CROP INTENSIFICATION AND RESOURCE MANAGEMENT IN BANANA BASED CROPPING SYSTEM

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DECLARATION

I hereby declare that this thesis entitled '**Crop intensification and resource management in banana based cropping system**' 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 of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled '**Crop intensification and resource management in banana based cropping system**' is a record of research work done independently by Mrs. Vandana Venugopal (2001-21-01) 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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Dedicated to

My Husband and Daughter

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LIST OF ABBREVIATIONS

%	–	Per cent
µmol	–	Micromol
ANOVA	–	Analysis of variance
BCR	–	Benefit-cost ratio
Ca	–	Calcium
CBR	–	Cost-benefit ratio
cv.	–	Cultivar
DAP	–	Days after planting
FIB	–	Farm Information Bureau
g	–	Gram
ha	–	Hectare
HDP	–	High Density Planting
K	–	Potassium
KAU	–	Kerala Agricultural University
kg	–	Kilogram
LAI	–	Leaf area index
m	–	Metre
MAP	–	Months after planting
mg	–	Milligram
Mg	–	Magnesium
N	–	Nitrogen
NHB	–	National Horticultural Board
P	–	Phosphorus
RDF	–	Recommended dose of fertilizers
RDN	–	Recommended dose of nutrients
Rs.	–	Rupees
SPB	–	State Planning Board
t	–	tonnes
TNAU	–	Tamil Nadu Agricultural University
TSS	–	Total soluble solids

Introduction

1. INTRODUCTION

Banana, known since antiquity, is an important fruit crop having great socio-economic significance in India. It supports the livelihood of millions of people. It is interwoven with the heritage of the nation and due to its multi-faceted uses it is referred to as 'Kalpatharu' (Plant of Virtues) meaning 'herb with all imaginable uses'. It can grow well under a wide range of agro climatic situations, ecological conditions and various systems of production. With a total annual production of 16.91 m t from 490.70 m ha area, banana contributes 37 per cent to the total fruit production in India (NHB, 2001).

To the Keralite, the term fruit is rather a synonym for banana. Banana is mostly grown by small and marginal farmers either in homesteads or in well drained rice fields. In Kerala, it is cultivated in an area of 0.04 m ha with an annual production of 0.33 m t (FIB, 2003).

Nendran is the most popular commercial cultivar in the State owing to its adaptability to varying environments, yield stability, excellent fruit quality attributes, sustained income and multiple uses ranging from that of a valued food for infants and invalids, to culinary and table purposes as well as diverse processed products.

Many small scale banana farmers are facing increasing difficulty in competing in a free market economy. Production and diversification alternatives for such growers have become clear needs. This emphasizes the need for evolving a new production technology for higher nutrient efficiencies and yields.

High density planting is such a novel technique which when judiciously planned in combination with other inputs at optimum level has broken the yield plateau in some horticultural crops. Moreover it contributes to the food and nutritional security of our ever increasing population

The basic principle of agricultural production is the efficient conversion of solar energy into food and other plant products. More the receipt of solar energy per unit area, greater will be the agricultural potential, provided sufficient water, nutrients and other inputs are available. Banana is cultivated widely in areas close to the equator, where the solar energy is abundant, and there the productivity largely depends upon the efficient utilization of this resource. Although banana is a crop belonging to the C_3 (Calvin Benson type) group of plants, it has shown tremendous potential to equal or out-yield many crop plants belonging to the C_4 group. Being adapted to grow under low light intensities (Samson, 1980), banana plants can withstand shade and hence are highly suitable for high density planting.

The conventional production practices followed in banana are highly labour and input intensive. Modified high density planting in banana is one of the approaches for reducing the cost of cultivation and increasing the productivity without affecting the quality of fruits. The spatial arrangement of plants in a plantation is very important and usually involves a choice between physiological efficiency and practical utility. Increasing spacing between pits and planting more than one sucker per pit will help to reduce the cost of cultivation and enable intercropping resulting in an enhancement of total returns. Selection of crops for intercropping and the geometry of planting should be designed in such a way that land, water and solar energy are being utilized to the maximum extent possible.

Inclusion of vegetables and medicinal plants along with modified planting geometry in banana is rather a relatively new concept yet to be explored. This practice ensures maximum utilization of the natural resources coupled with a simultaneous increase in horti-agricultural production. Selection of crops that can endure the partial shade of banana and can contribute to the income assumes much significance in banana cultivation.

Colocasia is one of the important edible aroids cultivated as an intercrop in banana fields. All parts of the crop are edible and rich in carbohydrates, proteins and minerals. The duration of the crop ranges from 6 to 7 months.

Cucumber is another profitable intercrop in banana based systems which can be harvested within 95 days.

Amaranthus, the most popular leafy vegetable of Kerala comes to harvest in 30 to 60 days. It is rich in protein, vitamin A, vitamin C and iron and hence is a supplier of valuable nutrients to the human diet. It can be grown throughout the year and is suitable as an intercrop of banana in its early growth stages.

Alpinia calcarata known as *Chittaratha* in Malayalam and *Kulainjan* in Hindi comes up well in the tropical climate. The economic part is the rhizome which is a major constituent of many formulations of indigenous systems of medicine for relieving throat inflammation, stimulating digestion, purifying blood and improving voice. The crop can be harvested in 18 months.

Banana is an exhaustive feeder of nutrients due to its rapid and vigorous growth and high productivity. Hence to ensure high yield of quality bananas, application of adequate dose of nutrients is of paramount importance. Nutrient application throughout the growth stages is important in realizing the economic yield in Nendran banana. Evidences available on the response of banana to nitrogen and potassium indicate that growth and productivity are affected if nutrients are not applied in optimum quantity (Murray, 1960; Osborne and Hewitt, 1963; Kohli *et al.*, 1984; Singh *et al.*, 1990). Competition for nutrients is one of the factors which result in reduced bunch weight under high density planting of banana. Hence there is a need for augmenting and optimizing the nutritional requirement of banana under high density planting. An integrated nutrient management practice combining organic and inorganic nutrient sources has to be followed to have good results.

Though banana pseudostem is a rich source of plant nutrients, its disposal after harvest creates great problem. The efficacy of incorporation of fresh crop residue (pseudostem) as such or as vermicompost needs to be evaluated. This practice helps to meet the organic manure requirement of the crop and also ensures sustainability by recycling of crop waste.

Proper management aims at providing appropriate support systems to facilitate optimum growth, yield and development process. Standardization of suitable management strategies to harness the efficient utilization of solar radiation and other resources aid to maximize production and quality at low level of competition in banana. In this context the specified objectives included in this study are listed as follows:

i) to study the effect of crop intensification on productivity enhancement through modified planting pattern in banana based cropping system

ii) to develop a fertilizer schedule for double sucker planted banana

iii) to assess the efficiency of recycling banana crop residues on the growth and yield of banana

iv) to work out the economics of double sucker planting pattern and intercropping

Review of Literature

2. REVIEW OF LITERATURE

The spatial arrangement of plants in a plantation is decided by a level where competition between plants is minimum, the total yield is maximum and quality is optimum. Thus the intensive system of Nendran banana cultivation common in the state of Kerala by farmers in their own field or on leased lands deserves our attention to test its feasibility on a commercial scale and to fix up the optimum plant density, right crop combination and fertilizer requirement. The important literature covering various aspects of the present study is briefly reviewed below:

2.1 HIGH DENSITY PLANTING (HDP) IN BANANA

High density planting has become the latest trend in Hi-tech horticulture. This has a lot of field applications owing to the continuing decline in the availability of cultivable land, rising energy and land costs (Singh *et al.*, 2002). HDP may be defined as a cropping system in which the highest number of plants belonging to one or more species of crops is accommodated within a unit area so as to obtain maximum output by optimum utilisation of land, solar radiation, water and nutrients from soil (Kurian and Iyer, 2002). The HDP has been successfully implemented in fruit crops such as apple (Awasthi and Mehta, 1993), mango (Ram, 1993), citrus (Goswami *et al.*, 1993) and banana (Reddy and Singh, 1993).

Choosing the correct planting density is very important for bridging the gap between the actual yield and potential yield of banana from a unit area. For the highest possible yield of good quality fruit there is an optimum plant density which should be maintained for sustaining the economic life of plantation (Sathiamoorthy and Mustaffa, 2001).

High density can be achieved in banana either due to decrease in spacing or increase in the number of suckers per pit or both. Modifying the planting systems by planting more suckers per pit with reduced fertilizer and irrigation could reduce the cost of cultivation. The optimum number varies with location, cultivar, soil fertility, management level and economic considerations (Reddy and Singh, 1993).

In most banana growing regions solar radiation is abundant and thus productivity largely depends on efficient utilization of this resource. HDP in banana thus provides high production and net returns facilitating efficient utilization of solar energy, water and nutrients (Apshara and Sathiamoorthy, 1999).

2.1.1 High Density Planting by Reduced Spacing

In India and abroad research work on planting densities generally with reduced spacing in banana has been attempted with varying success.

2.1.1.1 Effect of HDP by Reduced Spacing on Height of Plants

Chattopadhyay *et al.* (1980) noticed an increased height of banana plants 'Giant Governor' with increase in plant population both in plant and ratoon crops. Reddy (1982) found out that plant height in Robusta banana, was not influenced by plant population densities up to two MAP. However, significant difference in plant height was noticed from the fourth month onwards when plant height increased with increase in population density. At shooting plant height was maximum (270 cm) at 1.2 m x 1.2 m spacing and minimum (235 cm) at 2.1 m x 2.1 m spacing.

Mustaffa (1983) observed that the closer spacing (2.4 x 2.4 m) produced taller banana plants than the widely spaced ones (3 m x 3 m).

From the trials conducted at Banana Research Station, Kannara, Kerala (KAU, 1987) it was noticed that banana cv. Palayankodan planted at wider spacing recorded lesser height in the second ratoon. The closest spacing under square method (1.5 m x 1.5 m) recorded more height. In Nendran plant height at shooting was higher with closely spaced plants.

Plants at 1.2 m x 1.5 m spacing grew up to 4.04 m as against 3.75 m at 2 m x 2 m spacing. An increased pseudostem height in plants under HDP at flowering in bananas was noticed by Sathyanarayana and Rao (1985) and Daniells *et al.* (1987).

Rajeevan and Geetha (1989) carried out a study in Robusta at two planting densities (2.4 m x 1.8 m and 1 m x 1 m). The results showed that up to five months, plants at wider spacing as well as closer spacing showed no significant difference in their height. However at the time of flowering, the plants at closer spacing were significantly taller. From an experiment at College of Agriculture, Vellayani to standardize the spacing for tissue culture banana cv Nendran, Anil (1994), reported that plant height increased with decrease in spacing. However the plant height at1.75 m x 1.75 m was comparable with that of wider spacing. Krishnakumary *et al.* (1995) observed that different spacing adopted in Nendran did not show any significant difference in height in the third and fifth month of planting, though significant difference was observed at shooting stage. According to Baruah *et al.* (2002) the highest population of banana var. Malbhog recorded maximum height while the lowest plant population registered minimum height.

2.1.1.2 Effect of HDP by Reduced Spacing on Girth of Plants

Chattopadhyay *et al.* (1980) reported that increase in population decreased the girth of pseudostem of both plant and ratoon crops in Giant Governor banana.

Reddy (1982) noticed that different plant population densities in Robusta banana did not significantly affect the plant girth. However the growth was higher in plants with closer spacing (1.2 m x 1.2 m) than with wider spacing (2.1 m x 2.1 m).

From an experiment with Hill banana Mustaffa (1983) revealed that the plant girth increased significantly with wider spacing (3 m x 3 m) compared to closer spacing (2.4 m x 2.4 m). Similar observations on decrease in the girth of plants with increase in plant density were also made by Chattopadhyay *et al.* (1984).

The closest spacing in Palayankodan under square method recorded more girth (KAU, 1987). Rajeevan and Geetha (1989) found that Robusta plants at 2.4 m x 1.8 m were superior with respect to girth compared to those at 1 m x 1 m spacing at 5 months age. But at flowering, the plants did not show any significant differences in pseudostem girth. Anil (1994) observed variation in girth of tissue culture banana variety Nendran at different spacings at bunch emergence. At bunch emergence the girth of plants was found to be more in closer spacings. Krishnakumary *et al.* (1995) did not notice any significant difference in pseudostem girth at third, fifth and at shooting stage in banana cv. Nendran. The pseudostem girth was not significantly differed at all stages of growth except at 270 DAP in var. Malbhog (Baruah *et al.*, 2002).

2.1.1.3 Effect of HDP by Reduced Spacing on Leaf characters

The number of functional leaves per plant was not affected by the density up to seventh month, but it was influenced by spacing by the end of ninth month (Reddy, 1982). He also noticed that the number of functional leaves per plant decreased with increase in density of planting at flowering and there was a progressive and significant increase in LAI with increase in plant density.

Mustaffa (1983) reported that the number of leaves increased significantly with wider spacing and higher plant density reduced them.

From the studies in Basrai, Sathyanarayana (1985) found that closer spacing resulted in lesser number of leaves with reduced leaf area than in wider spacing. Rajeevan and Geetha (1989) reported similar results in Robusta. They recorded increased number of leaves (15.7) with widely spaced plants (2.4 m x 1.8 m) than those with closer spacing (11.3 leaves at 1 m x 1 m spacing).

Krishnakumary *et al.* (1995) observed no significant difference in leaf number at 3 MAP, 5 MAP and at shooting stage in banana cv. Nendran.

The functional leaf area decreased with increase in spacing during all stages except at harvest (Anil, 1994). He also noticed that LAI increased with increase in plant population density; the closest spacing recording the highest LAI at all stages of growth in tissue culture Nendran banana.

In an experiment on banana *Musa* Malbhog to study the effect of plant population on growth yield and quality of banana, the number of functional leaves at shooting was maximum in lower plant density and they showed a decreasing trend with increasing plant population (Baruah *et al.*, 2002).

2.1.1.4 Effect of HDP by Reduced Spacing on Time taken for flowering

Wider spacing resulted in earlier flowering as compared to closer spacing. Irizarry *et al.* (1978) noticed that banana spaced at 1.5 m x 1.5 m and 1.8 m x 1.8 m with one plant per hole flowered one month earlier than plants spaced at 1.2 m x 1.2 m.

Chattopadhyay *et al.* (1980) observed that larger plant population delayed shooting in both plant and ratoon crops. In plant crop the inflorescence appeared in 418 days after planting in closer spacing (2500 plants ha^{-1}) compared to 407 days in wider spacing (1125 plants ha^{-1}). In ratoon the values were 540 days and 516 days for closer spacing and wider spacing respectively.

Increase in the number of days for shooting with increase in population was also reported by Reddy (1982). He found that the number of days taken for shooting were maximum (382.4) in 1.2 m x 1.2 m spacing and minimum (336.1) in 2.1 m x 2.1 m spacing.

Rajeevan and Geetha (1989) observed that in Robusta banana, the duration for flowering was delayed significantly by reduced spacing. Plants at 1m x 1 m spacing took more time (292.2 days) for flowering as compared to that at 2.4 m x 1.8 m (236.8 days).

Anil (1994) recorded the shortest duration (233.3 days) for bunch emergence at the widest spacing (2.25 m x 2.25 m) and the duration (276.7 days) was highest at the closest spacing (1.25 m x 1.25 m) in tissue culture Nendran.

Krishnakumary *et al.* (1995) found that in Nendran, days to shooting were significantly delayed by reduction in spacing. Plants in the highest density (1.2 m x 1.5 m) took more time (271 days) for shooting as compared to plants grown under normal spacing (233 days at 2 m x 2 m).

2.1.1.5 Effect of HDP by Reduced Spacing on Crop Duration

Chundawat *et al.* (1983) reported more crop duration (605 days) at closer spacing (1.2 m x 1.2 m) compared to wider spacing (408 days at 1.8 m x 1.8 m) in Basrai banana.

Anil (1994) recorded shortest crop duration (326.1 days) in wider spacing (2.25 m x 2.25 m) and longest (376.1days) in closer spacing (1.25 m x 1.25 m) in tissue culture Nendran.

Krishnakumary *et al.* (1995) observed that days to shooting and consequently crop duration were significantly delayed in Nendran by reducing the spacing.

In another study with variety Rajapuri, Athani *et al.* (2002) noticed that closer spacing (1 m x 1.2 m x 2 m) resulted in maximum number of days for shooting and total crop duration than wider spacing (2.4 m x 2.4 m) both in plant and ratoon crops.

2.1.1.6 *Effect of HDP by Reduced Spacing on Bunch weight and Yield*

Several experiments revealed yield improvement in banana under HDP without any quality deterioration (Bhan and Majumdar, 1961; Chattopadhyay *et al.*, 1980; Jaramillo-de, 1984; Rajeevan and Geetha, 1989; Robinson and Nel, 1991; Chakrabarty *et al.*, 1992; Manivannan, 1994; Anil *et al.*, 1995; Krishnakumary *et al.*, 1995; Baruah *et al.*, 2002; Maharana, 2002; Athani *et al.*, 2002).

With an increase in plant density, reduction in bunch weight has been registered in many cultivars of banana var.Robusta (Reddy, 1982; Rajeevan and Geetha, 1989), Basrai (Chundawat *et.al.*, 1983) Giant Governor (Chattopadhyay *et al.*, 1984), Poovan (Sathyanarayana and Rao, 1985), Malbhog (Baruah *et al.*, 2002) and Rajapuri (Athani *et al.*, 2002).

Krishnakumary *et al.* (1995) reported that among the different spacings tried in Nendran, heaviest bunch weight was produced (11.38 kg) at normal spacing of 2 m x 2 m as against 7.26 kg plant^{-1} at closer spacing of 1.2 m x 1.5 m. Anil *et al.* (1995) noticed that though bunch weight decreased with decrease in spacing, the total yield on per hectare basis showed increase due to the more number of plants accommodated. In this experiment the bunch weight was minimum (6.05 kg plant^{-1}) for closer spacing (1.25 m x 1.25 m) compared to the wider spacing of 2.25 m x 2.25 m (9.5 kg plant^{-1}). However, the total yield was maximum (235.84 t ha^{-1}) at 1.25 m x 1.25 m and minimum (95 t ha^{-1}) at 2.25 m x 2.25 m in tissue culture Nendran banana.

2.1.1.7 *Effect of HDP by Reduced Spacing on Yield attributes*

Chattopadhyay *et al.* (1980 and 1984), Robinson and Nel (1986 and 1989), Rajeevan and Geetha (1989) and Krishnakumary *et al.* (1995) noted that the number of hands and fingers per bunch increased with increase in spacing. However, Reddy (1982) reported that varying plant spacing had no significant effect on number of hands and fingers per bunch.

Individual fruit weight, length and girth of finger increased significantly with increase in plant spacing (Chattopadhyay *et al.*, 1980 and 1984; Chundawat, 1983; Reddy, 1982; Mustaffa, 1983; Daniells *et al.*, 1987; Robinson and Nel, 1986 and 1989; Rajeevan and Geetha, 1989).

Chattopadhyay *et al.* (1980) and Reddy (1982) found that pulp/peel ratio decreased with increase in plant population.

2.1.1.8 Effect of HDP by Reduced Spacing on Quality of Fruits

Chattopadhyay *et al.* (1980) explained that the quality attributes like acidity, total soluble solids, total sugars and reducing sugars of banana fruits were not appreciably affected by plant population density. Reddy (1982) observed no effect on fruit quality in terms of TSS and sugar : acid ratio with varying plant population.

Irizzary *et al.* (1978), Chundawat (1983) and Morales and Rodriguez (1988) reported decrease in fruit quality with decrease in spacing. Anil *et al.* (1995) also noticed an increase in acidity and decrease in sugar content with decrease in spacing.

2.1.1.9 Effect of HDP by Reduced Spacing on Economics of Production

Reddy (1982) inferred from his experiment with Robusta banana that the cost of cultivation, gross income and net profit increased with increase in plant population. He concluded that net profit per unit area increased with increase in plant density and CBR increased with decrease in plant population density.

Rajeevan and Geetha (1989) worked out CBR in Robusta banana under two planting densities and it was 0.73 for normal spacing (2.4 m x 1.8 m) and 1.86 for high density planting (1 m x 1 m).

Anil *et. al.* (1994) reported that cost of cultivation increased with decrease in spacing and was the lowest in the widest spacing (2.25 m x 2.25 m) and highest in the closest spacing (1.25 m x1.25 m).The total income also increased with increase in plant population.Net profit per hectare of land increased at widest spacing and then decreased at closest spacing.

2.1.2 High Density Planting by Altering the Spacing and Accommodating more number of Suckers per Pit

Another way by which HDP could be achieved is by planting more than one sucker per pit. Studies on the effect of planting more than one sucker per pit in combination with variable planting distances are meagre. However, preliminary studies in this regard conducted earlier at Tamil Nadu showed encouraging results. Increasing the plant density by planting more number of suckers per pit has proved successful in increasing the yield without much quality deterioration (Belalcazar *et al.*, 1994).

2.1.2.1 Effect on Plant Height

The investigation on the effect of plant density (one sucker per hill, two suckers per hill and three suckers per hill) and spacing (2 m x 2 m, 2 m x 2.5 m and 2 m x 3 m) on growth and yield of plantain cv. Nendran (AAB) revealed that the increase in plant density significantly increased the pseudostem height. The pseudostem height was maximum (400.5 cm) at the densest treatment (2 m x 2 m with three suckers per hill) (Apshara *et al.*, 1999).

Nalina *et al.* (2000a) recorded that the pseudostem height of banana cv. Robusta during 3rd, 5th, 7th months and at shooting stage differed significantly with plant density. The treatments having four suckers per hill registered more plant height than those with one or three suckers per hill and planted at 1.8 m x 3.6 m and 3.6 m x 3.6 m. At shooting plant height was minimum (2.21 m) for the conventional planting (1.8 m x 3.6 m; one sucker/hill) as against a maximum of 2.82 m at 1.8 m x 3.6 m with four suckers per hill.

According to Hazarika and Mohan (2002) no significant variation was observed in plant height of banana cv. Jahaji with varying plant densities.

2.1.2.2 Effect on the Girth of Plants

Apshara *et al.* (2001) reported a decrease in pseudostem girth with increase in crop densities in 'Nendran'. The girth was 60.79 cm at 2 m x 2 m spacing with three suckers per hill (7500 plants) and the highest value of 64.06 was noticed at 2 m x 3 m with one sucker per hill (1666 plants).

Similar decrease in pseudostem girth with increase in the number of suckers per pit was also observed by Kumar and Nalina (2001). The girth was 0.85, 0.72 and 0.66 m with one, three and four suckers per pit respectively.

However, Hazarika and Mohan (2002) could not observe any significant variation in girth between high density planting and conventional planting.

2.1.2.3 Effect on Leaf Characters

Nalina *et al.* (2000a) noticed more number of leaves in all the HDP treatments in Robusta banana at all stages (3, 5, 7 MAP and at shooting). Leaf area measured at these stages also showed a similar trend. Treatments with four suckers per hill registered higher leaf number and more leaf area than three suckers per hill.

2.1.2.4 Effect on Time Taken to Flowering

Apshara and Sathiamoorthy (1999) observed a decrease in the number of days for shooting with decrease in the plant population of banana cv. Nendran. At 2 m x 2 m with three suckers per hill the time taken to flower was 301.65 days while it was only 229 days at 2 m x 3 m with one sucker per hill.

2.1.2.5 Effect on Crop Duration

Apshara *et al.* (2001) found that the planting density had marked effect on crop duration. The lowest population of 1666 plants ha^{-1} had a crop duration of 319.05 days while the treatment of 7500 plants ha^{-1}, the crop duration was 373.93 days.

Alagiamanavalan and Balakrishnan (1976) reported from their experiment with Robusta banana under different systems of planting (single and double planting) that the duration of the crop in the double planting was more (417 days) than in single sucker planting (395 days).

2.1.2.6 Effect on Bunch Weight and Yield

Alagiamanavalan and Balakrishnan (1976) in their study on planting systems in Robusta banana obtained reduction in individual bunch weight for double planting (18.98 kg $bunch^{-1}$) as against single planting (21.42 kg) at 2.4 x 1.8 m spacing.

Apshara and Sathiamoorthy (1999) observed a decrease in individual bunch weight with increase in plant population of banana var. Nendran. The bunch weight was the lowest in the highest planting density of three suckers per hill and the bunch weight ranged from 7.82 kg to 9.45 in different spacing. But the total yield (58.65 t ha^{-1}) was highest in the densest treatment (2 m x 2 m with three suckers per hill). Nalina (1999) noticed that though HDP reduced the individual bunch weight slightly it helped to enhance productivity per unit area. Similar results were observed by Robinson and Nel (1989), Manivannan (1994) and Mahalakshmi (2000).

2.1.2.7 HDP on Light Transmission

Nalina *et al.* (2000b) observed a lesser light transmission ratio in HDP than in normal Planting four suckers per hill recorded relatively reduced Light Transmission Ratio than three suckers per hill.

2.1.2.8 HDP on Quality Attributes

Multiple sucker planting technique had resulted in slight reduction in quality parameters (Apshara, 1997; Nalina, 1999 and Mahalakshmi, 2000). The TSS in Nendran was reported to be 25.7 per cent and 25.25 per cent under normal and high density planting respectively. Similarly for the var. Robusta the values observed were 21.21 and 19.15 per cent respectively.

To the contrary, Hazarika and Mohan (2002) reported that the quality attributes *viz*., TSS, total sugar and reducing sugars did not differ significantly with increase in plant density in banana cv. Jahaji.

2.12.9. HDP on Economics

Alagiamanavalan and Balakrishnan (1976) adopted a spacing of 2.4 m x 1.8 m for single and double system of planting in Roubusta banana. In double planting system, two suckers were planted in adjacent pits between rows spaced 30 cm apart. They pointed out that the net profit ha^{-1} was greater (Rs. 37, 740/-) than single planting (Rs. 20,920/-). However production cost was higher in double planting system. They have spent a production cost of Rs. 13,340 for double planting and Rs. 7900/- for single planting but the receipt was more for double planting (Rs. 51,080/-). Nalina (1999) reported that HDP in Robusta helped to increase productivity with higher CBR (1: 3.85 for 1.8 m x 3.6 m with three suckers per pit) as against 1: 2.75 for single sucker at 1.8 m x 1.8 m. Hazarika and Mohan (2002) obtained the highest benefit cost ratio where maximum plant population was accommodated per hectare.

2.2 RESPONSE OF BANANA TO FERTILIZER APPLICATION

Banana has been known as a plant with rapid growth rate and heavy consumption of nutrients. This makes manuring indispensable for the crop. It draws nutrients from a very limited soil depth because of its shallow root system. The effect of proper fertilization on banana are:

i. Increase of crop yield by improvement of bunch weight

ii. Reduction in crop duration

iii. Increasing the number of marketable good quality bunches per hectare

iv. Improvement in quality leads to high return to farmer

2.2.1 Nutrient Uptake of Banana

The uptake of major nutrients by a rainfed crop of banana cv. Palayankodan under different levels of nitrogen application was studied by Mathew (1980) .He found that potassium uptake did not show a corresponding increase with the levels of nitrogen applied.

Nambisan *et al.* (1980) worked out an uptake rate of Robusta banana producing 55 tonnes fruits ha^{-1} (325, 75, 1195 and 58 N, P, K and Ca kg ha^{-1} respectively).

The study conducted by Godefroy (1982) indicated that a banana crop yielding 40-60 tonnes of bunches ha^{-1} removed 80-120 kg N, 20-30 kg P, 240-360 kg K and 10-15 kg each of Ca and Mg. These results were conformed by the subsequent work of Mengel and Kirkby (1982).

Irizarry *et al.* (1982) studied the nutrient uptake at different growth stages in banana cv. Grand Naine. The uptake of N, P, K, Ca and Mg at harvest was estimated as 249, 21, 585, 147 and 60 kg ha^{-1} respectively.

Shanmughavelu *et al.* (1987) worked out the nutrient uptake by banana cv. Poovan yielding 35 t ha^{-1} and the values were 408, 35, 1285, 35 and 35 kg ha^{-1} for N, P, K, Ca and Mg respectively.

According to Chong *et al.* (1992) the nutrient uptake by banana with a population of 3000 plants was 448 kg ha^{-1} each for N and P, 1680 and 170 kg ha^{-1} for K and Mg respectively.

Banana require high amount of mineral nutrients for proper growth and production. A banana crop yielding 50 t ha^{-1} removed 320 kg N, 23 kg P_2O_5 and 925 kg K_2O every year (Kulasekaran, 1993). To maintain soil fertility and to permit continuous production these nutrients must be replenished every year through organic manures and mineral fertilizers.

The nutrient uptake by banana cv. Nendran in red loam soils of Vellayani was reported as 197-349 kg N; 60-86 kg P_2O_5 and 433-706 kg K_2O on per hectare basis (Anil, 1994).

2.2.2 Spacing on Nutrient Uptake of Banana

Randhawa *et. al.* (1973) reported that in Robusta banana 180g N,32g P_2O_5 and 225g K_2O $plant^{-1}year^{-1}$ gave a maximum fruit yield of 42-53t ha^{-1} when planted at a spacing of 2.4 m x1.8 m than further closer spacing

Patil *et. al.* (1978) in an experiment with Basrai found that when they were fertilized with 180 g N,180 g P_2O_5 and 180 g K_2O yielded 32.41 and79.93 t ha^{-1} at spacings 2m x2m and 1.2m x1.2m respectively.

Apshara (1997) while giving 25 and 50 percent extra doses for two and three suckers per hill planting respectively found the leaf nutrient concentration to be adequate.

2.2.3 Nutrient Management under HDP

Competition for nutrients is presumed as one of the factors for reduced bunch weight under HDP. Alagiamanavalan and Balakrishnan (1976) gave double the manurial doses for double sucker planting yet they obtained only reduced bunch weight suggesting that increased manurial dose might not be required for increased number of suckers per hill. On the other hand Irizarry *et al.* (1978) adopted same fertilizer level for single and double system of planting yet showed appreciable reduction in bunch weight and individual finger weight for double sucker planting.

Nalina (2000c) reported that in Robusta, yield attributing characters were not influenced with increase in nutrient level. Fifty per cent of recommended dose of nutrients was found to produce the maximum bunch yield. Fruit quality traits showed an improvement with increase in fertilizer levels. However, at 50 per cent recommended nutrient level the reduction in yield was not so marked to attain poor fruit qualities.

The experiments carried out by Apshara (1997) and Mahalakshmi (2000) had shown possibilities of decreasing fertilizer to a tune of 30 to 40 per cent concomitant with increased yield.

Valasalakumari *et al.* (2002) reported that crop geometry of 1.8 m x 3.6 m with two suckers per hill applied with 75 per cent of recommended dose of fertilizers was the best with respect to bunch weight, number of hands, number of fingers and compactness of bunch in plantain (*Musa* AAB Nendran).

Deshmukh and Badgujar (2002) recorded maximum bunch weight with 1.8 m x 3.6 m with three plants per hill at 75 per cent RDF of NK and maximum yield in 1.8 m x 1.8 m two plants per hill at 75 per cent RDF of NK through fertilization.

Kumar *et al.* (2002) reported that fertilization at 50 per cent additional to recommended dose of nutrients was superior for many of HDP systems.

2.2.4 Organic Manures

Considerable volume of scientific data is available to show that the produce obtained from organic farming is nutritionally superior with respect to taste, lustre and keeping quality. Sustained production strategies often involve judicious application of inorganic fertilizers with organic sources.

2.2.4.1 Response to Farmyard Manure

Lahav (1973) found that in banana application of FYM upto 80 t ha^{-1} $year^{-1}$ enhanced the growth, hastened flowering and shortened the flowering to harvest period and increased the bunch yield of banana by 33 per cent.

Application of 3.3 tonnes of cattle manure per acre every four months increased yield of banana cv. Embul from 6.2 t $acre^{-1}$ in untreated controls to 6.56 tonnes $acre^{-1}$ (Herath *et al.*, 1977).

A study conducted at the Kerala Agricultural University, Vellanikkara, Kerala revealed that the optimum proportion of organic to inorganic N for banana was 25 : 75 and the best source of organic manure was neem cake containing 5.2 per cent N (950 g $plant^{-1}$) followed by FYM containing 0.4 per cent N (12.5 kg $plant^{-1}$) (KAU, 1993). Similar results were reported by Prabhuram and Sathiamoorthy (1993) and Soorianathasundaram *et al.* (2001) with FYM.

Babu and Khanna (2002) studied the integrated effect of three levels of nutrients (50, 75 and 100 per cent of recommended dose of N, P and K) with or without FYM and Azolla (10 and 20 kg $plant^{-1}$ respectively) on productivity of banana and soil fertility. They found out that use of FYM was superior to biofertilizer with respect to growth and yield of banana and soil fertility.

Gomes *et al.* (1995) observed no significant difference in yield between the control and different sources and quantity of organic manure.

2.2.4.2 Response to Banana Pseudostem

Crop residues are important renewable organic resource and are readily available to farmers. Freshly added crop residues play a significant role in improving various physical conditions of the soil.

Incorporation of banana bunch stalk at the rate of 80 t ha^{-1} as mulch significantly increased soil potassium and resulted in the best yield response (Lassoudiere and Godefroy, 1971).

Bhattacharyya (1982) reported that the total nitrogen in leaf was increased by mulching with banana trash. For each tonne of fresh fruit harvested, one tonne of dry matter is added to the soil as trash. Nutrients from trash are washed into the soil solution from where they are reabsorbed by roots.

Koroky and Bhattacharyya (1991) found that organic mulches significantly increased the bunch weight and they could be profitably utilized for commercial banana production.

Retention of parent pseudostem added a huge biomass to the plantain and nutrients bound in the parent pseudostem. Keeping parent pseudostem intact not only produced highest bunch yield but also reduced 50 percent of the nutrient required for ratoon crop (Hasan *et al.*, 2002).

2.2.4.3 Response to Vermicompost

Vermicomposting means the use of earthworms for composting organic residues (Gaur and Sadasivam, 1993). It is a fast and safe waste disposal method which controls pathogenic organisms and eliminates unfavourable odours. The yield response of crops to fertilizer becomes more evident when they are applied in combination with vermicompost. The earthworm casts are higher in bacteria, organic matter, total and nitrate N available P and K (Brady, 1994; Gaur, 1982).

Use of vermicompost in combination with inorganic fertilizers resulted in early cropping owing to increased nutrient availability (Athani *et al.*, 1999) to banana cv. Rajapuri.

Ushakumari *et al.* (1997) recorded maximum bunch weight, number of hands bunch^{-1} and total number of fingers bunch^{-1} in banana cv. Njalipoovan when applied 10 kg vermicompost to supply the recommended dose of organic manure in addition to inorganic fertilizer@ 200 : 200 : 400 g NPK plant^{-1}. Field experiments were conducted to formulate an integrated nutrient management system for banana cv.

Nendran with treatment combinations of three organic fertilizers (Azospirillum, cowpea and vermicompost) and four rates of N (0, 95, 143 and 190 g plant^{-1}). Among the organic sources incorporation of cowpea as green manure and vermicompost resulted in the highest increase in bunch weight (Geetha and Nair, 2000).

2.3 INTERCROPPING

Intercropping refers to growing of two or more generally dissimilar crops simultaneously on the same piece of land, base crop necessarily in distinct row arrangement. The recommended optimum plant population of the base crop is suitably combined with an appropriate additional plant density of the associated crop and there is crop intensification in both time and space dimensions (Palaniappan and Sivaraman, 1996).

2.3.1 Intercropping in Banana

After planting or even as a ratoon crop there is a lag period of atleast four to five months before banana plants occupy full space and thus provides scope of taking atleast one intercrop (Chundawat, 1993).

Intercropping is advantageous from the point of view of economy of space, complete utilization of surplus nutrients, better utilization of solar energy, soil moisture reserve and increased gross return from unit area. At earlier stages of growth intercropping with vegetables like colocasia, yam, dioscorea, brinjal, chilli and okra are practiced in Kerala (Rao, 1974).

At the early stages of growth, radish, cauliflower, cabbage, spinach, chilli, brinjal, colocasia, yam, dioscorea, okra, basella, cucurbitaceous vegetables, marigold and tuberose can be grown as intercrops in banana plantation (Chattopadhyay, 1999).

2.3.1.1 Intercropping on Yield Characters

Devos and Wilson (1978) and Chundawat *et al.* (1984) found no yield reduction or delay in harvesting by intercropping banana. Devos and

Wilson (1978) reported that there was no significant decrease in yield of banana when intercropped with cocoyam, maize and cassava. Studies at TNAU revealed that intercropping banana with annual crops was remunerative (Ravikumar, 1980). Results of the studies on the banana based cropping system under rainfed conditions indicated that none of the intercrops tried namely cowpea, ginger, turmeric, tapioca, yam, dioscorea and colocasia reduced the vegetative growth and yield of banana (KAU, 1987). Mathew *et al.* (1987) reported that intercropping rainfed Palayankodan did not cause any yield reduction and had no favourable effect on yield of banana. In this study, it was noticed that the vegetative parameters were not influenced by the intercrops and hence the fruiting characters were also less likely to be influenced. Nayar and Suja (1996) reported no perceptible deleterious effects to intercropping banana cv.Nendran with Sree Keerthi (*Dioscorea alata*); Sree Priya (*D. rotundata* trailing type); Sree Dhanya (*D. rotundata* non trailing type) and Sree Latha (*D. esculenta*).

Akinyemi and Tijanieniola (2001) conducted a study to determine the optimum population densities of melon, maize and cassava intercropped with plantain and their effects on plantain in the intercropping system. The results showed that plantain at a spacing of 3 m x 2 m could be intercropped with melon population upto 20000 plants ha^{-1} without reduction in the yield of plantain. Intercropping maize and cassava reduced the bunch yield of plantain drastically. However a reasonable yield of both crops could be obtained by accommodating 5000 plants of cassava and 53000 plants of maize ha^{-1}.

Experiments carried out at Kannara, Kerala on intercropping banana with spices and medicinal plants showed that the growth and yield characters of banana were not influenced by the growing of turmeric, ginger, kacholam, plumbago and Indian arrowroot (KAU, 2002b).

The suitability of a wide range of crops as intercrops of banana was revealed from the studies conducted by Pushkaran *et al.* (1989).

Cucumber and amaranthus can be cultivated profitably with banana var. Nendran raised in September – October without affecting the yield of the base crop (KAU, 2002a).

2.3.1.2 Intercropping on Economics of Cultivation

Devos and Wilson (1979) and Chundawat *et al.* (1984) reported that the returns from the intercrops were not sufficiently high to compensate for the extra cost on the fertilizers and planting materials. However, Mathew *et al.* (1987) observed that the cost of cultivation of banana in intercropped plots (Cowpea, turmeric, ginger, tapioca, colocasia, yam and dioscorea) decreased since intercropping suppressed weed growth. The results suggested that intercropping of banana with turmeric or yam would prove profitable to the banana growers of Kerala under rainfed conditions.

The experiment conducted at Banana Research Station, Kannara revealed cucumber as the most economic intercrop of banana var.Nendran followed by colocasia and amaranthus (KAU, 1996). Intercropping dioscorea varieties, Sree Keerthi and Sree Priya with banana was very profitable in comparison to the sole cropping of banana (Nayar and Suja, 1996).

2.3.2 Role of Planting Pattern

Altering the orientation of planting rows keeping the total plant population constant is a viable method to increase net income by accommodating more intercrops. Paired row planting has been reported as superior for intercropping in banana (Nybe *et al.*, 1995).

Adopting high density of banana with more number of suckers per hill in single row planting with wider spacing enable intercropping with substantial reduction in cost of cultivation without affecting the quality of the produce (Valsalakumari *et al.*, 2002).

A scan of literature indicates that studies on standardization of optimum nutrient schedule and efficacy of intercropping under double sucker system of banana were meagre. In this context an investigation to assess the effect of planting pattern and intercrops on the growth and productivity of banana will be of more practical use. Moreover, standardization of optimum nutrient management schedule for paired planting of banana assumes great significance.

Materials and Methods

3. MATERIALS AND METHODS

The present investigation entitled "Crop intensification and resource management in banana based cropping system" was carried out in two consecutive cropping seasons of 2002-2003 and 2003-2004 as two separate experiments. The first experiment was aimed at making a critical comparison of double sucker planting with normal planting of banana var. Nendran grown under similar conditions. It also aimed at studying the feasibility of intercropping under the two planting patterns. The second experiment was undertaken to formulate an appropriate nutrient schedule for the double sucker planted banana. The experimental site, season and weather conditions, materials used and methods adopted for the study are detailed below.

3.1 EXPERIMENTAL SITE

3.1.1 Location

The field experiments were conducted in the reclaimed lowlands of the Instructional Farm attached to the College of Agriculture, Vellayani. Geographically the area is located at an altitude of 29 m above the mean sea level and at latitude of 8.5°N and longitude of 76.9°E longitude.

3.1.2 Soil

The soil of the experimental area was clay loam kaolin hypothermic family of Rhodic Haplustox. The physico-chemical characteristics of the experimental site are presented in Table 1.

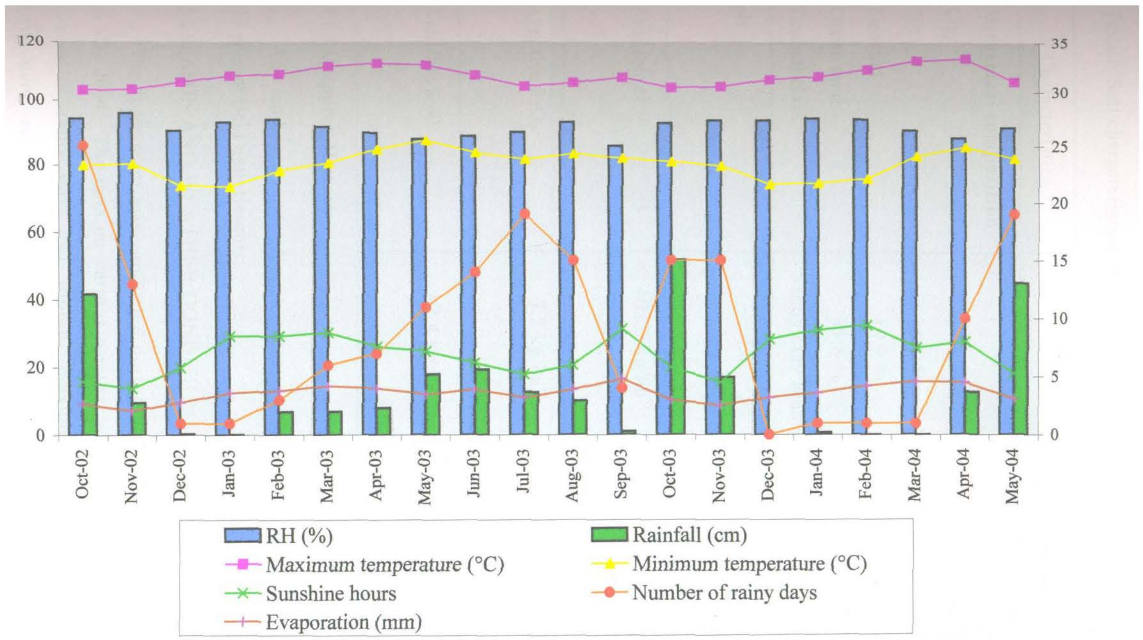


Fig. 1 Weather data during the cropping period

Table 1. Soil characteristics of the experimental field

Characteristics	Value	Method
Mechanical composition		
Clay	27.8 %	
Silt	21.4 %	International pipette method (Piper, 1967)
Finesand	19.2 %	
Coarse sand	31.6 %	
Textural class	Sandy clay loam	
pH	4.4	pH meter with glass electrode (Jackson, 1973)
Available N	103.5 kg ha^{-1}	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5	7.2 kg ha^{-1}	Bray's colorimetric method using ascorbic acid (Jackson, 1973)
Available K_2O	82.4 kg ha^{-1}	Neutral normal ammonium acetate method (Jackson, 1973)

3.1.3 Cropping History

The land was cropped with cassava prior to the commencement of the present field experiments.

