing characters number of spikes per plant was highest for the treatment with moderate level of NPK (30 30 60) and middle density (40 000 plants ha $^{1}$) planting Length and diameter of spikes did not vary with different treatments indicating them as varietal characters The cumulative yield was significantly higher for the above treatment The dry weight of spikes was one fifth of fresh weight The driage was not influenced by different treatments

The nitrogen content of vegetative parts decreased as the crop advanced whereas P content increased with ageing K content remained stable during the entire growth period The content of N P and K of spikes was much higher than vegetative parts The NPK uptake was higher in manured and fertilized plants

The crude alkaloid content of dried spikes did not vary with the treat ments imposed

The nitrogen content of soil in low density planted plots was higher than higher densities Application of 30 kg $P_2O_5$ per hectare retained the soil P status and it was on par with 60 kg $P_2O_5$ per hectare The K content was also higher under wider spacing receiving 20 t ha$^{1}$ organic manure and 60 kg $P_2O_5$ per hectare The available P and K content of soil was enhanced due to the combined application of organic and inorganic fertilizer

Economics of thippali cultivation revealed that during the first year a net loss was observed due to high cost of planting material and establishment cost However assuming the same yield level during second year it was seen that from second year onwards the crop could produce a net return of Rs 29465 per hectare under optimum conditions

Taking into account the spike and alkaloid yield soil fertility and net returns it was seen that thippali could be planted at 50 x 50 cm spacing with an application of 20 t ha$^{1}$ organic manure and 30 30 60 NPK kg ha$^{1}$

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* Originals not seen

# Appendices

APPENDIX I

Meteorological data (weekly average) for the experimental period (from 24 5 94 to 24 8 95)

| Standard week No | Month and date | Total rainfall (mm) | No of rainy days | Temperature Max C | Temperature Min C | Relative humidity Fore noon % | Relative humidity After noon % | Sun shine hours | Evaporation mm/day |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 21 | May 21 27 | 3 5 | | 33 9 | 25 3 | 89 | 62 | 7 6 | 4 3 |