3.2 SEASON AND WEATHER CONDITIONS

The experiment was conducted during the period from October 2002 to May 2004. The data on various weather parameters (monthly rainfall, number of rainy days per month, maximum temperature. minimum temperature, relative humidity, evaporation and sunshine) during the cropping period are presented in Figure 1 and in Appendix I.

Plate 1. General view of the experimental field

Plate 2. Normal planting pattern of banana

Plate 3. Modified planting pattern of banana

3.3 SEED MATERIAL AND CULTIVAR

The plantlets of the variety Nendran were obtained from the Biotechnology and Model Floriculture Centre, Kazhakkutam .To ensure maximum homogeneity in physiological maturity, tissue cultured plantlets of two and a half to three months old were used for planting the first crop. Selected suckers of first crop having uniform size and age were used for planting the second crop.

Seeds of cucumber and amaranthus, tubers of colocasia and slips of Chittaratha obtained from the Instructional Farm, College of Agriculture, Vellayani were used as the planting materials for the respective crops.

3.4 EXPERIMENTAL DESIGN AND LAYOUT

3.4.1 Experiment I

Layout plan of the experiment is presented in Figure.2.

The experiment was laid out in 2 x 4 Factorial Randomised Block Design with eight treatments and three replications. The plot size used was 12 m x 4 m

3.4.1.1 Treatments

1) Planting pattern

p_1 – Normal pattern with 2 m x 2 m spacing (2500 plants ha^{-1})

p_2 – Modified pattern with 3 m x 2 m spacing and planting two suckers per pit (3333 plants ha^{-1})

2) Intercrops

c_0 – No intercrop

c_1 – Vegetables- cucumber followed by amaranthus *i.e.*,(2 intercrops for one crop of banana)

c_2 – Tuber crop- colocasia (one intercrop for one crop of banana)

c_3 –Medicinal plant- chittaratha (one intercrop for two crops of banana)

Plate 4 Cucumber under normal system of banana

Plate 5 Cucumber under modified system of banana

Plate 6 Amaranthus under normal system of banana

Plate 7 Amaranthus under modified system of banana

Plate 8. Colocasia under normal system of banana

Plate 9. Colocasia under modified system of banana

Plate 10. Chittaratha under normal system of banana

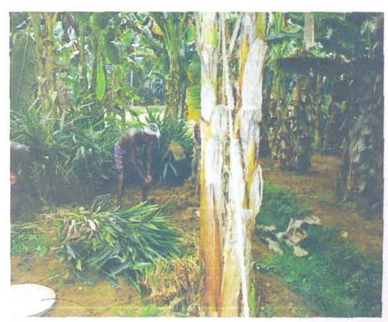


Plate 11. Harvest of chittaratha under modified system of banana

3.4.1.2 Treatment Combinations

$T_1 - p_1c_0$ – Normal planting + No intercrop

$T_2 - p_1c_1$ – Normal planting + Cucumber followed by Amaranthus

$T_3 - p_1c_2$ – Normal planting + Colocasia

$T_4 - p_1c_3$ – Normal planting + Chittaratha

$T_5 - p_2c_0$ – Modified planting + No intercrop

$T_6 - p_2c_1$ – Modified planting + Cucumber followed by Amaranthus

$T_7 - p_2c_2$ – Modified planting + Colocasia

$T_8 - p_2c_3$ – Modified planting + Chittaratha

Residues of the intercrops were recycled in the same plot after harvest. Management practices were followed as per the POP Recommendations, KAU (2002).

3.4.2 Experiment II

The layout of the experiment is presented in Figure.3.

The experiment was laid out in 3 x 3 Factorial Randomised Block Design with nine treatments and three replications. The plot size used was 6 m x 4 m. The suckers were planted with 3 m x 2 m spacing @ two suckers per pit.

3.4.2.1 Treatments

1) Levels of nutrients

f_1 : Recommended dose of nutrients (RDN-300 : 115 : 450 g NPK plant^{-1})

f_2 : f_1 + one-third additional dose (133 per cent of RDN)

f_3 : f_1 + two third additional dose (167 per cent of RDN)

2) Source of organic manure

o_1 : Control (FYM @ 15 kg pit^{-1})

o_2 : Banana residue after vermicomposting @ 5 kg pit^{-1}

o_3 : Banana residue fresh @ 20 kg pit^{-1}

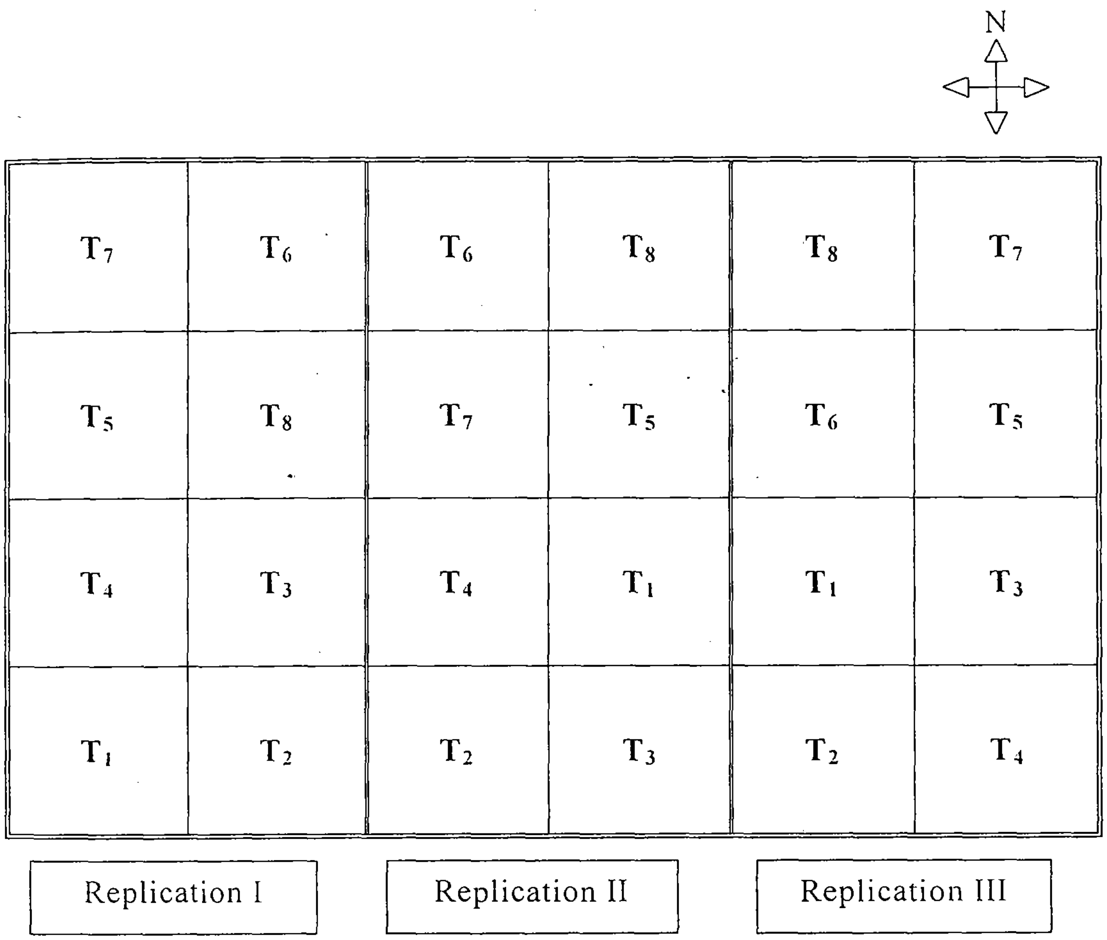
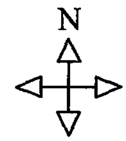


Fig. 2 Layout of the Experiment I



T_6	T_7	T_2
T_8	T_5	T_4
T_6	T_8	T_9
T_2	T_6	T_3
T_4	T_3	T_1
T_7	T_5	
T_3	T_2	
T_5	T_4	
T_9	T_1	
T_8	T_7	
T_1	T_9	

Treatment details

$T_1 - F_1O_1$
$T_2 - F_1O_2$
$T_3 - F_1O_3$
$T_4 - F_2O_1$
$T_5 - F_2O_2$
$T_6 - F_2O_3$
$T_7 - F_3O_1$
$T_8 - F_3O_2$
$T_9 - F_3O_3$

Replication I

Replication II

Replication III

Fig. 3 Layout of Experiment II

3.4.2.2 Treatment Combinations

T_1 – f_1o_1 – RDN + FYM @ 10 kg pit^{-1}

T_2 – f_1o_2 – RDN + VC @ 5 kg pit^{-1}

T_3 – f_1o_3 – RDN + BR @ 20 kg pit^{-1}

T_4 – f_2o_1 – RDN + $^1/_3$ additional dose + FYM @ 10 kg pit^{-1}

T_5 – f_2o_2 – RDN + $^1/_3$ additional dose + VC @ 5 kg pit^{-1}

T_6 – f_2o_3 – RDN + $^1/_3$ additional dose + BR @ 20 kg pit^{-1}

T_7 – f_3o_1 – RDN + $^2/_3$ additional dose + FYM @ 10 kg pit^{-1}

T_8 – f_3o_2 – RDN + $^2/_3$ additional dose + VC @ 5 kg pit^{-1}

T_6 – f_3o_3 – RDN + $^2/_3$ additional dose + BR @ 20 kg pit^{-1}

RDN – Recommended dose of nutrients 300 : 115 : 450 g plant^{-1} NPK

FYM – Farmyard manure

BR – Fresh banana residue

VC – Vermicomposted banana residue

In situ green manuring of banana with cowpea @ 4.3 kg pit^{-1} was followed uniformly for all treatments.

3.5. CULTIVATION PRACTICES OF MAINCROP

3.5.1 Field Preparation and Planting

For clearing weeds before planting Glyfos 41 percent SL @ 8 ml litre^{-1} was applied to the field. After two weeks, the land was ploughed twice, cleared of weeds and stubbles, clods broken and levelled. Pits of 50 cm x 50 cm x 50 cm were dug to accommodate one and two suckers as per the treatment schedule. In normal planting method single sucker was planted at the centre of the pit whereas in modified planting, two suckers were planted towards the sides of the pit at a spacing of 30 cm between plants.

3.5.2 Application of Organic and Inorganic Fertilizers

FYM @ 15 kg pit^{-1} were applied uniformly as basal for banana in Experiment I. Organic manure *viz.*, FYM @ 15 kg pit^{-1} fresh banana residue @ 20 kg pit^{-1} and vermicomposted banana residue @ 5 kg pit^{-1} were applied as basal as per the treatments and raked into the soil for Experiment II.

Urea (46 per cent N), Mussorie Rock Phosphate (22 per cent P_2O_5) and Muriate of Potash (60 per cent K_2O) were used as the sources of N, P and K respectively. As per the POP Recommendations of Kerala Agricultural University (2002) the fertilizers were applied in splits. Nitrogen and potassium were given in 6 splits (1,2,3,4,5 months after planting and at bunch emergence) and phosphorus in two splits (1 and 3 months after planting). In the experiment II, the quantity of nutrients varied according to the treatments.

3.5.3 Maintenance of the Crop

All the management practices as envisaged in the POP of KAU were carried out. Hand weeding and hoeing were resorted to as and when required for both the experiments. In experiment II, cowpea seeds @ 10-15 g pit^{-1} were sown uniformly in banana pits one week after planting and the green matter (approximately 4 kg pit^{-1}) produced was incorporated *in situ* at 50 per cent flowering. Periodic desuckering was followed upto the bunch emergence. During the dry period, banana was irrigated on alternate days with 40 litres of water per pit.

3.5.4 Plant Protection Measures

The major pest observed in the field was leaf-eating caterpillar. *Spodoptera* sp. that was effectively controlled by spraying Carbaryl 0.2

Plate 12. Propping in banana

Plate 13. *In situ* green manuring with cowpea in paired planting of banana

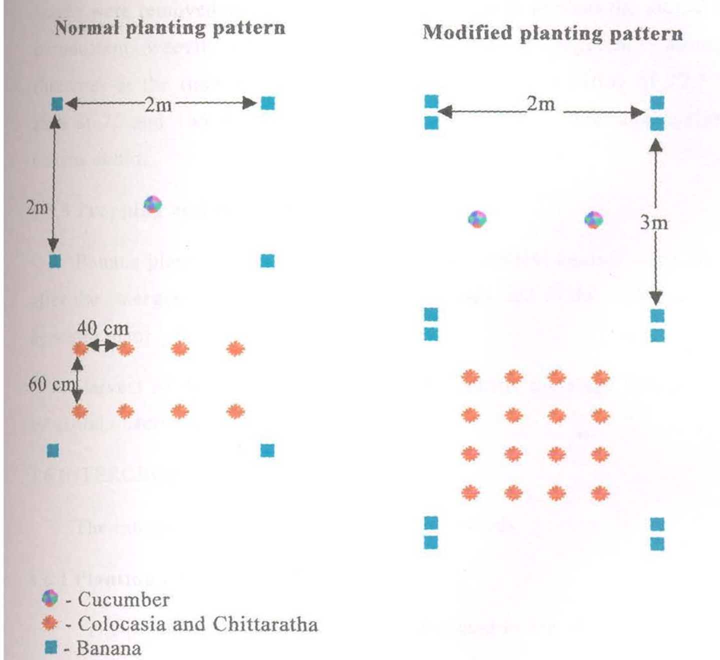


Fig. 4 Planting pattern of banana and intercrops

per cent at 3 MAP of first crop. During fourth and fifth months of planting Chlorpyriphos 0.03 per cent was applied along with Plantovit as a prophylatic measure against banana pseudostem weevil. Dried banana leaves were removed and the field was kept clean to prevent the attack of pseudostem weevil. Furadan 3G was applied @ 25gplant^{-1} around rhizomes at the time of planting followed by leaf axil filling of 12.5 g each at 75 and 165 days after planting as a preventive measure against banana aphid.

3.5.5 Propping and Harvesting

Banana plants were propped using rope to protect against wind soon after the emergence of the bunch. Each plant was tied to the sucker of the opposite plant.

Harvest of the bunches were done at maturity, the stage was judged by visual observations.

3.6 INTERCROPS

The interspaces were dug and cleared of weeds.

3.6.1 Planting pattern

The planting pattern of the field is depicted in Fig. 4.

Cucumber

In normal planting pattern single pit of size 60 cm diameter and 30 cm depth was taken at the centre of four banana plants whereas two pits of similar dimension were accommodated in double sucker planting. Two plants were trailed to opposite direction in each pit. Variety Mudicode Local was used for planting.

Amaranthus

After the harvest of cucumber, land was dug and residues of cucumber were incorporated. Raised beds of 1 m width and 2 m length were taken in between two rows of banana plants. Amaranthus seeds were broadcasted @ 1.5 kg ha^{-1} after two weeks. Amaranthus var. Arun was used for planting.

Colocasia and Chittaratha

Both were planted in ridges at 60 cm x 40 cm spacing such that four rows of four plants each were accommodated in each interspace under modified planting and two rows of four plants each under normal planting. Colocasia var. Thamarakannan was used for planting.

3.6.2 Manures and Fertilizers

Well rotten FYM was mixed with soil before planting for all crops as per Package of Practices Recommendations.

Urea, Mussorie Rock Phosphate and Muriate of Potash were given to all intercrops as per the recommendation for pure crop in Package of Practices Recommendations (KAU, 2002a).

3.6.3 Maintenance of the Crop

All management practices as envisaged in the POP were carried out .The crops were irrigated on alternate days.

3.6.4 Plant Protection Measures

Colocasia blight was controlled by applying Calixin @1 ml $litre^{-1}$.

For other crops incidence of any pest or disease were not noticed.

3.6.5 Harvest

Cucumber was harvested at maturity based on the visual observations (like change in colour, drying up of distal end of the vine attached to fruit etc.)

Amaranthus was uprooted at maximum vegetative growth stage (30 – 45 days).

Harvesting is done by digging for both colocasia and Chittaratha. The mother corms and side tubers /cormels were separated after harvest for colocasia. The rhizomes of Chittaratha were individually separated and washed to remove the soil. Rhizomes were dried in shade.

Planting pattern of banana and intercrops under modified and normal system were depicted in Figure.4.

3.7 BIOMETRIC OBSERVATIONS ON BANANA

3.7.1 Height of the Pseudostem

The height of pseudostem was measured from the base of the plant to the axil of the youngest leaf at bimonthly intervals upto bunch emergence and recorded in centimetres.

3.7.2 Girth of the Pseudostem

The girth of the pseudostem at 10 cm height above the ground level was measured using a flexible measuring tape at bimonthly intervals upto bunch emergence and recorded in centimetres.

3.7.3 Number of Functional Leaves

The total number of fully opened functional leaves retained by the plant at bimonthly intervals and at harvest were recorded.

3.7.4 Total Functional Leaf Area (m^2)

Leaf area was calculated using the equation developed by Murray (1960) at bimonthly intervals and at harvest.

Leaf area of index leaf = Length of lamina × Width of lamina × a constant (0.8)

Total functional leaf area = Number of functional leaves x Leaf area of index leaf

The third fully opened leaf from the apex is taken as the index leaf. The length of lamina was measured from the base of the leaf to the tip and width at the broadest part of the lamina.

3.7.5 Leaf Area Index

Leaf are index was calculated at bimonthly intervals and at harvest by the formula

$$\text{Leaf area index} = \frac{\text{Total functional leaf area}}{\text{Land area occupied by the crop}}$$

3.7.6 Crop Duration

Number of days taken from planting to shooting and from planting to harvest was recorded.

3.7.7 Bunch Characters

Bunches were harvested when fully mature as indicated by the disappearance of angles from fingers (Stover and Simmonds, 1987). The following observations were made on the bunch characters.

3.7.7.1 Weight of the Bunch

Weight of the bunch including the portion of the peduncle upto the first scar (exposed outside the plant) was recorded in kilograms and total bunch yield was worked out in t ha^{-1}.

3.7.7.2 Number of Hands per Bunch

The number of hands in each bunch was noted from the observational plants and their mean was recorded.

3.7.7.3 Number of Fingers per Bunch

The total number of fingers in each bunch in the observational plants was counted and the mean values were recorded.

3.7.7.4 Number of Fingers in the D Hand

The second hand from the top of the bunch is regarded as D hand. The number of fingers in the D hand was recorded.

3.7.8 Finger Characters (Mature)

The middle finger in the top row of the second hand (from the base of the bunch) was designated as the representative finger or index finger or D finger for studying the fruit characters (Gottriech *et al.*, 1964).

3.7.8.1 Weight of the Finger

The weight of the index finger was taken as the mean finger weight and expressed in grams.

3.7.8.2 Length of Finger

Length of fruit was measured from the tip of the finger to the point of attachment of the peduncle using a fine thread and scale and expressed in cm.

3.7.8.3 Girth of Finger

Girth of the finger was measured at the middle portion of the fruit using a fine thread and scale and expressed in cm.

3.7.8.4 Pulp-Peel Ratio

The weight of pulp and peel of ripe fruits were recorded separately and the ratio worked out.

3.7.9 Shelf Life

The number of days taken from harvest of the fruit to the development of black spots on the peel was recorded to determine the shelf life of the fruit at room temperature (Stover and Simmonds, 1987).

3.7.10 Quality Characters of Ripe Fruit

The fully ripe index finger selected for recording the observations was used for quality analysis. Known weight of samples taken from three portions *viz.*, top, middle and bottom of the sample fruit were macerated in a blender and made upto a known volume. Aliquots taken from these samples were used for the quality analysis of the fruit.

3.7.10.1 Total Soluble Solids

TSS was determined using a hand refractometer and expressed in per cent (Ranganna, 1977).

3.7.10.2 Acidity

Acidity was measured using titration method suggested by Ranganna (1977) and is expressed as percentage.

3.7.10.3 Total Sugars

Total sugar content was determined as per the method described by Ranganna (1977). The results were expressed as per cent on fresh weight basis.

3.7.10.4 Reducing sugars

Reducing sugar of the samples were determined as per the method suggested by Ranganna (1977) as per cent on fresh weight basis.

3.7.10.5 Non-reducing Sugars

Non-reducing sugar was computed using the following formula (Ranganna, 1977).

Non-reducing sugars = Total sugars – Reducing sugars

3.7.10.6 Sugar - Acid ratio

Sugar-acid ratio was arrived at by dividing the value for total sugars with the value for titrable acidity of the corresponding sample.

3.7.10.7 Ascorbic acid

Ascorbic acid was estimated as per the method developed by Ranganna (1977) and expressed in mg 100 g^{-1} of the fruit.

3.7.10.8 Total dry matter production

Fresh weight of all the plant parts of banana at harvest was recorded. Sample of leaves, pseudostem, fruit and rhizome were dried separately in oven at $70 \pm 5^{0}C$ till constant weight and dry weight expressed in tha^{-1}.

3.8 OBSERVATIONS ON CUCUMBER

3.8.1 Number of Fruits Harvested per Plant

The number of fruits harvested from all the plants in the net plot was counted and average worked out for a plant.

3.8.2 Length of Fruit

The length of all the fruits harvested from each observational plant was recorded in centimeters and the mean length worked out.

3.8.3 Girth of Fruit

The girth at the centre of each fruit harvested from the observational plant was recorded and the mean girth of the fruit calculated.

3.8.4 Weight of Fruit

The weight of all the fruits harvested from the observational plants were recorded in kilograms and the mean weight worked out.

3.8.5 Fruit Yield

Weight of the individual fruits from the various harvests of each plot was added at the end of the cropping period and the average yield was worked out.

3.8.6 Biomass Yield

Weight of the vines of all the observational plants in each plot was recorded after the final harvest of fruits and converted into biomass yield per hectare.

3.8.7 Dry Matter Partitioning

Leaves, stem and roots of observational plants were dried separately in oven at 70 ± 5°C till constant weight and expressed in percentage.

3.8.8 Root Studies at Harvest

Root studies were undertaken at the final harvest of the crop. Trenches were dug all around the plant and soil was removed by using water spray. The root system was carefully uprooted and washed. Root studies such as root depth, root spread fresh and dry weight of the root as well as root dry matter were recorded.

The depth upto which the main-root has penetrated was measured from the base of the plant to the tip of the root and expressed in centimeters.

The soil around the semicircular hemisphere of plant was slowly exposed and spread of the main roots was measured ignoring small rootlets.

3.9 OBSERVATIONS ON AMARANTHUS

3.9.1 Height of the Plant at Harvest

The height of the plants was measured from the ground level to the top most leaf bud from four observational plants and the mean expressed in cm.

3.9.2 Number of Harvests

Number of economic harvests possible for each treatment was recorded.

3.9.3 Yield per Harvest

Total weight of leaf and stem portion 10 cm above the ground were recorded for each plot and expressed in kg ha^{-1}.

3.9.4 Total Yield

The sum of yield from various harvests of each plot at the end of cropping period was obtained and the mean worked out in t ha^{-1}.

3.9.5 Biomass Yield

Total fresh weight of the plant was recorded at each harvest and the biomass yield was worked out.

3.9.6 Dry Matter Partitioning

Leaves, stem and roots of observational plants were dried separately in oven at 70 ± 5°C till two constant weight was obtained. The weight was averaged and expressed in percentage.

3.9.7 Root Studies at Harvest

Root masses of observational plants were carefully separated from soil at harvest stage. They were washed with clean water and oven dried to constant weight at 70 ± 5°C. From the data mean root dry weight was worked out and expressed as gram per plant.

Root depth and spread were worked out as in the case of cucumber.

3.10 OBSERVATIONS ON COLOCASIA

3.10.1 Number of Leaves at Harvest

Number of functional leaves from the observational plants were counted at harvest and their mean was worked out.

3.10.2 Number of Cormels per Plant

The cormels were separated from the observational plants and counted. From the data the mean was computed.

3.10.3 Weight of the Cormel

The weight of five randomly selected cormels from the observational plants were noted in grams and their mean calculated

3.10.4 Cormel Yield

The yield of the cormel obtained from the net area was recorded and expressed as t ha^{-1}.

3.10.5 Corm Yield

The yield of corm obtained from the net area was recorded and expressed as t ha^{-1}.

3.10.6 Cormel to Corm Ratio

The ratio of cormel yield to corm yield was calculated to obtain cormel to corm ratio in each treatment.

3.10.7 Biomass Yield

The yield of the vegetative parts at harvest was recorded from the net area and expressed as t ha^{-1}.

3.10.8 Dry matter Partitioning

Leaves, stem, petioles, corms and cormels of uprooted plants were separated and dried to constant weight at 70 ± 5°C in a hot air oven and expressed as percentage.

3.10.9 Root Studies at Harvest

Root depth, root spread and root dry matter was worked out immediately after the harvest of the crop as in the previous cases.

3.11 OBSERVATIONS ON CHITTARATHA

3.11.1 Height of the Plant at Harvest

Height of four observational plants from each plot was measured at harvest. The highest was measured from the ground level to the growing leaf bud. Mean plant height per plot was worked out and expressed in cm.

3.11.2 Yield of the Fresh Rhizome

The weight of rhizome from each net plot was converted to rhizome yield in t ha^{-1}.

3.11.3 Biomass Yield

The fresh weight of shoot portion from the net plot was recorded at harvest and expressed in t ha^{-1}.

3.11.4 Dry matter Partitioning

Samples of leaves, stem, root and rhizome were dried in a hot air oven at a temperature of 70 ± 5°C to constant dry weights. The dry weights were expressed in percentage.

3.11.5 Root Studies at Harvest

The root dry matter, root depth and root spread were studied as in the previous cases.

3.12 PLANT ANALYSIS

3.12.1 Nutrient Content and Uptake at Harvest – Experiment I and II

The plant samples were analysed for nitrogen, phosphorus and potassium content. The plant was separated into rhizome, pseudostem, leaves and fruits. There were chopped and dried separately in hot air oven at 70 ± 5°C till constant weights were obtained. The required quantity of powdered samples were then weighed out accurately and analysed. The methods adopted for the chemical analysis are given in Table.

Uptake of nutrients by each plant part at harvest was calculated from the values of dry matter production and percent nutrient content of each plant part and expressed as kg ha^{-1}.

3.12.2 Nutrient Content in Index Leaf at Bimonthly Intervals

For Experiment II, in addition to the above observations, the nutrient content of the third leaf was also estimated as per the methods cited in Table 2 at bimonthly intervals.

Table 2. Methods adopted for nutrient analysis of soil and plant

Estimated character	Method adopted	Reference
Soil		
Available N	Alkaline permanganate method	Subbiah&Asija, 1956
Available P_2O_5	Bray colorimetric method	Jackson, 1973
Available K_2O	Ammonium acetate method	Jackson, 1973
Plant		
Total N	Modified microkjeldhal method	Jackson, 1973
Total P	Vanadomolybdo phosphoric yellow colour method and read in spectro photometer at wavelength 470nm	Jackson, 1973
Total K	Flame photometric method in Systronics Flame photometer	Piper, 1967

3.13 SOIL ANALYSIS

3.13.1 Water Holding Capacity

Soil samples were collected from undisturbed top soil at 0 – 15 cm depth using a core sampler and WHC is determined as described by Gupta and Dakshinamoorthy (1980).

$$\text{Water holding capacity} = \frac{\text{Weight of water in soil}}{\text{Dry weight of soil}} \times Db \times 100$$

D_b = Bulk density (g cc^{-1})

3.13.2 Nutrient Analysis

Soil samples were collected from the experimental area before and after the investigation (Mohan and Rao, 1985). The composite sample drawn from the area before experiment was air-dried, powdered, sieved through 2 mm sieve and analysed for nitrogen, phosphorus and potassium as per methods mentioned in Table 2. After the experiment the soil samples were collected from individual plots.

3.13.3 Moisture Analysis

The soil moisture status was found out at monthly intervals by taking soil samples from the root zone of the crop at 15 cm depth. The percentage of moisture was estimated gravimetrically and expressed on dry weight basis.

3.14 PHYSIOLOGICAL OBSERVATIONS

Leaf temperature, total light interception (PAR 400-700 nm) and stomatal conductance were obtained using a Δ T porometer (Delta T Devices Cambridge-UK). The third fully opened leaf from the top was taken as the index leaf for this purpose.

3.15 ECONOMIC ANALYSIS

The total income, net income and the benefit: cost ratio (BCR) of various treatments was worked out considering cultivation and the income derived from each treatment. The norms and rates prevalent at Instructional Farm, College of Agriculture, Vellayani were followed for the estimation.

$$BCR = \frac{\text{Net income}}{\text{Total expenditure}}$$

3.16 INCIDENCE OF MAJOR PESTS AND DISEASES

The various pests and diseases observed in the field during the course of experimentation were recorded.

3.17 STATISTICAL ANALYSIS

The experimental data were analysed statistically by applying the techniques of analysis of variance as per the layout of the experiment (Panse and Sukhatme, 1985). The details of ANOVA are given below.

Experiment I			**Experiment II**		
Replication	–	2	Replication	–	2
Treatments	–	7	Treatments	–	8
P	–	1	F	–	2
C	–	3	O	–	2
PC	–	3	OF	–	4
Error	–	14	Error	–	16

Observations recorded for pseudostem height and girth at different growth stages for both experiments were correlated, the analysis of data were done in split plot fashion taking months after planting as subplot.

Experiment I			**Experiment II**		
Replication	–	2	Replication	–	2
Treatments	–	7	Treatments	–	8
P	–	1	F	–	2
C	–	3	O	–	2
PC	–	3	OF	–	4
Error (1)	–	14	Error (1)	–	16
Months after planting (M)	–	2	Months after planting (M)	–	2
PM	–	2	FM	–	4
CM	–	6	OM	–	4
PCM	–	6	FOM	–	8
Error (2)	–	32	Error (2)	–	36

Pooled analysis of yield and net income was done.

Results

4. RESULTS

Experiments were conducted at the Instructional Farm attached to the College of Agriculture, Vellayani during 2002-2003 and 2003-2004 to study the effect of crop intensification and resource management on the productivity enhancement in banana and to develop a fertilizer schedule for double sucker planted banana system. The experimental data collected were analysed statistically and the results are presented below.

4.1 EXPERIMENT I - EFFECT OF PLANTING PATTERN AND INTERCROP ON THE GROWTH AND PRODUCTIVITY OF BANANA

4.1.1 Banana – First Year

4.1.1.1 Height of the Pseudostem (cm)

The pseudostem height at 2, 4 and 6 MAP as influenced by planting pattern and intercrops are presented in Table 3.

Modified planting pattern resulted in a significant increase in plant height during initial stages of growth. However, at 6 MAP, no significant difference was observed in plant height. Growing intercrops did not influence the height of the pseudostem.

4.1.1.2 Girth of the Pseudostem (cm)

Pseudostem girth as influenced by planting pattern and intercrops at 2, 4 and 6 MAP are presented in Table 4.

Significant increase in girth of pseudostem was noticed at 2 MAP and 4 MAP under modified planting system. However during later stages significant increase in girth was registered with normal system of planting (65.43 cm).

Table 3 Effect of planting pattern and intercrops on the pseudostem height (cm) of banana (first crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Planting pattern			
p_1	37.88	165.50	326.75
p_2	52.77	196.21	332.17
Intercrops			
c_0	45.33	191.17	327.50
c_1	49.68	177.83	330.00
c_2	42.33	176.58	326.83
c_3	43.93	177.83	333.50
Interaction			
p_1c_0	46.50	185.00	332.67
p_1c_1	47.17	159.30	324.67
p_1c_2	32.50	164.00	322.33
p_1c_3	31.33	153.67	327.33
p_2c_0	44.17	197.33	322.33
p_2c_1	58.20	196.33	335.33
p_2c_2	52.17	189.17	331.33
p_2c_3	56.53	202.00	339.67

Effect	F value	SEm	CD
P	$F_{1,14} = 11.88^{**}$	3.489	10.583
C	$F_{3,14} = 0.26^{ns}$	4.934	-
PC	$F_{3,14} = 1.54^{ns}$	6.977	-
MAP (M)	$F_{2,32} = 3153.14^{**}$	2.531	7.302
M x P	$F_{2,32} = 6.37^{**}$	3.579	10.326
M x C	$F_{6,32} = 0.93^{ns}$	5.062	-
M x P x C	$F_{6,32} = 0.22^{ns}$	7.159	-

ns – not significant, **Significant at 1 per cent level

Table 4 Effect of planting pattern and intercrops on the pseudostem girth (cm) of banana (first crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Planting pattern			
p_1	11.54	43.07	65.43
p_2	14.67	46.06	62.39
Intercrops			
c_0	13.97	46.17	63.07
c_1	13.43	43.97	63.85
c_2	12.38	44.52	63.68
c_3	12.63	43.60	65.05
Interaction			
p_1c_0	13.67	46.60	66.20
p_1c_1	12.33	43.00	63.77
p_1c_2	10.33	42.33	64.93
p_1c_3	9.83	40.33	66.83
p_2c_0	14.27	45.73	59.93
p_2c_1	14.53	44.93	63.93
p_2c_2	14.43	46.70	62.43
p_2c_3	15.43	46.87	63.27

Effect	F value	SEm	CD
P	$F_{1,14} = 1.44^{ns}$	0.604	-
C	$F_{3,14} = 0.19^{ns}$	0.854	-
PC	$F_{3,14} = 1.68^{ns}$	1.208	-
MAP (M)	$F_{2,32} = 2537.43^{**}$	0.509	1.469
M x P	$F_{2,32} = 11.97^{*}$	0.720	2.077
M x C	$F_{6,32} = 1.01^{ns}$	1.018	-
M x P x C	$F_{6,32} = 0.88^{ns}$	1.440	-

ns – not significant. *Significant at 5 per cent level . **Significant at 1 per cent level

4.1.1.3 Number of Functional Leaves at 2, 4, 6 MAP and at Harvest

The number of functional leaves influenced by planting pattern and intercrops at 2, 4, 6 MAP and at harvest are depicted in Table 5.

The intercrops and its interaction with planting pattern had no significant influence on number of functional leaves at different observations. However the main effect of planting pattern at 2 MAP resulted in a significant influence in the number of functional leaves. Under modified system of planting, banana produced more leaves (8.33) compared to normal system (6.63).

4.1.1.4 Total Functional Leaf Area at 2, 4, 6 MAP and at Harvest (m^2)

Total functional leaf area at 2, 4, 6 MAP and at harvest are presented in Table 6.

The effect of intercrops and its interaction with planting pattern were non significant at all stages of observation. Planting pattern registered significant variation in leaf area at 2 and 4 MAP. Leaf area was higher for modified planting system of banana (0.52 m^2 and 8.22 m^2) compared to normal system (0.25 and 6.77 m^2).

4.1.1.5 Leaf Area Index

The leaf area index at 2, 4, 6 MAP and at harvest as influenced by planting pattern and intercrops are furnished in Table 7.

Leaf area index varied significantly with planting pattern at all stages of observation except during 6 MAP. Maximum leaf area index was observed under modified system of planting at 2 and 4 MAP and at harvest while no significant difference was seen at 6 MAP.

The effect of intercrop and its interaction with planting pattern was observed to be insignificant.

Table 5 Effect of planting pattern and intercrops on the number of functional leaves of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	6.63	11.71	10.96	5.33
p_2	8.33	11.34	10.61	6.15
$F_{1,14}$	2.95**	1.59^{ns}	0.79^{ns}	4.05^{ns}
SEm	0.257	0.206	0.278	0.287
CD	0.778	-	-	-
Intercrops				
c_0	7.77	12.18	10.23	5.50
c_1	7.90	11.10	10.99	5.67
c_2	6.97	11.27	11.23	5.83
c_3	7.27	11.55	10.68	5.97
$F_{3,14}$	1.44^{ns}	2.68^{ns}	1.20^{ns}	0.25^{ns}
SEm	0.363	0.291	0.393	0.406
Interaction				
p_1c_0	7.50	12.50	10.33	5.67
p_1c_1	6.67	11.33	11.00	5.33
p_1c_2	6.00	11.50	11.33	5.00
p_1c_3	6.33	11.50	11.17	5.33
p_2c_0	8.03	11.87	10.13	5.33
p_2c_1	9.13	10.87	10.97	6.00
p_2c_2	7.93	11.03	11.13	6.67
p_2c_3	8.20	1.60	10.20	6.00
$F_{3,14}$	1.29^{ns}	0.30^{ns}	0.28^{ns}	1.15^{ns}
SEm	0.513	0.412	0.556	0.574

ns – not significant
**Significant at 1 per cent level

Table 6 Effect of planting pattern and intercrops on total functional leaf area (m^2) of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	0.25	6.77	10.22	4.96
p_2	0.52	8.22	9.13	5.36
$F_{1,14}$	25.06**	7.19*	1.47^{ns}	0.44^{ns}
SEm	3.884	0.384	0.636	0.419
CD	0.117	1.165	-	-
Intercrops				
c_0	0.39	8.59	9.25	5.02
c_1	0.44	6.95	9.08	4.72
c_2	0.33	7.10	9.29	4.72
c_3	0.38	7.37	11.08	6.18
$F_{3,14}$	0.66^{ns}	1.90^{ns}	1.09^{ns}	1.37^{ns}
SEm	5.493	0.543	0.900	0.593
Interaction				
p_1c_0	0.38	8.62	9.34	5.15
p_1c_1	0.27	6.29	9.17	4.34
p_1c_2	0.17	6.41	1.50	4.64
p_1c_3	0.17	5.74	11.85	5.72
p_2c_0	0.40	8.56	9.17	4.89
p_2c_1	0.61	7.62	8.99	5.10
p_2c_2	0.49	7.78	8.06	4.80
p_2c_3	0.59	8.94	10.30	6.65
$F_{3,14}$	2.53^{ns}	1.51^{ns}	0.39^{ns}	0.22^{ns}
SEm	7.769	0.768	1.273	0.838

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 7 Effect of planting pattern and intercrops on the leaf area index (LAI) of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	0.06	1.69	2.56	1.24
p_2	0.18	2.75	3.04	1.78
$F_{1,14}$	41.96**	39.95**	3.72^{ns}	9.74**
SEm	0.012	0.118	0.148	0.124
CD	0.037	0.357	-	0.375
Intercrops				
c_0	0.12	2.51	2.70	1.46
c_1	0.14	2.06	2.65	1.40
c_2	0.11	2.10	2.66	1.38
c_3	0.12	2.21	3.20	1.83
$F_{3,14}$	0.65^{ns}	1.49^{ns}	1.12^{ns}	1.43^{ns}
SEm	0.017	0.167	0.252	0.175
Interaction				
p_1c_0	0.10	2.16	2.34	1.29
p_1c_1	0.17	1.57	2.29	1.09
p_1c_2	0.14	1.60	2.64	1.16
p_1c_3	0.14	1.44	2.97	1.43
p_2c_0	0.13	2.86	3.05	1.63
p_2c_1	0.21	2.54	3.00	1.71
p_2c_2	0.17	2.59	2.68	1.60
p_2c_3	0.19	2.98	3.43	2.22
$F_{3,14}$	2.38^{ns}	1.11^{ns}	0.38^{ns}	0.33^{ns}
SEm	0.024	0.235	0.357	0.247

ns – not significant
**Significant at 1 per cent level

4.1.1.6 Propping Requirement

The requirement for propping was uniform for all treatments. Propping was provided by tying individual plant with sucker of the opposite plant.

4.1.1.7 Pest and Disease Incidence

Variation was not observed between treatments in incidence of pests and diseases. A general outbreak of leaf eating caterpillar was noticed and was controlled by spraying Carbaryl.

4.1.1.8 Duration of the Crop (days)

Duration of crop observed at shooting and at harvest are presented in Table 8.

Neither the planting pattern nor the intercrops and their interaction had no significant influence on days for shooting as well as the total duration of crop.

4.1.1.9 Bunch, Hand and Finger Characters

The effect of planting pattern and intercrops on bunch, hand and finger characters *viz.*, number of hands per bunch, number of fingers per bunch, number of fingers in D hand, weight of the D hand (kg), weight of the D finger (g), length and girth of D finger (cm) and pulp : peel ratio are presented in Tables 9, 10 and 12 .

Number of hands and fingers per bunch influenced significantly by the main effect of planting pattern. The maximum number of hands (5.58) and fingers per bunch (52.04) were recorded in the normal system of planting. However, the intercrops and its interaction with planting pattern did not produce any significant influence on number of hands and fingers per bunch. The main effect of planting pattern, intercrops and their interaction had no influence on number of fingers in D hand and weight of D hand.

Table 8 Effect of planting pattern and intercrops on the number of days for shooting and harvest of banana (first crop)

	Days for shooting	Days for harvest
Planting pattern		
p_1	197.38	278.65
p_2	194.86	248.23
$F_{1,14}$	0.72 ^{ns}	1.87 ^{ns}
SEm	2.094	15.750
Intercrops		
c_0	192.63	275.42
c_1	198.22	274.82
c_2	198.20	274.48
c_3	195.42	229.02
$F_{3,14}$	0.81 ^{ns}	1.06 ^{ns}
SEm	2.961	22.274
Interaction		
p_1c_0	190.83	278.33
p_1c_1	197.50	274.83
p_1c_2	199.00	277.26
p_1c_3	202.17	284.17
p_2c_0	194.43	272.50
p_2c_1	198.93	274.83
p_2c_2	197.40	271.70
p_2c_3	188.67	173.81
$F_{3,14}$	1.66 ^{ns}	1.43 ^{ns}
SEm	4.187	31.500

ns – not significant

Table 9 Effect of planting pattern and intercrops on the bunch and hand characteristics of banana (first crop)

	Number of hands per bunch	Number of fingers per bunch	Number of fingers in D hand	Weight of D hand (kg)
Planting pattern				
p_1	5.58	52.04	10.33	2.08
p_2	5.19	47.00	10.11	2.13
$F_{1,14}$	8.01*	6.97*	0.71^{ns}	0.15^{ns}
SEm	0.010	1.350	0.189	0.009
CD	0.297	4.096	-	-
Intercrops				
c_0	5.30	48.72	10.05	2.20
c_1	5.55	53.17	10.55	2.15
c_2	5.32	46.78	10.08	2.03
c_3	5.38	49.42	10.20	2.04
$F_{3,14}$	0.68^{ns}	1.96^{ns}	0.73^{ns}	0.39^{ns}
SEm	0.138	1.910	0.267	0.129
Interaction				
p_1c_0	5.33	51.83	10.33	2.20
p_1c_1	6.00	55.83	10.67	2.20
p_1c_2	5.33	46.83	9.83	1.93
p_1c_3	5.67	53.67	10.50	2.00
p_2c_0	5.27	45.60	9.77	2.20
p_2c_1	5.10	50.50	10.43	2.10
p_2c_2	5.30	46.73	10.33	2.13
p_2c_3	5.10	45.17	9.90	2.10
$F_{3,14}$	2.28^{ns}	0.87^{ns}	0.91^{ns}	0.25^{ns}
SEm	0.196	2.701	0.378	0.182

ns – not significant
*Significant at 5 per cent level

Table 10 Effect of planting pattern and intercrops on the finger characteristics of banana (first crop)

	Weight of the D finger (g)	Length of the D finger (cm)	Girth of the D finger (cm)
Planting pattern			
p_1	163.75	26.82	13.42
p_2	182.42	27.23	13.92
$F_{1,14}$	3.04 ^{ns}	0.30 ^{ns}	3.89 ^{ns}
SEm	7.566	0.538	0.179
Intercrops			
c_0	179.17	27.42	14.00
c_1	170.83	25.88	13.50
c_2	166.17	27.58	13.33
c_3	176.17	27.22	13.83
$F_{3,14}$	0.29 ^{ns}	1.04 ^{ns}	1.44 ^{ns}
SEm	10.700	0.761	0.253
Interaction			
p_1c_0	156.67	26.50	13.33
p_1c_1	166.67	26.60	13.50
p_1c_2	165.00	27.33	13.17
p_1c_3	166.67	26.83	13.67
p_2c_0	201.67	28.33	14.67
p_2c_1	175.00	25.17	13.50
p_2c_2	167.33	27.83	13.50
p_2c_3	185.67	27.60	14.00
$F_{3,14}$	0.78 ^{ns}	0.80 ^{ns}	1.30 ^{ns}
SEm	15.132	1.076	0.358

ns – not significant

Length, girth and weight of the D finger also did not vary significantly with different planting pattern, intercrops as well as their interaction. Results showed that the pulp: peel ratio also was not influenced by the treatments.

4.1.1.10 Bunch Weight (kg plant^{-1}) and Yield (t ha^{-1})

Weight of banana bunch and yield as influenced by planting pattern and intercrops are presented in Table 11.

The intercrops, planting pattern as well as their interaction had no significant influence on bunch weight. However modifying the planting pattern with two suckers per pit at 3 m x 2 m spacing produced significantly higher bunch yield (32 t ha^{-1}) than normal planting system (26.26 t ha^{-1}). Total yield per hectare also was not influenced by intercrops and its interaction with planting pattern.

4.1.1.11 Shelf Life (days)

The shelf life of banana is presented in Table 12.

Main effect of planting pattern, intercrops and their interaction significantly influenced the shelf life. Under normal planting the shelf life remained same (8.33 days) for pure crop of banana as well as banana intercropped with cucumber – amaranthus and colocasia but it increased when intercropped with chittaratha (11 days). Under modified planting pattern no significant difference in shelf life was observed when intercropped with cucumber – amaranthus (11 days), chittaratha (9.67 days), colocasia (9 days) and also with pure crop (10 days).

Planting pattern and intercrops had significant influence on shelf life. Banana intercropped with chittaratha recorded maximum shelf life (10.33 days) whereas colocasia recorded the minimum (8.67) days).

Table 11 Effect of planting pattern and intercrops on bunch weight and yield of banana (first crop)

	Bunch weight (kg $plant^{-1}$)	Yield (t ha^{-1})
Planting pattern		
p_1	10.50	26.26
p_2	9.68	32.00
$F_{1,14}$	2.07^{ns}	12.09**
SEm	0.401	1.168
CD	-	3.542
Intercrops		
c_0	9.63	27.87
c_1	10.28	29.13
c_2	9.93	28.92
c_3	10.52	30.60
$F_{3,14}$	0.47^{ns}	0.46^{ns}
SEm	0.568	1.651
Interaction		
p_1c_0	10.17	25.43
p_1c_1	11.07	27.67
p_1c_2	10.10	25.27
p_1c_3	10.67	26.67
p_2c_0	9.10	30.30
p_2c_1	9.50	30.60
p_2c_2	9.77	32.57
p_2c_3	10.37	34.53
$F_{3,14}$	0.29^{ns}	0.48^{ns}
SEm	0.803	2.336

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 12 Effect of planting pattern and intercrops on the pulp: peel ratio and shelf life of banana (first crop)

	Pulp: peel ratio	Shelf life (days)
Planting pattern		
p_1	2.54	9.00
p_2	2.25	9.92
$F_{1,14}$	1.87^{ns}	6.99*
SEm	0.151	0.244
CD	-	0.743
Intercrops		
c_0	2.49	9.17
c_1	2.17	9.67
c_2	2.44	8.67
c_3	2.47	10.33
$F_{3,14}$	0.48^{ns}	4.22*
SEm	0.213	0.346
CD	-	1.051
Interaction		
p_1c_0	2.72	8.33
p_1c_1	2.14	8.33
p_1c_2	2.35	8.33
p_1c_3	2.95	11.00
p_2c_0	2.26	10.00
p_2c_1	2.21	11.00
p_2c_2	2.53	9.00
p_2c_3	1.99	9.67
$F_{3,14}$	1.54^{ns}	6.07**
SEm	0.301	0.490
CD	-	1.486

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

4.1.1.12 Quality Attributes

Quality attributes like TSS (%), ascorbic acid (mg/100 g), acidity (%), total, reducing and non-reducing sugar (%) and sugar acid ratio are presented in Table 13.

TSS, ascorbic acid, acidity, total, reducing and non-reducing sugar were not influenced by planting pattern, intercrops and its interaction. The main effect of planting pattern caused significant variation in sugar acid ratio. Sugar acid ratio was maximum (60.51) from banana planted under modified system. However, the intercrops and its interaction with planting pattern had no significant influence on sugar acid ratio.

4.1.1.13 Dry Matter Production of Plant Parts (t ha^{-1})

Dry matter produced by fruit, leaf, pseudostem and rhizome as well as total dry matter production are presented in Table 14.

Main effect of intercrops and its interaction with planting pattern had no influence on dry matter production by plants and its parts except rhizome. However it varied significantly with planting pattern. The total dry matter and those produced by fruit, leaf, pseudostem and rhizome registered maximum value under modified planting pattern, the values being 25.52, 10.88, 3.67 and 4.83 and 6.14 t ha^{-1} respectively. Under normal planting pattern dry matter production of rhizome was not significantly different due to intercrops. But under modified planting pattern, banana intercropped with cucumber-amaranthus produced higher dry matter production (6.63 t ha^{-1}) which were on par with that obtained from chittaratha (6.44 t ha^{-1}).

4.1.1.14 **Nutrient Content at Harvest**

4.1.1.14.1 Nitrogen (per cent)

Nitrogen content of fruit, leaf, pseudostem and rhizome as influenced by planting pattern and intercrops are presented in Table 15.

Table 13 Effect of planting pattern and intercrops on the quality attributes of banana (first crop)

	TSS (%)	Ascorbic acid (mg/100 g)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar acid ratio
Planting pattern							
p_1	29.83	23.15	0.36	18.22	12.68	5.54	50.86
p_2	30.17	23.15	0.33	19.81	12.52	7.28	60.51
$F_{1,14}$	0.54 ^{ns}	0.00^{ns}	1.60 ^{ns}	1.23^{ns}	0.00 ^{ns}	2.77 ^{ns}	4.90*
SEm	0.322	1.722	0.001	1.010	0.525	0.738	3.084
CD	-	-	-	-	-	-	9.354
Intercrops							
c_0	29.67	20.84	0.36	19.19	13.41	5.78	54.47
c_1	29.67	27.78	0.37	19.25	12.15	7.10	53.12
c_2	31:00	18.52	0.34	18.87	13.28	5.60	55.67
c_3	29.67	25.47	0.31	18.74	11.57	7.17	59.47
$F_{3,14}$	2.14 ^{ns}	3.01 ^{ns}	1.55 ^{ns}	0.00 ^{ns}	1.44 ^{ns}	0.65 ^{ns}	0.39 ^{ns}
SEm	0.456	2.436	0.002	1.429	0.742	1.044	4.361
Interaction							
p_1c_0	28.67	23.15	0.35	18.72	13.12	5.60	53.77
p_1c_1	31.33	27.78	0.41	18.08	13.85	4.23	44.57
p_1c_2	31.00	13.89	0.35	17.83	12.43	5.40	51.17
p_1c_3	29.33	27.78	0.33	18.26	11.31	6.95	53.92
p_2c_0	30.67	18.52	0.37	19.65	13.70	5.96	55.17
p_2c_1	29.00	27.78	0.33	20.43	10.45	9.98	61.66
p_2c_2	31.00	23.15	0.33	19.92	14.12	5.79	60.18
p_2c_3	30.00	23.15	0.30	19.22	11.83	7.39	65.01
$F_{3,14}$	2.32 ^{ns}	1.81 ^{ns}	1.06 ^{ns}	0.01 ^{ns}	2.26 ^{ns}	1.64 ^{ns}	0.55 ^{ns}
SEm	0.644	3.445	0.003	2.021	1.049	1.477	6.167

ns – not significant
*Significant at 5 per cent level

Table 14 Effect of planting pattern and intercrops on the dry matter production (t ha^{-1}) of plant parts of banana (first crop)

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	8.93	2.46	4.16	4.91	20.45
p_2	10.88	3.67	4.83	6.14	25.52
$F_{1,14}$	11.95**	25.22**	10.17**	82.14**	33.38**
SEm	0.399	0.170	0.149	0.010	0.620
CD	1.210	0.515	0.452	0.292	1.880
Intercrops					
c_0	9.44	3.21	4.21	5.33	22.18
c_1	9.91	2.95	4.55	5.81	23.22
c_2	9.86	2.83	4.60	5.35	22.64
c_3	10.40	3.28	4.62	5.61	23.91
$F_{3,14}$	0.49^{ns}	0.78^{ns}	0.85^{ns}	2.89^{ns}	0.73^{ns}
SEm	0.564	0.240	0.211	0.136	1.876
Interaction					
p_1c_0	8.65	2.69	3.94	4.76	20.03
p_1c_1	9.41	2.44	4.06	4.99	20.90
p_1c_2	8.59	2.18	4.37	5.10	20.23
p_1c_3	9.07	2.54	4.27	4.77	20.65
p_2c_0	10.23	3.72	4.48	5.89	24.32
p_2c_1	10.40	3.46	5.05	6.63	25.54
p_2c_2	11.13	3.48	4.83	5.60	25.04
p_2c_3	11.74	4.01	4.97	6.44	27.16
$F_{3,14}$	0.50^{ns}	0.20^{ns}	0.30^{ns}	4.03*	0.32^{ns}
SEm	0.798	0.340	0.300	0.193	1.239
CD	-	-	-	0.585	-

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

Table 15 Effect of planting pattern and intercrops on the nitrogen content (%) in different parts of banana (first crop)

	Nitrogen content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	0.65	1.83	1.34	1.50
p_2	0.70	2.02	0.99	1.10
$F_{1,14}$	2.78 ^{ns}	16.26**	85.12**	374.69**
SEm	0.002	0.003	0.003	0.001
CD	-	0.009	0.008	0.044
Intercrops				
c_0	0.73	1.79	1.10	1.14
c_1	0.62	1.97	1.15	1.33
c_2	0.60	1.87	1.18	1.37
c_3	0.77	2.06	1.22	1.36
$F_{3,14}$	8.70**	6.53**	1.75 ^{ns}	28.40**
SEm	0.002	0.005	0.004	0.002
CD	0.008	0.140	-	0.006
Interaction				
p_1c_0	0.73	1.74	1.27	1.44
p_1c_1	0.60	1.79	1.46	1.06
p_1c_2	0.63	1.72	1.31	1.87
p_1c_3	0.65	2.07	1.33	1.62
p_2c_0	0.73	1.85	0.93	0.84
p_2c_1	0.63	2.15	0.84	1.59
p_2c_2	0.56	2.02	1.05	0.88
p_2c_3	0.87	2.05	1.12	1.10
$F_{3,14}$	5.15*	3.44*	5.62**	248.57**
SEm	0.004	0.007	0.005	0.029
CD	0.120	0.199	0.165	0.009

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

Planting pattern had no effect on nitrogen content of fruit. But the interaction of planting pattern and intercrops gave differential response. Under modified planting pattern with chittaratha as an intercrop fruit registered a high nitrogen content while under other intercrop situations no significant difference was seen.

The leaf nitrogen content was maximum under modified planting system (2.02%) and with chittaratha (2.06%) among intercrops. Under normal planting pattern high nitrogen content was noticed when intercropped with chittaratha but under modified planting pattern nitrogen content of leaf from plants intercropped with cucumber-amaranthus was significantly higher than that recorded from pure crop. Cucumber-amaranthus was on par with chittaratha and colocasia in modified planting.

In general normal planting pattern resulted in high nitrogen content in pseudostem. Under normal planting pattern, intercropping with cucumber-amaranthus registered higher nitrogen content in pseudostem which was on par with colocasia and chittaratha but significantly different from pure crop. Under modified planting pattern maximum was recorded from chittaratha which was on par with colocasia and significantly higher than that from pure crop and cucumber-amaranthus.

Both main effects and interaction were significant in rhizome nitrogen content. Under normal planting pattern maximum nitrogen content was recorded when intercropped with colocasia followed by chittaratha and pure crop. Under modified planting pattern maximum was from cucumber-amaranthus which was significantly higher in comparison with no intercrop, colocasia and chittaratha. Lowest nitrogen content was recorded from cucumber-amaranthus in conventionally planted banana and from pure crop in modified system. So nitrogen content was highly influenced by the interaction of planting pattern and intercrops.

4.1.1.14.2 Phosphorus (per cent)

Phosphorus content of plant parts of banana as influenced by planting pattern and intercrops are presented in Table 16.

Phosphorus content in the fruit had no significant variation with the planting pattern and its interaction with intercrops. However phosphorus content in the fruit varied significantly as an effect of intercropping. Maximum value for phosphorus in the fruit was observed when intercropped with cucumber amaranthus (0.41 %) followed by colocasia (0.21 %), no intercrop (0.16 %) and chittaratha (0.14 %).

Main effect of planting pattern and its interaction with intercrops imparted significance for leaf phosphorus content. Though it did not vary significantly with intercropping, higher leaf phosphorus content was noticed in normal planting pattern. Under normal system of planting pure crop of banana recorded maximum phosphorus content of the leaves (0.63 %). For the modified system, leaf phosphorus content was the highest when intercropped with colocasia (0.47 %).

Phosphorus content of pseudostem showed significant variation only with change in planting pattern. The value was the highest under the modified system (0.40 %).

Main effect of planting pattern, intercrops and their interaction significantly influenced the phosphorus content of rhizome. The phosphorus in rhizome was maximum (0.58 %) when intercropped with chittaratha. In general normal planting pattern registered higher phosphorus content but differed on interaction with intercrops. Under normal planting pattern, maximum phosphorus content was recorded from rhizome of pure crop while under modified planting pattern it was from rhizome of banana intercropped with chittaratha, p_1c_0 and p_2c_3 are also on par.

Table 16 Effect of planting pattern and intercrops on the phosphorus content (%)in different parts of banana (first crop)

	Phosphorus content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	0.23	0.46	0.33	0.49
p_2	0.23	0.34	0.40	0.43
$F_{1,14}$	0.01 ^{ns}	9.12**	8.81*	29.66**
SEm	0.002	0.003	0.002	0.001
CD	-	0.008	0.006	0.002
Intercrops				
c_0	0.16	0.42	0.39	0.47
c_1	0.41	0.38	0.41	0.34
c_2	0.21	0.41	0.32	0.46
c_3	0.14	0.40	0.35	0.58
$F_{3,14}$	24.59**	0.22 ^{ns}	2.69 ^{ns}	73.10**
SEm	0.002	0.004	0.003	0.001
CD	0.007	-	-	0.004
Interaction				
p_1c_0	0.15	0.63	0.32	0.70
p_1c_1	0.42	0.46	0.35	0.35
p_1c_2	0.23	0.35	0.28	0.48
p_1c_3	0.12	0.41	0.35	0.45
p_2c_0	0.16	0.21	0.46	0.24
p_2c_1	0.39	0.30	0.48	0.33
p_2c_2	0.19	0.47	0.35	0.45
p_2c_3	0.16	0.39	0.34	0.71
$F_{3,14}$	0.55 ^{ns}	8.86**	1.83 ^{ns}	166.04**
SEm	0.003	0.006	0.004	0.002
CD	-	0.168	-	0.005

ns -- not significant
*Significant at 5 per cent level **Significant at 1 per cent level

4.1.1.14.3 Potassium (per cent)

The potassium content of the plant parts as influenced by planting pattern and the intercrops are presented in Table 17.

Potassium content in the fruit varied with planting pattern and its interaction with intercrops. The content was higher in normal system (2.18 %) compared to modified system of planting (1.82 %). Under modified system potassium content was on par with all intercrops. Under normal system highest value was noticed in pure crop of banana and under modified system maximum from cucumber-amaranthus. No significant difference between normal and modified planting pattern under cucumber-amaranthus and chittaratha but significantly higher in pure crop of banana planted under normal system.

Leaf potassium content had no variation with planting pattern and its interaction with intercrops. However it differed significantly with intercrops. The highest content was observed with chittaratha (2.87 %) followed by intercrops of cucumber – amaranthus (2. 73 %).

Main effect of planting pattern and its interaction with intercrops significantly influenced the potassium content in the pseudostem though the different intercrops had no influence. The potassium content in the pseudostem was maximum under normal planting system. Among the interactions normal planting with cucumber – amaranthus (9.27 %) intercropping and modified system with colocasia (7.27 %) as intercrop registered the highest potassium in the pseudostem. No significant difference was observed between normal and modified planting pattern under pure crop, colocasia and chittaratha but significantly higher when intercropped with cucumber-amaranthus in normal system.

Potassium content in the rhizome showed significant variation with the main effect of planting pattern, intercrops and their interaction. The highest value was observed under the normal system of planting (6.32 %).

Table 17 Effect of planting pattern and intercrops on the potassium content (%)in different parts of banana (first crop)

	Potassium content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	2.18	2.65	7.33	6.32
p_2	1.82	2.43	5.75	4.80
$F_{1,14}$	6.84*	2.31 ^{ns}	8.39*	60.20**
SEm	0.010	0.101	0.385	0.138
CD	0.300	-	1.166	0.419
Intercrops				
c_0	2.20	2.10	5.83	4.90
c_1	2.07	2.73	7.10	8.90
c_2	1.97	2.47	6.87	4.73
c_3	1.77	2.87	6.35	3.70
$F_{3,14}$	1.70 ^{ns}	5.63**	1.08 ^{ns}	137.25**
SEm	0.140	0.143	0.544	0.195
CD	-	0.432	-	0.593
Interaction				
p_1c_0	2.60	2.40	6.93	4.93
p_1c_1	2.00	3.07	9.27	9.27
p_1c_2	2.40	2.40	6.47	7.47
p_1c_3	1.73	2.73	6.63	3.60
p_2c_0	1.80	1.80	4.73	4.87
p_2c_1	2.13	2.40	4.93	8.53
p_2c_2	1.53	2.53	7.27	2.00
p_2c_3	1.80	3.00	6.07	3.80
$F_{3,14}$	3.71*	2.89 ^{ns}	4.13*	46.37**
SEm	0.198	0.202	0.769	0.276
CD	0.601	-	2.333	0.839

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

However, banana intercropped with cucumber – amaranthus recorded maximum potassium (8.9 %) content in the rhizome. Potassium content in rhizome showed differential response when intercropped with colocasia under different planting pattern. Banana when intercropped with colocasia registered a marked value of 7.47 % under normal system in comparison to a lower value of 2.00 % under modified system. But with other intercrops no significant difference was observed with planting patterns.

4.1.1.15 Nutrient Uptake (kg ha^{-1})

4.1.1.15.1 Nitrogen

The uptake of nitrogen by different plant parts are presented in Table 18.

Main effect of planting pattern, intercrops and their interaction was significant in deciding the nitrogen uptake by fruit. The nitrogen uptake by fruit was more (76.20 kg ha^{-1}) under modified system and it registered highest value with chittaratha (80.90 kg ha^{-1}) among intercrops. No significant difference in nitrogen uptake was noticed with pure crop as well as with intercrops (colocasia and cucumber-amaranthus) under both planting patterns. On intercropping banana with chittaratha, nitrogen uptake was almost double under modified planting pattern in comparison with normal planting pattern.

The nitrogen uptake by leaves and pseudostem did not vary with intercrops and its interaction with planting pattern. However planting pattern significantly influenced nitrogen uptake. The uptake of nitrogen by the leaf was higher (73.90 kg ha^{-1}) under modified system. On the contrary nitrogen uptake by pseudostem was maximum (61.20 kg ha^{-1}) under normal system.

Nitrogen uptake by rhizome was higher (73.50 kg ha^{-1}) under normal system. The highest value of 78.30 kg ha^{-1} was recorded when banana was intercropped with cucumber–amaranthus. Under normal

Table 18 Effect of planting pattern and intercrops on the nitrogen uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	58.10	44.90	61.20	73.50	231.80
p_2	76.20	73.90	47.60	68.20	266.00
$F_{1,14}$	18.25**	32.61**	5.92*	8.19*	14.19**
SEm	3.010	3.590	3.940	1.320	6.410
CD	9.130	10.910	12.000	4.000	19.440
Intercrops					
c_0	68.30	57.70	57.40	58.80	230.60
c_1	61.10	58.80	50.70	78.30	248.80
c_2	58.40	53.60	53.50	72.20	237.70
c_3	80.90	67.50	56.00	74.20	278.60
$F_{3,14}$	5.59**	1.32 ^{ns}	0.28 ^{ns}	20.35**	5.45*
SEm	4.250	5.080	5.580	1.860	9.060
CD	12.910	-	-	5.650	27.490
Interaction					
p_1c_0	63.00	46.60	73.20	68.40	227.90
p_1c_1	56.00	43.20	58.90	53.20	211.20
p_1c_2	54.40	37.10	56.20	95.20	242.90
p_1c_3	58.90	52.70	56.40	77.30	245.30
p_2c_0	73.60	68.70	41.60	49.30	233.20
p_2c_1	66.10	74.60	42.40	103.30	286.40
p_2c_2	62.30	70.20	60.80	49.20	232.40
p_2c_3	102.90	82.30	55.60	71.00	311.80
$F_{3,14}$	4.11*	0.23 ^{ns}	1.49 ^{ns}	118.29**	5.63**
SEm	6.020	7.190	7.890	2.640	12.820
CD	18.250	-	-	8.000	38.880

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

planting pattern banana intercropped with colocasia recorded maximum value for nitrogen uptake by rhizome. Nitrogen uptake value by rhizome under modified system was almost double than under normal system when intercropped with cucumber–amaranthus. However, on intercropping banana with chittaratha no significant difference was seen between normal and modified planting pattern.

Total nitrogen uptake of banana was significantly influenced by planting pattern, intercrops and their interaction. Maximum nitrogen uptake was registered under modified system (266.00 kg ha^{-1}) compared to normal system (231.80 kg ha^{-1}). Among the intercrops, higher value was noticed with chittaratha (278.60 kg ha^{-1}). When banana was intercropped with colocasia and also grown as pure crop no significant difference in total nitrogen uptake was observed under both systems. But when intercropped with cucumber-amaranthus and chittaratha, total nitrogen uptake was significantly higher from plants grown under modified system.

4.1.1.15.2 Phosphorus

Phosphorus uptake by different plant parts as influenced by planting pattern and intercrops are presented in Table 19.

The phosphorus uptake by fruit showed no significant variation with planting pattern and its interaction with intercrops, while it differed significantly with intercrops, the highest value being recorded by cucumber-amaranthus (39.20 kg ha^{-1}).

Main effect of planting pattern and intercrops had no significant influence on phosphorus uptake by leaves. However the interaction between planting pattern and intercrops was significant which need not be given much importance since the individual factor had no response.

The uptake of phosphorus by pseudostem differed significantly with planting pattern while the other effects were not significant. The

Table 19 Effect of planting pattern and intercrops on the phosphorus uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	20.70	11.40	13.50	21.10	69.80
p_2	24.10	12.50	19.70	26.60	82.90
$F_{1,14}$	2.30 ^{ns}	0.62 ^{ns}	13.15**	5.96*	12.02**
SEm	1.590	0.990	1.190	0.070	2.680
CD	-	-	3.630	2.180	8.140
Intercrops					
c_0	15.00	12.50	16.80	23.50	67.70
c_1	39.20	10.70	19.00	19.60	88.40
c_2	20.60	11.80	14.60	24.70	71.70
c_3	11.90	12.90	16.00	33.70	77.50
$F_{3,14}$	25.91**	0.49 ^{ns}	1.18 ^{ns}	34.65**	5.63**
SEm	2.250	1.390	1.690	1.020	3.800
CD	6.850	-	-	3.080	11.510
Interaction					
p_1c_0	13.30	17.00	12.60	33.30	76.20
p_1c_1	38.70	11.20	14.00	17.50	81.40
p_1c_2	19.80	7.30	12.20	24.30	63.60
p_1c_3	11.00	10.20	15.20	21.50	57.80
p_2c_0	16.60	8.00	20.90	13.80	59.30
p_2c_1	39.60	10.20	24.00	21.70	95.50
p_2c_2	21.30	16.30	17.00	25.00	79.70
p_2c_3	18.80	15.60	16.70	46.00	97.10
$F_{3,14}$	0.48 ^{ns}	8.05**	1.21 ^{ns}	78.72**	9.25**
SEm	3.190	1.970	2.390	1.440	5.370
CD	-	6.00	-	4.400	16.280

ns – not significant
**Significant at 1 per cent level

uptake of phosphorus by pseudostem was higher under modified system of planting (19.70 kg ha^{-1}).

The main effect of planting pattern, intercrops and their interaction significantly influenced the uptake of phosphorus by rhizome as well as total uptake. The phosphorus uptake by rhizome (26.60 kg ha^{-1}) and total phosphorus uptake were maximum under modified system of planting (82.90 kg ha^{-1}). Among the intercrops chittaratha significantly enhanced phosphorus uptake by rhizome whereas banana intercropped with cucumber-amaranthus registered the highest value of total phosphorus uptake (88.40 kg ha^{-1}). When banana was grown as pure crop highest uptake of phosphorus was seen under normal planting pattern while banana intercropped with chittaratha registered higher phosphorus uptake under modified system. No significant difference in phosphorus uptake between normal and modified planting pattern under cucumber-amaranthus and colocasia.

4.1.1.15.3 Potassium

Potassium uptake by different plant parts as influenced by planting pattern and intercrops are presented in Table 20.

The potassium uptake by fruit and pseudostem did not vary with planting pattern, intercrops and their interaction.

The foliage uptake of potassium was significantly influenced by planting pattern while other effects remained insignificant. Potassium uptake by leaf was higher under modified system of planting (89.50 kg ha^{-1}) compared to normal system (65.90 kg ha^{-1}).

Main effect of intercrops and its interaction with planting was significant for potassium uptake by rhizome. The uptake by rhizome registered maximum value with cucumber-amaranthus intercropping (512.60 kg ha^{-1}). Under normal as well as modified planting system, potassium uptake was higher when intercropped with cucumber –

Table 20 Effect of planting pattern and intercrops on the potassium uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	194.40	65.90	305.50	312.00	877.80
p_2	197.50	89.50	279.40	302.30	868.60
$F_{1,14}$	0.00 ^{ns}	9.23**	0.71 ^{ns}	0.58 ^{ns}	0.054^{ns}
SEm	12.420	5.480	21.900	9.010	28.250
CD	-	16.630	-	-	-
Intercrops					
c_0	203.40	65.60	245.00	261.20	775.20
c_1	204.50	80.20	315.70	512.60	1113.00
c_2	189.90	70.00	316.70	246.10	822.50
c_3	186.10	95.00	292.50	208.60	782.10
$F_{3,14}$	0.29 ^{ns}	2.83 ^{ns}	118.00 ^{ns}	118.52**	16.28**
SEm	17.570	7.750	30.970	12.740	40.00
CD	-	-	-	38.670	121.200
Interaction					
p_1c_0	225.60	64.60	273.40	235.00	798.60
p_1c_1	186.30	77.50	382.10	460.20	1106.20
p_1c_2	206.70	52.00	282.90	380.50	921.90
p_1c_3	159.20	69.60	283.70	172.10	684.70
p_2c_0	181.20	66.60	216.50	287.50	751.80
p_2c_1	222.60	83.00	249.30	565.00	1119.90
p_2c_2	173.10	88.00	350.40	111.60	723.20
p_2c_3	212.90	120.30	301.20	245.00	879.50
$F_{3,14}$	1.96 ^{ns}	2.33 ^{ns}	1.99 ^{ns}	46.66**	4.15*
SEm	24.850	10.950	13.790	18.030	56.510
CD	-	-	-	54.680	171.420

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

amaranthus, the values being 460.20 kg ha^{-1} and 565.00 kg ha^{-1} respectively. Under pure crop situation no significant difference in potassium uptake by rhizome under the two planting patterns while under cucumber-amaranthus and chittaratha it was significantly higher under modified planting pattern and colocasia under normal planting pattern.

The total uptake of potassium by banana was significantly influenced by intercrops and its interaction while planting pattern exerted no influence on total potassium uptake. Maximum potassium uptake was noticed (1113.00 kg ha^{-1}) when banana was intercropped with cucumber-amaranthus. Under both normal and modified system of planting, higher values of 1106.20 kg ha^{-1} and 1119.90 kg ha^{-1} were registered with cucumber-amaranthus intercropping. No significant difference between normal and modified planting pattern under c_0 and c_1.Significantly higher total potassium uptake was recorded with colocasia in normal system and with chittaratha in modified system of planting.

4.1.1.16 Economic Analysis

Total income (Rs.), net income (Rs.) and benefit-cost ratio as influenced by planting pattern, intercrops and their interaction are presented in Table 21.

The planting pattern showed significant influence on total and net income as well as BCR. Higher values of total income (Rs. 5,50,528), net income (Rs. 4,43,312) and BCR (3.94) were registered under modified planting.

Compared to pure crop, total income was more in all intercropped treatments. However, the intercrops of colocasia and cucumber-amaranthus registered significantly higher net income (Rs. 5,01,483 and Rs. 4,94,525 respectively) than chittaratha (Rs. 2,64,554) which was on par with pure crop (Rs.2,89,842). Intercropping chittaratha was not found

Table 21 Effect of planting pattern and intercrops on the economics of banana cultivation (First crop)

	Total Income (Rs.)	Net income (Rs.)	Benefit : Cost ratio
Planting pattern			
p_1	456506	341890	3.14
p_2	550528	433312	3.94
$F_{1,14}$	21.38**	20.21**	28.39**
SEm	14378.39	14378.66	0.136
CD	43616.66	43617.49	0.412
Intercrops			
c_0	385594	289842	3.04
c_1	595395	494525	4.91
c_2	611950	501483	4.54
c_3	421128	264554	1.68
$F_{3,14}$	32.97**	39.58**	17.74**
SEm	20334.11	20334.49	0.192
CD	61683.28	61684.44	0.582
Interaction			
p_1c_0	350633	253178	2.60
p_1c_1	536373	434666	4.27
p_1c_2	572350	462715	4.22
p_1c_3	366666	217001	1.45
p_2c_0	420556	326506	3.47
p_2c_1	654417	554384	5.54
p_2c_2	651550	540250	4.85
p_2c_3	475589	312107	1.91
$F_{3,14}$	0.32^{ns}	0.27^{ns}	0.83^{ns}
SEm	28756.77	28757.32	0.271

ns -- not significant
**Significant at 1 per cent level

to be economic. Among BCR values, the highest value of 4.91 was registered by cucumber-amaranthus and was on par with colocasia (4.54).

4.1.1.17 Physiological Observations

The mean of physiological observations like leaf temperature (°C), light interaction (μmol $m^{-2}s^{-1}$) and stomatal conductance (S cm^{-1}) at 2 and 4 MAP are presented in Table 22.

The light interception values ranged from 408.3 to 586.7 μmol m^{-2} s^{-1} in normal planting at 2 MAP whereas the values ranged from 316.32 to 540 in modified planting. With increase in the age of the crop a decreasing trend with light interception was noticed.

Stomatal conductance values recorded at 2 MAP ranged from 0.23 to 0.51 S cm^{-1} and 0.22 to 0.46 S cm^{-1} in normal and modified planting pattern respectively. The observations recorded at 4 MAP showed an increasing trend with that of second month and the values ranged from 9.8 to 14.6 S cm^{-1}.

4.1.2 Banana – Second Crop

4.1.2.1 Height of the Pseudostem (cm)

The pseudostem height at 2, 4 and 6 MAP as influenced by planting pattern and intercrops are presented in Table 23.

In the second crop, pseudostem height was not influenced by planting pattern but growing intercrops resulted in a significant increase in height with progress in growth stages. During initial stages (2and 4 MAP) plant height was maximum in pure crop of banana which was on par with chittaratha. However, at 6 MAP banana intercropped with cucumber-amaranthus registered higher pseudostem height followed by pure crop. At this stage minimum height was recorded from plots where banana was intercropped with chittaratha. No interaction was observed between planting pattern and intercrops.

Table 22 Effect of planting pattern and intercrops on the physiological observations of banana cultivation (first crop)

Treatments	Leaf temperature (°C)		Stomatal conductance (s cm^{-1})		Light interception (μ mol m^{-2} s^{-1})	
	2 MAP	4 MAP	2 MAP	4 MAP	2 MAP	4 MAP
p_1c_0	30.4	31.4	0.23	11.9	430.0	260.0
p_1c_1	30.6	31.4	0.31	10.2	586.7	255.0
p_1c_2	30.6	31.4	0.39	9.8	408.3	251.7
p_1c_3	31.2	31.5	0.51	12.5	415.0	271.7
p_2c_0	30.5	31.5	0.46	12.8	501.7	123.7
p_2c_1	30.1	31.4	0.22	13.1	385.0	113.3
p_2c_2	30.7	31.4	0.34	14.6	540.0	68.3
p_2c_3	30.0	31.5	0.36	10.6	316.3	145.0

*Not statistically analysed

Table 23 Effect of planting pattern and intercrops on the pseudostem height (cm) of banana (second crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Planting pattern			
p_1	88.08	164.86	310.54
p_2	88.58	159.42	299.96
Intercrops			
c_0	91.83	169.00	312.75
c_1	87.42	168.82	324.83
c_2	85.08	162.25	294.92
c_3	89.00	148.50	288.50
Interaction			
p_1c_0	93.83	176.67	323.00
p_1c_1	87.00	175.10	333.33
p_1c_2	87.33	163.00	303.83
p_1c_3	84.17	144.67	282.00
p_2c_0	87.83	161.33	302.50
p_2c_1	82.83	162.53	316.33
p_2c_2	93.83	161.50	286.00
p_2c_3	88.58	152.33	295.00

Effect	F value	SEm	CD
P	$F_{1,14} = 0.98^{ns}$	3.696	-
C	$F_{3,14} = 2.75^{ns}$	5.227	-
PC	$F_{3,14} = 1.00^{ns}$	7.392	-
MAP (M)	$F_{2,32} = 2125.85^{**}$	2.392	6.901
M x P	$F_{2,32} = 1.35^{ns}$	3.383	-
M x C	$F_{6,32} = 3.30^{*}$	4.784	13.802
M x P x C	$F_{6,32} = 0.43^{ns}$	6.766	-

ns – not significant, *Significant at 5 per cent level, **Significant at 1 per cent level

4.1.2.2 Girth of the Pseudostem (cm)

Pseudostem girth as influenced by planting pattern and intercrops at 2, 4 and 6 MAP are presented in Table 24.

Planting pattern alone influenced the pseudostem girth. During initial stages of plant growth; planting pattern showed no significant influence on pseudostem girth. Maximum values of 43.78cm and 63.46 cm was noticed at later stages (4 and 6 MAP) in the normal system of planting. No interaction was observed between planting pattern and intercrops.

4.1.2.3 Number of Functional Leaves at 2, 4, 6 MAP and at harvest

Total functional leaf area at 2, 4, 6 MAP and at harvest are presented in Table 25.

Number of functional leaves observed at 2, 4 and 6 MAP showed no variation with planting pattern, intercrops and their interaction. However at harvest the effect of planting pattern, intercrops and their interaction was significant. The number of functional leaves at harvest was more under modified system (6.17) compared to normal planting system (5.33). Significant difference between normal and modified planting pattern was observed with pure crop and intercropping of cucumber-amaranthus and chittaratha. But intercropping with colocasia functional leaves of banana in modified planting pattern was significantly higher than that at normal planting pattern.

4.1.2.4 Total Functional Leaf Area at 2, 4, 6 MAP and at Harvest (m^2)

The total functional leaf area at 2, 4, 6 MAP and at harvest are presented in Table 26.

The total functional leaf area at 2, 4, 6 MAP and at harvest was not influenced by planting pattern, intercrops and their interaction.

Table 24 Effect of planting pattern and intercrops on the pseudostem girth (cm) of banana (second crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Planting pattern			
p_1	27.13	43.78	63.46
p_2	27.79	40.73	57.67
Intercrops			
c_0	27.33	43.30	61.92
c_1	28.25	43.57	63.00
c_2	27.33	43.43	59.17
c_3	26.92	38.73	58.17
Interaction			
p_1c_0	27.50	45.33	65.00
p_1c_1	26.83	45.60	65.17
p_1c_2	27.50	44.83	63.00
p_1c_3	26.67	39.37	60.67
p_2c_0	27.17	41.27	58.83
p_2c_1	29.67	41.53	60.83
p_2c_2	27.17	42.03	55.33
p_2c_3	27.17	38.10	55.67

Effect	F value	SEm	CD
P	$F_{1,14}$ = 5.33*	0.835	2.533
C	$F_{3,14}$ = 1.80^{ns}	1.181	-
PC	$F_{3,14}$ = 0.17^{ns}	1.670	-
MAP (M)	$F_{2,32}$ = 863.13**	0.564	1.628
M x P	$F_{2,32}$ = 8.24*	0.798	2.303
M x C	$F_{6,32}$ = 1.37^{ns}	1.129	-
M x P x C	$F_{6,32}$ = 0.33^{ns}	1.597	-

ns – not significant. *Significant at 5 per cent level.**Significant at 1 per cent level

Table 25 Effect of planting pattern and intercrops on the number of functional leaves of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	8.42	8.04	11.03	5.33
p_2	7.92	8.04	10.29	6.17
$F_{1,14}$	1.43 ^{ns}	0.00 ^{ns}	3.28 ^{ns}	21.87**
SEm	0.295	0.214	0.286	0.126
CD	-	-	-	0.382
Intercrops				
c_0	8.67	8.08	10.30	5.67
c_1	8.00	8.17	10.83	5.42
c_2	8.33	7.92	11.08	6.25
c_3	7.67	8.00	10.42	5.67
$F_{3,14}$	1.06 ^{ns}	0.13 ^{ns}	0.81 ^{ns}	3.94*
SEm	0.412	0.302	0.405	0.178
CD	-	-	-	0.540
Interaction				
p_1c_0	9.00	8.50	10.93	5.67
p_1c_1	8.33	8.33	11.00	5.33
p_1c_2	8.67	7.83	11.50	5.00
p_1c_3	7.67	7.50	10.67	5.33
p_2c_0	8.33	7.67	9.67	5.67
p_2c_1	7.67	8.00	10.67	5.50
p_2c_2	8.00	8.00	10.67	7.50
p_2c_3	7.67	8.50	10.17	6.00
$F_{3,14}$	0.16 ^{ns}	1.67 ^{ns}	0.26 ^{ns}	10.35**
SEm	0.591	0.427	0.572	0.252
CD	-	-	-	0.764

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 26 Effect of planting pattern and intercrops on total functional leaf area (m^2) of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	1.95	4.32	12.62	6.01
p_2	1.72	3.96	11.42	6.54
$F_{1,14}$	0.95 ^{ns}	1.16 ^{ns}	4.45 ^{ns}	2.10 ^{ns}
SEm	0.166	0.234	0.403	0.262
Intercrops				
c_0	2.12	4.32	11.61	6.23
c_1	1.68	4.27	13.38	6.59
c_2	1.78	4.21	11.10	5.79
c_3	1.78	3.77	11.98	6.48
$F_{3,14}$	0.68 ^{ns}	0.58 ^{ns}	2.96 ^{ns}	0.92
SEm	0.235	0.331	0.569	0.370
Interaction				
P_1c_0	2.35	4.62	11.90	5.82
P_1c_1	1.67	4.78	14.26	6.96
p_1c_2	2.13	4.44	11.96	5.17
p_1c_3	1.66	3.43	12.35	6.06
p_2c_0	1.89	4.01	11.33	6.63
p_2c_1	1.68	3.76	12.50	6.22
p_2c_2	1.43	3.97	10.23	6.41
p_2c_3	1.90	4.10	11.61	6.90
$F_{3,14}$	0.86^{ns}	1.20 ^{ns}	0.31^{ns}	1.40^{ns}
SEm	0.332	0.468	0.805	0.523

ns – not significant

4.1.2.5 Leaf Area Index at 2, 4, 6 MAP and at Harvest

Leaf area index at 2, 4, 6 MAP and at harvest are furnished in Table 27.

Neither the planting pattern nor the intercrops influenced the LAI at initial stage of plant growth while it had significant effect at 4, 6 MAP and at harvest. At all growth stages, leaf area index was high with modified planting pattern.

4.1.2.6 Duration of the Crop (days)

Duration of crop observed at shooting and at harvest is presented in Table 28.

Days for shooting were not influenced by the treatments. However the days for harvest varied with the intercrops and its interaction with planting pattern. Crop duration was more with intercrop of colocasia (275 days). Duration of the crop was not significantly different at different planting systems with intercrops cucumber-amaranthus and chittaratha and also with pure crop. But with colocasia banana under modified planting pattern took more days for harvest.

4.1.2.7 Bunch, Hand and Finger Characters

The data on bunch, hand and finger characters *viz.*, number of hands per bunch, number of fingers per bunch, number of fingers in D hand, weight of the D hand (kg), weight of the D finger (g), length and girth of D finger (cm) and pulp : peel ratio as influenced by planting pattern and intercrops are presented in Tables 29, 30 and 32.

Planting pattern influenced the number of hands and fingers per bunch. Both were higher (5.08 and 48.17) under normal system of planting. Number of fingers in D hand, weight of D hand, length of D finger and pulp : peel ratio were not influenced by the treatments.