| 22 | May 28 June 3 | 171 8 | 6 | 30 2 | 22 8 | 95 | 80 | 2 8 | 2 6 |
| 23 | June 4 10 | 280 0 | 7 | 26 6 | 22 9 | 96 | 92 | 0 08 | 1 9 |
| 24 | June 11 17 | 219 2 | 7 | 28 4 | 22 7 | 97 | 84 | 0 72 | 2 9 |
| 25 | June 18 24 | 66 6 | 4 | 30 9 | 23 7 | 96 | 70 | 5 8 | 3 7 |
| 26 | June 25 July 1 | 253 8 | 7 | 29 5 | 22 7 | 96 | 80 | 2 7 | 2 9 |
| 27 | July 2 8 | 77 0 | 6 | 29 7 | 22 8 | 96 | 82 | 3 2 | 3 2 |
| 28 | July 9 15 | 311 5 | 7 | 28 8 | 22 0 | 97 | 87 | 1 1 | 2 8 |
| 29 | July 16 22 | 293 7 | 7 | 29 9 | 21 9 | 97 | 84 | 1 0 | 2 6 |
| 30 | July 23 29 | 219 3 | 6 | 28 2 | 22 7 | 96 | 88 | 0 4 | 2 8 |
| 31 | July 30 Aug 5 | 352 9 | 7 | 27 4 | 22 1 | 97 | 88 | 1 3 | 2 3 |
| 32 | Aug 6 12 | 32 4 | 2 | 30 2 | 23 7 | 94 | 73 | 3 5 | 3 0 |
| 33 | Aug 13 19 | 46 0 | 3 | 31 0 | 22 9 | 95 | 69 | 5 0 | 3 2 |
| 34 | Aug 20 26 | 80 6 | 5 | 30 1 | 22 7 | 94 | 72 | 2 0 | 3 1 |
| 35 | Aug 27 Sep 2 | 167 9 | 7 | 29 6 | 22 5 | 97 | 81 | 1 7 | 2 9 |
| 36 | Sep 3 9 | 99 2 | 5 | 30 3 | 23 1 | 96 | 73 | 5 3 | 3 4 |
| 37 | Sep 10 16 | 8 2 | 1 | 32 2 | 23 4 | 93 | 63 | 9 0 | 3 9 |
| 38 | Sep 17 23 | 1 2 | | 32 1 | 22 6 | 88 | 55 | 9 1 | 4 2 |
| 39 | Sep 24 30 | 1 6 | | 33 2 | 23 8 | 90 | 59 | 7 5 | 3 9 |
| 40 | Oct 1 7 | 52 0 | 4 | 31 7 | 22 3 | 94 | 71 | 5 0 | 3 1 |
| 41 | Oct 8 14 | 52 6 | 3 | 32 6 | 22 8 | 90 | 65 | 6 9 | 3 6 |
| 42 | Oct 15 21 | 88 2 | 6 | 31 9 | 22 4 | 94 | 69 | 7 3 | 3 0 |
| 43 | Oct 22 28 | 120 2 | 5 | 33 2 | 22 8 | 94 | 70 | 7 9 | 3 0 |
| 44 | Oct 29 Nov 4 | 68 3 | 6 | 31 9 | 22 5 | 91 | 68 | 5 9 | 2 6 |
| 45 | Nov 5 11 | 102 2 | 2 | 31 2 | 22 8 | 78 | 64 | 7 3 | 4 5 |
| 46 | Nov 12 18 | 0 | | 31 3 | 24 4 | 77 | 57 | 7 8 | 5 4 |
| 47 | Nov 19 25 | 0 | | 32 2 | 24 1 | 69 | 52 | 9 1 | 5 3 |
| 48 | Nov 26 Dec 2 | 0 | | 32 9 | 22 1 | 74 | 49 | 10 34 | 4 3 |
| 49 | Dec 3 9 | 0 | | 31 9 | 21 6 | 68 | 43 | 10 9 | 5 0 |
| 50 | Dec 10 16 | 0 | | 32 1 | 20 1 | 71 | 41 | 10 8 | 5 4 |
| 51 | Dec 17 23 | 0 | | 32 2 | 24 0 | 75 | 50 | 10 4 | 5 8 |
| 52 | Dec 24 31 | 0 | - | 31 9 | 23 1 | 68 | 44 | 10 3 | 6 1 |
| 1 | Jan 1 7 | | | 31 8 | 22 1 | 71 | 42 | 9 5 | 5 8 |
| 2 | Jan 8 14 | | | 33 3 | 21 5 | 88 | 49 | 8 5 | 4 1 |
| 3 | Jan 15 21 | | | 31 7 | 23 8 | 71 | 42 | 9 7 | 6 2 |