Table 27 Effect of planting pattern and intercrops on the leaf area index (LAI) of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Planting pattern				
p_1	0.49	1.08	3.16	1.50
p_2	0.58	1.32	3.81	2.18
$F_{1,14}$	1.51^{ns}	5.49*	16.83**	35.57**
SEm	0.050	0.073	0.113	0.080
CD	-	0.222	0.342	0.244
Intercrops				
c_0	0.51	1.25	3.38	1.84
c_1	0.50	1.23	3.87	1.90
c_2	0.51	1.22	3.20	1.72
c_3	0.53	1.11	3.48	1.91
$F_{3,14}$	0.55^{ns}	0.34^{ns}	3.12^{ns}	0.62^{ns}
SEm	0.071	0.103	0.160	0.114
Interaction				
p_1c_0	0.59	1.16	2.98	1.46
p_1c_1	0.43	1.20	3.56	1.74
p_1c_2	0.53	1.11	2.99	1.30
p_1c_3	0.42	0.86	2.09	1.52
p_2c_0	0.63	1.34	3.78	2.21
p_2c_1	0.57	1.26	4.17	2.07
p_2c_2	0.48	1.33	3.41	2.14
p_2c_3	0.63	1.37	3.87	2.31
$F_{3,14}$	0.69^{ns}	0.83^{ns}	0.31^{ns}	1.09^{ns}
SEm	1.000	0.146	0.685	0.161

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 28 Effect of planting pattern and intercrops on the number of days for shooting and harvest of banana (second crop)

	Days for shooting	Days for harvest
Planting pattern		
p_1	188.50	269.75
p_2	191.83	272.08
$F_{1,14}$	0.62 ^{ns}	3.21 ^{ns}
SEm	2.991	0.922
Intercrops		
c_0	185.83	270.33
c_1	188.83	270.33
c_2	193.67	275.00
c_3	192.33	268.00
$F_{3,14}$	0.70 ^{ns}	5.07*
SEm	4.230	1.304
CD	-	3.956
Interaction		
p_1c_0	186.67	270.33
p_1c_1	185.33	272.67
p_1c_2	188.00	268.00
p_1c_3	194.00	268.00
p_2c_0	185.00	270.33
p_2c_1	192.33	268.00
p_2c_2	199.33	282.00
p_2c_3	190.67	268.00
$F_{3,14}$	0.68 ^{ns}	9.59**
SEm	5.983	1.844
CD	-	5.595

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

Table 29 Effect of planting pattern and intercrops on the bunch and hand characteristics of banana (second crop)

	Number of hands per bunch	Number of fingers per bunch	Number of fingers in D hand	Weight of D hand (kg)
Planting pattern				
p_1	5.08	48.17	10.17	2.48
p_2	4.75	44.33	10.25	2.42
$F_{1,14}$	4.87*	5.72*	0.02 ^{ns}	0.51 ^{ns}
SEm	0.107	1.134	0.401	5.790
CD	0.324	3.438	-	-
Intercrops				
c_0	4.67	45.00	11.00	2.53
c_1	5.17	48.67	10.17	2.60
c_2	4.83	45.50	9.67	2.33
c_3	5.00	45.83	10.00	2.32
$F_{3,14}$	2.003 ^{ns}	1.06 ^{ns}	1.00 ^{ns}	3.02 ^{ns}
SEm	0.151	1.603	0.568	0.080
Interaction				
p_1c_0	5.00	48.67	10.33	2.40
p_1c_1	5.33	51.00	10.33	2.67
p_1c_2	5.00	47.67	10.00	2.50
p_1c_3	5.00	45.33	10.00	2.33
p_2c_0	4.33	41.33	11.67	2.67
p_2c_1	5.00	46.33	10.00	2.53
p_2c_2	4.67	43.33	9.33	2.17
p_2c_3	5.00	46.33	10.00	2.30
$F_{3,14}$	0.81 ^{ns}	1.19 ^{ns}	6.60 ^{ns}	2.33 ^{ns}
SEm	0.214	2.267	0.803	0.120

ns – not significant
*Significant at 5 per cent level

Table 30 Effect of planting pattern and intercrops on the finger characteristics of banana (second crop)

	Weight of the D finger (g)	Length of the D finger (cm)	Girth of the D finger (cm)
Planting pattern			
p_1	205.58	26.67	14.33
p_2	197.25	26.33	14.25
$F_{1,14}$	0.41 ^{ns}	0.36 ^{ns}	0.13 ^{ns}
SEm	9.214	0.395	0.163
Intercrops			
c_0	190.33	26.58	14.33
c_1	237.50	27.67	14.92
c_2	179.17	25.25	13.92
c_3	198.67	26.50	14.00
$F_{3,14}$	3.78*	3.123 ^{ns}	3.86*
SEm	13.030	0.559	0.700
CD	39.527	-	0.231
Interaction			
p_1c_0	180.67	26.67	14.00
p_1c_1	241.67	27.50	15.00
p_1c_2	208.33	26.00	14.33
p_1c_3	191.67	26.50	14.00
p_2c_0	200.00	26.50	14.67
p_2c_1	233.33	27.83	14.83
p_2c_2	150.00	24.50	13.50
p_2c_3	205.67	26.50	14.00
$F_{3,14}$	1.85 ^{ns}	0.52 ^{ns}	1.78 ^{ns}
SEm	18.427	0.791	0.327

ns – not significant
*Significant at 5 per cent level

Planting pattern and its interaction with intercrops had no influence on the weight and girth of D finger. Intercrops significantly influenced these characters. The weight and girth were maximum (237.50 g and 14.92 cm) when banana was intercropped with cucumber-amaranthus.

4.1.2.8 Bunch Weight (kg plant^{-1}) and Yield (t ha^{-1})

Weight of banana bunch and yield as influenced by planting pattern and intercrops are presented in Table 31.

Bunch weight was not significant but yield per hectare was found to be significant under different planting pattern and under different intercrops. Yield was maximum under modified system (34.66t ha^{-1}). Bunch weight and yield was maximum when banana was intercropped with cucumber-amaranthus (11.75 kg plant^{-1} and 34.10 t ha^{-1}).

However the interaction between planting pattern and intercrops had no significant influence on bunch weight and yield.

Pooled data of yield for two years varied significantly with planting pattern. However, it remained insignificant with intercrops and its interaction with planting pattern. Pooled yield was maximum under modified system of planting.

4.1.2.9 Shelf Life (days)

The shelf life of banana is presented in Table 32.

Planting pattern showed significant influence on shelf life with maximum being recorded (10.25 days) under modified system. However, the shelf life did not vary significantly with intercrops.

The interaction of treatments had significant influence. Under pure crop and intercropping with cucumber-amaranthus and colocasia the shelf life was high in fruits of banana planted in modified system while no significant difference under p_2c_3. Under normal planting pattern no significant difference in shelf life of fruit under c_0,c_1 and c_2 but high under c_3.

Table 31 Effect of planting pattern and intercrops on the bunch weight and yield of banana (second crop)

	Bunch weight (kg plant^{-1})	Yield (t ha^{-1})	Pooled Yield (t ha^{-1})
Planting pattern			
p_1	11.02	27.54	26.90
p_2	10.40	34.66	33.34
$F_{1,14}$	3.54^{ns}	48.27**	43.91**
SEm	0.232	0.725	0.69
CD	-	2.199	1.97
Intercrops			
c_0	10.42	30.14	29.01
c_1	11.75	34.10	31.61
c_2	10.20	29.53	29.22
c_3	10.47	30.65	30.63
$F_{3,14}$	4.61*	3.99*	1.60^{ns}
SEm	0.328	1.025	0.97
CD	0.995	3.109	-
Interaction			
p_1c_0	11.00	27.50	26.47
p_1c_1	12.17	30.42	29.04
p_1c_2	10.73	26.83	26.05
p_1c_3	10.17	25.42	26.04
p_2c_0	9.83	32.77	31.55
p_2c_1	11.33	37.77	34.19
p_2c_2	9.67	32.22	32.39
p_2c_3	10.77	35.89	35.21
$F_{3,14}$	1.58^{ns}	1.40^{ns}	0.97^{ns}
SEm	0.464	1.449	1.370

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 32 Effect of planting pattern and intercrops on the pulp: peel ratio and shelf life of banana (second crop)

	Pulp: peel ratio	Shelf life (days)
Planting pattern		
p_1	2.53	8.92
p_2	2.78	10.25
$F_{1,14}$	2.69 ^{ns}	32.58**
SEm	0.108	0.165
CD	-	0.501
Intercrops		
c_0	2.88	9.67
c_1	2.63	9.67
c_2	2.63	9.17
c_3	2.48	9.83
$F_{3,14}$	1.19 ^{ns}	1.53 ^{ns}
SEm	0.152	0.233
Interaction		
p_1c_0	2.43	8.33
p_1c_1	2.50	8.33
p_1c_2	2.73	8.33
p_1c_3	2.47	10.67
p_2c_0	3.33	11.00
p_2c_1	2.77	11.00
p_2c_2	2.53	10.00
p_2c_3	2.50	9.00
$F_{3,14}$	2.41 ^{ns}	19.34**
SEm	0.215	0.330
CD	-	1.002

ns – not significant
**Significant at 1 per cent level

4.1.2.10 Quality Attributes

Quality attributes like TSS (%), ascorbic acid (mg/100 g), acidity (%), total, reducing and non-reducing sugar (%) and sugar acid ratio are presented in Table 33.

Among the quality aspects, TSS in fruits varied significantly with intercrops. Maximum value (29.83 %) was observed with colocasia as intercrop which was on par with c_0 and c_3 and high in comparison with cucumber-amaranthus.

Ascorbic acid, acidity and sugar-acid ratio showed significant variation with planting pattern, intercrops and their interaction. Total reducing and non reducing sugar did not vary with these treatments except for the interaction effect on non reducing sugar.

Ascorbic acid and acidity were more (0.17 mg 100 g^{-1} and 0.51 %) with normal planting system whereas the sugar: acid ratio was the highest (49.96) under modified system. Maximum ascorbic acid content was noticed with colocasia the values being 0.2 mg/100 g of fruit. Acidity recorded higher value when banana was intercropped with cucumber – amaranthus which was on par with other intercrops. Sugar : acid ratio registered lowest value with cucumber – amaranthus.

Ascorbic acid content of fruits from plants grown with colocasia was high under both normal and modified planting pattern and was not significantly different. This was followed by fruits from pure crop. In pure crop situations fruits from normal planting pattern registered high vitamin C content than modified system. The trend was same under chittaratha. There was no significant difference noticed in cucumber-amaranthus.

Acidity in fruits differed with respect to different planting pattern and intercrops. Under pure crop and intercropping with chittaratha fruits from normal planting pattern were found to have high acidity than that

Table 33 Effect of planting pattern and intercrops on the quality attributes of banana (second crop)

	TSS (%)	Ascorbic acid (mg/100 g)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar acid ratio
Planting pattern							
p_1	29.25	0.17	0.51	19.85	16.66	3.19	39.41
p_2	29.00	0.15	0.44	21.55	16.73	4.82	49.96
$F_{1,14}$	0.69^{ns}	15.99**	12.57**	2.31^{ns}	0.01^{ns}	11.58**	19.93**
SEm	0.212	0.003	0.014	0.793	0.606	0.339	1.671
CD	-	0.009	0.040	-	-	1.029	5.069
Intercrops							
c_0	29.00	0.16	0.46	20.82	17.76	3.06	46.50
c_1	28.50	0.15	0.54	20.63	15.71	4.92	38.53
c_2	29.83	0.20	0.50	19.47	15.83	3.64	49.25
c_3	29.17	0.13	0.51	21.88	17.46	4.42	44.46
$F_{3,14}$	3.36*	55.99**	8.78**	0.78^{ns}	1.58^{ns}	2.96^{ns}	3.70*
SEm	0.300	0.004	0.020	1.121	0.853	0.480	2.363
CD	0.911	0.001	0.062	-	-	-	7.168
Interaction							
p_1c_0	29.00	0.17	0.54	19.18	16.29	2.89	35.16
p_1c_1	29.00	0.15	0.53	20.66	16.67	3.99	39.34
p_1c_2	29.67	0.20	0.42	20.22	16.60	3.62	48.78
p_1c_3	29.33	0.15	0.57	19.34	17.07	2.27	34.36
p_2c_0	29.00	0.15	0.39	22.45	19.23	3.22	57.83
p_2c_1	28.00	0.15	0.55	20.59	14.74	5.85	37.72
p_2c_2	30.00	0.20	0.38	19.47	15.07	3.65	49.72
p_2c_3	29.00	0.10	0.45	21.88	17.86	6.57	54.56
$F_{3,14}$	0.90^{ns}	7.99**	3.56*	1.81^{ns}	1.75^{ns}	4.13*	7.17**
SEm	0.425	0.006	0.029	1.585	1.206	0.678	3.342
CD	-	0.018	0.087	-	-	2.058	10.138

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

from modified system .But no significant difference was seen from cucumber-amaranthus and colocasia under both planting pattern.

Non reducing sugar in fruits under p_1 and p_2 with pure crop and intercrops, c_1 and c_2 showed no significant difference. Under modified planting with c_3 showed a significantly high content of non-reducing sugar.

Fruits from pure crop of banana and those inter cropped with chittaratha under modified system registered high sugar acid ratio.

4.1.2.11 Dry Matter Production of Plant Parts (t ha^{-1})

Dry matter produced by fruit, leaf, pseudostem and rhizome as well as total dry matter production are presented in Table 34.

The dry matter produced by fruit did not vary with the interaction of planting pattern and intercrops. However the main effect of planting pattern and intercrops were significant. The dry matter produced by fruit recorded maximum value (11.78 t ha^{-1}) under modified system. The dry matter produced by fruit registered higher value with cucumber-amaranthus (11.59 t ha^{-1}).

However the treatments did not influence the leaf dry matter.

The interaction of planting pattern and intercrops had no significant effect on the dry matter produced by pseudostem. But the effect of planting pattern and intercrops was significant. The dry matter produced by the pseudostem was higher under normal system (3.36 t ha^{-1}) than modified system (2.88 t ha^{-1}) and it registered higher value with chittaratha (3.32 t ha^{-1}) and was on par with pure crop and cucumber-amaranthus.

No significant influence exerted by planting pattern, intercrops and their interaction on the dry matter produced by rhizome

Table 34 Effect of planting pattern and intercrops on the dry matter production (t ha^{-1}) of plant parts of banana (second crop)

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	9.37	2.60	3.36	2.63	17.95
p_2	11.78	2.84	2.88	2.50	20.01
$F_{1,14}$	48.16**	2.34^{ns}	33.79**	3.46^{ns}	30.65**
SEm	0.246	0.112	5.778	4.751	0.263
CD	0.747	-	0.175	-	0.798
Intercrops					
c_0	10.25	2.48	3.22	2.48	18.43
c_1	11.59	2.90	3.10	2.58	20.18
c_2	10.04	2.98	2.58	2.48	18.36
c_3	10.42	2.52	3.32	2.70	18.96
$F_{3,14}$	4.00*	2.66^{ns}	6.06**	2.35^{ns}	5.12*
SEm	0.348	0.158	8.171	0.067	1.372
CD	1.056	-	0.248	-	1.128
Interaction					
p_1c_0	9.35	2.63	3.57	2.53	18.08
p_1c_1	10.34	2.67	3.20	2.57	18.78
p_1c_2	9.13	2.57	3.20	2.70	17.59
p_1c_3	8.64	2.53	3.47	2.70	17.34
p_2c_0	11.14	2.33	2.87	2.43	18.77
p_2c_1	12.84	3.13	3.00	2.60	21.57
p_2c_2	10.95	3.40	2.50	2.27	19.12
p_2c_3	12.20	2.50	3.17	2.70	20.57
$F_{3,14}$	1.41^{ns}	2.57^{ns}	2.59^{ns}	2.52^{ns}	2.45^{ns}
SEm	0.492	0.224	0.116	9.501	0.526

ns – not significant

*Significant at 5 per cent level   **Significant at 1 per cent level

Total dry matter production was also significantly influenced by planting pattern and intercrops. Total dry matter production was maximum under modified system (20.01 t ha^{-1}). Banana intercropped with cucumber-amaranthus registered maximum dry matter production (20.18 t ha^{-1}). However the interaction had no significant influence on total dry matter produced.

4.1.2.12 **Nutrient Content at Harvest (per cent)**

4.1.2.12.1 Nitrogen

Nitrogen content of fruit, leaf, pseudostem and rhizome as influenced by planting pattern and intercrops are presented in Table 35.

The nitrogen content in fruit varied with planting pattern, intercrops and their interaction. The content in fruit (0.62 per cent) was higher under normal system. Chittaratha as intercrop enhanced the nitrogen content (0.65 %) of banana fruit. High fruit nitrogen was observed in normal planting pattern with intercrop c_1, c_3 and without intercrop, while no significant difference was seen in other cases.

Nitrogen content of pseudostem did not differ significantly with planting pattern, intercrops and their interaction.

The leaf and rhizome nitrogen content was not significant with the planting pattern. However effect of intercrops and its interaction with planting pattern was found significant. The lowest nitrogen content in both leaf (2.03 %) and rhizome (0.95 %) was observed in banana intercropped with colocasia. The higher value in leaf and rhizome were noticed with pure crop (2.32 %) and cucumber-amaranthus (1.11 %) respectively.

Leaf nitrogen was not significantly different in pure crop and inter crop c_1 under normal and modified planting pattern but significantly high in modified system with colocasia and in normal system with chittaratha.

Table 35 Effect of planting pattern and intercrops on the nitrogen content (%) in different parts of banana (second crop)

	Nitrogen content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	0.62	2.15	1.21	1.07
p_2	0.54	2.14	1.18	1.05
$F_{1,14}$	27.99**	0.02^{ns}	0.09^{ns}	1.74^{ns}
SEm	0.011	0.045	7.158	1.070
CD	0.034	-	-	-
Intercrops				
c_0	0.60	2.32	1.21	1.10
c_1	0.58	2.13	1.41	1.11
c_2	0.50	2.03	1.02	0.95
c_3	0.65	2.11	1.15	1.06
$F_{3,14}$	14.37**	3.63*	2.63^{ns}	24.12**
SEm	0.016	0.063	0.101	1.513
CD	0.048	0.191	-	0.046
Interaction				
p_1c_0	0.66	2.30	1.06	1.16
p_1c_1	0.66	2.01	1.34	0.99
p_1c_2	0.50	1.83	1.27	0.95
p_1c_3	0.68	2.47	1.18	1.16
p_2c_0	0.54	2.34	1.36	1.05
p_2c_1	0.50	2.24	1.48	1.23
p_2c_2	0.50	2.24	0.77	0.95
p_2c_3	0.62	1.76	1.12	0.95
$F_{3,14}$	4.42*	15.04**	2.91^{ns}	41.69**
SEm	0.023	0.089	0.143	0.021
CD	0.068	0.271	-	0.065

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Maximum was from p_1c_3 (2.47%) which was on par with p_2c_2(2.24%),p_1c_0(2.30%) ,p_2c_0(2.34%) and p_2c_1(2.24%).

In pure crop and intercropping with chittaratha rhizome nitrogen was found to be high in normal planting pattern (1.16%) while intercropping with cucumber-amaranthus (1.23 %) high value was recorded in modified system. But no significant difference was seen with intercrop colocasia.

4.1.2.12.2 Phosphorus

Phosphorus content of plant parts of banana as influenced by planting pattern and intercrops are presented in Table 36.

Neither the planting pattern nor the intercrops and their interaction influenced the phosphorus content in the fruit, pseudostem and rhizome. However the leaf phosphorus was significant with intercrops and its interaction with planting pattern. Maximum phosphorus content in leaf (0.15 %) was registered on intercropping with cucumber-amaranthus and with pure crop.

Foliar phosphorus did not vary significantly in banana intercropped with colocasia and chittaratha under both planting patterns. Maximum value of leaf phosphorus was registered under modified system in pure crop of banana. On the contrary higher value of phosphorus was recorded in leaves of banana intercropped with cucumber-amaranthus under normal planting.

4.1.2.12.3 Potassium

The potassium content of the plant parts as influenced by planting pattern and the intercrops are presented in Table 37.

Planting pattern had no significant influence on fruit phosphorus. Among the intercrops, significantly higher values were seen with cucumber-amaranthus. Fruit potassium content of banana intercropped with cucumber-amaranthus and chittaratha did not vary with planting

Table 36 Effect of planting pattern and intercrops on the phosphorus content (%)in different parts of banana (second crop)

	Phosphorus content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	0.13	0.14	0.15	0.17
p_2	0.13	0.14	0.14	0.16
$F_{1,14}$	0.00^{ns}	0.33^{ns}	1.62^{ns}	0.72^{ns}
SEm	0.004	0.003	0.004	0.006
Intercrops				
c_0	0.13	0.15	0.15	0.18
c_1	0.13	0.15	0.14	0.16
c_2	0.13	0.14	0.14	0.16
c_3	0.13	0.13	0.16	0.16
$F_{3,14}$	0.00^{ns}	3.890*	2.09^{ns}	0.72^{ns}
SEm	0.006	0.004	0.006	0.009
CD	-	0.001	-	-
Interaction				
p_1c_0	0.13	0.13	0.14	0.19
p_1c_1	0.13	0.17	0.15	0.16
p_1c_2	0.13	0.14	0.14	0.16
p_1c_3	0.13	0.13	0.16	0.16
p_2c_0	0.13	0.16	0.15	0.16
p_2c_1	0.13	0.13	0.13	0.16
p_2c_2	0.13	0.14	0.13	0.16
p_2c_3	0.13	0.13	0.15	0.16
$F_{3,14}$	0.00^{ns}	10.99**	1.14^{ns}	0.72^{ns}
SEm	0.008	0.006	0.008	0.013
CD	-	0.002	-	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 37 Effect of planting pattern and intercrops on the potassium content (%) in different parts of banana (second crop)

	Potassium content			
	Fruit	Leaf	Pseudostem	Rhizome
Planting pattern				
p_1	1.46	1.80	5.36	4.92
p_2	1.43	1.97	4.77	4.52
$F_{1,14}$	4.24^{ns}	7.17*	8.64*	32.03**
SEm	0.011	0.046	0.144	0.051
CD	-	0.139	0.436	0.154
Intercrops				
c_0	1.43	2.07	5.41	6.41
c_1	1.49	1.80	5.91	4.57
c_2	1.41	1.76	4.91	4.03
c_3	1.43	1.91	4.03	3.87
$F_{3,14}$	4.58*	4.70*	15.53**	264.55**
SEm	0.016	0.065	0.203	0.071
CD	0.049	0.196	0.617	0.218
Interaction				
p_1c_0	1.48	2.03	4.96	7.79
p_1c_1	1.47	1.52	6.07	3.72
p_1c_2	1.49	1.69	5.93	4.51
p_1c_3	1.40	1.96	4.49	3.68
p_2c_0	1.39	2.12	5.85	4.04
p_2c_1	1.52	2.08	5.76	4.43
p_2c_2	1.33	1.83	3.88	3.55
p_2c_3	1.47	1.87	3.57	4.05
$F_{3,14}$	11.82**	4.54*	9.12**	175.22**
SEm	0.023	0.092	0.287	0.102
CD	0.069	0.278	0.872	0.308

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

pattern. In the pure crop of banana as well as when intercropped with colocasia, fruit potassium was significantly higher under normal system.

Main effect of planting pattern, intercrops and its interaction had significant influence on the potassium content in the leaf, pseudostem and rhizome.

Higher leaf potassium (1.97 %) was noticed under modified system of planting. On the contrary, the potassium content in the pseudostem and rhizome was higher in the normal planting pattern (5.36 % and 4.92 %).

Maximum potassium content in the leaf (2.07 %) and rhizome (6.41 %) was observed with no intercrop. Pseudostem recorded higher potassium (5.91 %) when banana was intercropped with cucumber-amaranthus.

Planting pattern had no significant influence on leaf potassium when raised as pure crop and intercropped with colocasia and chittaratha. But when intercropped with cucumber-amaranthus higher potash content in the foliage was registered under modified system (2.08%). Under normal planting it varied with intercropping and maximum value being recorded with pure crop of banana (2.03%).

Pseudostem potash varied significantly with planting pattern when intercropped with colocasia, chittaratha and without intercrop. Except for pure crop, higher values of potassium in pseudostem were noticed under normal planting pattern. Under both systems of planting it differed with intercrops. Higher values were recorded with cucumber-amaranthus which was on par with colocasia under normal system and pure crop under modified system.

Banana without intercrop and with colocasia as intercrop showed higher values of potassium in rhizome under normal system while cucumber-amaranthus and chittaratha registered increased values of potassium under modified system which was on par with pure crop.

Intercropping caused significant variation in rhizome potash under both planting systems.

4.1.2.13 Nutrient Uptake (kg ha^{-1})

4.1.2.13.1 Nitrogen

The uptake of nitrogen by different plant parts are presented in Table 38.

Uptake of nitrogen by fruit, leaves, pseudostem and rhizome did not vary with planting pattern. The nitrogen uptake of the plant parts varied significantly with intercrops except for leaves. Nitrogen uptake by fruit and rhizome was significantly lower when banana intercropped with colocasia. Higher values by pseudostem was noticed when intercropped with cucumber-amaranthus.

The interaction of planting pattern and intercrops was significant for nitrogen uptake by fruit, leaves and rhizome. No significant difference was noticed between normal and modified planting pattern under c_0, c_1 and c_2.Significantly higher values were observed when banana was intercropped with chittaratha under modified system. Lowest values of nitrogen uptake by fruits were recorded with colocasia as intercrop.

Under normal system nitrogen uptake by leaves registered minimum value on intercropping with colocasia in comparison to pure crop of banana which was on par with cucumber-amaranthus and chittaratha .On the contrary, highest nitrogen uptake value was seen with colocasia under modified system which was on par with cucumber-amaranthus intercropping. Unlike the pure crop, values varied significantly with planting pattern when intercropped.

Planting pattern exerted significant influence on uptake of nitrogen by rhizome irrespective of the intercrops. Uptake was higher under normal planting pattern with c_0, $c_2$and c_3 while it registered higher values under modified system with cucumber-amaranthus

Table 38 Effect of planting pattern and intercrops on the nitrogen uptake by different parts of banana (second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	58.40	55.80	40.60	27.90	182.70
p_2	63.60	61.20	36.30	26.20	187.30
$F_{1,14}$	4.54^{ns}	2.04^{ns}	3.47^{ns}	3.94^{ns}	0.73^{ns}
SEm	1.710	2.660	1.600	0.620	3.780
Intercrops					
c_0	60.80	57.60	38.50	27.40	184.20
c_1	66.10	62.00	44.00	28.70	200.70
c_2	50.40	61.20	33.40	23.60	168.70
c_3	66.70	53.20	38.00	28.50	186.50
$F_{3,14}$	9.74**	1.12^{ns}	3.64*	7.37**	6.05**
SEm	2.420	3.760	2.270	0.870	5.350
CD	7.350	-	6.900	2.650	16.230
Interaction					
p_1c_0	61.40	60.70	37.90	29.40	189.40
p_1c_1	67.90	53.70	43.00	25.40	189.90
p_1c_2	46.00	46.30	40.30	25.70	158.50
p_1c_3	58.40	62.50	40.80	31.30	193.00
p_2c_0	60.20	54.40	39.00	25.50	179.10
p_2c_1	64.20	70.20	44.90	32.10	211.40
p_2c_2	54.80	76.10	26.20	21.60	178.60
p_2c_3	75.10	43.90	35.20	25.70	176.60
$F_{3,14}$	3.78*	8.41**	2.77^{ns}	10.57**	3.09^{ns}
SEm	3.430	5.320	3.210	1.230	7.560
CD	10.390	16.100	-	3.740	-

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

The total uptake of nitrogen was influenced by intercrops. However the main effect of planting pattern and its interaction with intercrop was insignificant. Total uptake had registered maximum value (200.70 kg ha^{-1}) when intercropped with cucumber-amaranthus.

4.1.2.13.2 Phosphorus

Phosphorus uptake by different plant parts as influenced by planting pattern and intercrops are presented in Table 39.

The uptake of phosphorus by fruit varied significantly with the main effect of planting pattern and intercrops. Maximum phosphorus uptake registered was under modified system of planting (15.32 kg ha^{-1}) and among intercrops cucumber-amaranthus registered the highest (15.07 kg ha^{-1}) value.

The uptake by leaves did not vary significantly with planting pattern and its interaction with intercrops. However the main effect of intercrops was significant. Maximum value (4.30 kg ha^{-1}) was recorded when intercropped with cucumber-amaranthus and was on par with colocasia (4.15 kg ha^{-1}).

The uptake of phosphorus by pseudostem had no significant influence with interaction of intercrops and planting pattern. But the main effect of planting pattern and intercrops were significant, the highest value being noticed in normal system (4.96 kg ha^{-1}). Among intercrops chittaratha had the highest uptake (5.14 kg ha^{-1}) which was on par with pure crop.

Phosphorus uptake by rhizome did not vary significantly with treatments.

Total P uptake vary significantly with the main effect of planting pattern and intercrops and their interaction had no significant influence. Total P uptake registered higher value under modified system of planting

Table 39 Effect of planting pattern and intercrops on the phosphorus uptake by different parts of banana (second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	12.18	3.70	4.96	4.39	25.23
p_2	15.32	3.95	4.05	3.99	27.31
$F_{1,14}$	48.05**	1.16^{ns}	14.87**	3.29^{ns}	12.22**
SEm	0.320	0.170	0.167	0.157	0.422
CD	0.972	-	0.508	-	1.279
Intercrops					
c_0	13.32	3.58	4.66	4.35	25.92
c_1	15.07	4.30	4.35	4.12	27.84
c_2	13.05	4.15	3.87	3.97	25.04
c_3	13.55	3.27	5.14	4.32	26.28
$F_{3,14}$	3.98*	4.01*	5.06*	0.66^{ns}	3.83*
SEm	0.453	0.241	0.237	0.222	0.596
CD	1.374	0.730	0.718	-	1.809
Interaction					
p_1c_0	12.16	3.42	5.01	4.82	25.41
p_1c_1	13.45	4.52	4.80	4.11	26.87
p_1c_2	11.87	3.55	4.49	4.32	24.22
p_1c_3	11.24	3.29	5.55	4.32	24.40
p_2c_0	14.48	3.73	4.32	3.88	26.42
p_2c_1	16.67	4.07	3.90	4.14	28.81
p_2c_2	14.24	4.76	3.25	3.62	25.86
p_2c_3	15.86	3.25	4.73	4.32	28.16
$F_{3,14}$	1.41^{ns}	2.16^{ns}	0.25^{ns}	1.24^{ns}	0.98^{ns}
SEm	0.641	0.340	0.335	0.314	0.844

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

(27.31 kg ha^{-1}) and when intercropped with cucumber-amaranthus (27.84 kg ha^{-1}) which was on par with chittaratha (26.28 kg ha^{-1}).

4.1.2.13.3 Potassium

Potassium uptake by different plant parts as influenced by planting pattern and intercrops are presented in Table 40.

Planting pattern influenced the uptake of potassium by plant parts. Potash uptake by fruit and leaves were higher (168.60 and 55.80 kg ha^{-1}) under modified system whereas maximum uptake by the pseudostem and rhizome was observed under normal system (128.50 and 179.30 kg ha^{-1}).

Though intercrops significantly influenced the potassium uptake by fruit, pseudostem and rhizome, uptake by leaves was not influenced by intercrops. Highest potassium uptake by fruit and pseudostem (173.50 and 184.20 kg ha^{-1}) was noticed with cucumber-amaranthus intercropping whereas the uptake by rhizome was the highest (160.10 kg ha^{-1}) in pure crop of banana.

The interaction effect of planting pattern and intercrops had significant influence in the potassium uptake by all plant parts. Planting pattern showed significant variation on potassium uptake by fruit when banana was grown with cucumber-amaranthus and chittaratha higher values being registered under modified system.

No difference in foliar uptake was seen when banana was intercropped with chittaratha and also grown as a pure crop. But when intercropped with cucumber-amaranthus and colocasia, potassium uptake by leaves was significantly high from plants under the modified system.

Differential response for uptake of potash by pseudostem under different planting systems when intercropped with colocasia and chittaratha was observed. Uptake by pseudostem of banana under the normal planting pattern when intercropped with colocasia registered a marked value of 190 kg ha^{-1} as against colocasia under the modified

Table 40 Effect of planting pattern and intercrops on the potassium uptake by different parts of banana (second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Planting pattern					
p_1	136.40	46.60	179.20	128.50	491.20
p_2	168.60	55.80	137.80	113.40	475.60
$F_{1,14}$	39.03**	7.14*	26.12**	13.96**	2.22^{ns}
SEm	3.650	2.450	5.740	2.860	7.390
CD	11.060	7.430	17.400	8.690	-
Intercrops					
c_0	146.40	51.50	172.20	160.10	530.20
c_1	173.50	52.90	184.20	118.30	528.80
c_2	140.10	52.90	143.80	101.10	438.20
c_3	150.00	48.20	134.00	101.40	436.50
$F_{3,14}$	7.99**	0.37^{ns}	8.43**	44.86**	25.95**
SEm	5.150	3.600	24.610	4.050	10.450
CD	15.650	-	8.110	12.270	31.690
Interaction					
p_1c_0	138.40	53.60	177.20	197.50	566.60
p_1c_1	151.80	40.50	194.10	95.50	482.00
p_1c_2	134.20	42.60	190.00	121.70	490.50
p_1c_3	121.00	49.60	155.70	99.20	425.60
p_2c_0	154.00	49.40	167.20	122.60	493.70
p_2c_1	195.30	65.20	174.20	141.00	575.70
p_2c_2	145.80	62.10	97.50	80.40	385.80
p_2c_3	149.00	46.70	112.20	109.50	447.30
$F_{3,14}$	4.65*	4.68*	5.14*	43.61**	18.75**
SEm	7.290	4.900	11.470	5.730	14.770
CD	22.130	14.860	34.800	17.380	44.820

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

system (97.50 kg ha^{-1}). But pure crop and intercrop cucumber-amaranthus showed no variation in potassium uptake between normal and modified planting systems.

Uptake of potash by rhizome differed significantly with planting pattern in pure crop and when intercropped with c_1 and c_2.The uptake values were the maximum under normal system with c_0 and c_2 while it was higher under modified system with cucumber-amaranthus as intercrop.

Total uptake of potassium was not influenced by planting pattern. However intercrops had significant influence on total potassium uptake with maximum value recorded with pure crop of banana (530.20 kg ha^{-1}). Significant variation in total potassium uptake between planting pattern was noticed when raised as pure crop and intercropped with c_1 andc_2. Pure crop and intercropping colocasia in normal system and intercropping cucumber-amaranthus under modified system registered higher uptake values.

4.1.2.14 Economic Analysis

Total income (Rs.), net income (Rs.) and benefit-cost ratio as influenced by planting pattern, intercrops and their interaction are presented in Table 41.

Main effect of planting pattern, intercrops and their interaction had significant influence on total income, net income and benefit-cost ratio (BCR).

Total income registered higher value (Rs. 557920) under modified system. Similarly net income as well as BCR was higher under modified system, values being Rs. 470696 and 5.44 respectively.

The highest total income, net income and BCR of Rs. 604380, Rs. 515176 and 5.81 were realized ha^{-1} when banana was intercropped with cucumber-amaranthus.

Table 41 Effect of planting pattern and intercrops on the economics of banana cultivation (second crop)

	Total Income (Rs.)	Net income (Rs.)	Benefit : Cost ratio	Pooled Net income (Rs.)
Planting pattern				
p_1	441877	349761	3.82	345826
p_2	557920	470696	5.44	452004
$F_{1,14}$	75.85**	82.38**	128.13**	78.23**
SEm	9421.6	13324.3	0.144	8488.8
CD	28580.4	28580.8	0.308	24370.1
Intercrops				
c_0	415104	331018	3.97	310430
c_1	604380	515176	5.81	504851
c_2	432659	333857	3.38	417670
c_3	547451	460863	5.36	362709
$F_{3,14}$	46.74**	48.22**	63.18**	47.91**
SEm	13324.2	18843.4	0.203	12004.9
CD	40418.8	40419.4	0.436	34464.5
Interaction				
p_1c_0	377500	290045	3.32	271612
p_1c_1	507029	415322	4.53	424995
p_1c_2	392725	293090	2.94	377903
p_1c_3	490254	400589	4.47	308796
p_2c_0	452709	371991	4.61	349249
p_2c_1	701731	615030	7.10	584707
p_2c_2	472592	374624	3.82	457438
p_2c_3	604647	521137	6.24	416623
$F_{3,14}$	4.35*	4.35*	6.37**	2.54^{ns}
SEm	18843.2	26648.5	0.288	16977.6
CD	57160.8	57161.6	0.617	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Among the interactions, maximum values were obtained for all economic parameters when banana was intercropped with cucumber-amaranthus under both systems.

Pooled net income for two years showed significance with planting pattern and intercrops. Modified system of planting among planting systems and cucumber-amaranthus among intercrops proved superior to all other treatments.

4.1.2.15 Physiological Observations

The mean of physiological observations like leaf temperature (°C), light interception (μmol $m^{-2}s^{-1}$) and stomatal conductance (S cm^{-1}) at 2 and 4 MAP are presented in Table 42.

Leaf temperature showed reduction as age advanced the values ranged from 34-34.6 at two months after planting and 32.4 to 32.7 at four months after planting. Stomatal conductance values recorded at 2 MAP ranged from 0.36 to 0.77 S cm^{-1} and 0.38 to 0.48 s cm^{-1} in normal and modified planting pattern respectively. The values recorded at 4 MAP showed an increasing trend and ranged from 0.94 to 4.33.

As the time progressed, a declining trend with light interception was noticed. The light interception values ranged form 1206.7 to 1943.3 μmol $m^{-2}s^{-1}$ in normal planting whereas the values ranged from 1590 to 1803.3 μmol $m^{-2}s^{-1}$ under modified system at two months after planting.

4.1.2.16 Soil Nutrient Status after the Experiment

The available nutrient content of soil recorded after harvest of second crop of banana is presented in Table 43.

Available soil nitrogen and phosphorus did not differ with planting pattern. However available soil potassium showed significant difference with planting systems, the value being maximum under normal system of planting (542.78 kg ha^{-1}) compared to modified system (417.23 kg ha^{-1}).

Table 42 Effect of planting pattern and intercrops on the physiological observations of banana cultivation (second crop)

Treatments	Leaf temperature (°C)		Stomatal conductance (S cm^{-1})		Light interception (μ mol m^{-2} s^{-1})	
	2 MAP	4 MAP	2 MAP	4 MAP	2 MAP	4 MAP
p_1c_0	34.6	32.5	0.77	0.94	1206.7	90.0
p_1c_1	34.1	32.7	0.72	1.13	1900.0	80.0
p_1c_2	34.1	32.4	0.59	1.25	1943.3	246.7
p_1c_3	34.5	32.6	0.36	1.19	1423.3	843.3
p_2c_0	34.2	32.4	0.38	1.90	1780.0	343.3
p_2c_1	34.0	32.5	0.39	2.85	1803.3	86.7
p_2c_2	34.2	32.5	0.48	1.93	1676.7	83.3
p_2c_3	34.0	32.5	0.41	4.33	1590.0	96.7

*Not statistically analysed

Table 43 Effect of planting pattern and intercrops on soil nutrient status after the experiment, kg ha^{-1}

	Available nitrogen	Available phosphorus	Available potassium
Planting pattern			
p_1	151.57	9.60	542.78
p_2	149.48	9.67	417.23
$F_{1,14}$	1.12^{ns}	0.54^{ns}	83.97**
SEm	1.395	7.492	9.688
CD	-	-	29.390
Intercrops			
c_0	155.76	7.19	471.74
c_1	135.89	15.36	470.03
c_2	169.34	7.87	590.88
c_3	141.12	8.13	387.37
$F_{3,14}$	58.55**	1312.59**	37.36**
SEm	1.973	0.106	13.702
CD	5.986	0.321	41.564
Interaction			
p_1c_0	163.07	7.87	370.35
p_1c_1	160.98	13.36	490.01
p_1c_2	169.34	9.12	878.31
p_1c_3	112.90	7.76	432.47
p_2c_0	148.44	6.50	573.14
p_2c_1	110.81	17.09	450.06
p_2c_2	169.34	6.61	303.45
p_2c_3	169.34	8.49	342.27
$F_{3,14}$	126.27**	153.05**	141.28**
SEm	2.791	0.150	19.377
CD	8.465	0.455	58.781

ns – not significant
**Significant at 1 per cent level

Main effect of intercrops and its interaction with planting pattern was significant for available nitrogen, phosphorus and potassium. The available nitrogen and potassium were the maximum with colocasia intercrop (169.34 and 590.88 kg ha^{-1}) while available phosphorus was the highest with cucumber-amaranthus (15.36 kg ha^{-1}).

Significant difference in available nitrogen with respect to planting patterns were seen when banana was grown as pure crop as well as intercropped with cucumber-amaranthus and chittaratha. However no variation was observed between planting patterns when intercropped with colocasia. Available nitrogen status in soil was more when intercropped with cucumber-amaranthus and without intercrop under normal system of planting banana. Modified system of planting intercropped with chittaratha registered higher soil nitrogen.

Under normal and modified planting pattern, intercropping with cucumber-amaranthus recorded high available phosphorus in soil which was significantly superior to others. Soil phosphorus varied markedly between the two planting patterns with different intercrops.

Planting pattern exerted significant variation on available soil potassium when intercropped with colocasia and chittaratha and also without intercrop. When intercropped, soil potassium was higher under normal system of planting but without intercrop available potash was higher under the modified system.

4.1.2.17 Water Holding Capacity and Soil Moisture Content

The data on water holding capacity and soil moisture content recorded at monthly intervals are presented in Appendix II. Since banana was irrigated on alternative days variation was not observed in these parameters between treatments.

4.1.2.18 Intercrops

The observations on intercrops are presented in Tables 44, 45, 46 and 47.

4.1.2.18.1 Cucumber

During first year cucumber produced 14 fruits per plant with an average weight of 1.55 kg per plant under normal planting pattern. However the number of fruits produced per plant registered 19.3 weighing 1.76 kg on an average. The total yield was more under modified system (35.59 t ha^{-1}) compared to that of normal system (16.58 t ha^{-1}). Highest biomass production was noticed under modified system. The trend was similar during second year also.

The length of the root, root spread and weight was slightly more under modified system.

4.1.2.18.2 Amaranthus

The height of the plant registered higher values at modified system during first and second year. Total yield was higher under normal system (8.21 t ha^{-1}) during first year whereas it was more under modified system during second year (2.21 t ha^{-1}). The length varied from 9.1 to 11.6 cm under modified system while it was 12.2 to 15.1 cm under normal system. The spread varied from 3.5 to 10.2 with the change in planting pattern. The roots of a single plant weighed more under normal system (3.19 g and 4.03 g) compared to modified system (1.66 g and 2.45 g).

4.1.2.18.3 Colocasia

Number of leaves at harvest, number of cormels per plant, weight of the cormel (g), corm and cormel yield ha^{-1}, cormel-corm ratio, biomass yield and root parameters of colocasia were recorded.

Number of leaves were more (12.3) under normal system of planting during first year. During second year, leaves at harvest was

Table 44 Effect of planting pattern on cucumber

Observations	Normal planting pattern		Modified planting pattern	
	I year	II year	I year	II year
Number of fruits per plant	14.0	13	19.3	15.2
Weight of the fruit (kg)	1.55	1.11	1.76	1.66
Yield (t ha^{-1})	16.58	12.77	35.59	28.05
Biomass yield (t ha^{-1})	1.44	1.41	1.43	0.93
Dry matter partitioning (%) Shoot:	70.5	80	68.5	60.2
Root:	2.2	2.5	2.92	4.1
Fruit:	27.3	17.5	28.6	35.7
Root studies at harvest				
Length (cm)	64.2	62.4	73.7	70
Spread (cm)	28.5	29.2	37.8	35.4
Weight (g)	167	170	230	240

Table 45 Effect of planting pattern on amaranthus

Observations	Normal planting pattern		Modified planting pattern	
	I year	II year	I year	II year
Height of the plant at harvest (cm)	32	38	41.8	46
Number of harvest	3	2	3	2
Yield per harvest (t ha^{-1})	2.73	1.08	0.76	1.11
Total yield (t ha^{-1})	8.21	2.16	2.30	2.21
Biomass yield (t ha^{-1})	8.21	2.16	2.30	2.21
Dry matter partitioning (%) Shoot:	93.1	73.6	88.5	83.4
Root:	6.9	26.4	11.5	16.6
Root studies at harvest				
Length (cm)	12.2	15.1	9.1	11.6
Spread (cm)	3.5	9.6	5.8	10.2
Weight (g)	3.19	4.03	1.66	2.45

Table 46 Effect of planting pattern on colocasia

Observations	Normal planting pattern		Modified planting pattern	
	I year	II year	I year	II year
Number of leaves at harvest	12.3	3.3	5	3.7
Number of cormels per plant	30.3	5.0	25	7.3
Weight of the cormel (g)	36	33.3	29.2	30.8
Cormel yield (t ha^{-1})	10.21	0.73	7.39	0.99
Corm yield (t ha^{-1})	8.48	1.26	5.21	1.27
Cormel : corm ratio	1.22	0.58	1.41	0.78
Biomass yield (t ha^{-1})	2.63	1.09	1.83	1.43
Dry matter partitioning (%) Shoot:	6.4	16.8	9.7	28.2
Root:	5.6	32.7	6.1	20.2
Corm	19.0	18.8	22.9	20.9
Cormel	69.0	31.7	61.3	30.7
Root studies at harvest				
Length (cm)	17.0	22.3	18.9	29.3
Spread (cm)	19.3	17.7	19.3	19.3
Weight (g)	360	330	370	330

Table 47 Effect of planting pattern on chittaratha

Observations	Normal planting pattern	Modified planting pattern
Height of the plant at harvest (cm)	161.3	168.7
Yield of the rhizome (t ha^{-1})	15.56	12.37
Biomass yield (t ha^{-1})	29.81	23.66
Dry matter partitioning (%) Shoot:	25.3	16.3
Root:	5.2	3.3
Rhizome:	69.5	80.4
Root studies at harvest		
Length (cm)	43.0	68.7
Spread (cm)	26.0	35.3
Weight (g)	210	450

almost similar (3.33 and 3.4) with two systems of planting. Yield attributes registered higher value under modified system during second year except for cormel weight, whereas during first year except for cormel yield and cormel to corm ratio.

The length of root ranged from 17 to 22.3 cm under normal system and 18.9 to 29.3 cm under modified system. The spread of the root was almost similar under both systems. The root weight ranged from 130 to 170 g plant^{-1}.

4.1.2.18.4 Chittaratha

The height of the plant registered higher value under modified system (168.7 cm). Biomass yield and rhizome yield were more under normal planting with values being 29.81 and 15.56 t ha^{-1} respectively.

The length, spread and weight were 43 cm, 26 cm and 210 g plant^{-1} under normal planting pattern and 68.7 cm, 35.3 cm and 450 g plant^{-1}.

4.2 EXPERIMENT II – NUTRIENT MANAGEMENT AND RECYCLING OF BANANA RESIDUES IN PAIRED PLANTING SYSTEM

4.2.1 Banana – First Crop

4.2.1.1 Height of the Pseudostem (cm)

The pseudostem height (cm) at 2, 4 and 6 MAP as influenced by levels of nutrients and sources of organic manure are presented in Table 48.

The main effect of nutrient levels, organic sources and their interaction did not cause any variation in plant height recorded at 2, 4 and 6 MAP.

Table 48 Effect of nutrient levels and sources of organic manure on the pseudostem height (cm) of banana (first crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	43.76	187.44	341.67
f_2	41.27	162.33	336.67
f_3	39.59	166.22	333.67
Sources of organic manure			
o_1	44.10	173.22	335.89
o_2	40.56	174.89	344.11
o_3	39.96	167.89	332.00
Interaction			
f_1o_1	44.00	119.33	345.33
f_1o_2	46.43	193.00	338.00
f_1o_3	40.83	179.00	341.67
f_2o_1	44.87	173.00	347.33
f_2o_2	35.27	153.67	343.33
f_2o_3	43.67	160.33	319.33
f_3o_1	43.43	156.33	315.00
f_3o_2	39.97	178.00	351.00
f_3o_3	35.37	164.33	335.00

Effect	F value	SEm	CD
F	$F_{2,16}$ = 1.71^{ns}	4.789	-
O	$F_{2,16}$ = 0.47^{ns}		-
FO	$F_{4,16}$ = 0.84^{ns}	8.294	-
MAP (M)	$F_{2,36}$ = 2631.63**	2.896	8.296
M x F	$F_{4,36}$ = 1.57^{ns}	5.005	-
M x O	$F_{4,36}$ = 0.46^{ns}		-
M x F x O	$F_{8,36}$ = 1.24^{ns}	8.669	-

ns – not significant. **Significant at 1 per cent level

4.2.1.2 Girth of the pseudostem (cm)

The girth of pseudostem at 2, 4 and 6 MAP as influenced by nutrient levels and organic sources are summarized in Table 49.

The pseudostem girth did not vary significantly with nutrient levels, organic sources and their interaction at 2 and 4 MAP. The main effect of nutrient levels and organic sources had no influence on girth at 6 MAP. However the interaction effect of treatments showed significant variation on pseudostem girth. The treatment receiving organic matter as banana residue in fresh state @ 20 kg $plant^{-1}$ and two-third additional to recommended dose of nutrients showed maximum girth (68.20 cm).

4.2.1.3 Number of Functional Leaves at 2, 4, 6 MAP and at Harvest

The number of functional leaves at 2, 4, 6 MAP and at harvest as influenced by levels of nutrients and sources of organic manure are given in Table 50.

The different treatments and their interaction had no influence on the number of functional leaves recorded at different interval.

4.2.1.4 Total Functional Leaf Area (m^2) and Leaf Area Index

The total functional leaf area and leaf area index at 2, 4, 6 MAP and at harvest as influenced by nutrient levels and organic sources are presented in Table 51 and 52.

The total functional leaf area showed no variation among treatments except at 4 MAP where significant influence was noticed with nutrient levels. Maximum leaf area of 6.87 m^2 was recorded under recommended dose of nutrients.

LAI was not influenced by different levels of nutrients, organic sources and their interaction during second month, sixth month and at harvest. Nutrient levels had significant effect on LAI during fourth month after planting. Maximum value was recorded at recommended dose of

Table 49 Effect of nutrient levels and sources of organic manure on the pseudostem girth (cm) of banana (first crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	13.30	47.11	65.40
f_2	12.94	43.11	66.91
f_3	12.32	41.11	64.69
Sources of organic manure			
o_1	13.49	43.94	63.69
o_2	12.77	45.83	66.54
o_3	12.30	41.56	66.77
Interaction			
f_1o_1	13.27	47.17	66.27
f_1o_2	14.03	50.83	65.27
f_1o_3	12.60	43.33	64.67
f_2o_1	14.43	45.67	66.10
f_2o_2	11.35	43.00	66.43
f_2o_3	13.03	40.67	68.20
f_3o_1	12.77	39.00	58.70
f_3o_2	12.93	43.67	67.92
f_3o_3	11.27	40.67	67.43

Effect	F value	SEm	CD
F	$F_{2,16}$ = 1.62^{ns}	1.018	-
O	$F_{2,16}$ = 1.66^{ns}		-
FO	$F_{4,16}$ = 1.14^{ns}	1.764	-
MAP (M)	$F_{2,36}$ = 1062.67**	0.814	2.337
M x F	$F_{4,36}$ = 1.47^{ns}	1.410	-
M x O	$F_{4,36}$ = 1.47^{ns}		-
M x F x O	$F_{8,36}$ = 0.57^{ns}	2.442	-

ns – not significant, **Significant at 1 per cent level

Table 50 Effect of nutrient levels and sources of organic manure on the number of functional leaves of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	7.02	11.56	10.44	5.53
f_2	6.61	10.83	11.11	5.39
f_3	6.88	11.11	10.61	5.72
$F_{2,16}$	0.72^{ns}	1.42^{ns}	1.37^{ns}	0.44^{ns}
SEm	0.246	0.306	0.300	0.253
Sources of organic manure				
o_1	7.08	11.33	10.67	5.44
o_2	6.99	11.11	10.78	5.67
o_3	6.44	11.06	10.72	5.53
$F_{2,16}$	1.94^{ns}	0.23^{ns}	0.35^{ns}	0.20^{ns}
SEm	0.246	0.306	0.300	0.253
Interaction				
f_1o_1	6.93	11.67	10.50	5.67
f_1o_2	7.37	11.67	10.33	5.50
f_1o_3	6.77	11.33	10.50	5.43
f_2o_1	7.27	11.50	11.17	5.33
f_2o_2	6.67	10.50	11.17	5.52
f_2o_3	5.90	10.50	11.00	5.33
f_3o_1	7.03	10.83	10.33	5.33
f_3o_2	6.93	11.17	10.83	6.00
f_3o_3	9.67	11.33	10.67	5.83
$F_{4,16}$	0.68^{ns}	0.66^{ns}	0.14^{ns}	0.28^{ns}
SEm	0.426	1.587	0.513	0.438

ns – not significant

Table 51 Effect of nutrient levels and sources of organic manure on total functional leaf area (m^2) of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	0.33	6.87	9.19	4.85
f_2	0.31	5.07	9.34	4.55
f_3	0.28	4.68	9.82	5.36
$F_{2,16}$	0.41^{ns}	4.86*	0.33^{ns}	1.16^{ns}
SEm	0.041	0.479	0.568	0.376
CD	-	1.437	-	-
Sources of organic manure				
o_1	0.35	5.83	9.18	4.69
o_2	0.31	5.85	9.77	5.17
o_3	0.27	5.35	9.40	4.89
$F_{2,16}$	0.85^{ns}	0.34^{ns}	0.27^{ns}	0.41^{ns}
SEm	0.041	0.479	0.568	0.376
Interaction				
f_1o_1	0.33	7.37	8.34	4.44
f_1o_2	0.38	7.01	9.93	5.26
f_1o_3	0.28	6.22	9.31	4.84
f_2o_1	0.39	5.44	10.63	5.09
f_2o_2	0.22	4.40	8.92	4.42
f_2o_3	0.32	4.70	8.48	4.13
f_3o_1	0.31	4.69	8.59	4.53
f_3o_2	0.31	6.13	10.46	5.83
f_3o_3	0.21	5.14	10.40	5.71
$F_{4,16}$	0.89^{ns}	0.68^{ns}	1.44^{ns}	0.88^{ns}
SEm	0.071	0.830	0.984	0.653

ns – not significant
*Significant at 5 per cent level

Table 52 Effect of nutrient levels and sources of organic manure on the leaf area index (LAI) of banana (first crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	0.11	2.29	3.07	1.60
f_2	0.11	1.69	3.12	1.52
f_3	0.10	1.56	3.28	1.79
$F_{2,16}$	0.36^{ns}	3.92*	0.33^{ns}	1.17^{ns}
SEm	0.014	0.197	0.190	0.126
CD	-	0.590	-	-
Sources of organic manure				
o_1	0.12	1.94	3.06	1.56
o_2	0.10	2.03	3.26	1.72
o_3	0.10	1.58	3.14	1.63
$F_{2,16}$	0.86^{ns}	1.48^{ns}	0.28^{ns}	0.40^{ns}
SEm	0.014	0.197	0.190	0.126
Interaction				
f_1o_1	0.11	2.46	2.78	1.48
f_1o_2	0.13	2.34	3.31	1.75
f_1o_3	0.09	2.08	3.11	1.61
f_2o_1	0.11	1.81	3.55	1.70
f_2o_2	0.07	1.69	2.98	1.47
f_2o_3	0.11	1.57	2.83	1.38
f_3o_1	0.11	1.56	2.87	1.51
f_3o_2	0.10	2.05	3.49	1.94
f_3o_3	0.08	1.09	3.47	1.91
$F_{4,16}$	0.92^{ns}	0.48^{ns}	1.43^{ns}	0.88^{ns}
SEm	0.024	0.341	0.329	0.218

ns – not significant
*Significant at 5 per cent level

nutrients (2.29). It progressively decreased with increasing levels of nutrients. However LAI was not influenced by organic sources and its interaction with nutrient levels.

4.2.1.5 Propping Requirement

The requirement for propping was uniform for all treatments. Propping was provided by tying individual plant with sucker of the opposite plant.

4.2.1.6 Pest and Disease Incidence

Variation was not observed between treatments in incidence of pests and diseases. A general outbreak of leaf eating caterpillar was noticed and was controlled by spraying Carbaryl.

4.2.1.7 Duration of the Crop (days)

The duration in number of days from planting to shooting and planting to harvest are presented in Table.53

Duration of crop as observed at shooting and at harvest did not show any variation due to treatments.

4.2.1.8 Post Harvest Observations

The post harvest observations *viz.*, number of hands per bunch, number of fingers per bunch, weight of D hand (kg), number of fingers in D hand, weight (g), length (cm) and girth (cm) of D finger, bunch weight (kg $plant^{-1}$) and yield (t ha^{-1}) are presented in Tables 54,55 and 56

All the post harvest observations were not influenced significantly by the effect of nutrient levels, organic sources and their interaction.

4.2.1.9 Pulp : Peel Ratio

The pulp: peel ratio as influenced by nutrient levels, organic sources and their interaction is given in Table 57.

Table 53 Effect of nutrient levels and sources of organic manure on the date of shooting and harvest (days) of banana (first crop)

	Date of shooting	Date of harvest
Levels of nutrients		
f_1	197.32	278.06
f_2	204.40	284.80
f_3	203.78	285.39
$F_{2,16}$	1.17^{ns}	1.80^{ns}
SEm	3.627	3.040
Sources of organic manure		
o_1	200.56	282.97
o_2	199.86	281.69
o_3	205.09	283.59
$F_{2,16}$	0.61^{ns}	0.10^{ns}
SEm	3.627	3.040
Interaction		
f_1o_1	198.27	279.83
f_1o_2	197.93	277.17
f_1o_3	195.77	277.17
f_2o_1	198.90	281.43
f_2o_2	205.37	285.30
f_2o_3	208.93	287.67
f_3o_1	204.50	287.63
f_3o_2	196.27	282.60
f_3o_3	210.57	285.93
$F_{4.16}$	0.70^{ns}	0.29^{ns}
SEm	6.282	5.26

ns – not significant

Table 54 Effect of nutrient levels and sources of organic manure on the bunch and hand characteristics of banana (first crop)

	Number of hands per bunch	Number of fingers per bunch	Number of fingers in D hand	Weight of D hand (kg)
Levels of nutrients				
f_1	5.33	48.71	10.22	2.41
f_2	5.43	51.78	10.50	2.27
f_3	5.43	50.03	10.44	2.28
$F_{2,16}$	0.38^{ns}	1.22^{ns}	0.89^{ns}	1.56^{ns}
SEm	0.094	1.391	0.156	0.062
Sources of organic manure				
o_1	5.36	49.54	10.50	2.33
o_2	5.40	51.72	10.56	2.37
o_3	5.44	49.26	10.11	2.25
$F_{2,16}$	0.22^{ns}	0.94^{ns}	2.41^{ns}	0.95^{ns}
SEm	0.094	1.391	0.156	0.062
Interaction				
f_1o_1	5.43	50.63	10.67	2.47
f_1o_2	5.20	48.87	10.33	2.47
f_1o_3	5.37	46.63	9.67	2.28
f_2o_1	5.43	52.73	10.83	2.40
f_2o_2	5.43	52.33	10.67	2.27
f_2o_3	5.43	50.27	10.00	2.13
f_3o_1	5.20	45.27	10.00	2.13
f_3o_2	5.57	53.97	10.67	2.37
f_3o_3	5.53	50.87	10.67	2.33
$F_{4,16}$	0.94^{ns}	1.70^{ns}	2.92^{ns}	1.49^{ns}
SEm	0.162	2.409	0.270	0.107

ns – not significant

Table 55 Effect of nutrient levels and sources of organic manure on the finger characteristics of banana (first crop)

	Weight of the D finger (g)	Length of the D finger (cm)	Girth of the D finger (cm)
Levels of nutrients			
f_1	180.33	27.22	14.00
f_2	175.78	26.67	13.67
f_3	159.56	26.94	13.33
$F_{2,16}$	3.17^{ns}	0.34^{ns}	2.53^{ns}
SEm	6.133	0.475	0.210
Sources of organic manure			
o_1	171.89	26.67	13.67
o_2	179.22	27.83	13.83
o_3	164.56	26.33	13.56
$F_{2,16}$	1.43^{ns}	2.75^{ns}	0.49^{ns}
SEm	6.133	0.475	0.210
Interaction			
f_1o_1	175.00	27.50	13.67
f_1o_2	187.00	28.17	14.17
f_1o_3	179.00	26.00	14.17
f_2o_1	182.33	26.33	13.83
f_2o_2	188.33	27.83	13.83
f_2o_3	156.67	25.83	13.33
f_3o_1	158.33	26.17	13.33
f_3o_2	162.33	27.50	13.50
f_3o_3	158.00	27.17	13.17
$F_{4,16}$	0.73^{ns}	0.69^{ns}	0.49^{ns}
SEm	10.623	0.822	0.363

ns – not significant

Table 56 Effect of nutrient levels and sources of organic manure on the bunch weight and yield in banana (first crop)

	Bunch weight (kg plant^{-1})	Yield (t ha $^{-1}$)
Levels of nutrients		
f_1	10.57	35.22
f_2	10.62	35.40
f_3	10.26	34.18
$F_{2,16}$	0.38^{ns}	0.69^{ns}
SEm	0.319	1.502
Sources of organic manure		
o_1	10.13	33.78
o_2	11.10	36.99
o_3	10.21	34.03
$F_{2,16}$	2.84^{ns}	0.09^{ns}
SEm	0.319	1.502
Interaction		
f_1o_1	10.77	35.89
f_1o_2	10.87	36.22
f_1o_3	10.07	33.55
f_2o_1	10.60	35.33
f_2o_2	11.07	36.88
f_2o_3	10.20	34.00
f_3o_1	9.03	30.11
f_3o_2	11.37	37.88
f_3o_3	10.37	34.55
$F_{4,16}$	1.45^{ns}	0.26^{ns}
SEm	0.552	2.601

ns – not significant

Significant interaction was observed between nutrient levels and sources of organic manure. When nutrient levels were combined with farm yard manure, no significant difference was seen in pulp peel ratio .But when nutrient levels were combined with vermicompost the ratio was maximum at $f_1 0_2$ and reduction in ratio was observed at $f_2 o_2$ and $f_3 o_2$ which were on par. The ratio was high at $f_1 o_3$ which was on par with $f_2 o_3$ in comparison with $f_3 o_3$.No significant difference between f_2 and f_3 were observed when they were combined with different organic sources, but when f_1 was combined with o_2 and o_3,an increase in pulp: peel ratio were observed, which were more or less similar.

4.2.1.10 Shelf Life

The shelf life as influenced by nutrient levels and organic sources are furnished in Table.57

The nutrient levels, organic sources and their interaction had no influence on shelf life of banana fruit.

4.2.1.11 **Quality Attributes**

Quality attributes *viz.*, TSS (%), ascorbic acid (mg 100 g^{-1}), acidity (%), total sugar (%), reducing sugar (%), non reducing sugar (%) and sugar: acid ratio is summarized in Table.58

Ascorbic acid, acidity, reducing sugar and sugar: acid ratio did not register any variation with nutrient levels, organic sources and their interaction. Total sugar content and TSS in the fruit varied significantly with organic sources. Maximum value for TSS was observed when vermicompost @ 5 kg pit^{-1} was applied and it was on par with farm yard manure. Total sugar was higher (17.90 %) when farmyard manure 15 kg pit^{-1} was applied which was on par with vermicompost application (17.55 %). However TSS and total sugar did not show any variation with levels of nutrients and its interaction with organic sources.

Table 57 Effect of nutrient levels and sources of organic manure on the pulp: peel ratio and shelf life of banana (first crop)

	Pulp: peel ratio	Shelf life (days)
Levels of nutrients		
f_1	3.12	9.00
f_2	2.51	9.78
f_3	2.41	9.67
$F_{2,16}$	4.84*	1.21^{ns}
SEm	0.175	0.380
CD	0.526	-
Sources of organic manure		
o_1	2.42	9.44
o_2	2.90	9.22
o_3	2.73	9.78
$F_{2,16}$	1.91^{ns}	0.54^{ns}
SEm	0.175	0.380
Interaction		
f_1o_1	2.37	9.00
f_1o_2	3.63	9.00
f_1o_3	3.37	9.00
f_2o_1	2.14	9.00
f_2o_2	2.44	9.33
f_2o_3	2.94	11.00
f_3o_1	2.74	10.33
f_3o_2	2.62	9.33
f_3o_3	1.87	9.33
$F_{4,16}$	3.52*	1.42^{ns}
SEm	0.304	0.660
CD	0.911	-

ns – not significant
*Significant at 5 per cent level

Table 58 Effect of nutrient levels and sources of organic manure on the quality attributes of banana (first crop)

	TSS (%)	Ascorbic acid (mg/100 g)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar acid ratio
Levels of nutrients							
f_1	29.56	20.06	0.33	16.16	11.63	5.43	49.79
f_2	30.33	23.15	0.59	17.43	12.83	4.61	59.05
f_3	29.22	21.61	0.34	16.28	11.22	5.06	48.20
$F_{2,16}$	1.69^{ns}	0.73^{ns}	0.77^{ns}	0.76^{ns}	1.16^{ns}	0.61^{ns}	3.98^{ns}
SEm	0.439	1.810	0.167	0.807	0.775	0.525	2.936
Sources of organic manure							
o_1	30.00	20.06	0.32	17.90	12.63	5.27	55.25
o_2	30.44	24.69	0.63	17.55	12.81	5.08	53.76
o_3	28.67	20.06	0.31	14.42	10.24	4.74	48.03
$F_{2,16}$	4.45*	2.18^{ns}	1.16^{ns}	5.64*	3.44^{ns}	0.26^{ns}	1.68^{ns}
SEm	0.439	1.810	0.167	0.807	0.775	0.525	2.936
CD	1.315	-	-	2.419	-	-	-
Interaction							
f_1o_1	29.67	18.52	0.37	17.90	12.41	5.50	48.86
f_1o_2	30.00	27.78	0.32	15.53	11.60	4.93	51.04
f_1o_3	29.00	13.89	0.31	15.06	10.89	5.84	49.48
f_2o_1	30.33	18.52	0.31	18.74	11.94	6.79	60.95
f_2o_2	30.33	23.15	1.18	18.51	15.16	3.35	61.88
f_2o_3	30.33	27.78	0.27	15.05	11.37	3.67	54.32
f_3o_1	30.00	23.15	0.29	17.07	13.54	3.53	55.94
f_3o_2	31.00	23.15	0.38	18.61	11.66	6.95	48.36
f_3o_3	26.67	18.52	0.34	13.16	8.44	4.71	40.30
$F_{4,16}$	2.46^{ns}	2.91^{ns}	1.00^{ns}	0.89^{ns}	1.44^{ns}	4.01*	0.69^{ns}
SEm	0.760	3.135	0.290	1.398	1.343	0.910	5.085
CD	-	-	-	-	-	2.726	-

ns – not significant
*Significant at 5 per cent level

The main effect of nutrient levels and organic sources on non-reducing sugar remained insignificant. However the interaction was significant. Highest value was registered for f_3o_2 (6.95 %).

4.2.1.12 Dry Matter Production (t ha^{-1})

The dry matter produced by fruit, leaf, pseudostem and rhizome as influenced by levels of nutrients and sources of organic manure are furnished in Table. 59

The total dry matter as well as those produced by different plant parts were not influenced by the treatments.

4.2.1.13 Nutrient Content in Index Leaf (%)

4.2.1.13.1 Nitrogen

Nitrogen content in index leaf at 2, 4 and 6 MAP as influenced by nutrient levels and sources of organic manure are presented in Table.60

The effect of nutrient levels, organic sources and their interaction was significant at 2 MAP. Maximum nitrogen content (3.41 %) noticed when 133 per cent of recommended nutrient dose was applied. It was on par with recommended dose of nutrients (3.38 %). Nitrogen content in the index leaf was the highest with banana pseudostem in fresh state @ 20 kg pit^{-1} (3.43 %) followed by vermicompost (3.35 %) and farmyard manure (3.21 %). Among interactions, nitrogen content was highest with f_2O_2 (3.87 %).

Nitrogen content in the index leaf at 4 MAP had no significant influence with levels of nutrients, organic sources and their interaction.

Nitrogen content varied significantly at 6 MAP with levels of nutrients. Maximum nitrogen content was noticed with 167 per cent of recommended nutrient dose (2.60 %). However the effect of organic sources and its interaction with nutrient levels showed no distinct pattern.

Table 59 Effect of nutrient levels and sources of organic manure on the dry matter production (t ha^{-1}) of plant parts of banana (first crop)

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	11.97	2.87	3.87	2.86	21.58
f_2	12.04	2.74	3.64	2.97	21.39
f_3	11.62	2.90	3.62	2.96	21.10
$F_{2,16}$	0.38^{ns}	0.27^{ns}	0.76^{ns}	0.43^{ns}	0.18^{ns}
SEm	0.361	0.160	0.155	0.087	0.571
Sources of organic manure					
o_1	11.48	2.94	3.71	2.86	21.01
o_2	12.58	2.83	3.80	3.00	22.21
o_3	11.57	2.74	3.62	2.92	20.86
$F_{2,16}$	2.85^{ns}	0.37^{ns}	0.33^{ns}	0.54^{ns}	1.68^{ns}
SEm	0.361	0.160	0.155	0.087	0.571
Interaction					
f_1o_1	12.20	3.25	4.13	2.94	22.53
f_1o_2	12.31	2.50	3.83	2.88	21.53
f_1o_3	11.11	2.87	3.63	2.76	20.67
f_2o_1	12.01	3.03	3.67	2.87	21.58
f_2o_2	12.54	2.67	3.70	3.00	21.91
f_2o_3	11.56	2.53	3.57	3.03	20.69
f_3o_1	10.24	2.53	3.33	2.80	18.90
f_3o_2	12.88	3.33	3.87	3.10	23.18
f_3o_3	11.75	2.83	3.67	2.97	21.22
$F_{4,16}$	1.45^{ns}	2.23^{ns}	0.81^{ns}	0.57^{ns}	2.15^{ns}
SEm	0.625	0.277	0.269	0.151	0.990

ns – not significant

Table 60 Effect of nutrient levels and sources of organic manure on the nitrogen content in index leaf at 2, 4 and 6 MAP (first crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	3.38	2.97	2.48
f_2	3.41	2.93	2.24
f_3	3.20	3.07	2.60
$F_{2,16}$	29.05**	0.88^{ns}	5.86*
SEm	0.020	0.078	0.075
CD	0.061	-	0.226
Sources of organic manure			
o_1	3.21	2.91	2.58
o_2	3.35	2.97	2.33
o_3	3.43	3.10	2.41
$F_{2,16}$	31.36**	1.52^{ns}	2.73^{ns}
SEm	0.020	0.078	0.075
CD	0.061	-	-
Interaction			
f_1o_1	3.32	2.89	2.48
f_1o_2	3.12	3.03	2.46
f_1o_3	3.69	2.99	2.50
f_2o_1	3.21	3.03	2.28
f_2o_2	3.87	2.84	2.03
f_2o_3	3.14	2.94	2.41
f_3o_1	3.08	2.82	2.97
f_3o_2	3.08	3.04	2.50
f_3o_3	3.45	3.36	2.32
$F_{4,16}$	103.67**	1.71^{ns}	3.00^{ns}
SEm	0.035	0.134	0.130
CD	0.105	-	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

4.2.1.13.2 Phosphorus

The phosphorus content at 2, 4 and 6 MAP given in Table.61 indicates that nutrient levels, organic sources and their interaction had no significant influence on P content of index leaf on phosphorus content of index leaf.

4.2.1.13.3 Potassium

The potassium content in the index leaf at 2, 4 and 6 MAP is given in Table. 62

The nutrient levels, organic sources and their interaction did not show any variation at 2 and 6 MAP. The potassium content at 4 MAP showed significant difference with levels of nutrients and sources of organic manure. However their interaction was insignificant. Highest value of potassium (6.55 %) was noticed at recommended dose of nutrients. With increase in dose of fertilizer, there was a decreasing trend. Significant reduction in potassium content was observed when fresh banana pseudostem was added.

4.2.1.14 Nutrient Content of Plant Parts (per cent)

4.2.1.14.1 Nitrogen

The nitrogen content in different parts of the plant as influenced by nutrient levels and organic sources are given in Table.63

The effect of nutrient levels, organic sources and their interaction was significant with the nitrogen content of fruit, pseudostem and rhizome Maximum nitrogen content in the fruit (0.69 %) was registered with RDN while in the rhizome (1.62 %) with one-third additional dose. Nitrogen content in the pseudostem with one-third (1.21 %) and two-third (1.22 %) additional dose were on par and significantly higher than the recommended dose of nutrients (1.08 %).

Table 61 Effect of nutrient levels and sources of organic manure on the phosphorus content in index leaf at 2, 4 and 6 MAP (first crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	0.40	0.13	0.46
f_2	0.45	0.15	0.31
f_3	0.35	0.13	0.36
$F_{2,16}$	0.84^{ns}	0.33^{ns}	1.66^{ns}
SEm	0.055	0.021	0.060
Sources of organic manure			
o_1	0.42	0.10	0.42
o_2	0.43	0.18	0.42
o_3	0.35	0.14	0.28
$F_{2,16}$	0.73^{ns}	2.99^{ns}	1.99^{ns}
SEm	0.055	0.021	0.060
Interaction			
f_1o_1	0.44	0.08	0.72
f_1o_2	0.41	0.13	0.35
f_1o_3	0.35	0.18	0.31
f_2o_1	0.45	0.07	0.21
f_2o_2	0.50	0.23	0.40
f_2o_3	0.40	0.15	0.31
f_3o_1	0.37	0.16	0.35
f_3o_2	0.39	0.17	0.52
f_3o_3	0.29	0.07	0.21
$F_{4,16}$	0.05^{ns}	2.77^{ns}	3.00^{ns}
SEm	0.094	0.037	0.103

ns – not significant

Table 62 Effect of nutrient levels and sources of organic manure on the potassium content in index leaf at 2, 4 and 6 MAP (first crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	6.42	6.55	3.81
f_2	6.29	5.69	4.31
f_3	6.36	5.31	3.82
$F_{2,16}$	0.17^{ns}	9.41**	3.37^{ns}
SEm	0.160	0.204	0.160
CD	-	0.612	-
Sources of organic manure			
o_1	6.20	6.13	3.76
o_2	6.44	6.16	4.11
o_3	6.42	5.24	4.08
$F_{2,16}$	0.71^{ns}	6.49*	1.59^{ns}
SEm	0.160	0.204	0.160
CD	-	0.612	-
Interaction			
f_1o_1	6.27	7.20	3.43
f_1o_2	7.13	6.80	4.03
f_1o_3	5.87	5.60	3.97
f_2o_1	6.40	5.87	4.40
f_2o_2	5.73	5.80	4.37
f_2o_3	6.73	5.40	4.17
f_3o_1	5.93	5.33	3.43
f_3o_2	6.47	5.87	3.93
f_3o_3	6.67	4.73	4.10
$F_{4,16}$	4.98**	1.07^{ns}	0.89^{ns}
SEm	0.278	0.353	0.270
CD	0.832	-	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 63 Effect of nutrient levels and sources of organic manure on the nitrogen content in different parts of banana (first crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	0.69	2.04	1.08	1.49
f_2	0.66	2.06	1.21	1.62
f_3	0.66	2.11	1.22	1.49
$F_{2,16}$	8.73**	3.18^{ns}	23.72**	11.86**
SEm	0.006	0.021	0.017	0.020
CD	0.017	-	0.050	0.060
Sources of organic manure				
o_1	0.65	1.97	1.07	1.52
o_2	0.71	2.34	1.45	1.84
o_3	0.65	1.90	0.99	1.34
$F_{2,16}$	35.47**	125.05**	219.11**	161.20**
SEm	0.006	0.021	0.017	0.020
CD	0.017	0.063	0.050	0.060
Interaction				
f_1o_1	0.67	1.90	0.93	1.49
f_1o_2	0.73	2.42	1.44	1.90
f_1o_3	0.67	1.79	0.86	1.06
f_2o_1	0.62	1.83	0.90	1.46
f_2o_2	0.73	2.28	1.51	1.87
f_2o_3	0.64	2.07	1.32	1.53
f_3o_1	0.65	2.19	1.38	1.61
f_3o_2	0.67	2.32	1.40	1.74
f_3o_3	0.65	1.83	0.88	1.42
$F_{4,16}$	6.23**	22.40**	60.92**	24.98**
SEm	0.010	0.037	0.029	0.034
CD	0.030	0.110	0.086	0.103

ns – not significant
**Significant at 1 per cent level

Highest value of nitrogen content was noticed in the fruit (0.71 %), pseudostem (1.45 %) and rhizome (1.84 %) of the treatment receiving vermicompost followed by farmyard manure and banana pseudostem in fresh state.

The nitrogen content in the leaf did not vary significantly with levels of nutrients. However the effect of organic sources and its interaction with nutrient levels was significant. Nitrogen content in the leaves was maximum (2.34 %) when the organic manure applied was vermicompost. It was followed by farmyard manure (1.97 %) and fresh pseudostem (1.90 %).

When f_1 and f_2 were combined with organic manure, nitrogen content in fruit was found to be high with vermicompost in comparison with farmyard manure and banana pseudostem. But f_3 in combination with the organics did not produce any difference in nitrogen content of fruit

Different nutrient levels with vermicompost resulted in high nitrogen content in leaf. With farmyard manure, maximum nitrogen content was observed when combined with f_3 i.e., at f_3o_1. Incorporating vermicompost resulted in high nitrogen content at f_1 which was on par with f_3 while nutrients combined with banana pseudostem recorded higher values with 133 percent of RDN.

Application of vermicompost enhanced the nitrogen content in pseudostem at f_1, f2 and f_3.

Nitrogen content in rhizome was high with farm yard manure when combined at f_3 and with vermicompost high and on par at f_1 and f_2 .High value was observed at f_2 with banana pseudostem. Maximum values were observed at f_1o_2 and f_2o_2.

4.2.1.14.2 Phosphorus

The phosphorus content of leaves, pseudostem, fruit and rhizome are presented in Table.64

Table 64 Effect of nutrient levels and sources of organic manure on the phosphorus content in different parts of banana (first crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	0.16	0.30	0.46	0.51
f_2	0.17	0.33	0.53	0.54
f_3	0.10	0.34	0.50	0.46
$F_{2,16}$	259.68**	8.12**	8.94**	81.66**
SEm	0.002	0.006	0.012	0.005
CD	0.007	0.019	0.036	0.014
Sources of organic manure				
o_1	0.15	0.26	0.49	0.46
o_2	0.13	0.30	0.54	0.53
o_3	0.15	0.40	0.46	0.52
$F_{2,16}$	9.95**	126.35**	10.06**	67.16**
SEm	0.002	0.006	0.012	0.005
CD	0.007	0.190	0.036	0.014
Interaction				
f_1o_1	0.17	0.13	0.36	0.48
f_1o_2	0.13	0.31	0.54	0.55
f_1o_3	0.17	0.46	0.49	0.49
f_2o_1	0.17	0.29	0.56	0.43
f_2o_2	0.17	0.27	0.58	0.60
f_2o_3	0.17	0.44	0.46	0.51
f_3o_1	0.10	0.37	0.55	0.47
f_3o_2	0.10	0.33	0.50	0.45
f_3o_3	0.10	0.31	0.44	0.46
$F_{4,16}$	11.97**	85.27**	13.28**	54.02**
SEm	0.001	0.011	0.012	0.008
CD	0.012	0.034	0.062	0.025

ns – not significant
**Significant at 1 per cent level

The main effect of nutrient levels, organic sources and their interaction was significant for phosphorus content in all plant parts. Maximum phosphorus accumulation was noticed in the treatments receiving one-third additional dose in fruit (0.17 %), pseudostem (0.53 %) and rhizome (0.54 %). Highest phosphorus content was registered in the leaves (0.34 %) with two-third additional dose.

Phosphorus content in the fruit was the highest (0.15 %) and on par with farmyard manure and fresh pseudostem while it was 0.13 per cent with vermicompost. However the phosphorus content in the rhizome (0.53 %) and pseudostem (0.54%) were higher for vermicompost addition while that in the leaf (0.40 %) was more for incorporation of fresh banana residue.

Phosphorus content in fruit was significantly low at f_3 when combined with organic manures. No significant difference was seen when f_2 and f_3 were combined with organic sources, but at f_1, a low value was observed at f_1o_2.No significant difference at f_1 and f_2 combined with o_1 and o_3.

In the leaf maximum value was recorded at f_3 when combined with o_1 and minimum was recorded at f_1 when combined with o_1.With vermicompost maximum was at f_3o_2 which was on par with f_1o_2.The values were very high when $f_1$and f_2 were combined with o_3.

High values of pseudostem phosphorus were recorded when all nutrient levels were combined with vermicompost which was on par with f_2o_1 and f_3o_1. This ranged from 0.50 to 0.58. When nutrient doses were combined with o_3 no significant difference was seen in phosphorus content. However at f_1o_1 a low value was obtained.

Maximum phosphorus content was seen in rhizome at f_2o_2 (0.60%)followed by f_1o_2 and f_2o_3. No significant difference in P content when nutrient levels were combined with o_1 and when f_1 and f_2 combined with o_3, but significant differences among f_1, f_2 and f_3 when combined with o_2 were seen.

4.2.1.14.3 Potassium

The potassium content of plant parts as influenced by nutrient levels and organic sources are presented in Table.65

The main effect of nutrient levels, organic sources and their interaction significantly influenced potassium content of leaves and pseudostem. Fruit potassium was significantly influenced by organic sources and its interaction with nutrient levels. On the contrary, potassium content in rhizome varied significantly with nutrient levels and its interaction with organic sources.

The highest value of potassium was observed in the pseudostem (5.82 %) and rhizome (5.49 %) at recommended dose of nutrients (f_1) and were on par with 133 per cent of RDN. There was a declining trend for potassium in rhizome and pseudostem with increasing levels. Maximum content of leaf potassium (3.40 %) was observed at higher level of nutrients applied (f_3).

The potassium content in pseudostem was the highest (5.83 %) with farmyard manure whereas with fresh banana pseudostem recorded higher value (2.60 %) in fruit. Leaves recorded maximum values of 3.27 per cent and 3.16 per cent of potassium with fresh and vermicomposted banana pseudostem which were on par. An increasing trend was noticed for potassium in leaves and fruit from farmyard manure to vermicompost to fresh banana residue.

Significant reduction in fruit K content was seen when f_3 was combined with o_1.No significant difference in K content with vermicompost at all nutrient levels. Significant increase in potassium content when f_3 was combined with o_3. With different organics at f_1 maximum K content was seen when combined with banana pseudostem; at

Table 65 Effect of nutrient levels and sources of organic manure on the potassium content in different parts of banana (first crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	2.38	3.00	5.82	5.49
f_2	2.31	2.96	5.61	5.36
f_3	2.22	3.40	5.27	4.80
$F_{2,16}$	3.33^{ns}	20.80**	15.09**	32.95**
SEm	0.013	0.054	0.072	0.064
CD	-	0.161	0.216	0.191
Sources of organic manure				
o_1	2.00	2.93	5.83	5.27
o_2	2.31	3.16	5.40	5.22
o_3	2.60	3.27	5.47	5.16
$F_{2,16}$	49.17**	10.00**	10.45**	0.77^{ns}
SEm	0.013	0.054	0.072	0.064
CD	0.128	0.161	0.216	-
Interaction				
f_1o_1	2.17	3.80	6.27	5.00
f_1o_2	2.20	2.40	5.40	5.00
f_1o_3	2.47	2.80	5.80	5.47
f_2o_1	2.27	2.60	6.10	5.27
f_2o_2	2.40	3.27	5.60	5.40
f_2o_3	2.27	3.00	5.13	5.40
f_3o_1	1.27	2.40	5.13	4.53
f_3o_2	2.33	3.80	5.20	5.27
f_3o_3	3.07	4.00	5.47	4.60
$F_{4,16}$	52.68**	75.58**	9.26**	16.92**
SEm	0.074	0.093	0.125	0.110
CD	0.222	0.279	0.375	0.331

ns – not significant
**Significant at 1 per cent level

f_2 no significant difference and at f_3 maximum was recorded at f_3o_3 and minimum at f_3o_1.

Maximum foliar potassium content recorded at f_1o_1 at the recommended dose of nutrients, at f_2 and at f_3 K content was maximum with o_2 and o_3 which were on par.

Higher values of potassium content at f_1o_1 followed by f_1o_3 and f_1o_2 were noticed when f_1 was combined with organic sources. Maximum were recorded at f_2o_1 followed by f_2o_2 and f_2o_3 with 133 percent of RDN and organic manures. No significant difference was seen when f_3 was combined with o_1, o_2 and o_3.

When organic manures were combined with f_1, no significant difference between o_1 and o_2 was observed, but high rhizome K was with o_3. No significant difference was noticed at f_2 whereas at f_3, high value was registered at o_2 with no significance at o_1 and o_3.

4.2.1.15 Nutrient Uptake (kg ha^{-1})

4.2.1.15.1 Nitrogen

The uptake of nitrogen by different plant parts as influenced by levels of nutrients and sources of organic manure are presented in Table.66

The total uptake as well as uptake by all plant parts except rhizome were not influenced by levels of nutrients. In the rhizome maximum nitrogen uptake was noticed at f_2 (133 per cent of RDN) value being 48.00 kg ha^{-1} and was on par with 167 per cent of RDN.

However sources of organic manure had significant influence on the uptake of nitrogen by all plant parts. Higher value of uptake was registered in all plant parts when vermicompost was added.

The interaction did not cause significant variation in total nitrogen uptake by fruit and leaf. The interaction significantly influenced nitrogen

Table 66 Effect of nutrient levels and sources of organic manure on the nitrogen uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	82.70	57.90	41.60	42.70	225.00
f_2	79.80	56.10	44.10	48.00	228.10
f_3	76.60	61.60	44.20	47.00	229.40
$F_{2,16}$	1.50^{ns}	0.72^{ns}	0.55^{ns}	4.13*	0.11^{ns}
SEm	2.480	3.310	1.970	1.370	6.810
CD	-	-	-	4.120	-
Sources of organic manure					
o_1	74.30	57.60	39.20	43.50	214.60
o_2	89.20	56.10	55.10	55.00	265.40
o_3	75.60	51.90	35.60	39.20	202.40
$F_{2,16}$	11.15**	4.68*	27.59**	34.98**	24.07**
SEm	2.480	3.310	1.970	1.370	6.810
CD	7.430	6.000	5.910	4.120	20.410
Interaction					
f_1o_1	81.80	61.80	38.60	43.90	226.00
f_1o_2	89.90	60.70	55.10	55.00	260.60
f_1o_3	76.40	51.30	31.20	29.40	188.30
f_2o_1	74.50	55.40	32.90	41.70	204.50
f_2o_2	91.50	60.50	56.00	56.00	264.10
f_2o_3	73.50	52.50	43.60	46.30	215.90
f_3o_1	66.70	55.70	46.10	44.90	213.50
f_3o_2	86.30	77.20	54.10	53.90	271.50
f_3o_3	76.90	51.90	32.20	42.10	203.10
$F_{4,16}$	1.07^{ns}	1.25^{ns}	3.69*	5.14**	1.16^{ns}
SEm	4.290	5.730	3.410	2.380	1.790
CD	-	-	10.230	7.130	-

ns – not significant
*Significant at 5 per cent level   **Significant at 1 per cent level

uptake by pseudostem and rhizome. Irrespective of the levels of nutrients received nitrogen uptake was maximum with vermicompost.

No significant difference in nitrogen uptake by pseudostem between f_1 and f_2 in combination with o_1 but significantly higher at f_3o_1. High nitrogen uptake values for pseudostem at o_2 irrespective of all nutrient levels were obtained but they were on par. No significant difference with f_1 and f_3 in combination with o_3 but significantly higher at f_2o_3 was observed.

Maximum uptake values by rhizome were obtained when nutrient levels were combined with o_2, but no significant difference was seen at different levels of nutrients. Uptake values were less when nutrient levels were combined with o_1 and o_3, the lowest being recorded by o_3.No significant difference was observed for nutrient levels in combination with o_1 and f_2 and f_3 in combination with o_3.