Contd

Appendix I Continued

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|
| 4 | Jan 22 28 | | | 33 3 | 21 8 | 77 | 34 | 10 4 | 6 6 |
| 5 | Jan 29 Feb 4 | | | 33 9 | 24 2 | 69 | 37 | 10 8 | 6 98 |
| 6 | Feb 5 11 | | | 34 7 | 23 4 | 71 | 37 | 10 3 | 7 5 |
| 7 | Feb 11 18 | | | 35 6 | 22 6 | 79 | 39 | 9 9 | 5 6 |
| 8 | Feb 19 25 | 0 5 | | 36 1 | 23 4 | 89 | 50 | 9 7 | 4 9 |
| 9 | Feb 26 March 4 | | | 37 2 | 23 1 | 90 | 37 | 9 0 | 5 6 |
| 10 | March 5 11 | 1 8 | | 36 9 | 23 8 | 86 | 38 6 | 8 6 | 5 5 |
| 11 | March 12 18 | 1 0 | | 37 8 | 23 8 | 82 | 41 | 9 3 | 5 8 |
| 12 | March 19 25 | | | 38 9 | 23 7 | 75 | 33 | 10 3 | 7 6 |
| 13 | March 26 Apr 1 | | | 36 5 | 24 5 | 86 | 47 | 9 5 | 5 9 |
| 14 | Apr 2 8 | 54 8 | 1 | 37 5 | 24 4 | 86 | 49 | 8 9 | 6 0 |
| 15 | Apr 9 15 | 46 2 | 1 | 36 3 | 24 7 | 89 | 52 | 9 1 | 5 6 |
| 16 | Apr 16 22 | 12 6 | 2 | 35 7 | 25 0 | 87 | 60 | 8 9 | 5 2 |
| 17 | Apr 23 29 | 5 1 | 1 | 37 2 | 25 5 | 85 | 58 | 9 6 | 5 3 |
| 18 | Apr 30 May 6 | 110 0 | 4 | 35 4 | 24 5 | 89 | 61 | 7 6 | 4 5 |
| 19 | May 7 13 | 290 9 | 7 | 31 3 | 23 8 | 96 | 74 | 1 3 | 6 3 |
| 20 | May 14 20 | 23 2 | 3 | 33 0 | 24 3 | 92 | 64 | 6 8 | 4 1 |
| 21 | May 21 27 | 0 6 | | 33 8 | 23 8 | 87 | 61 | 8 8 | 4 6 |
| 22 | May 28 June 3 | 4 2 | | 34 5 | 23 7 | 91 | 63 | 8 1 | 4 7 |
| 23 | June 4 10 | 68 3 | 2 | 33 1 | 23 6 | 92 | 73 | 9 4 | 3 8 |
| 24 | June 11 17 | 294 4 | 7 | 30 1 | 22 5 | 96 | 85 | 0 8 | 3 0 |
| 25 | June 18 24 | 41 0 | 5 | 31 1 | 22 1 | 95 | 79 | 4 5 | 3 0 |
| 26 | June 25 July 1 | 167 1 | 6 | 30 9 | 23 9 | 94 | 85 | 3 1 | 3 7 |
| 27 | July 2 8 | 122 6 | 4 | 30 7 | 23 4 | 94 | 78 | 3 4 | 3 2 |
| 28 | July 9 15 | 160 3 | 7 | 28 9 | 23 0 | 96 | 86 | 1 2 | 2 6 |
| 29 | July 16 22 | 227 8 | 6 | 30 0 | 23 2 | 97 | 81 | 1 8 | 2 6 |
| 30 | July 23 29 | 209 0 | 6 | 29 8 | 23 1 | 96 | 79 | 2 3 | 3 1 |
| 31 | July 30 Aug 5 | 169 9 | 5 | 30 2 | 23 3 | 95 | 76 | 3 6 | 2 6 |
| 32 | Aug 6 12 | 40 8 | 5 | 31 3 | 24 1 | 93 | 73 | 4 6 | 3 5 |
| 33 | Aug 13 19 | 113 7 | 4 | 31 3 | 23 6 | 94 | 74 | 5 2 | 3 3 |
| 34 | Aug 20 26 | 109 8 | 6 | 31 0 | 24 2 | 94 | 80 | 3 7 | 2 8 |
| 35 | Aug 27 Sept 2 | 194 4 | 7 | 28 5 | 23 3 | 95 | 87 | 0 2 | 2 9 |

# RESPONSE OF *Piper longum* IN COCONUT GARDENS TO DIFFERENTIAL SPACING AND MANURIAL REGIMES

By

**N. SHEELA**

## ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree of

**Master of Science in Agriculture**

Faculty of Agriculture
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**1996**

# ABSTRACT

An experiment was conducted during 1994 95 in the KADP farm of the College of Horticulture Vellanikkara to evaluate the response of *Piper longum* as an intercrop in coconut gardens to differential spacing and manurial regimes The experiment was laid out in randomised block design with three replications The study revealed that plant height number of branches number of leaves and total dry matter increased with higher dose of organic manure and 30 30 60 NPK kg ha $^{1}$ The optimum spacing was found to be 50 x 50 cm The above treatment recorded the maximum number of spikes and total dry spike yield (449 kg ha $^{1}$)

The NPK content of spikes was more than vegetative parts The nitrogen content decreased as the crop grew but phosphorus content increased and potassium content remained more or less same The uptake of N P and K was highest in fertilizer applied plots The total alkaloid yield was highest in the treatment receiving 50 x 50 cm spacing 20 t ha $^{1}$ organic manure and 30 30 60 NPK kg ha $^{1}$

The organic and inorganic fertilizers and their combinations did not have any significant effect on the chemical properties of soil However the plots receiving inorganic fertilizers alone showed a reducing trend in available N P and K

Thippali cultivation involves high investment for planting material and maintenance and harvesting are also labour intensive The labour cost in Kerala is very high It is a crop which requires a periodical harvesting (maximum yield in July August and October November months) and care should be taken to harvest

only the mature spikes Thippali being a perennial crop no net return could be obtained in the first year of planting The yield level indicated that it should be a profitable crop from the second year of planting