4.2.1.15.2 Phosphorus

Phosphorus uptake by different plant parts as influenced by nutrient levels and organic sources are furnished in Table.67

The total as well as uptake of phosphorus by fruit and rhizome were significant with nutrient levels. The total uptake, uptake by fruit and rhizome registered higher value (65.2 kg ha^{-1}, 20.5 kg ha^{-1}and16.2 kg ha^{-1}) when recommended dose and one-third additional dose was applied. However the uptake by leaves and pseudostem was not significant.

The organic sources exerted significant effect on uptake of phosphorus by leaf, pseudostem and rhizome. However the uptake by fruit and total uptake did not vary with sources of organic manure. The uptake of phosphorus recorded maximum value of 11.10 kg ha^{-1} in leaf; 20.40 kg ha^{-1} in pseudostem with application of fresh and vermicomposted pseudostem. In the rhizome significantly lower values were observed with farmyard manure.

Table 67 Effect of nutrient levels and sources of organic manure on the phosphorus uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	18.70	8.50	17.80	14.10	59.40
f_2	20.50	9.00	19.50	16.20	65.20
f_3	11.50	9.70	18.00	13.50	52.70
$F_{2,16}$	43.97**	0.90^{ns}	1.19^{ns}	6.74**	10.53**
SEm	0.720	0.630	8.060	0.530	1.930
CD	2.150	-	-	1.580	5.790
Sources of organic manure					
o_1	17.10	7.40	18.00	13.20	55.70
o_2	16.70	8.70	20.40	15.90	61.80
o_3	16.80	11.10	16.80	15.20	59.90
$F_{2,16}$	0.08^{ns}	8.44**	4.61*	7.36**	2.63^{ns}
SEm	0.720	0.630	0.860	0.530	1.930
CD	-	1.900	2.570	1.580	-
Interaction					
f_1o_1	20.30	4.30	14.90	11.10	53.60
f_1o_2	16.00	7.80	20.60	15.80	60.20
f_1o_3	19.80	13.30	17.80	13.60	64.50
f_2o_1	20.90	8.80	20.60	12.30	62.50
f_2o_2	21.30	7.20	21.40	18.00	67.90
f_2o_3	19.30	11.10	16.40	18.40	65.30
f_3o_1	10.20	9.30	18.40	13.10	51.00
f_3o_2	12.90	11.00	19.30	14.00	57.20
f_3o_3	11.40	8.80	16.30	13.50	49.90
$F_{4,16}$	2.66^{ns}	6.53**	1.68^{ns}	4.36*	1.07^{ns}
SEm	1.240	1.100	1.490	0.910	3.340
CD	-	3.290	-	2.730	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The interaction effect of treatments did not significantly influence the phosphorus uptake by fruit, pseudostem as well as total uptake. However the interaction caused significant variation in phosphorus uptake by leaves and rhizome.

High values of phosphorus uptake by leaf were recorded for f_1 and f_2 in combination with o_3 and for f_3 with o_2. However no significant difference among o_1, o_2 and o_3 was seen when organic manure was combined with f_2 and f_3. But when combined with f_1, lower values were recorded under o_1 and o_2; maximum was seen at f_1o_3 which was on par with f_2o_3 and f_3o_2.

Lowest values of P uptake by rhizome were recorded when all nutrient levels were combined with o_1. No significant difference was noticed when nutrients are combined with o_1. High values when f_2 was combined with o_2 and o_3 which were on par with f_10_2. No significant difference when f_3 is combined with different sources of organic manure.

4.2.1.15.3 Potassium

The uptake of potassium by different parts of banana as influenced by nutrient levels and organic sources are presented in Table 68.

The potassium uptake by leaves and pseudostem varied significantly with levels of nutrients. Maximum potassium uptake registered was with highest dose (f_3) of nutrients in leaves (100.3 kg ha^{-1}) and with lowest dose of nutrients (f_1) in pseudostem (225.4 kg ha^{-1}). However the uptake of potassium by fruit, rhizome and total uptake had no significant influence.

The organic sources did not significantly influence the uptake of potassium by leaves, pseudostem rhizome and total uptake. However significant variation was noticed in the uptake by fruit. The uptake was maximum (301.3 kg ha^{-1}) where pseudostem was added fresh and was on par with vermicompost application.

Table 68 Effect of nutrient levels and sources of organic manure on the potassium uptake by different parts of banana (first crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	284.80	87.70	225.40	157.40	755.20
f_2	278.60	80.50	204.70	158.90	722.70
f_3	263.70	100.30	191.00	142.20	697.20
$F_{2,16}$	1.09^{ns}	4.83*	4.18*	3.20^{ns}	1.79^{ns}
SEm	10.390	4.560	8.450	5.160	21.740
CD	-	13.670	25.350	-	-
Sources of organic manure					
o_1	235.20	87.40	218.20	151.30	859.90
o_2	290.80	91.20	205.00	156.60	681.70
o_3	301.30	89.80	197.90	150.60	724.30
$F_{2,16}$	11.69**	0.17^{ns}	1.47^{ns}	0.40^{ns}	1.74^{ns}
SEm	1.039	4.560	8.450	5.160	21.740
CD	3.116	-	-	-	-
Interaction					
f_1o_1	301.40	123.10	259.10	176.30	859.90
f_1o_2	270.90	59.70	206.60	144.40	681.70
f_1o_3	282.20	80.30	210.50	151.30	724.30
f_2o_1	273.10	78.40	223.90	150.90	726.40
f_2o_2	301.00	87.00	207.40	162.00	757.40
f_2o_3	261.80	76.00	182.80	163.80	684.40
f_3o_1	130.90	60.80	171.50	126.70	489.90
f_3o_2	300.40	126.70	201.10	163.30	791.50
f_3o_3	359.90	113.30	200.50	136.60	810.30
$F_{4,16}$	16.92**	18.29**	2.93^{ns}	4.12*	14.06**
SEm	18.000	7.900	14.600	8.940	37.650
CD	53.970	23.680	-	26.790	112.890

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The interaction effect of treatments showed significant variation in potassium uptake by all parts except pseudostem.

No significant difference in K uptake values by fruit when f_1 and f_2 was combined with organic sources. But when f_3 is combined with o_1 a significantly low uptake value was observed and high value at f_3o_3 followed by f_3o_2.

When f_1 and f_3 were combined with organic sources no significant difference in K uptake by leaf was seen between o_2 and o_3; significantly higher values were obtained with f_1o_1 and low value at f_3o_1. At f_1o_1, f_3o_2 and f_3o_3 the uptake values were higher.

Irrespective of the organic sources the uptake by rhizome was high at f_2 and were on par with f_1. At f_3 lower values were obtained with farm yard manure and banana pseudostem which were on par.

The total K uptake was significantly lower at f_3o_1 and higher values were recorded at f_1o_1 in comparison with f_1o_2 and f_1o_3. Total K uptake at f_2 irrespective of organic sources was found on par. However at f_3 significantly lower values were recorded with farmyard manure.

4.2.1.16 Economic Analysis

Total income (Rs.), net income (Rs.) and BCR as influenced by levels of nutrients and sources of organic manure are presented in Table 69.

Total and net income did not vary with nutrient levels, organic sources and their interaction. However, benefit-cost ratio was significant with main effect of nutrient levels and organic sources. But the interaction effects of treatments had no influence on BCR.

Maximum value of BCR was obtained at recommended dose of nutrients (3.80) and with banana pseudostem as source of organic manure (4.04).

Table 69 Effect of nutrient levels and organic sources on the economics of banana cultivation (first crop)

	Total Income (Rs.)	Net income (Rs.)	Benefit : Cost ratio
Levels of nutrients			
f_1	484499	381282	3.80
f_2	486906	378189	3.57
f_3	471019	357257	3.20
$F_{2,16}$	0.39^{ns}	0.89^{ns}	4.34*
SEm	13802.5	13802.5	0.147
CD	-	-	0.440
Sources of organic manure			
o_1	465723	366324	3.71
o_2	507607	374459	2.82
o_3	469093	375945	4.04
$F_{2,16}$	2.84^{ns}	0.14^{ns}	18.71**
SEm	13802.5	13802.5	0.147
CD	-	-	0.440
Interaction			
f_1o_1	493165	399115	4.25
f_1o_2	497497	396697	2.89
f_1o_3	462834	375034	4.27
f_2o_1	485943	386393	3.88
f_2o_2	506163	372863	2.81
f_2o_3	468612	375312	4.02
f_3o_1	418061	313466	3.00
f_3o_2	519162	380817	2.75
f_3o_3	475833	377488	3.84
$F_{4,16}$	1.45^{ns}	1.45^{ns}	1.43^{ns}
SEm	23906.66	23906.6	0.254

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

4.2.1.17 Physiological Observations

The leaf temperature, light interaction ($\mu mol\ m^{-2}s^{-1}$) and stomatal conductance ($S\ cm^{-1}$) at 2 and 4 MAP as influenced by nutrient levels and organic sources are presented in Table 70.

Observations on leaf temperature did not show any variation due to treatments and physiological growth stage of crop.

The values of stomatal conductance ranged from 0.34 to 1.12 $S\ cm^{-1}$ at 2 MAP. However the values increased at 4 MAP ranging from 10.1 to 14.2 Scm^{-1} with the treatments imposed.

The light interception showed a declining trend with age. It ranged from 523.3 to 1453.3 $\mu mol\ m^{-2}s^{-1}$ at 2 MAP whereas the values were from 140 to 280 $\mu mol\ m^{-2}s^{-1}$ at 4 MAP.

4.2.2 Banana – Second Crop

4.2.2.1 Height of the Pseudostem (cm)

The pseudostem height at 2, 4 and 6 MAP as influenced by levels of nutrients, sources of organic manure and periods of observation are presented in Table 71.

The effect of nutrient levels, sources of organic manure and their interaction did not cause any significant variation in plant height at 2, 4 and 6 MAP.

4.2.2.2 Girth of the Pseudostem (cm)

The pseudostem girth at 2, 4 and 6 MAP as influenced by the nutrient levels, organic sources and periods of observation are furnished in Table 72.

Pseudostem girth was neither influenced by nutrients nor manure at different periods of time.

Table 70 Effect of nutrient levels and sources of organic manure on the physiological observations of banana cultivation (first crop)

Treatments	Leaf temperature (°C)		Stomatal conductance (S cm^{-1})		Light interception (μ mol m^{-2} s^{-1})	
	2 MAP	4 MAP	2 MAP	4 MAP	2 MAP	4 MAP
f_1o_1	32.30	31.50	0.51	12.10	816.70	140.00
f_1o_2	32.00	32.70	0.79	11.40	1453.30	178.00
f_1o_3	33.20	32.30	0.61	10.10	1090.00	277.70
f_2o_1	32.60	32.60	1.12	12.10	1070.00	280.00
f_2o_2	32.10	32.20	0.34	13.20	883.30	159.70
f_2o_3	31.70	33.00	0.36	10.60	790.00	221.00
f_3o_1	32.70	32.30	0.41	14.20	1113.30	258.70
f_3o_2	32.20	31.70	0.41	12.30	753.30	255.30
f_3o_3	32.90	31.90	0.88	14.10	523.30	252.70

*Not statistically analysed

Table 71 Effect of nutrient levels and sources of organic manure on the pseudostem height (cm) of banana (second crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	84.50	148.89	288.33
f_2	82.22	144.11	278.17
f_3	79.22	146.11	278.44
Sources of organic manure			
o_1	84.78	137.44	281.83
o_2	74.50	145.78	281.28
o_3	86.67	155.89	281.83
Interaction			
f_1o_1	93.00	144.67	298.67
f_1o_2	68.00	143.00	280.00
f_1o_3	92.17	159.00	286.33
f_2o_1	80.00	121.00	273.00
f_2o_2	77.00	150.33	281.67
f_2o_3	89.67	161.00	279.83
f_3o_1	81.33	146.67	273.83
f_3o_2	78.17	144.00	282.17
f_3o_3	78.17	147.67	279.33

Effect	F value	SEm	CD
F	$F_{2,16}$ = 0.52^{ns}	4.679	-
O	$F_{2,16}$ = 0.80^{ns}		-
FO	$F_{4,16}$ = 0.88^{ns}	8.104	-
MAP (M)	$F_{2,36}$ = 1296.97**	2.830	8.124
M x F	$F_{4,36}$ = 0.25^{ns}	4.901	-
M x O	$F_{4,36}$ = 1.58^{ns}		-
M x F x O	$F_{8,36}$ = 0.52^{ns}	8.489	-

ns – not significant, **Significant at 1 per cent level

Table 72 Effect of nutrient levels and sources of organic manure on the pseudostem girth (cm) of banana (second crop) at 2, 4 and 6 MAP

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	26.28	38.06	58.39
f_2	28.39	37.67	58.11
f_3	26.67	37.44	57.72
Sources of organic manure			
o_1	26.89	36.83	57.83
o_2	26.44	37.28	59.44
o_3	28.00	39.06	56.94
Interaction			
f_1o_1	28.50	37.67	58.17
f_1o_2	24.00	37.33	61.00
f_1o_3	26.33	39.17	56.00
f_2o_1	27.00	33.33	57.00
f_2o_2	28.00	38.33	58.67
f_2o_3	30.17	41.33	58.67
f_3o_1	25.17	39.50	58.33
f_3o_2	27.33	36.17	58.67
f_3o_3	27.50	36.67	56.17

Effect	F value	SEm	CD
F	$F_{2,16} = 0.27^{ns}$	0.754	-
O	$F_{2,16} = 0.30^{ns}$		-
FO	$F_{4,16} = 1.34^{ns}$	1.305	-
MAP (M)	$F_{2,36} = 463.24^{**}$	0.731	2.099
M x F	$F_{4,36} = 0.32^{ns}$	1.266	-
M x O	$F_{4,36} = 0.97^{ns}$		-
M x F x O	$F_{8,36} = 0.75^{ns}$	2.193	-

ns -- not significant, **Significant at 1 per cent level

4.2.2.3 Number of Functional Leaves at 2, 4, 6 MAP and at Harvest

The functional leaves at 2, 4, 6 MAP and at harvest as influenced by levels of nutrients and sources of organic manure are furnished in Table 73.

Number of functional leaves at 2 and 6 MAP did not vary significant with nutrient levels, organic sources and their interaction. The nutrient levels and organic sources had no effect on leaf number at 4 MAP. But the interaction caused significant variation in the number of functional leaves at harvest. Maximum value of 9.33 per cent was recorded at f_2o_3. At harvest the number was significantly influenced by organic sources. But fertilizer levels and its interaction with organic sources was insignificant. Maximum number of functional leaves was noticed with farmyard manure (6.11) followed by vermicompost (5.44) and fresh banana residue (4.33).

4.2.2.4 Total Functional Leaf Area (m^2) and Leaf Area Index

The total functional leaf area and leaf area index at harvest as influenced by levels of nutrients and organic sources are summarized in Tables 74 and 75.

The total functional leaf area (m^2) did not differ significantly with levels of nutrients and organic sources at 2 and 4 MAP. However, the nutrient levels influenced the number of functional leaves at six months after planting and at harvest. But the interaction effect was insignificant.

At six months after planting and at harvest functional leaf area was maximum (12.23 and 6.40 m^2) at f_2. Lowest values (10.53 and 4.83 m^2) was observed with recommended dose of nutrients.

At harvest total functional leaf area was maximum with farmyard manure (6.16 m^2) followed by vermicompost (5.78 m^2) and fresh banana pseudostem (4.79 m^2).

Table 73 Effect of nutrient levels and sources of organic manure on the number of functional leaves of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	7.78	8.22	10.81	4.89
f_2	7.22	8.22	10.87	5.67
f_3	7.33	8.00	11.06	5.33
$F_{2,16}$	0.38^{ns}	0.39^{ns}	0.17^{ns}	2.07^{ns}
SEm	0.475	0.207	0.311	.271
Sources of organic manure				
o_1	7.11	8.22	11.17	6.11
o_2	7.56	7.89	10.79	5.44
o_3	7.67	8.33	10.78	4.33
$F_{2,16}$	0.38^{ns}	1.25^{ns}	0.51^{ns}	10.97**
SEm	0.475	0.207	0.311	0.271
CD	-	-	-	0.810
Interaction				
f_1o_1	8.00	8.33	11.17	6.00
f_1o_2	7.33	8.33	10.27	5.33
f_1o_3	8.00	8.00	11.00	3.33
f_2o_1	7.00	7.67	10.83	6.00
f_2o_2	6.67	7.67	10.77	5.67
f_2o_3	8.00	9.33	11.00	5.33
f_3o_1	6.33	8.67	11.50	6.33
f_3o_2	8.67	7.67	11.33	5.33
f_3o_3	7.00	7.67	10.33	4.33
$F_{4,16}$	1.34^{ns}	4.43*	0.85^{ns}	1.40^{ns}
SEm	0.822	0.358	0.538	0.469
CD	-	1.073	-	-

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Table 74 Effect of nutrient levels and sources of organic manure on total functional leaf area (m^2) of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	1.70	3.61	10.53	4.83
f_2	1.49	3.42	12.23	6.40
f_3	1.49	3.58	11.49	5.51
$F_{2,16}$	0.29^{ns}	0.21^{ns}	3.91*	5.04*
SEm	0.221	0.219	0.430	0.350
CD	-	-	1.289	1.050
Sources of organic manure				
o_1	1.45	3.16	11.21	6.16
o_2	1.42	3.48	11.42	5.78
o_3	1.81	3.97	11.61	4.79
$F_{2,16}$	0.95^{ns}	3.44^{ns}	0.22^{ns}	4.07*
SEm	0.221	0.219	0.430	0.350
CD	-	-	-	1.050
Interaction				
f_1o_1	1.96	3.21	10.53	5.66
f_1o_2	1.33	3.65	10.99	5.69
f_1o_3	1.80	3.97	10.07	3.14
f_2o_1	1.20	2.32	11.86	6.64
f_2o_2	1.14	3.45	11.69	6.19
f_2o_3	2.12	4.49	13.13	6.36
f_3o_1	1.19	3.97	11.24	6.19
f_3o_2	1.79	3.34	11.59	5.46
f_3o_3	1.50	3.45	11.65	4.87
$F_{4,16}$	1.22^{ns}	3.27*	0.68^{ns}	1.52^{ns}
SEm	0.383	0.380	0.745	0.607
CD	-	1.139	-	-

ns – not significant
*Significant at 5 per cent level

Table 75 Effect of nutrient levels and sources of organic manure on the leaf area index (LAI) of banana (second crop) at 2, 4, 6 MAP and at harvest

	2 MAP	4 MAP	6 MAP	At harvest
Levels of nutrients				
f_1	0.57	1.20	3.51	1.61
f_2	0.50	1.14	4.08	2.13
f_3	0.50	1.20	3.83	1.84
$F_{2,16}$	0.29^{ns}	0.24^{ns}	4.01*	4.91*
SEm	0.075	0.073	0.142	0.118
CD	-	-	0.425	0.353
Sources of organic manure				
o_1	0.48	1.06	3.74	2.06
o_2	0.47	1.16	3.81	1.93
o_3	0.60	1.32	3.87	1.60
$F_{2,16}$	0.98^{ns}	3.32^{ns}	0.21^{ns}	3.99*
SEm	0.073	0.073	0.142	0.118
CD	-	-	-	0.353
Interaction				
f_1o_1	0.65	1.07	3.51	1.89
f_1o_2	0.45	1.22	3.67	1.89
f_1o_3	0.60	1.32	3.35	1.05
f_2o_1	0.40	0.77	3.96	2.21
f_2o_2	0.38	1.15	3.90	2.07
f_2o_3	0.71	1.49	4.37	2.12
f_3o_1	0.40	1.32	3.75	2.06
f_3o_2	0.59	1.11	3.87	1.83
f_3o_3	0.50	1:15	3.89	1.63
$F_{4,16}$	1.24^{ns}	3.15*	0.69^{ns}	1.47^{ns}
SEm	0.127	0.383	0.246	0.204
CD	-	0.128	-	-

ns – not significant
*Significant at 5 per cent level

Nutrient levels caused significant variation in LAI during later stages of observation (6 MAP and at harvest) while it was insignificant during second and fourth month. Maximum values were registered at f_2 at sixth month (4.08) and at harvest (2.13) which was on par with f_3.

Organic sources had no influence on LAI except at harvest. Leaf area index registered maximum value of 2.06 with farmyard manure and was on par with vermicompost (1.93).

The interaction effect remained insignificant at all stages of observation except fourth month after planting. Highest LAI was noticed at f_2O_3 the value being 1.49.

Irrespective of the treatments, LAI increased upto 6 MAP, reached maximum value and the decreased.

4.2.2.5 **Duration of the Crop (days)**

The period taken from planting to shooting and planting to harvest are presented in Table 76.

The effect of nutrient levels, organic sources and its interaction had no significant influence on data of shooting. Date of harvesting did not vary with nutrient levels and its interaction with organic sources. However organic sources exerted significant influence on crop duration. The duration was maximum with farmyard manure (285.89 days) followed by vermicompost (283.56 days) and banana pseudostem (272.67 days).

4.2.2.6 Post Harvest Observation

4.2.2.6.1 Number of Hands per Bunch

The number of hands produced per bunch as influenced by nutrient levels and organic sources are presented in Table 77.

The effect of nutrient levels and its interaction with organic sources found to be significant. The number of hands per bunch did not vary significantly with sources of organic manure.

Table 76 Effect of nutrient levels and sources of organic manure on the date of shooting and harvest (days) of banana (second crop)

	Date of shooting	Date of harvest
Levels of nutrients		
f_1	204.89	276.56
f_2	211.56	283.56
f_3	213.67	282.00
$F_{2,16}$	0.55^{ns}	1.66^{ns}
SEm	6.196	2.840
Sources of organic manure		
o_1	217.33	285.89
o_2	212.00	283.56
o_3	200.78	272.67
$F_{2,16}$	1.86^{ns}	6.17*
SEm	6.196	2.840
CD	-	8.515
Interaction		
f_1o_1	200.67	275.00
f_1o_2	217.67	284.33
f_1o_3	196.33	270.33
f_2o_1	229.67	296.00
f_2o_2	215.00	284.33
f_2o_3	190.00	270.33
f_3o_1	221.67	286.67
f_3o_2	203.33	282.00
f_3o_3	216.00	277.33
$F_{4,16}$	1.75^{ns}	1.83^{ns}
SEm	10.733	4.919

ns – not significant *Significant at 5 per cent level
*Significant at 5 per cent level

Maximum number of hands was recorded in the treatments receiving higher dose of nutrients (f_2 and f_3) along with farmyard manure (6.0). Similarly f_3 (167 per cent of recommended nutrient dose) enhanced the number of hands over other nutrient levels, value being 5.67. Increasing levels of nutrients showed an increasing trend.

4.2.2.6.2 Number of Fingers per Bunch

The number of fingers per bunch as influenced by nutrient levels and organic sources are presented in Table 77.

The effect of nutrient levels, organic sources and their interaction was significant on finger number per bunch. As the level of nutrients increased there was an increasing trend in the number of fingers pre bunch. The value was minimum with recommended dose of nutrients (45.78) and maximum with two-third additional dose (54.78). Among organic sources, farmyard manure recorded the highest number of fingers (53.56). Maximum finger number (59) was registered for the nutrient f_2o_1 (133 per cent of recommended nutrient dose + farmyard manure).

4.2.2.6.3 Weight (kg) and Number of Fingers in D Hand

The finger number and weight of D hand as influenced by levels of nutrients and organic sources are presented in Table 77.

Both the finger number and weight of the D hand was not influenced by levels of nutrients. Sources of organic manure caused significant variation in the number of fingers in D hand while it had no influence on its weight. The number was maximum with farmyard manure (10.33) and was on par with vermicompost (10.22).

The interaction effect of treatments showed significant effect on both the observations. Maximum number of finger (11.33) was observed in the treatment f_2o_1 (133 per cent of recommended nutrient dose + farmyard manure) while the weight was the highest (2.67 kg) with f_3o_1.

Table 77 Effect of nutrient levels and sources of organic manure on the bunch and hand characteristics of banana (second crop)

	Number of hands per bunch	Number of fingers per bunch	Number of fingers in D hand	Weight of D hand (kg)
Levels of nutrients				
f_1	4.67	45.78	9.78	2.28
f_2	5.22	48.78	10.11	2.37
f_3	5.67	54.78	10.11	2.39
$F_{2,16}$	15.25**	7.17**	0.69^{ns}	1.13^{ns}
SEm	0.128	1.711	0.232	0.055
CD	0.385	5.131	-	-
Sources of organic manure				
o_1	5.33	53.56	10.33	2.43
o_2	5.11	48.33	10.22	2.29
o_3	5.11	47.44	9.44	2.31
$F_{2,16}$	1.00^{ns}	3.72*	4.34*	1.98^{ns}
SEm	0.128	1.711	0.232	0.055
CD	-	5.131	0.697	-
Interaction				
f_1o_1	4.00	43.33	9.00	2.33
f_1o_2	5.33	52.33	11.00	2.40
f_1o_3	4.67	41.67	9.33	2.10
f_2o_1	6.00	59.00	11.33	2.30
f_2o_2	4.67	42.67	10.00	2.30
f_2o_3	5.00	44.67	9.00	2.50
f_3o_1	6.00	58.33	10.67	2.67
f_3o_2	5.33	50.00	9.67	2.17
f_3o_3	5.67	56.00	10.00	2.33
$F_{4,16}$	10.00**	5.58**	6.40**	4.63*
SEm	0.222	8.887	0.403	0.096
CD	0.666	2.964	1.207	0.287

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

4.2.2.6.4 Weight of the D Finger (g)

The weight of the D finger as influenced by nutrient levels and organic sources are given in Table 78.

The effect of organic sources on finger weight was not significant. However it varied significantly with nutrient levels and its interaction with organic sources. The finger weight was maximum (217.78 g) with f_2.

Among the interaction, f_2O_1 (133 per cent of recommended nutrient dose + farmyard manure) registered the highest finger weight of 250 g.

4.2.2.6.5 Fruit Size

Fruit size indicated by the length and girth of D finger as influenced by levels of nutrients and organic sources are presented in Table 78.

The nutrient levels significantly influenced the length and girth of D finger and the highest values (26.72 cm and 14.44 cm) were recorded with recommended dose of nutrients + one-third additional dose and girth was on par with recommended dose of nutrients.

The organic sources had significant effect on length and girth of D finger. The values of length ranged from 25.50 to 26.56, the maximum being with vermicompost (26.56 cm). Highest value of girth was registered on addition of fresh banana pseudostem (14.50 cm). The influence of farmyard manure and vermicompost on girth was observed to be on par.

The interaction effect of treatments significantly influenced the length of the finger while it was not significant on girth. Maximum values were recorded with vermicompost at f_1 (27.00 cm) and f_3 (26.17 cm).

4.2.2.6.6 Bunch Weight (kg plant^{-1}) and Yield (t ha^{-1})

The bunch weight and yield as influenced by organic sources, nutrient levels and its interaction are given in Table 79.

Table 78 Effect of nutrient levels and sources of organic manure on the finger characteristics of banana (second crop)

	Weight of the D finger (g)	Length of the D finger (cm)	Girth of the D finger (cm)
Levels of nutrients			
f_1	186.11	25.94	14.11
f_2	217.78	26.72	14.44
f_3	169.11	25.33	13.56
$F_{2,16}$	9.33**	6.47**	4.72*
SEm	8.085	0.274	0.207
CD	24.240	0.820	0.630
Sources of organic manure			
o_1	196.33	24.94	13.89
o_2	179.44	26.56	13.72
o_3	197.22	25.50	14.50
$F_{2,16}$	1.54^{ns}	3.75*	3.93*
SEm	8.085	0.274	0.207
CD	-	0.820	0.620
Interaction			
f_1o_1	183.33	26.33	14.00
f_1o_2	200.00	27.00	14.00
f_1o_3	175.00	24.50	14.33
f_2o_1	250.00	26.83	14.33
f_2o_2	161.67	26.50	13.83
f_2o_3	241.67	26.83	15.17
f_3o_1	155.67	24.67	13.33
f_3o_2	176.67	26.17	13.33
f_3o_3	175.00	25.17	14.00
$F_{4,16}$	6.08**	3.24*	0.53^{ns}
SEm	14.004	0.474	0.358
CD	41.985	1.421	-

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

Table 79 Effect of nutrient levels and sources of organic manure on the bunch weight and yield in banana (second crop)

	Bunch weight (kg $plant^{-1}$)	Yield (t ha^{-1})	Pooled Yield (t ha^{-1})
Levels of nutrients			
f_1	10.63	35.44	35.33
f_2	11.01	36.70	36.05
f_3	11.57	38.55	36.36
$F_{2,16}$	3.36^{ns}	3.35^{ns}	0.62^{ns}
SEm	0.256	0.854	0.670
Sources of organic manure			
o_1	11.39	37.96	35.86
o_2	10.94	36.48	36.73
o_3	10.88	36.25	35.14
$F_{2,16}$	1.18^{ns}	1.18^{ns}	1.40^{ns}
SEm	0.256	0.854	0.670
Interaction			
f_1o_1	10.33	34.44	35.16
f_1o_2	11.57	38.55	37.38
f_1o_3	10.00	33.33	33.44
f_2o_1	12.33	41.11	38.21
f_2o_2	9.83	32.77	34.82
f_2o_3	10.87	36.22	35.10
f_3o_1	11.50	38.33	34.22
f_3o_2	11.43	38.11	37.99
f_3o_3	11.77	39.22	36.88
$F_{4,16}$	5.22**	5.23**	3.41*
SEm	0.444	1.479	1.170
CD	1.331	4.436	3.350

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The main effect of nutrient levels and organic sources were not significant on bunch weight and yield. The interaction effect significantly influenced the bunch weight and yield. With vermicompost, recommended dose of nutrients; with farmyard manure, 133 per cent of RDN and with banana pseudostem higher levels of nutrients was found sufficient to produce higher bunch weight and yield.

Similar trend was observed also on pooled yield of two years.

4.2.2.7 Pulp-Peel Ratio

The pulp-peel ratio as influenced by the levels of nutrients and organic sources is presented in Table 80.

The effect of levels of nutrients was significant on pulp-peel ratio. Maximum value was recorded at recommended dose of nutrients plus one-third additional dose (3.37).

The organic sources and its interaction with nutrient levels had no significant influence on pulp-peel ratio.

4.2.2.8 Shelf life

The shelf life as influenced by the effect of nutrient levels, organic sources and their interaction is furnished in Table 80.

None of the treatments had influence on shelf life.

4.2.2.9 Quality Attributes

4.2.2.9.1 TSS (per cent)

The total soluble sugars as influenced by nutrient levels and organic sources are presented in Table 81.

Though organic sources and its interaction with nutrient levels had no effect on TSS (%), it varied significantly with levels of nutrients. The TSS at recommended dose of nutrients (30.56) and at f_2 were one par and significantly higher than f_3.

Table 80 Effect of nutrient levels and sources of organic manure on the pulp: peel ratio and shelf life of banana (second crop)

	Pulp: peel ratio	Shelf life (days)
Levels of nutrients		
f_1	2.94	8.89
f_2	3.37	9.33
f_3	2.66	9.56
$F_{2,16}$	8.64**	1.07^{ns}
SEm	0.122	0.330
CD	0.365	-
Sources of organic manure		
o_1	3.08	9.22
o_2	2.93	9.33
o_3	2.96	9.22
$F_{2,16}$	0.41^{ns}	0.00^{ns}
SEm	0.122	0.330
Interaction		
f_1o_1	2.67	9.00
f_1o_2	3.00	8.67
f_1o_3	3.15	9.00
f_2o_1	3.87	9.33
f_2o_2	3.10	9.33
f_2o_3	2.13	9.33
f_3o_1	2.70	9.33
f_3o_2	2.70	10.00
f_3o_3	2.60	9.33
$F_{4,16}$	2.71^{ns}	0.27^{ns}
SEm	0.211	0.570

ns – not significant
**Significant at 1 per cent level

4.2.2.9.2 Ascorbic Acid (mg 100 g^{-1} fruit)

The ascorbic acid content as influenced by levels of nutrients and organic sources is presented in Table 81.

Ascorbic acid content varied with levels of nutrients and its interaction with organic sources. However the effect of organic sources remained insignificant.

The content of ascorbic aid at f_1 and f_2 were same (0.17 mg 100 g^{-1}) and it was significantly superior to f_3 (0.14 mg 100 g^{-1}).

Among interactions maximum content of 0.20 mg 100 g^{-1} was noticed with f_2o_1.

4.2.2.9.3 Acidity (%)

The acidity of the fruit as influenced by the nutrient levels and organic sources are presented in Table 81.

The nutrient levels, organic sources and their interaction significantly influenced the acidity of the fruit.

Highest value of 0.51 per cent for acidity was recorded with f_2 (133 per cent of recommended nutrient dose). Vermicompost as organic sources enhanced acidity (0.49 %) while farmyard manure reduced the same (0.46 %).

Among combinations, acidity was the least with farmyard manure at f_1 and f_2 being 0.42 per cent and 0.44 per cent respectively. Acidity was the highest (0.58 per cent) at f_2o_3 (133 per cent of recommended nutrient dose + fresh banana pseudostem).

4.2.2.9.4 Sugar Content (%)

The total, reducing and non-reducing sugar as influenced by nutrient levels and organic sources are presented in Table 81.

Table 81 Effect of nutrient levels and sources of organic manure on the quality attributes of banana (second crop)

	TSS (%)	Ascorbic acid (mg/100 g)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non-reducing sugar (%)	Sugar acid ratio
Levels of nutrients							
f_1	30.78	0.17	0.47	20.46	17.96	2.50	44.34
f_2	30.78	0.17	0.51	22.43	18.11	4.32	44.86
f_3	30.00	0.14	0.46	18.76	16.24	2.52	40.88
$F_{2,16}$	19.61**	4.67*	13.95**	22.54**	6.04*	15.69**	5.02*
SEm	0.101	0.007	0.007	0.387	0.422	0.263	0.966
CD	0.304	0.020	0.021	1.158	1.266	0.790	2.898
Sources of organic manure							
o_1	30.56	0.17	0.46	20.81	16.99	3.81	45.70
o_2	30.56	0.16	0.49	19.32	17.26	2.06	39.46
o_3	30.44	0.16	0.48	21.52	18.06	3.46	44.93
$F_{2,16}$	0.40^{ns}	2.00^{ns}	5.82*	8.46**	1.71^{ns}	12.47**	12.39**
SEm	0.101	0.007	0.007	0.387	0.422	0.263	0.966
CD	-	-	0.021	1.158	-	0.790	2.898
Interaction							
f_1o_1	30.67	0.17	0.42	18.22	14.71	3.51	43.62
f_1o_2	31.00	0.15	0.53	19.26	17.87	1.39	36.16
f_1o_3	30.67	0.18	0.45	23.88	21.29	2.59	53.25
f_2o_1	31.00	0.20	0.44	24.97	19.60	5.37	56.45
f_2o_2	30.67	0.15	0.51	19.36	16.86	2.50	38.16
f_2o_3	30.67	0.17	0.58	22.95	17.87	5.08	38.98
f_3o_1	30.00	0.15	0.52	19.23	16.67	2.56	37.02
f_3o_2	30.00	0.17	0.44	19.33	17.05	2.28	44.06
f_3o_3	30.00	0.12	0.43	17.73	15.00	2.72	41.56
$F_{4,16}$	1.00^{ns}	4.67*	33.37**	15.82**	12.16**	2.60^{ns}	27.29**
SEm	0.176	0.012	0.036	0.670	0.732	0.456	1.674
CD	-	0.035	0.012	2.007	2.194	-	5.019

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The effect of levels of nutrients was significant for total, reducing and non-reducing sugar. In all the treatments, maximum value was recorded with f_2 for total sugar (22.43 %), reducing sugar (18.11 %) and non-reducing sugar (4.32 %).

The organic sources influenced significantly the total and non-reducing sugar while its effect was not significant on reducing sugar. Total sugar content recorded highest value with fresh banana residue (21.52 %) and was on par with farmyard manure whereas highest content of non-reducing sugar was noted with farmyard manure (3.81 %) which was on par with banana pseudostem.

The interaction effect significantly influenced the total and reducing sugar. Highest value of total and reducing sugar was noticed at f_1 with fresh banana pseudostem values being 23.88 per cent and 21.29 per cent respectively.

4.2.2.9.5 Sugar Acid Ratio

The sugar acid ratio as influenced by nutrient levels and organic sources is presented in Table 81.

The main effect of nutrient levels, sources of organic manure and their interaction was significant. Sugar acid ratio at f_1 (44.34) and f_2 (44.86) was found to be on par and superior to f_3 (40.88). Highest value of sugar acid ratio was recorded with farmyard manure (45.70) and was on par with fresh banana residue (44.93).

Among interactions the lowest ratio was recorded with vermicompost at f_1 (36.16) and f_2 (38.16).

4.2.2.10 Dry Matter Production (t ha^{-1})

Dry matter produced by the leaves, pseudostem fruit and rhizome as well as the total dry matter as influenced by levels of nutrients and sources of organic manure are given in Table 82.

Table 82 Effect of nutrient levels and sources of organic manure on the dry matter production (t ha^{-1}) of plant parts of banana (second crop)

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	12.05	2.61	2.61	2.34	19.60
f_2	12.48	3.01	3.06	2.91	21.45
f_3	13.10	2.53	3.08	2.90	21.62
$F_{2,16}$	3.35^{ns}	5.22*	8.86**	10.28**	12.20**
SEm	0.290	0.113	0.088	0.100	0.321
CD	-	0.304	0.261	0.303	0.962
Sources of organic manure					
o_1	12.90	3.23	2.98	2.89	22.00
o_2	12.40	2.61	3.08	2.76	20.84
o_3	12.32	2.31	2.69	2.51	19.82
$F_{2,16}$	1.18^{ns}	17.27**	5.22*	3.60^{ns}	11.52**
SEm	0.290	0.113	0.088	0.101	0.321
CD	-	0.34	0.261	-	0.962
Interaction					
f_1o_1	11.71	2.89	2.87	2.43	19.89
f_1o_2	13.11	2.90	2.80	2.57	21.37
f_1o_3	11.33	2.03	2.17	2.03	17.53
f_2o_1	13.98	3.33	3.07	3.33	23.71
f_2o_2	11.14	2.77	3.27	2.70	19.87
f_2o_3	12.31	2.93	2.83	2.70	20.78
f_3o_1	13.03	3.47	3.00	2.90	22.40
f_3o_2	12.95	2.17	3.17	3.00	21.29
f_3o_3	13.33	1.97	3.07	2.80	21.16
$F_{4,16}$	5.24**	4.44*	1.73^{ns}	1.81^{ns}	7.58**
SEm	0.503	0.195	0.153	0.175	0.556
CD	1.507	0.585	-	-	1.666

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The nutrient levels and the organic sources had no influence on the dry matter production of fruit. However the interaction effect was significant and the highest value of 13.98 t ha^{-1} was observed with recommended dose of nutrients plus one-third additional dose + farmyard manure.

The effect of nutrient levels, organic sources and their interaction significantly varied leaf dry matter. The dry matter production recorded higher value (3.01 t ha^{-1}) with f_2 among nutrient levels and with farmyard manure (3.23 t ha^{-1}) among organic sources. Among interactions farmyard manure at f_3 registered the highest leaf dry matter (3.47 t ha^{-1}).

The dry matter produced by the pseudostem showed significant variation with respect to the levels of nutrients and sources of organic manure. Their interaction was not significant. Maximum dry matter was accumulated (3.08 t ha^{-1}) at f_3 and found on par with f_2. Among the different sources of organic manure dry matter produced in the pseudostem was maximum in vermicompost addition (3.08 t ha^{-1}) and was on par with farmyard manure application.

The dry matter production by the rhizome was not influenced by sources of organic manure and its interaction with levels of nutrients. However the nutrient levels significantly influenced rhizome dry matter and the RDN was found significantly inferior to the higher nutrient levels.

Main effect of nutrient levels, organic sources and their interaction had significant influence on total dry matter production. Dry matter production at f_3 (21.62 t ha^{-1}) was on par with F_2 (21.45 t ha^{-1}) and were significantly higher than recommended dose of nutrients (19.60 t ha^{-1}). Maximum dry matter production was noticed with farmyard manure (22.00 t ha^{-1}) among organic sources. At higher nutrient levels total dry matter production recorded higher values with farmyard manure while at recommended dose of nutrients with vermicompost (21.37 t ha^{-1}).

4.2.2.11 Nutrient Contents (%) in Index Leaf at 2, 4 and 6 MAP

4.2.2.11.1 Nitrogen

The nitrogen content in the index leaf at 2, 4 and 6 MAP as influenced by levels of nutrients and sources of organic manure are presented in Table 83.

The effect of nutrient levels on nitrogen content at 2, 4 and 6 MAP was significant. Maximum value for nitrogen content was registered at the highest dose of nutrients applied (f_3) both at 2 MAP (3.32 %) and 6 MAP (2.69 %). At 6 MAP, nitrogen content was highest with vermicompost application. However, at 4 MAP, maximum nitrogen in the leaf (4.02 %) was recorded at the recommended dose of nutrients (f_1) and was on par with f_2 (133 % of RDN).

The organic sources had significant influence on nitrogen content at 4 and 6 MAP. It showed no significant effect at 2 MAP. The highest value was recorded with farmyard manure (3.99 %) at 4 MAP while highest value with vermicompost (2.78 %) at 6 MAP.

The nitrogen content in the leaf increased with age at first and then decreased towards harvest.

The interaction effect of treatments showed significant influence on foliage nitrogen with a maximum of 3.53 for with f_3o_2 at 2 MAP, 5.71 per cent with farmyard manure and recommended dose of nutrients at 4 MAP and 3.08 with vermicompost and 133 per cent of RDN.

4.2.2.11.2 Phosphorus

The phosphorus content in the index leaf at 2, 4 and 6 MAP as influenced by levels of nutrients and sources of organic manure are presented in Table 84.

The main effect of nutrient levels, organic sources and their interaction changed foliage phosphorus at all stages of observation.

Table 83 Effect of nutrient levels and sources of organic manure on the nitrogen content in index leaf at 2, 4 and 6 MAP (second crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	2.84	4.02	2.43
f_2	2.77	3.80	2.62
f_3	3.32	3.04	2.69
$F_{2,16}$	32.04**	35.40**	17.35**
SEm	5.244	8.664	0.033
CD	0.157	0.260	0.100
Sources of organic manure			
o_1	2.90	3.99	2.44
o_2	3.05	3.52	2.78
o_3	2.98	3.35	2.53
$F_{2,16}$	1.81^{ns}	15.03**	28.29**
SEm	5.244	8.664	0.033
CD	-	0.260	0.100
Interaction			
f_1o_1	2.86	5.71	2.76
f_1o_2	2.69	3.16	2.49
f_1o_3	2.97	3.19	2.02
f_2o_1	2.61	3.47	2.18
f_2o_2	2.92	4.25	3.08
f_2o_3	2.80	3.68	2.61
f_3o_1	3.25	2.80	2.37
f_3o_2	3.53	3.14	2.76
f_3o_3	3.17	3.17	2.95
$F_{4,16}$	3.92*	44.58**	50.81**
SEm	0.091	0.150	0.058
CD	0.272	0.450	0.175

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

Table 84 Effect of nutrient levels and sources of organic manure on the phosphorus content in index leaf at 2, 4 and 6 MAP (second crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	0.24	0.27	0.16
f_2	0.21	0.15	0.15
f_3	0.20	0.15	0.14
$F_{2,16}$	13.82**	131.02**	103.70**
SEm	0.006	0.006	0.001
CD	0.018	0.018	0.003
Sources of organic manure			
o_1	0.23	0.24	0.15
o_2	0.20	0.16	0.14
o_3	0.22	0.16	0.15
$F_{2,16}$	6.04*	57.46**	13.23**
SEm	0.006	0.006	0.001
CD	0.018	0.018	0.003
Interaction			
f_1o_1	0.21	0.42	0.15
f_1o_2	0.23	0.18	0.15
f_1o_3	0.28	0.20	0.18
f_2o_1	0.21	0.15	0.17
f_2o_2	0.21	0.16	0.15
f_2o_3	0.22	0.13	0.13
f_3o_1	0.27	0.15	0.13
f_3o_2	0.16	0.15	0.13
f_3o_3	0.16	0.15	0.15
$F_{4,16}$	20.57**	55.27**	99.08**
SEm	0.018	0.010	0.002
CD	0.031	0.031	0.006

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

The phosphorus content was maximum with recommended dose of nutrients at 2 MAP (0.24 %), 4 MAP (0.27 %) and 6 MAP (0.16 %).

Farmyard manure as the source of organics enhanced the phosphorus content in the index leaf to 0.23, 0.24 and 0.15 per cent at 2, 4 and 6 MAP respectively.

Maximum values were registered at recommended dose of nutrients (f_1) with banana pseudostem at 2 MAP (0.28 %) and 6 MAP (0.18 %) and with farmyard manure at 4 MAP (0.42 %). In general foliage phosphorus was reduced in f_3 irrespective of sources of organic manure.

4.2.2.11.3 Potassium

The potassium content in the index leaf at 2, 4 and 6 MAP as influenced by levels of nutrients and sources of organic manure are summarized in Table 85.

The nutrient levels, sources of organic manure and their interaction effects had no influence on the foliar potash content at 2 MAP. However the main effects as well as the interaction were significant at 4 and 6 MAP.

Maximum potassium content during 4 MAP (6.22 %) was recorded by f_3 and was on par with f_2. Similarly highest value of foliage potash (6.22 %) was observed with vermicompost addition which was on par with farmyard manure (6.02 %). K content was significantly high when o_2 was combined with f_2 and o_1 was combined with f_3. There was no significant difference between f_1o_1 and f_1o_3 and also between f_3o_2 and f_3o_3. Higher values were recorded at f_2o_2.

Potassium content in the index leaf at 6 MAP was maximum (5.51 %) at recommended dose of nutrients (f_1) and found on par with f_2 (5.42 %). Maximum foliage potash was noticed in the treatment receiving fresh banana pseudostem as organic manure (5.51 %). When organic manure was combined with f_2 and f_3, no significant difference in K uptakes

Table 85 Effect of nutrient levels and sources of organic manure on the potassium content in index leaf at 2, 4 and 6 MAP (second crop), per cent

	2 MAP	4 MAP	6 MAP
Levels of nutrients			
f_1	5.40	5.51	5.51
f_2	5.31	6.18	5.42
f_3	5.40	6.22	4.98
$F_{2,16}$	0.50^{ns}	28.04**	32.50**
SEm	0.229	0.075	0.050
CD	-	0.226	0.150
Sources of organic manure			
o_1	5.51	6.02	5.09
o_2	5.16	6.22	5.31
o_3	5.44	5.67	5.51
$F_{2,16}$	0.68^{ns}	13.99**	17.78**
SEm	0.229	0.075	0.050
CD	-	0.226	0.150
Interaction			
f_1o_1	6.07	5.60	5.20
f_1o_2	5.20	5.00	5.80
f_1o_3	4.93	5.93	5.53
f_2o_1	5.07	5.87	5.27
f_2o_2	4.67	7.47	5.20
f_2o_3	6.20	5.20	5.80
f_3o_1	5.40	6.60	4.80
f_3o_2	5.60	6.20	4.93
f_3o_3	5.20	5.87	5.20
$F_{4,16}$	2.90^{ns}	43.53**	7.06**
SEm	0.396	0.130	0.087
CD	-	0.391	0.260

ns – not significant
**Significant at 1 per cent level

between o_1 and o_2, high at f_2o_3 and f_3o_3 and it was on par with f_1o_2.Significantly higher values of potash at f_1 was recorded in the interaction with o_2 .

4.2.2.12 Nutrient Content (%) in the Plant Parts at Harvest

4.2.2.12.1 Nitrogen

The nitrogen content of the leaf, fruit, pseudostem and rhizome as influenced by the levels of nutrients and organic sources are presented in Table 86.

The effect of nutrient levels was significant on nitrogen content in plant parts. Maximum nitrogen content noticed in the fruit (0.77 %) at f_2, leaf (2.27 %) and rhizome (1.13 %) at f_3 and pseudostem (1.467 %) at f_1.

The sources of organic manure had significant effect on nitrogen content in plant parts except rhizome. The highest values were recorded with vermicompost and fresh banana residue in pseudostem (1.38 and 1.39 %) and fruit (0.70 and 0.70 %) which were on par. In the leaves, highest values were recorded by farmyard manure (2.27 %) and vermicompost (2.28 %) which were on par.

The interaction effect of treatments showed significant influence on the nitrogen content of all plant parts. High nitrogen content was recorded in fruit at f_2o_2 which was on par with f_2o_1 and low at f_1o_1. When f_1 was combined with manures, high value was observed at f_1o_3.When f_2 was combined with organics, high nitrogen content at f_2o_1 which was on par with f_2o_2.When f_3 was combined with organic sources, f_3o_2 was noticed to be on par with f_3o_3 and was significantly inferior to f_3o_1.

When organic manure was combined with f_1 foliar nitrogen was maximum at o_2 and no significant difference between f_1o_2 and f_1o_3. No significant difference was registered when f_2 was combined with organic manure. On combining f_3 with different organics, maximum at f_3o_1 and lower at f_3o_2 and f_3o_3 was noticed.

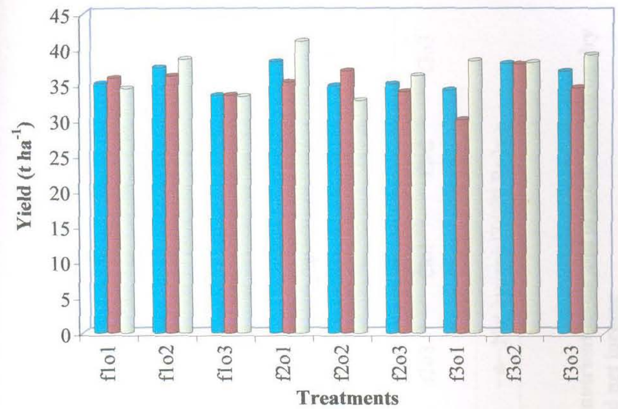


Fig. 12 Interaction effect of treatment on yield during 2002-03 and 2003-04

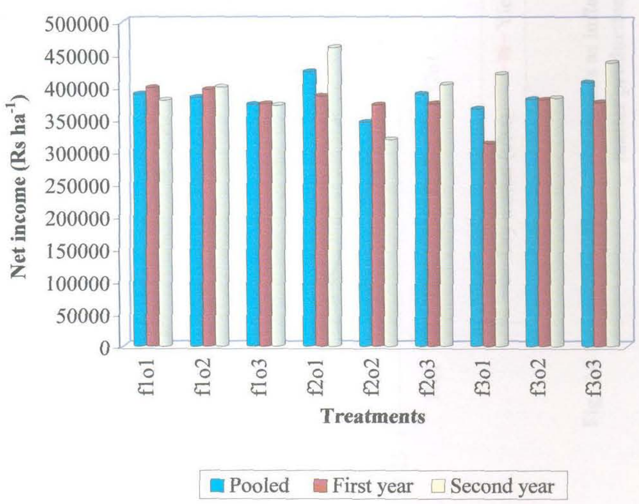


Fig. 13 Interaction effect of treatment on net income during 2002-03 and 2003-04

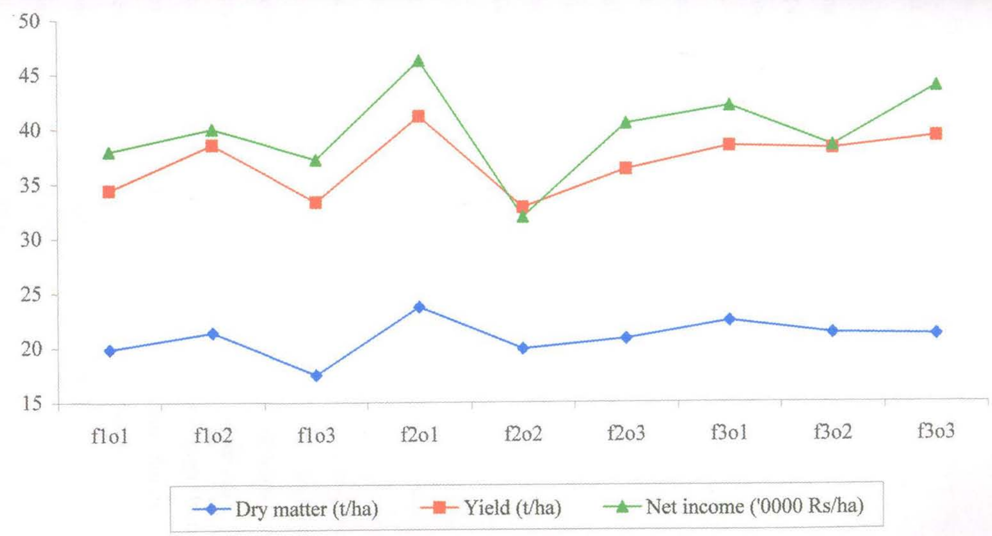


Fig. 14 Interaction effect of treatments as influenced by nutrient levels and organic sources on dry matter production, yield and net income

Table 86 Effect of nutrient levels and sources of organic manure on the nitrogen content in different parts of banana (second crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	0.63	2.00	1.46	0.75
f_2	0.77	2.23	1.25	1.04
f_3	0.67	2.27	1.21	1.13
$F_{2,16}$	116.58**	12.65**	16.10**	17.94**
SEm	0.006	0.042	0.034	0.047
CD	0.019	0.126	0.100	0.140
Sources of organic manure				
o_1	0.67	2.27	1.16	1.04
o_2	0.70	2.28	1.38	0.90
o_3	0.70	1.95	1.39	0.97
$F_{2,16}$	6.43**	19.15**	14.92**	2.31^{ns}
SEm	0.006	0.042	0.034	0.047
CD	0.019	0.126	0.100	-
Interaction				
f_1o_1	0.52	1.90	1.16	0.97
f_1o_2	0.63	2.24	1.68	0.50
f_1o_3	0.74	1.85	1.55	0.78
f_2o_1	0.78	2.26	1.16	0.93
f_2o_2	0.80	2.31	1.22	1.06
f_2o_3	0.71	2.13	1.38	1.12
f_3o_1	0.71	2.65	1.16	1.23
f_3o_2	0.65	2.28	1.23	1.14
f_3o_3	0.65	1.89	1.23	1.02
$F_{4,16}$	62.36**	9.26**	5.71**	4.55*
SEm	0.011	0.073	0.058	0.081
CD	0.033	0.218	0.174	0.243

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

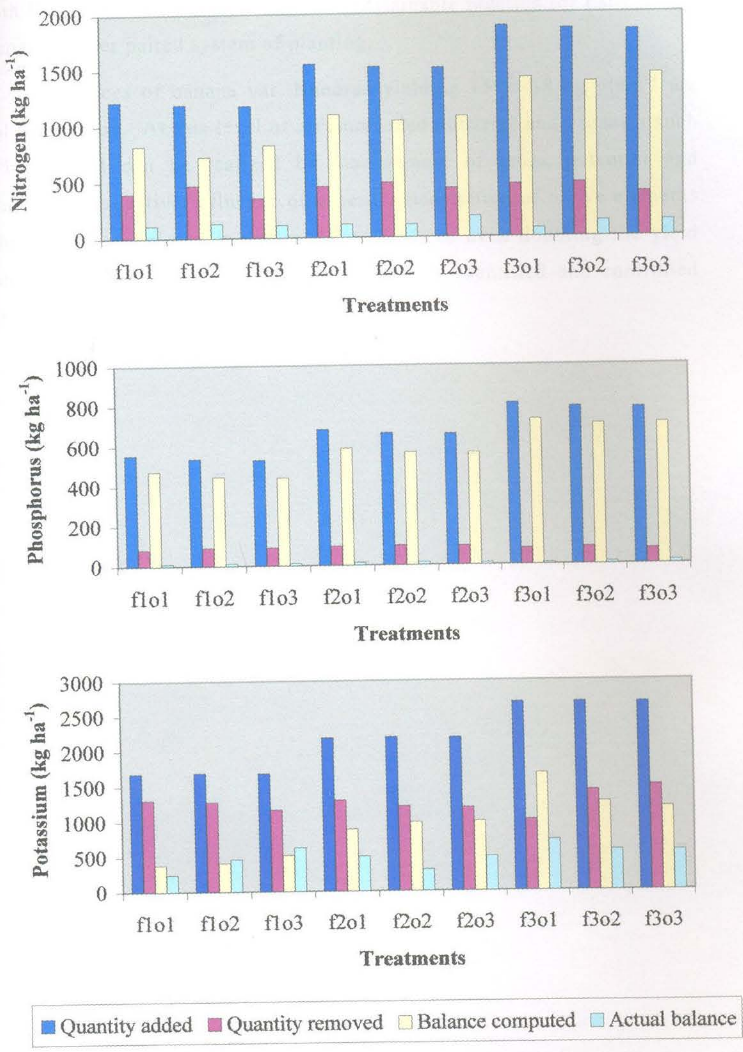


Fig. 15 Balance sheet of soil nutrients as influenced by nutrient levels and organic sources

When nutrients were combined with o_1, no significant difference in nitrogen content of pseudostem was seen and was also lower. When combined with o_2 and o_3, high value at f_1o_2 and f_1o_3 were recorded. No significant difference in nitrogen content when o_1, o_2 and o_3 were combined with f_3.

When nutrients were combined with o_1, maximum rhizome nitrogen was at f_3o_1; with o_2 maximum at f_3o_2 and f_2o_2 which were on par and with o_3, maximum at f_2o_3 and f_3o_3 which were on par.

4.2.2.12.2 Phosphorus

The phosphorus content of the leaf, fruit, pseudostem and rhizome as influenced by the levels of nutrients and organic sources are presented in Table 87.

The phosphorus content in the fruit and leaf did not vary with nutrient levels, organic sources and their interaction.

Nutrient levels and its interaction with organic sources had significant influence of phosphorus content in the pseudostem. However the content did not vary with organic sources. The phosphorus content recorded the highest value of 0.17 per cent in pseudostem at recommended dose of fertilizers. At higher levels of nutrients f_2 and f_3 maximum pseudostem phosphorus was recorded with vermicompost (0.16 and 0.14 %). At f_1 (RDN) maximum phosphorus was recorded with fresh banana residue (0.20 %) in pseudostem.

The phosphorus content in the rhizome was significantly influenced by the treatments. Maximum phosphorus was registered with recommended dose (0.19 %) of nutrients (f_1) among nutrient levels and with farmyard manure (0.17 %) among organic manures.

At f_1 maximum phosphorus content was recorded with, fresh banana pseudostem incorporation in pseudostem and with farmyard manure in rhizome. However at f_2 and f_3, no significant difference was

Table 87 Effect of nutrient levels and sources of organic manure on the phosphorus content in different parts of banana (second crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	0.13	0.14	0.17	0.19
f_2	0.14	0.15	0.15	0.16
f_3	0.14	0.13	0.13	0.14
$F_{2,16}$	0.28^{ns}	3.03^{ns}	15.99**	19.48**
SEm	0.004	0.006	0.005	0.005
CD	-	-	0.015	0.016
Sources of organic manure				
o_1	0.13	0.13	0.15	0.17
o_2	0.14	0.14	0.15	0.16
o_3	0.13	0.15	0.16	0.15
$F_{2,16}$	3.59^{ns}	1.41^{ns}	1.78^{ns}	4.00*
SEm	0.004	0.006	0.005	0.005
CD	-	-	-	0.016
Interaction				
f_1o_1	0.13	0.13	0.16	0.22
f_1o_2	0.14	0.13	0.16	0.16
f_1o_3	0.13	0.15	0.20	0.18
f_2o_1	0.13	0.14	0.15	0.16
f_2o_2	0.15	0.15	0.16	0.16
f_2o_3	0.13	0.16	0.15	0.15
f_3o_1	0.14	0.13	0.13	0.14
f_3o_2	0.14	0.13	0.14	0.15
f_3o_3	0.13	0.13	0.13	0.13
$F_{4,16}$	0.69^{ns}	0.43^{ns}	3.11*	4.19*
SEm	0.006	0.010	0.009	0.009
CD	-	-	0.026	0.028

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

registered in pseudostem phosphorus and rhizome phosphorus with different organic sources.

4.2.2.12.3 Potassium

The potassium content of fruits, leaf, pseudostem and rhizome are summarized in Table 88.

Levels of nutrients had significant influence on potassium content in all parts of banana. The fruit potassium was high at f_2 and f_3 values being 1.51 per cent and 1.52 per cent respectively. The potassium content in the rhizome (6.63 %) recorded higher value at f_3 whereas in the pseudostem (6.88 %) at RDN f_1. In leaves, potassium content at RDN was higher (2.01 %) and on par with f_2.

Organic sources caused significant variation in the potassium content of leaf, pseudostem and rhizome. Highest values of 2.22 per cent and 7.13 per cent in leaf and pseudostem was observed with fresh banana pseudostem addition whereas in rhizome (5.51 %) with vermicompost.

Among interactions, significant influence was noticed in potassium content of leaf, pseudostem and rhizome. %) with vermicompost, at f_2 (4.24 %) with farmyard manure and at f_3 (7.84 %).

Foliar K was the maximum when banana pseudostem was combined with f_1, f_2 and f_3. No significant difference was noticed between different nutrient levels when combined with o_2 and o_3. However with farmyard manure, higher value of leaf K was registered at 133 percent of RDN.

Higher potassium values were recorded in pseudostem when o_3 was used as organic manure irrespective of nutrient levels. With farmyard manure as organic source, pseudostem K did not vary between f_1 and f_2 but was significantly higher at f_3. When vermicompost and fresh banana residue was combined with nutrient levels, higher pseudostem K was noticed at recommended dose of nutrients.

Table 88 Effect of nutrient levels and sources of organic manure on the potassium content in different parts of banana (second crop), per cent

	Fruit	Leaf	Pseudostem	Rhizome
Levels of nutrients				
f_1	1.40	2.01	6.88	4.13
f_2	1.51	2.01	4.80	3.54
f_3	1.52	1.87	5.74	6.63
$F_{2,16}$	11.73**	37.32	993.90**	3775.23**
SEm	0.019	0.013	0.033	0.027
CD	0.056	0.040	0.099	0.080
Sources of organic manure				
o_1	1.44	1.96	4.40	4.27
o_2	1.50	1.71	5.89	5.51
o_3	1.49	2.22	7.13	4.52
$F_{2,16}$	2.40^{ns}	372.84**	1703.04**	602.76**
SEm	0.019	0.013	0.033	0.027
CD	-	0.040	0.099	0.080
Interaction				
f_1o_1	1.41	1.97	4.20	4.20
f_1o_2	1.43	1.68	8.03	5.40
f_1o_3	1.37	2.37	8.43	2.79
f_2o_1	1.48	2.07	4.09	4.24
f_2o_2	1.52	1.76	4.27	3.44
f_2o_3	1.52	2.21	6.04	2.95
f_3o_1	1.44	1.84	4.92	4.37
f_3o_2	1.54	1.69	5.38	7.68
f_3o_3	1.58	2.08	6.93	7.84
$F_{4,16}$	2.03^{ns}	15.95	322.10**	1099.16**
SEm	0.032	0.023	0.057	0.046
CD	-	0.069	0.172	0.139

ns – not significant

*Significant at 5 per cent level **Significant at 1 per cent level

4.2.2.13 Nutrient Uptake (kg ha^{-1})

4.2.2.13.1 Nitrogen

The nitrogen uptake by fruit, leaf, pseudostem and rhizome as influenced by nutrient levels and organic sources are presented in Table 89.

The main effect of nutrient levels significantly influenced the uptake of nitrogen by fruit, leaf and rhizome. Maximum nitrogen uptake was noticed in the leaf (67.3 kg ha^{-1}) and fruit (95.5 kg ha^{-1}) with f_2 (RDN and one-third additional dose). Nitrogen uptake by rhizome registered higher value of 32.9 kg ha^{-1} at f_3 and was on par with f_2. Nutrient levels did not influence the uptake by pseudostem.

Organic sources caused significant variation in nitrogen uptake by leaf and pseudostem. Leaf registered maximum uptake (74.1 kg ha^{-1}) with farmyard manure while pseudostem (42.0 kg ha^{-1}) recorded higher nitrogen uptake with vermicompost addition. Uptake of nitrogen by fruit and rhizome did not vary with sources of organic manure.

The main effect of nutrient levels, organic sources and their interaction exerted significant influence on total nitrogen uptake. Higher values were recorded at f_2 (230.9 kg ha^{-1}) among nutrient levels and with farmyard manure (226.6 kg ha^{-1}) among organic sources.

Nitrogen uptake by fruit recorded significantly higher value at f_2o_1. No significant variation was noticed between nutrient levels with o_2 and o_3 at f_1. However no significant difference was noticed at f_3 when combined with various sources of organic manure.

As the nutrient levels increased, there was a progressive increase in foliar uptake of nitrogen when combined with farmyard manure. When o_3 was combined with nutrient levels, significantly lower uptake was registered at f_1 and f_3.

Total nitrogen uptake was significantly lower at f_1o_1 than at f_2o_1 and f_3o_1 which were on par. When vermicompost was used as source of

Table 89 Effect of nutrient levels and sources of organic manure on the nitrogen uptake by different parts of banana (second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	75.20	52.40	38.00	17.50	183.10
f_2	95.50	67.30	38.10	30.00	230.90
f_3	88.60	59.50	37.20	32.90	218.10
$F_{2,16}$	24.16**	8.13**	0.10^{ns}	26.31**	33.04**
SEm	2.090	2.620	1.640	1.590	4.310
CD	6.280	7.870	-	4.770	12.930
Sources of organic manure					
o_1	88.00	74.10	34.50	30.00	226.60
o_2	86.20	59.40	42.00	25.30	212.80
o_3	85.10	45.70	36.90	25.00	192.70
$F_{2,16}$	0.48^{ns}	29.17**	5.46*	3.24^{ns}	15.65**
SEm	2.090	2.620	1.640	1.590	4.310
CD	-	7.870	4.920	-	12.930
Interaction					
f_1o_1	61.60	54.90	33.20	23.60	173.30
f_1o_2	83.60	61.80	47.20	13.00	208.50
f_1o_3	80.50	37.50	33.50	16.00	167.40
f_2o_1	109.60	75.40	35.50	31.00	251.60
f_2o_2	89.70	64.00	39.70	27.60	222.00
f_2o_3	87.10	62.50	39.30	30.40	219.30
f_3o_1	92.80	91.90	34.70	35.70	255.00
f_3o_2	85.30	49.50	39.00	34.30	208.00
f_3o_3	87.80	37.20	37.80	28.60	191.40
$F_{4,16}$	11.43**	11.17**	1.88^{ns}	1.37^{ns}	9.22**
SEm	0.363	4.540	2.840	2.760	7.470
CD	1.088	13.620	-	-	22.390

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

organic manure, nitrogen uptake did not show variation among nutrient levels. When f_2 was combined with o_3, higher values of total nitrogen uptake were recorded.

4.2.2.13.2 Phosphorus

The phosphorus uptake by fruit, leaf, pseudostem and rhizome as well as total uptake as influenced by nutrient levels and organic sources are furnished in Table 90.

No significant variation was noticed in total uptake as well as uptake by fruit, pseudostem and rhizome by levels of nutrients, organic sources and their interaction.

The uptake of phosphorus in leaf showed significant difference with all the treatments. Maximum uptake by leaves was noticed at f_2 (133 per cent of recommended nutrient dose). Higher value of phosphorus uptake by leaves was noticed with farmyard manure (4.30 kg ha^{-1}).

No significant difference was observed in foliar P uptake between organic sources at f_1. At f_2 P uptake by leaf was on par with farmyard manure and pseudostem application whereas at f_3 registered higher value with farmyard manure.

4.2.2.13.3 Potassium

The uptake of potassium by fruit, leaf, pseudostem, rhizome and total uptake as influenced by nutrient levels, organic sources and its interaction are summarized in Table 91.

Main effect of nutrient levels was significant on uptake of potassium by fruit, leaf, pseudostem and rhizome. Potassium uptake in fruit was higher at f_3 and was on par with f_2 whereas in the pseudostem significantly higher values were observed at f_1 and f_3. Maximum uptake was noticed by leaf (60.90 kg ha^{-1}) at f_2 and by rhizome (193.10 kg ha^{-1}) at f_3.

Table 90 Effect of nutrient levels and sources of organic manure on the phosphorus uptake by different parts of banana (second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	16.15	3.53	4.46	4.38	28.53
f_2	16.97	4.50	4.68	4.57	30.73
f_3	17.97	3.39	4.22	4.06	29.55
$F_{2,16}$	1.48^{ns}	12.71**	1.81^{ns}	1.29^{ns}	1.61^{ns}
SEm	0.749	0.180	0.173	0.226	0.868
CD	-	0.539	-	-	-
Sources of organic manure					
o_1	17.23	4.30	4.35	4.92	30.80
o_2	17.85	3.39	4.71	4.31	30.27
o_3	16.02	3.62	4.30	3.80	27.74
$F_{2,16}$	1.54^{ns}	6.90**	1.73^{ns}	6.11^{ns}	3.55^{ns}
SEm	0.749	0.180	0.173	0.226	0.868
CD	-	0.539	-	-	-
Interaction					
f_1o_1	15.22	3.73	4.59	5.35	28.89
f_1o_2	18.51	3.79	4.48	4.11	30.87
f_1o_3	14.73	3.08	4.33	3.69	25.83
f_2o_1	18.17	4.67	4.58	5.33	32.75
f_2o_2	16.75	3.60	5.23	4.32	29.89
f_2o_3	16.00	5.23	4.24	4.06	29.54
f_3o_1	18.30	4.51	3.90	4.06	30.77
f_3o_2	18.29	2.82	4.44	4.49	30.03
f_3o_3	17.33	2.56	4.32	3.64	27.84
$F_{4,16}$	0.94^{ns}	6.67**	1.08^{ns}	1.43^{ns}	0.85^{ns}
SEm	1.298	0.311	0.299	0.392	1.504
CD	-	0.933	-	-	-

ns – not significant
**Significant at 1 per cent level

Table 91 Effect of nutrient levels and sources of organic manure on the potassium uptake by different parts of banana(second crop), kg ha^{-1}

	Fruit	Leaf	Pseudostem	Rhizome	Total
Levels of nutrients					
f_1	169.50	51.30	175.90	99.30	496.00
f_2	187.90	60.90	145.40	104.60	498.80
f_3	199.90	47.10	176.90	193.10	617.00
$F_{2,16}$	8.05**	8.59**	11.57**	141.38**	62.08**
SEm	5.400	2.400	5.270	13.290	8.770
CD	16.190	7.200	15.790	4.430	45.520
Sources of organic manure					
o_1	186.70	63.20	131.10	123.50	504.50
o_2	185.70	44.70	178.20	154.10	562.70
o_3	185.00	51.40	188.80	119.50	544.60
$F_{2,16}$	0.03^{ns}	15.19**	33.96**	18.22**	11.55^{ns}
SEm	5.400	2.400	5.270	13.290	8.770
CD	-	7.200	15.790	4.430	-
Interaction					
f_1o_1	165.50	56.90	120.30	102.20	444.90
f_1o_2	187.20	48.70	224.90	138.90	599.70
f_1o_3	155.80	48.30	182.60	56.70	443.30
f_2o_1	206.90	68.90	125.50	141.40	542.70
f_2o_2	169.50	48.70	139.40	92.90	450.50
f_2o_3	187.10	65.00	171.20	79.60	503.20
f_3o_1	187.70	63.80	147.60	126.80	525.80
f_3o_2	200.40	36.70	170.30	230.40	637.80
f_3o_3	211.60	40.90	212.60	222.10	687.30
$F_{4,16}$	4.28*	2.53^{ns}	9.49**	42.36**	31.22**
SEm	0. 360	4.160	9.120	23.020	15.180
CD	28.050	-	27.350	7.680	45.520

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

Organic sources had significant influence on uptake of potassium by leaf, pseudostem and rhizome. However uptake by fruit was insignificant. Maximum uptake was registered in leaf with farmyard manure (63.20 kg ha^{-1}), in pseudostem with fresh banana residue (188.80 kg ha^{-1}) and in rhizome with vermicompost (154.10 kg ha^{-1}).

Main effect of nutrient levels and its interaction with organic sources showed significant variation in total potassium uptake. Highest uptake of 617.00 kg ha^{-1} was recorded at f_3 (167 per cent of recommended nutrient dose).

Uptake of potassium by fruit registered maximum values at f_2o_1, f_3o_2 and f_3o_3 which were on par.

Uptake of K by pseudostem did not vary significantly with nutrient levels when farmyard manure was used as organic source. When vermicompost was used, K uptake registered higher values at RDN whereas with banana pseudostem higher values at 167 per cent of RDN was seen. At f_1, with vermicompost and at f_2 and f_3 with banana pseudostem, significantly higher values were recorded.

When f_1 was combined with organic sources, higher uptake of K by rhizome was noticed with vermicompost; at f_2 with farmyard manure and at f_3 with vermicompost and banana residue which were on par. Similar trend was observed in the case of total K uptake.

4.2.2.14 Economic Analysis

The total and net income (Rs) and benefit-cost ratio as influenced by nutrient levels and organic sources are presented in Table 92.

The total income, net income and BCR did not vary with nutrient levels. However organic sources caused significant difference in net income and BCR. Net income registered higher value with farmyard manure (Rs. 420737). Maximum BCR was recorded with banana

Table 92 Effect of nutrient levels and organic sources on the economics of banana cultivation (second crop)

	Total Income (Rs.)	Net income (Rs.)	Benefit : Cost ratio	Pooled Net income (Rs.)
Levels of nutrients				
f_1	487390	384173	3.81	382728
f_2	503756	395039	3.79	386615
f_3	527820	414058	3.75	385658
$F_{2,16}$	3.35^{ns}	1.86^{ns}	0.07^{ns}	0.05^{ns}
SEm	11104.6	11104.7	0.107	8774.0
Sources of organic manure				
o_1	520136	420737	4.23	393531
o_2	500867	367718	2.77	371089
o_3	497963	404815	4.34	390380
$F_{2,16}$	1.17^{ns}	6.00*	67.44**	1.92^{ns}
SEm	11104.6	11104.7	0.107	8774.0
CD	-	33293.4	0.321	-
Interaction				
f_1o_1	474376	380326	4.04	389721
f_1o_2	527849	400049	3.13	384874
f_1o_3	459946	372146	3.24	373590
f_2o_1	561086	461536	4.64	423965
f_2o_2	452709	319409	2.40	346136
f_2o_3	497472	404172	4.33	389742
f_3o_1	524946	420351	4.02	366909
f_3o_2	522042	383697	2.77	382258
f_3o_3	536742	438127	4.45	407808
$F_{4,16}$	5.23**	5.23**	3.88*	3.41*
SEm	19233.8	19233.9	0.185	15197.0
CD	57665.5	57665.9	0.556	43563.9

ns – not significant
*Significant at 5 per cent level **Significant at 1 per cent level

pseudostem (4.34) and it was on par with farmyard manure (4.23). Lowest BCR of 2.77 was noticed with vermicompost.

Interaction of the treatments had significant influence on total income, net income and BCR. Net income as well as BC ratio recorded higher values with farmyard manure at f_2; with vermicompost at f_1 and with pseudostem at f_2 and f_3 which were on par.

Pooled data of net income did not show variation with nutrient levels and organic sources. However, their interaction was significant. Maximum values were recorded with farmyard manure at f_2; vermicompost at f_1 and banana pseudostem on par at f_3 and f_2.

4.2.2.15 Physiological Observations

The mean values of leaf temperature (°C), light interception (μmol $m^{-2}s^{-1}$) and stomatal conductance (S cm^{-1}) at 2 and 4 MAP as influenced by nutrient levels and organic sources are presented in Table 93.

Leaf temperature variation due to treatments was not pronounced. Stomatal conductance values were lower at 2 MAP in comparison to that at 4 MAP. Values of stomatal conductance ranged from 0.28 to 1.10 S cm^{-1} at 2 MAP whereas at 4 MAP from 0.56 to 5.29 S cm^{-1}.

Light interception values were more at initial stages and values ranged from 799.3 to 1980 μmol $m^{-2}s^{-1}$. The light interception recorded at 4 MAP ranged from 115 to 1161.7 μmol $m^{-2}s^{-1}$. The values showed a decreasing trend with growth.

4.2.2.16 Soil Nutrient Status after the Experiment

The soil nutrient status after two years of experiment as influenced by levels of nutrients and sources of organic manure are summarized in Table 94. Balance sheet of soil nutrients were worked out utilizing the nutrient gains and losses recorded in the experiment are furnished in Table 95.

Table 93 Effect of nutrient levels and sources of organic manure on the physiological observations of banana cultivation (second crop)

Treatments	Leaf temperature (°C)		Stomatal conductance (S cm^{-1})		Light interception (μ mol m^{-2} s^{-1})	
	2 MAP	4 MAP	2 MAP	4 MAP	2 MAP	4 MAP
f_1o_1	34.8	33.3	0.28	1.31	799.3	390.0
f_1o_2	33.5	34.5	0.60	1.83	1041.7	116.7
f_1o_3	34.4	32.9	0.78	5.29	1980.0	115.0
f_2o_1	33.7	33.7	0.49	1.37	1496.7	116.7
f_2o_2	34.8	32.8	1.10	2.99	1926.7	621.7
f_2o_3	33.2	35.7	0.55	1.10	1350.0	705.0
f_3o_1	34.1	33.1	0.46	0.56	1520.0	141.7
f_3o_2	34.9	33.4	0.51	2.25	1840.0	125.0
f_3o_3	34.9	33.0	0.78	1.23	1640.0	646.7

*Not statistically analysed

Table 94 Effect of nutrient levels and sources of organic manure on soil nutrient status after the experiment, kg ha^{-1}

	Available nitrogen	Available phosphorus	Available potassium
Levels of nutrients			
f_1	117.77	10.80	443.12
f_2	138.13	12.16	431.87
f_3	118.47	11.74	622.22
$F_{2,16}$	105.63**	72.09**	140.88*
SEm	1.125	0.082	8.998
CD	3.372	0.246	26.977
Sources of organic manure			
o_1	101.40	9.89	488.32
o_2	127.18	12.34	448.60
o_3	145.80	12.48	560.30
$F_{2,16}$	393.01**	314.31**	39.60**
SEm	1.125	0.082	8.998
CD	3.372	0.246	26.977
Interaction			
f_1o_1	109.76	9.44	239.53
f_1o_2	130.67	11.64	463.83
f_1o_3	112.90	11.33	626.01
f_2o_1	119.17	12.58	499.97
f_2o_2	112.90	14.26	306.13
f_2o_3	182.33	9.65	489.51
f_3o_1	75.26	7.66	725.46
f_3o_2	137.98	11.12	575.83
f_3o_3	142.17	16.46	565.38
$F_{4,16}$	199.63**	499.31**	98.71**
SEm	1.948	0.142	15.585
CD	5.841	0.426	46.726

**Significant at 1 per cent level

Table 95 Balance sheet of the soil nutrients (kg ha^{-1})

Treatments	Initial status			Quantity added as fertilizer			Quantity added as organic *manure*			Quantity added as green manure			Total quantity added			Quantity removed		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
f_1o_1	103.49	7.2	82.4	1000	384	1500	44.8	25	25	71.64	42.98	57.31	1219.93	555.47	1685.8	399.3	82.5	1304.8
f_1o_2	103.49	7.2	82.4	1000	384	1500	16.8	6.6	30	71.64	42.98	57.31	1191.93	537.07	1690.8	469.1	91	1281.4
f_1o_3	103.49	7.2	82.4	1000	384	1500	4.2	1	23.2	71.64	42.98	57.31	1179.33	531.47	1684	355.7	90.2	1167.6
f_2o_1	103.49	7.2	82.4	1332	510	2000	44.8	25	25	71.64	42.98	57.31	1551.93	681.47	2185.8	456.1	95.3	1299.1
f_2o_2	103.49	7.2	82.4	1332	510	2000	16.8	6.6	30	71.64	42.98	57.31	1523.93	663.07	2190.8	486.1	98.3	1207.9
f_2o_3	103.49	7.2	82.4	1332	510	2000	4.2	1	23.2	71.64	42.98	57.31	1511.33	657.47	2184	435.2	94.3	1187.6
f_3o_1	103.49	7.2	82.4	1666	638	2500	44.8	25	25	71.64	42.98	57.31	1885.93	809.47	2685.8	468.5	81.7	1015.7
f_3o_2	103.49	7.2	82.4	1666	638	2500	16.8	6.6	30	71.64	42.98	57.31	1857.93	791.07	2690.8	479.5	87	1429.3
f_3o_3	103.49	7.2	82.4	1666	638	2500	4.2	1	23.2	71.64	42.98	57.31	1845.33	785.47	2684	394.5	77.4	1497.6

Treatments	Soil status after the experiment					
	Computed			Actual		
	N	P	K	N	P	K
f_1o_1	820.63	472.97	381	109.76	9.44	239.53
f_1o_2	722.83	446.07	409.4	130.67	11.64	463.83
f_1o_3	823.63	441.27	516.4	112.9	11.33	626.01
f_2o_1	1095.8	586.17	886.7	119.17	12.58	499.97
f_2o_2	1037.8	564.77	982.9	112.9	14.26	306.13
f_2o_3	1076.1	563.17	996.4	182.33	9.65	489.51
f_3o_1	1417.4	727.77	1670.1	75.26	7.66	725.46
f_3o_2	1378.4	704.07	1261.5	137.98	11.12	575.83
f_3o_3	1450.8	708.07	1186.4	142.17	16.46	565.38

Levels of nutrients, organic sources and their interactions caused variation on available nitrogen, phosphorus and potassium status of the soil.

Available nitrogen and phosphorus values were significantly higher at f_2 (133 per cent of recommended nutrient dose). Available potassium status was maximum at f_3 (622.22 kg ha^{-1}).

Highest values of available nitrogen (145.8 kg ha^{-1}) phosphorus (12.48 kg ha^{-1}) and potassium (560.3 kg ha^{-1}) were recorded with incorporation of fresh banana pseudostem and was found on par with vermicompost addition.

At f_1 available soil nitrogen was higher with vermicompost and at f_2 with banana pseudostem. When f_3 was combined with farmyard manure, significantly lower available soil nitrogen was noticed than with vermicompost and fresh banana pseudostem which were on par.

Available P content in soil was higher at f_2 with farmyard manure and vermicompost. At f_2 banana residue incorporation registered lowest value.

Significantly higher available potassium in soil was noticed when f_3 was combined with farmyard manure and vermicompost. When pseudostem was combined with nutrient levels, highest value was recorded at recommended dose of nutrients.

In general there was a build up of soil nutrients after the experiment. The computed values were more than the actual values obtained by direct analysis of the soil.

4.2.2.17 Water Holding Capacity and Soil Moisture Content

The data on water holding capacity and soil moisture content recorded at monthly intervals are presented in Appendix II. Since banana was irrigated on alternative days variation was not observed in these parameters.

Discussion

5. DISCUSSION

An investigation was designed to study the possibility of enhancing productivity of banana by modifying the planting pattern and accommodating different intercrops. This study was also intended to assess the efficiency of recycling banana residues as organic manure and to standardise an optimum nutrient schedule for double sucker planted banana in lowlands. The results of the experiment presented in the previous chapter are discussed below.

Perusal of the results on growth and yield showed variation between years and this might be attributed to the difference in planting material used. Tissue culture plantlets were used in first year and uniform sized suckers of the first crop were used during second year.

5.1 EXPERIMENT I : EFFECT OF PLANTING PATTERN AND INTERCROPS ON THE GROWTH AND PRODUCTIVITY OF BANANA

5.1.1 Growth and Productivity as Influenced by Planting Pattern

Results on the plant height revealed a significant positive influence of planting pattern on pseudostem height of first crop of banana during its early stages of growth (2 and 4 MAP). The increase in height under high density planting is a shade avoidance mechanism under low light which is mediated through the photoreceptor-phytochrome (Lambers *et al.*, 1998). This can be confirmed from the lower light interception values registered in the experiment ranging from 68.3 to 145 μmol $m^{-2}s^{-1}$ under modified system compared to 251.7 to 271.7 μmol $m^{-2}s^{-1}$ under normal system at 4 MAP. Leaf number recorded at early stages of this experiment also confirms this result. Similar results were earlier observed by Apshara and Sathiamoorthy (1999) and Krishnakumary *et al.* (1995). After six months of planting, the height did not show any variation with pattern of planting.

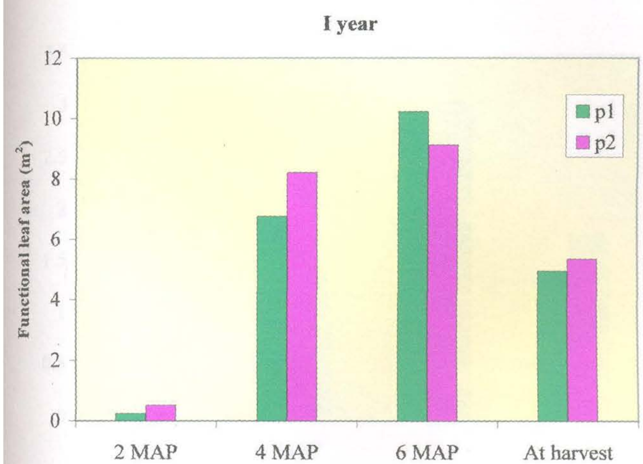
The plant might have adjusted itself by differential orientation of leaves to trap maximum solar radiation and thereby combat competition. This might have resulted in lack of significant effect of planting pattern on height at 6 MAP. The leaf number remained almost same at 6 MAP under both planting patterns. No influence was observed in second year on height which could be related to difference in growth pattern of tissue culture plantlet and suckers.

Contrary to plant height the influence of planting pattern on pseudostem girth was significant during later stages, maximum values being registered under normal system in both crops. This could be attributed to more space available for the development of pseudostem. Reduction in pseudostem girth under high density planting is a normal phenomenon as observed by Ahmed and Mannan (1970), Chattopadhyay *et al.* (1980), Reddy (1982), Apshara (1997) and Baruah *et al.* (2002).

The total functional leaf area was higher in modified system compared to conventional planting during vegetative stage of first crop of banana (Fig. 5). However, this variation did not sustain at shooting. The failure of banana to register any difference at shooting is due to the fact that leaf production become slower and static at this stage. However, it was not influenced by planting pattern during second year.

Leaf area index, an ideal factor to determine the effect of planting density in banana also showed variation with planting patterns (Fig. 6). Except at shooting stage for first crop and at 2 MAP for the second crop, leaf area index differed significantly with planting pattern. Higher leaf area index noticed under modified system might be due to more number of leaves accommodated per unit land area under modified system. This view has been shared by many workers (Reddy, 1982; Turner, 1982; Stover, 1984; Apshara, 1997; Nalina *et al.*, 2000).

Duration was not influenced by planting pattern during both the seasons. Though two suckers were accommodated per pit, wider interspace



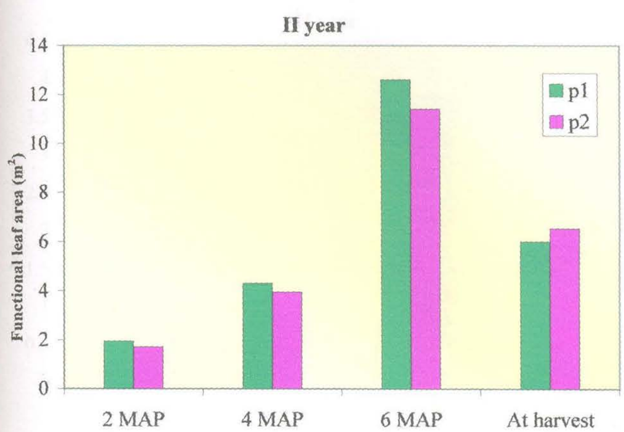


Fig. 5 Main effect of planting pattern on functional leaf area at bimonthly intervals during 2002-03 and 2003-04

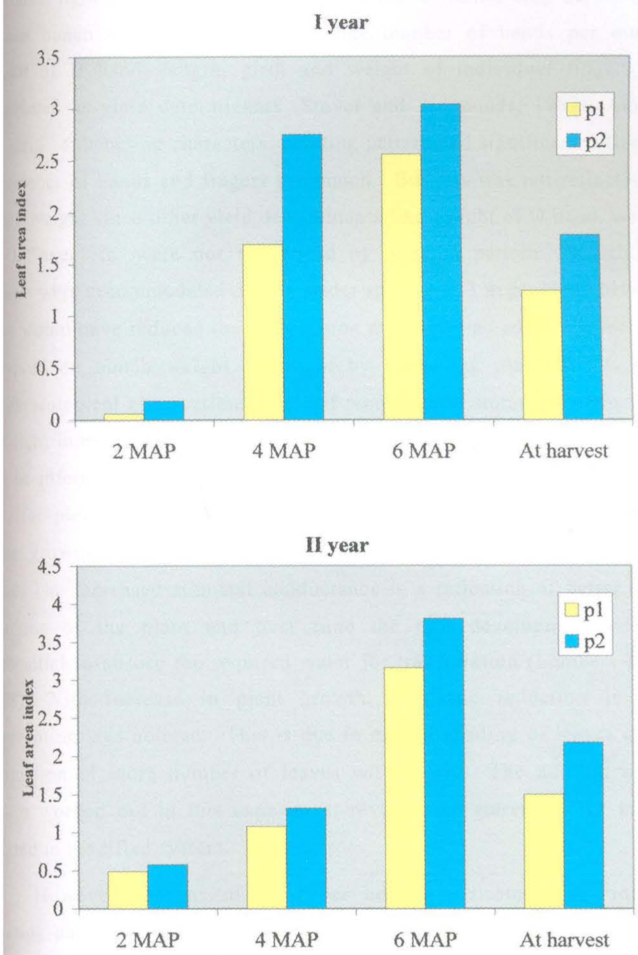


Fig. 6 Main effect of planting pattern on leaf area index at bimonthly intervals during 2002-03 and 2003-04

provided might have resulted in less competition between plants for nutrients, light and water which must have led to similar crop duration. In banana bunch and finger characters like number of hands per bunch, weight of D hand, length, girth and weight of individual fingers are considered as yield determinants (Stover and Simmonds, 1987). Among the yield contributing characters, planting pattern had significant influence on number of hands and fingers per bunch. But this was not reflected on bunch weight since other yield determinants like weight of D hand, weight of D finger etc. were not influenced by planting pattern. Though two suckers were accommodated per pit, wider spacing of 3 m provided between rows would have reduced the competition and hence no adverse effect was observed on bunch weight per plant by increasing plant density. The ecophysiological observations like leaf temperature, stomatal conductance and light interception showed not much variation with planting system. It can be inferred that there was no limitation to the stomatal diffusion of CO_2 for photosynthesis under modified planting. But in general as the plant growth progressed, stomatal conductance showed an increasing trend. The increased stomatal conductance is a reflection of better water relations of the plant and over time the root development will be substantial to absorb the required water for transpiration (Lambers *et al.*, 1998). With increase in plant growth, a drastic reduction in light interception was noticed. This is due to mutual shading of leaves due to production of more number of leaves with growth. The nutrient uptake values worked out in this experiment revealed no starvation for banana planted in modified system.

However analysis of yield per hectare indicated that modified planting pattern produced maximum yield (Fig. 7). Yield in banana is a function of number of bunches per hectare and individual bunch weight. Paired planting gave 22 and 26 per cent yield improvement over conventional planting during first and second year respectively. The better effect of modified system is due to 33 per cent more plant

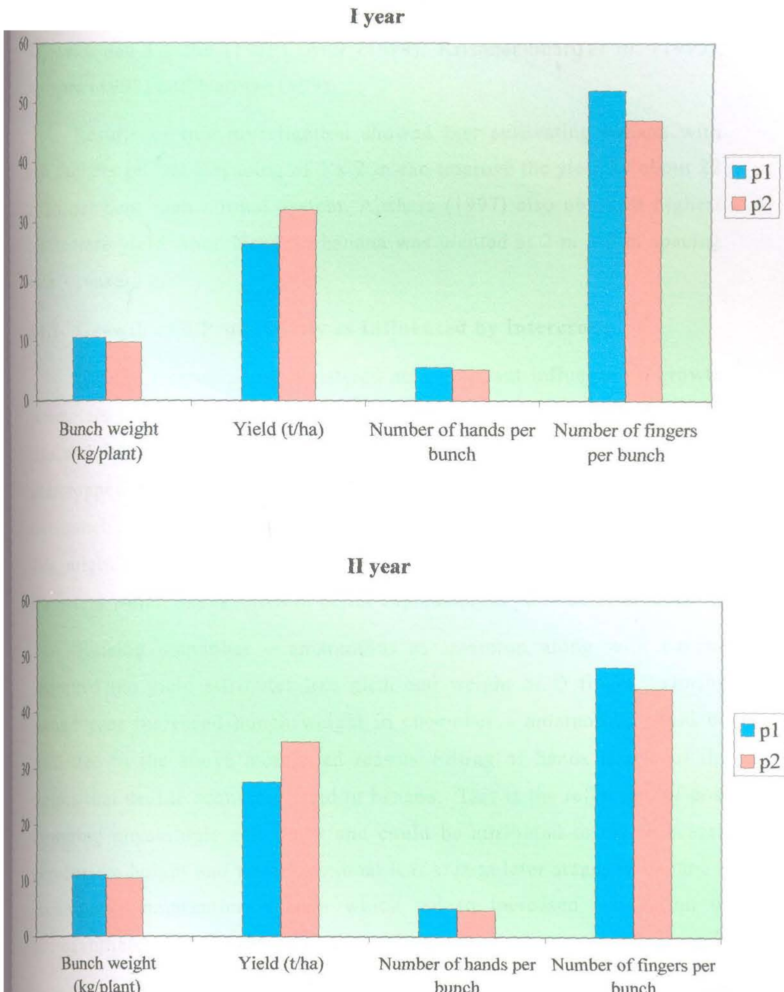


Fig. 7 Main effect of planting pattern on yield and yield attributes of banana during 2002-03 and 2003-04

population in the system thereby increasing productivity. Similar yield improvement in high density planting was reported by Reddy (1982), Rajeevan and Geetha (1989), Anil (1994), Krishnakumary *et al.* (1995), Apshara (1997) and Nalina (1999).

Results of this investigation showed that cultivating banana with two suckers pit^{-1} at a spacing of 3 x 2 m can improve the yield by about 22 to 26 per cent than normal system. Apshara (1997) also obtained highest per hectare yield when Nendran banana was planted at 2 m x 3 m spacing with 3 suckers pit^{-1}.

5.1.2 Growth and Productivity as Influenced by Intercrops

Though intercropping registered no significant influence on growth parameters like pseudostem girth, pseudostem height, total functional leaf area and LAI a positive trend was observed in cucumber – amaranthus intercropped banana during second year. Perusal of yield data showed that bunch weight was significantly higher in cucumber – amaranthus. This might be due to the cumulative positive influence of these growth characters which has resulted in better expression of yield determinants.

Raising cucumber – amaranthus as intercrop along with banana improved the yield attributes like girth and weight of D finger. During second year increased bunch weight in cucumber – amaranthus could be attributed to the above mentioned reason. Filling of hands is one of the factors that decide economic yield in banana. This is the reflection of post flowering physiologic efficiency and could be attributed to the increased pseudostem height and total functional leaf area at later stages in banana + cucumber – amaranthus system which led to increased production of photosynthates by effective utilization of light.

Low growing nature of cucumber allows better utilization of the inlet radiation for the photosynthetic activities by banana. Cucumber provided mat-layer mechanism which resulted in reduction in weed growth, increase water percolation thus providing a suitable microclimate for satisfactory development of banana. Moreover increased addition of intercrop residue over two years might have improved the organic carbon content and nutrient uptake by banana which must have resulted in higher bunch weight. The N and K uptake (200.7 and 528.8 kg ha^{-1}) of banana in cucumber-amaranthus intercropped plots also confirms this observation. Suitability of cucumber and amaranthus as intercrop in normal system of planting was reported by KAU (1996).

These results showed that cucumber followed by amaranthus intercropping sequence is economically viable in banana based cropping system.

5.1.3 Growth and Productivity as Influenced by Interaction between Planting Pattern and Intercrops

The interaction effect due to planting pattern and intercropping on growth and yield parameters was not significant during two years of experimentation.

Banana can trap nutrients only from a limited area as it possess a shallow root system. Maximum percentage of active roots in banana was confined to a distance of 20 cm in irrigated crop from the base of the plant and to a depth of 30 cm (Sobhana, 1985). Banana as well as all intercrops were separately fertilized. Spiral arrangement of banana leaves also helped in better infiltration of light through the canopy. All these provided favourable rhizosphere and phyllosphere area for the development of intercrops without any detrimental effect on growth and productivity of banana.

To conclude, intercropping can be practised in both normal and modified system of planting banana successfully for maximizing land use efficiency and generating supplemental income.

Plate 14 Bunches produced from various treatment combinations of Experiment I

5.1.4 Quality Attributes

Experimental results during first year reveal that TSS, ascorbic acid, acidity, total reducing and non-reducing sugar were not influenced by treatments. However sugar : acid ratio was positively influenced by planting pattern is attributed to the amount of acidity and total sugars present within the fruit. A fruit with a decreased acidity percentage along with an increased sugar content is considered as superior when quality is taken into account. In the present experiment it was observed that acidity decreased while sugar content increased with increase in plant population thereby maintaining the fruit quality. However contrary results were reported by Irizarry *et al.* (1978), Chundawat *et al.* (1983), Morales and Rodriguez (1988) and Anil (1994). In general, intercropping did not deleteriously affect the fruit quality. Sugar – acid ratio recorded minimum value when banana was intercropped with cucumber–amaranthus. This can be related to the increased dry matter produced by the crop and possible dilution effect.

5.1.5 Dry Matter Production

Cumulative dry matter production was observed to be higher in modified system than normal system. This could be accounted to the increased density. The modified system accounted to 25 and 12 per cent increase in cumulative dry matter production than the normal system during first and second year. Differential increase in dry matter production over years could be related to increased vegetative growth reduced of tissue culture plantlet over sucker. Loomis and Williams (1963) observed that with increase in leaf area index there was a corresponding increase in light absorption and dry matter production. This report is in agreement with the result observed in the present study as the computed values of leaf area index was higher in the modified system due to high plant density.

During second year banana intercropped with cucumber – amaranthus enhanced the dry matter production. This could be attributed to the increased growth parameters like pseudostem height, girth, total functional leaf and LAI registered in this treatment.

5.1.6 Nutrient Content and Uptake

Third fully opened leaf is taken as the index leaf and nutrient concentration of index leaf (third fully opened leaf) in plant is said to provide information on the nutrient status of the plant. The leaf nutrient standard for banana suggested by Ashokkumar (1977) is 0.98 – 2.26, 0.11 – 0.37 per cent and 3.6 – 5.0 per cent for NPK respectively.

A perusal of the data on nutrient content indicated that the plants grown under different planting pattern and intercrops did not suffer for nutrients. In various planting densities the leaf nutrient levels were within the adequacy limits. So also the different intercrops tried along with banana had no adverse effect on reducing the leaf nutrient status. Further the results clearly revealed that leaf nitrogen content was improved in modified planting whereas the leaf phosphorus was maximum in normal planting. Leaf potassium content was unaffected by planting pattern. Raising chittaratha as intercrop increased the nitrogen and potassium content during first year might be due to slow initial growth rate of chittaratha. During second year foliar nitrogen and potassium content registered higher values in pure crop under both systems. Leaf phosphorus content was more with cucumber – amaranthus under normal system and with pure crop under modified system. Under modified system, the demand for nutrients will be more as the nutrients from the availability zone has to be shared by two plants.

If nutrients are considered individually, a value equal or higher than critical value are not always associated with high yield and a lower value than critical value are not always related to low yield (Dumas and Martin-Prevel, 1958). The extremely wide range of critical values is a limiting factor for the use of critical value approach in nutritional diagnosis (Angeles *et al.*, 1993). The values on nutrient content seemed to be erratic as the content is influenced by a number of factors like growth of the plant, availability of water, environment etc. for uptake of nutrients. Hence it will be more appropriate to discuss the uptake values.

During both the years total nitrogen uptake was highest under modified system of planting (Fig. 8). Enhanced dry matter production in modified system contributed to this. Chittaratha as intercrop enhanced the nitrogen uptake of banana in first year whereas intercropping cucumber – amaranthus enhanced the uptake in second year. Since these treatments registered higher dry matter production, uptake which is a product of the nutrient content and dry matter was also higher. Chittaratha crop being in vegetative stage during the first year which might have reduced its nutrient requirement and thus enable increased uptake by banana. In second year early harvested cucumber-amaranthus might have encouraged nitrogen uptake by banana. Moreover incorporation of more crop residues in this system also might have improved nitrogen uptake.

As in nitrogen uptake, phosphorus uptake was maximum under modified system during first and second year owing to increase in dry matter production (Fig. 8). Similarly enhanced dry matter production in amaranthus and chittaratha intercropped field helped to register highest P uptake in these treatments.

Potassium uptake was higher when banana was intercropped with cucumber – amaranthus in both systems during first year (Fig. 8). This could be attributed to increased potassium content noticed in these treatment combinations. However during second year, the potassium uptake registered higher values with pure crop in normal system and cucumber – amaranthus in modified system. This could be attributed to increased absorption of potassium by pure crop of banana while in cucumber – amaranthus both nutrient absorbed by plant and dry matter limiting factor for the use of critical value approach in nutritional diagnosis (Angeles *et al.*, 1993). The values on nutrient content seemed to be erratic as the content is influenced by a number of factors like growth of the plant, availability of water, environment etc. for uptake of nutrients. Hence it will be more appropriate to discuss the uptake values.

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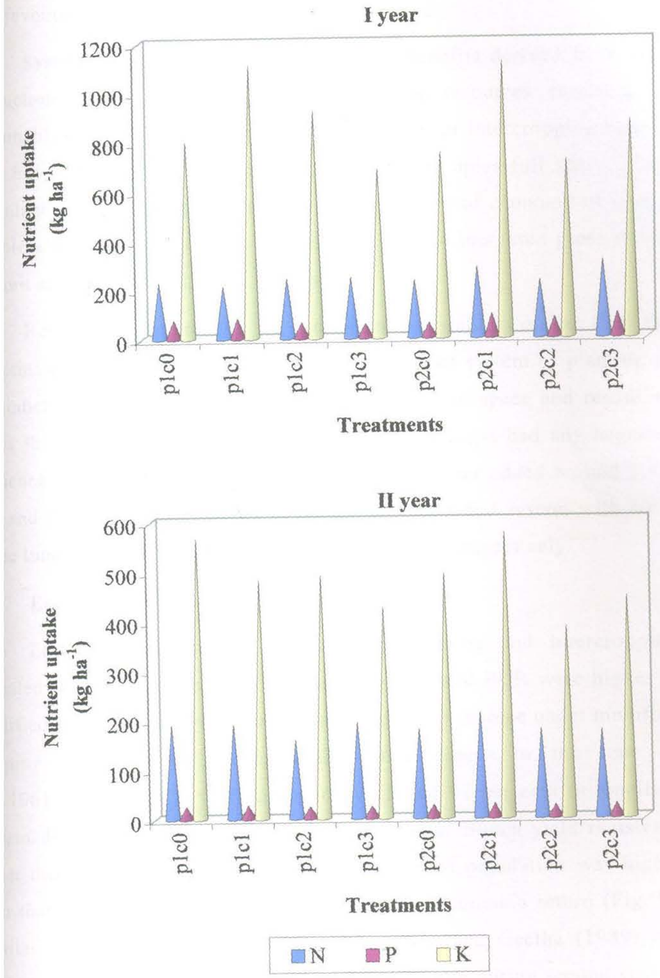

Fig. 8 Interaction effect of treatments on nutrient uptake during 2002-03 and 2003-04

produced were maximum. Nutrient addition through residue incorporation also favoured nutrient uptake by banana.

System approach seeks to increase the benefits derived from crop production by efficient utilization of natural resources resulting in sustainable productivity of crops. There is scope for intercropping banana as it has a lag phase of 4-5 months, before it occupies full space. The advantages of intercropping from the point of view of economy of space, complete utilization of surplus nutrient reserve and increased gross return per unit area have already been documented.

Review of the results of the intercrop yield revealed that the performance of the crop was better under modified system of planting in cucumber. This is attributed to better availability of space and resources under this system of planting. None of the intercrops had any negative influence on the bunch weight of banana. Cucumber added around 1.4 t ha^{-1} and 2.4 t ha^{-1} crop residue in normal and modified system with NPK to the tune of 2.2, 0.52, 3.6 and 3.8, 0.89, 3.8 t ha^{-1} respectively.

5.1.7 Economic Parameters

Economic analysis of high density planting and intercropping revealed that total income, net income (Fig. 10) and BCR were higher at modified planting pattern. Average increase in net income under modified planting pattern over conventional system comes to the tune of Rs. 106178 ha^{-1}. BCR was improved by 25 and 42 per cent in modified system during first and second year respectively. Bunch yield registered under modified system owing to increase in plant population was higher than that under normal system leading to more economic return (Fig. 9). Similar observations were noticed by Rajeevan and Geetha (1989) and Anil (1994). So also the economic return was more during second year as the cost of cultivation was reduced by way of obtaining suckers from the experimental field itself.

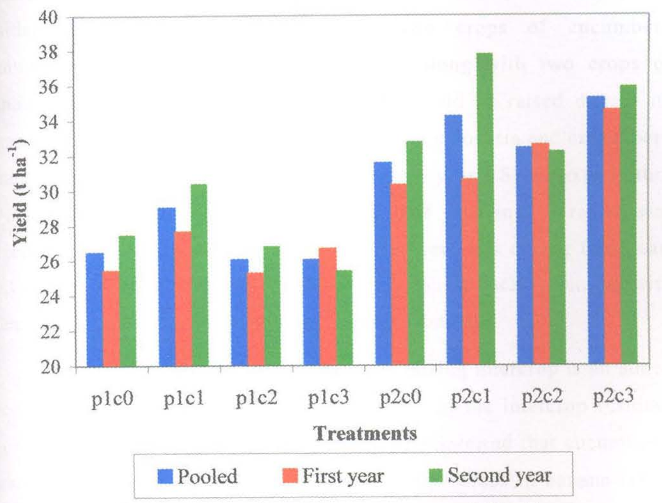

Fig. 9 Interaction effect of treatments on yield of banana during 2002-03 and 2003-04

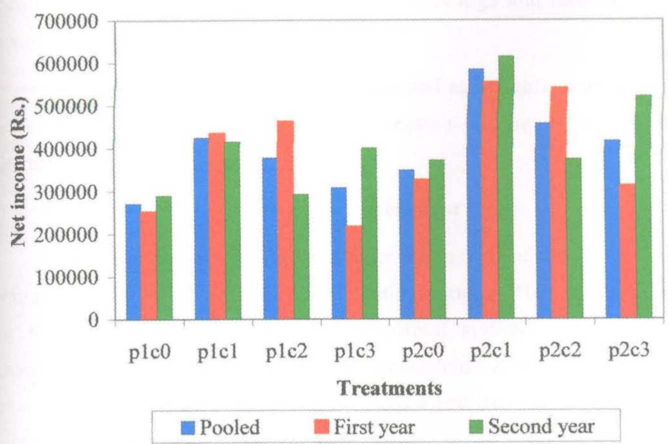

Fig. 10 Interaction effect of treatments on net income of banana during 2002-03 and 2003-04

Intercropped banana with colocasia and cucumber–amaranthus registered higher profit and benefit–cost ratio than chittaratha. Considering the duration of intercrops, two crops of cucumber–amaranthus and colocasia could be obtained along with two crops of banana whereas only one crop of chittaratha could be raised due to its longer duration (18 months). So the income from colocasia and cucumber–amaranthus is more than chittaratha during first year. Since expenditure was incurred for raising chittaratha during first year and no return was realized from the crop. Net income and BCR were less during first year. Based on the result it could be concluded that double sucker planting with colocasia and cucumber – amaranthus is more economic.

From the economic point of view also, raising intercrop is an added source of income to farmer. The incorporation of the intercrop residues favourably improved the soil. Hence it could be inferred that cucumber – amaranthus and colocasia are equally good as intercrops in banana raised in modified planting. Growing chittaratha is more economic than pure crop. However when compared with other intercrops it is less economic since the expenditure for initial establishment is high and returns will be obtained only after 18 months.

Raising profitable intercrops is suggested as a viable alternative for the better utilization of resources and increasing income. The results of this study also supports these findings.

5.1.8 Soil Nutrient Status after the Experiment

Soil nutrient analysis was done after the harvest of the second crop. Available N and P did not vary with planting pattern. However available soil K was significantly higher under normal system. Banana is an exhaustive feeder of nutrients especially potassium. Available K was less under modified system due to higher uptake resulted from 33 per cent more population.

Results also indicate a higher nitrogen and potassium status of soil in plots where banana was intercropped with colocasia and higher phosphorus content in plots intercropped with cucumber – amaranthus. This might be attributed to decreased absorption of nutrients. Moreover recycling of crop residues might have favourably improved the soil nutrient status.

When compared with the initial soil nutrient status, available N and K content of the soil after the experiment showed marked improvement. Inorganic fertilizers added to all experimental plots along with recycled residue might have contributed to enhancement of nutrients in soil. However the available phosphorus content was reduced than initial status with pure crop and colocasia in modified system of planting. This could be attributed to the increased uptake of phosphorus by pure crop of banana under modified system whereas colocasia might have absorbed more phosphorus for its growth and development and the residue returned was minimal. Hence it could be inferred that addition of required amount of nutrients along with proper incorporation of crop residue is ideal for enhancing soil nutrient status in a banana based cropping system.

Overall review of the results clearly indicated that planting of Nendran at 3 m x 2 m with two suckers per pit is better than planting single sucker at 2 m x 2 m spacing for getting maximum yield per unit area with good sized bunches. Differences in bunch size between conventional planting and modified planting is very less. Adopting high density planting with two suckers per pit at a spacing of 3 m x 2 m enables intercropping which led to substantial increase in economic return without affecting the quality of the bunch. Promising intercrops observed from the experiment are cucumber – amaranthus and colocasia. In addition raising intercrops with proper recycling of crop residues is not causing any deterioration to soil. Moreover the added advantage of soil nutrient improvement was also observed by this practice.

5.2 EXPERIMENT II – NUTRIENT MANAGEMENT AND RECYCLING OF BANANA RESIDUES IN PAIRED PLANTING SYSTEM

5.2.1 Growth and Productivity as Influenced by Nutrient Levels

During both the years of study, nutrient levels recorded no significant effect on yield. In general, a similar trend was observed in growth parameters and yield determinants. However total functional leaf area and leaf area index registered significant variation towards later stages. These positive influence were not reflected on yield. Photosynthetic efficiency towards later stages could not contribute to productivity as primordial development coincides with fourth month of planting. During second year though the number of hands and fingers per bunch increased with increasing levels of nutrients, corresponding lower values of finger characters resulted in lack of variation in bunch weight between various sources of organic manure. This result showed that recommended dose of nutrients is sufficient for double sucker planted banana crop.

5.2.2 Growth and Productivity as Influenced by Organic Sources

Organic manures failed to show any response on bunch weight. None of the growth characters and yield determinants were influenced by organic manures. However during second year total functional leaf area and leaf area index showed significance but these factors could not contribute to productivity. Though the number of fingers per bunch was higher with FYM, length and girth of D finger registered minimum value, thereby nullified their effect on yield.

5.2.3 Quality Attributes

According to Sheela (1995) quality of the fruit was best expressed in terms of high TSS, total and non-reducing sugar, low acidity and high sugar acid ratio.

Plate 15. Bunches produced from various treatment combinations in Experiment II

The influence of nutrients levels, organic sources and their interaction did not influence the quality parameters except TSS and total sugar during first year. Both of these showed a drastic reduction in value with fresh banana residue incorporation. This could be attributed to the decreased supply of nutrients from the pseudostem which might have affected the metabolic activities of the plant and thereby the biosynthesis of quality components.

During second year, TSS, ascorbic acid and sugar acid ratio were high at recommended dose of nutrients as well as at 133 per cent additional dose. Improvement in sugar acid ratio is due to higher sugar content noticed at these levels. Higher potassium content in index leaf at 4 MAP might have helped in the synthesis of sugars (Martin-Prevel, 1962).

Though significant increase was observed with vermicompost, it was below the threshold level.

5.2.4 Dry Matter Production

Dry matter production of the different plant parts as well as total dry matter was not influenced by nutrient levels and organic sources during first year. However they exerted significant influence during second year.

Maximum dry matter was produced by farmyard manure at higher nutrient levels of f_2 and f_3. This could be attributed to the better nutrient availability leading to greater growth and yield.

5.2.5 Nutrient Content in the Index Leaf at Bimonthly Intervals

During the first year of study nutrient content except K did not show much variation with the treatments whereas during second year N, P and K content of index leaf differed significantly between the treatments. Significant difference during second year could be related to nutrient removal by first crop which might have lowered the soil nutrient status.

Its effect was more pronounced in banana as it is an exhaustive feeder of potassium.

5.2.6 Nutrient Content and Uptake at Harvest

Results of experiment showed that nutrient accumulation was more in rhizome and pseudostem. It indicates an inhibition in translocation of nutrients. All nutrients are mobile, an upward translocation is expected . Reverse result might be due to precipitation with some unfavourable native elements. Inspite of excess physical content, physiologic unavailability due to metabolic inactivation cannot be ruled out in the plants as a factor of growth and yield limitation. More nitrogen in the fruit points out the failure of the crop in conversion of nitrogen to carbohydrate. This could be attributed to the negative influence of excess concentration of native elements. In the present study continuous irrigation might have aggravated the situation by enhancing duration of reductive phase in rhizosphere environment.

Total uptake of nitrogen by first season banana was influenced by organic sources and highest value was registered with vermicompost (Fig. 11). Since nitrogen in vermicompost is in a readily available form it might have enhanced nitrogen uptake by banana. Nutrient levels had a significant role on P uptake, maximum being registered with RDN + one-third additional dose. Total uptake of potassium was higher with FYM at f_1, vermicompost at f_2 and banana pseudostem at f_3.

During second year, total uptake of nitrogen was more at f_2 among nutrient levels. Farmyard manure and vermicompost behaved similarly among organic sources. However nutrient levels and organic sources had no effect on phosphorus uptake. Total uptake of potash increased with increasing levels of potassium application. Maximum N and K uptake were with RDN for vermicompost and 133 per cent additional dose of FYM and banana pseudostem could be attributed to lower N content in FYM and pseudostem compared to vermicompost. The trend observed in

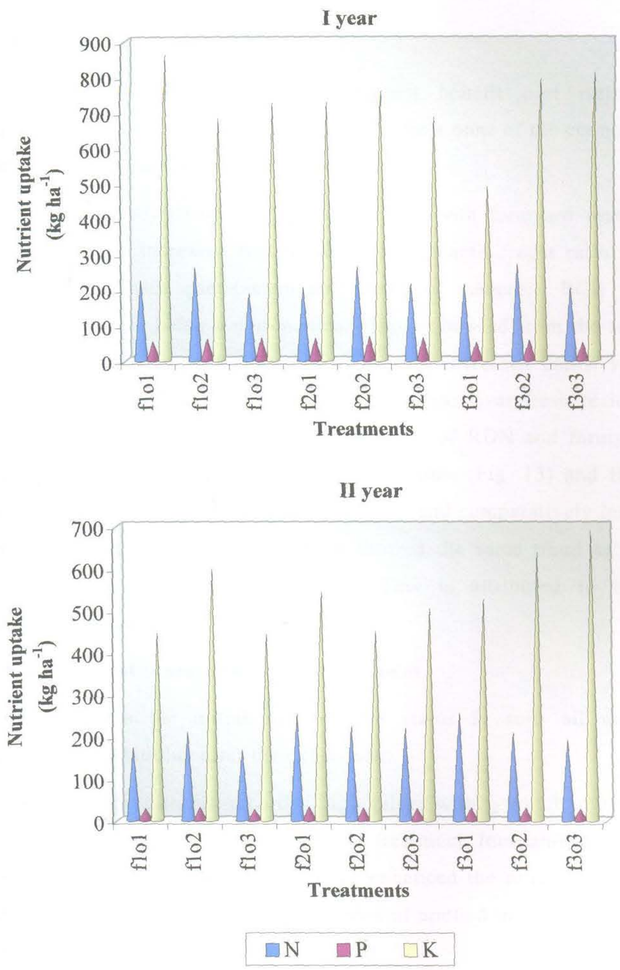

Fig. 11 Interaction effect of treatments on nutrient uptake during 2002-03 and 2003-04

interaction effect of treatments on N and K uptake is in line with that of yield.

5.2.7 Economic Analysis

First crop of banana recorded highest benefit cost ratio at recommended dose of nutrients. During second year none of the economic parameters were influenced by nutrient levels.

During second season, higher net income with farmyard manure could be related to increased bunch yield while benefit : cost ratio was maximum with banana pseudostem and farmyard manure. BCR was higher in pseudostem being a non-monetary input obtained from the same plant and it was on par with farmyard manure as increased bunch yield compensated marginal increase in cost of cultivation over fresh residue. Among the treatment combinations, 133 per cent of RDN and farmyard manure proved superior in total income, net income (Fig. 13) and BCR because of higher bunch yield (Fig. 12) obtained and comparatively lesser cost of cultivation. However economics showed the same trend as dry matter production and yield (Fig. 14). This is attributed to high productivity in these treatments.

5.2.8 Soil Nutrient Status after the Experiment

Compared to the initial soil nutrient status in soil, all major nutrients showed a buildup after the experiment.

Available soil nitrogen recorded high values with f_2 which might be due to decreased losses of the nutrient in the treatment. Inorganic nitrogen added to all experimental plots might have enhanced the nitrate nitrogen content of the soil, possibly due to conversion of applied mineral nitrogen through nitrification process (Krishnan, 1986).

Higher status of available P in the soil after harvest was noticed as the phosphatic fertilizers which are highly reactive might got fixed in the soil and released phosphorus slowly to the available pool. Maximum value of available soil phosphorus with vermicompost addition could be attributed to the formation of phosphohumic complexes.

Improvement in soil potassium at f_3 level could be related to the higher dose of potassium added.

Available N, P and K in soil were more with incorporation of fresh banana pseudostem, could be attributed to low uptake values of nitrogen, phosphorus and potassium noticed in the treatment. In addition, crop residues add to slow and passive recalcitrant pools of soil organic matter. Their nitrogen release potential is rather low due to higher C : N ratio and consequent slow rate of mineralisation. Under adequate supply of N and P when crop residues are returned to the soil, the added nutrients might be immobilized in fairly stable organic carbon compounds (Tisdale *et al.*, 1995). Less loss could be noticed due to slow mineralisation. Application of banana stems may significantly increase soil potassium (Lassoudiere and Godefroy, 1971) also supports the result.

Both the actual and computed values of soil nutrients in the balance sheet are on positive side indicating good nutrient management in all treatment combinations (Fig. 15). The variation in the computed values and actual values for nitrogen might be due to low nitrogen use efficiency and different types of losses like leaching, surface runoff and immobilization by microbes. The actual phosphorus was very low compared to computed value since the soil in experimental field belongs to the order oxisol which is characterized by high P fixation due to increased weathering and increased clay fraction dominated by hydrous oxides, iron and aluminium. In general not much variation in K status between actual and computed values except at highest dose of nutrients applied. This can be attributed to interaction of potassium with other cations, leaching losses and luxury consumption.

From the present study we can recommend farmyard manure and fresh banana pseudostem with 133 per cent of RDN and vermicompost with RDN as economically viable and sustainable practice for banana var. Nendran under paired system of planting.

Instances of banana var. Nendran yielding 15 to 18 kg $plant^{-1}$ are not uncommon. At this level of recommended nutrients and organics such a high yield can be realized by management of redox potential and warding off negative influence of excess concentration of native elements which can be explored in future. Possibility of even doubling the yield cannot be ruled out if the limiting factors are identified and controlled through amelioration.

Summary

6. SUMMARY

An investigation entitled "Crop intensification and resource management in banana based cropping system" was undertaken at the Instructional Farm, College of Agriculture, Vellayani during the period 2002-2003 and 2003-2004. The study was conducted in two experiments. Experiment I was intended to study the effect of planting pattern and intercrops on the growth and productivity of banana. Experiment II was to assess the nutrient management and recycling of banana residues in paired planting system.

In Experiment I efficacy of intercropping was evaluated under two systems of planting in banana. The planting pattern included normal planting with one sucker at 2 m x 2 m spacing and modified planting with two suckers per pit at 3 m x 2 m spacing. The intercrops studied were cucumber followed by amaranthus, colocasia and chittaratha along with a control (no intercrop). The experiment was laid out in factorial randomised block design replicated thrice.

Different levels of inorganic nutrients and organic sources on modified system of planting was studied in Experiment II. The treatments constituted three levels of nutrients *viz.*, recommended dose of nutrients (RDN), 133 per cent of RDN and 167 per cent of RDN as well as three sources of organic manure *viz.*, farmyard manure, banana residue in fresh state and vermicomposted. The experiment was in factorial randomised block design with three replications. The results of the experiments are summarized below:

Experiment I

1. Plant height indicated a positive influence under modified planting pattern during the initial growth stages. Pseudostem girth was

maximum during later stages under normal planting pattern. The number of functional leaves, total functional leaf area and leaf area index registered higher values under modified system.

2. Though crop duration was insignificant during first year, maximum duration was noticed during second year when banana was intercropped with colocasia.

3. Stomatal conductance showed an increasing trend and light interception a decreasing trend with age of the crop.

4. Among the bunch characters studied, number of hands and fingers per bunch were positively influenced by planting pattern. Normal system of planting banana recorded maximum number of hands and fingers per bunch in both seasons. All other fruit characters were insignificant.

5. Bunch weight did not show any variation with planting pattern. However total yield per hectare was maximum under modified system of planting. Intercrops exerted a positive influence on both bunch weight and yield, during second year, maximum being recorded with cucumber-amaranthus as intercrop. Same trend was shown on pooled analysis of yield data.

6. Shelf life was influenced by planting pattern, intercrops and their interaction during first year while intercrops had no influence during second year. Highest shelf-life was recorded with modified system in both seasons. In normal system an increase in shelf-life was noticed when banana was intercropped with chittaratha in both crop seasons.

7. All the quality attributes studied except sugar-acid ratio were not influenced by planting pattern. During first year highest sugar-acid ratio was recorded under modified system. Second year results revealed positive influence of normal planting pattern on acidity

and ascorbic acid content. Better quality attributes like non-reducing sugars and sugar acid ratio were improved in modified system. At normal and modified planting sugar acid ratio and ascorbic acid content was higher when colocasia was raised as intercrop.

8. Dry matter production was maximum under paired planting during both the seasons. During second year intercropping with cucumber-amaranthus produced more dry matter accumulation in banana than other intercrops tried.

9. Total uptake of nitrogen and phosphorus by first crop was the highest under modified system of planting while total potassium uptake registered higher values under conventional system of planting. No significant difference in uptake of NPK was observed by planting pattern during second year. Highest uptake of nitrogen was registered with chittaratha as intercrop in both systems during first year while chittaratha under normal system and cucumber-amaranthus under modified system registered higher values during second year. Phosphorus and potassium uptake recorded maximum value with cucumber-amaranthus under both systems of first crop of banana. Phosphorus uptake by chittaratha and potassium uptake by pure crop of banana were on par with cucumber-amaranthus intercropped banana during second year.

10. Maximum total income, net income and B : C ratio were recorded with modified system of planting during both seasons. Net profit and BC ratio were higher when banana was intercropped with cucumber-amaranthus and colocasia during first year and with cucumber-amaranthus and chittaratha during second year. At normal and modified systems in both crop BCR and net income were higher with cucumber-amaranthus.

11. Available NPK content of soil after harvest was higher compared to initial status for all treatments.

Experiment – II

1. The pseudostem height did not show any difference with nutrient levels and organic sources in either season.
2. The pseudostem girth at sixth month was maximum at f_3o_3. However it was insignificant during second year.
3. The number of functional leaves, total functional leaf area and LAI showed significance during fourth month at recommended dose of nutrients for first crop of banana. During second year, these characters recorded maximum values with farmyard manure and at RDN + one-third additional dose.
4. Duration of the crop upto shooting as well as to harvest was insignificant during first year. However during second year, banana with farmyard manure took more days to harvest.
5. An increase in stomatal conductance and decrease in light interception was noticed with progress of crop growth.
6. None of the treatments had significant influence on yield attributes and yield during first year except for high pulp : peel ratio at recommended dose of nutrients. During second year, higher bunch weight as well as bunch characters were recorded at o_1 and o_3 with f_2 and o_2 with f_1. Pooled analysis also showed similar trend as in second crop.
7. TSS was maximum with the organic source of banana pseudostem and total sugar with farmyard manure during first year. TSS, ascorbic acid and sugar acid ratio recorded higher values at f_1 and f_2. Acidity was the least with farmyard manure application.

8. Shelf life did not vary with any of the treatments in either seasons.

9. Application of farmyard manure along with the nutrient levels of f_1 and f_2 enhanced the dry matter production.

10. The foliage nitrogen content in the index leaf was maximum with f_2 at early stages and with f_3 towards later stages. The leaf phosphorus content of first crop of banana showed no response with any of the treatment combinations. During sixth month, highest value of foliar potassium was registered at recommended dose of nutrients. During second year, foliar phosphorus in index leaf was maximum at RDN among nutrient levels and with farmyard manure among organic sources.

11. Total nitrogen uptake was maximum with vermicompost while phosphorus uptake with RDN + one-third additional dose. Total uptake of potassium was higher with FYM at f_1, vermicompost at f_2 and banana pseudostem at f_3 during first year. Total uptake of nitrogen was more at f_2 and FYM for second crop of banana. Uptake of potash increased with increasing levels of potassium application.

12. FYM and banana pseudostem along with 133 per cent of RDN and vermicompost with RDN proved superior to all other treatments with respect to economical parameters during second year.

13. Soil nutrient status improved after two years of experimentation.

From the result of the present investigation the following adhoc recommendation can be given to farmers. Raise banana with two suckers per pit at a spacing of 3 m x 2 m either with cucumber-amaranthus or colocasia as intercrop.

The double sucker planting can be manured with 133 per cent RDN (400: 153 : 600 g NPK pit^{-1}) if the organic source is FYM @ 15 kg pit^{-1} /

fresh banana pseudostem @ 20 kg pit^{-1} and recommended dose of nutrients (300: 119 : 450 g NPK pit^{-1}) with vermicompost @ 5 kg ha^{-1} for maximum yield and net returns.

Future line of research

1. Further research is required to explore the nutrient interactions in banana under double sucker planting.
2. Scope of drip fertigation in double sucker system to overcome the management inadequacies may be investigated with a view to improve the efficiency of irrigation and fertilizer application thus reducing the cost of cultivation.

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CROP INTENSIFICATION AND RESOURCE MANAGEMENT IN BANANA BASED CROPPING SYSTEM

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ABSTRACT

The influence of crop intensification in banana by modifying the planting pattern and intercropping on productivity enhancement and developing an optimum fertilizer schedule for double sucker planting were evaluated by conducting two field investigations at College of Agriculture, Vellayani during 2002-2003 and 2003-2004.

The first investigation was laid in factorial randomised block design with two systems of planting and four intercrops, replicated thrice.

Perusal of the results showed an increase in the number of functional leaves, total functional leaf area and leaf area index under modified system while maximum pseudostem girth was recorded under normal system of planting towards later stages of observation.

Among the yield attributes, number of hands and fingers per bunch recorded the highest values in normal planting system during both the seasons.

Individual bunch weight did not register any variation with planting systems. However, maximum yield per hectare was registered in double sucker planting.

During both the years sugar : acid ratio was maximum under modified system. Modified system of planting banana produced more dry matter during both the years. N and P uptake was enhanced in modified system and whereas K uptake was more in normal planting pattern during first year. N uptake was the highest with chittaratha and P and K uptake with cucumber-amaranthus under both systems during first year. During second year, N uptake showed maximum value with chittaratha under normal system and with cucumber-amaranthus in modified system. P uptake by chittaratha and K uptake by the pure crop of banana were on par with intercropping with cucumber-amaranthus.

Economic analysis revealed that combination of modified planting pattern intercropped with cucumber-amaranthus recorded the highest net profit and BCR. The highest net profit of Rs. 554384 and Rs. 615030 were realized ha^{-1} during first and second year respectively in this treatment.

The second investigation was conducted with three levels of nutrients and three sources of organic manure laid out in factorial randomized block design with three replications.

The nutrient levels and organic sources had no influence on pseudostem height, girth and number of functional leaves during both the years. However total functional leaf area and leaf area index showed a linear negative trend with increasing dose of fertilizers during first year. During second year, total functional leaf area and leaf area index registered maximum values at 133 per cent of recommended dose with farmyard manure at shooting and at harvest.

During first year yield and yield attributes were unaffected by treatments, whereas during second year bunch characters like number of hands and fingers per bunch and bunch weight were maximum when farmyard manure/pseudostem along with 133 per cent of recommended dose and when vermicompost along with recommended dose of nutrients were applied.

Among the quality attributes higher values of TSS was observed with fresh banana pseudostem and total sugar with farmyard manure during first year. TSS, ascorbic acid and SAR recorded higher values at recommended dose and 133 per cent of recommended dose during second year.

Application of farmyard manure along with 133 or 167 per cent of recommended dose of nutrients enhanced dry matter production of banana in second year. Compared to leaf nutrient content, accumulation of nutrients in fruit, pseudostem and rhizome were found to be high during both the years.

Foliar nitrogen was maximum at 133 per cent of recommended dose in early stages and at 166 per cent of recommended dose at later stages. Foliar potassium at 6 MAP registered marked value at recommended dose during first year. Phosphorus recorded higher values with RDN among nutrient levels and FYM among organic sources during second year.

First crop of banana registered highest B : C ratio with recommended dose of nutrients and fresh banana pseudostem incorporation. Highest net profit of Rs. 461536 ha^{-1} and BCR of 4.64 was realized when farmyard manure was applied along with 133 per cent of recommended dose of nutrition.

Therefore it can be concluded from the study that planting banana at 3 m x 2 m spacing with two suckers pit^{-1}and raising cucumber-amaranthus as intercrop is beneficial for getting higher yield per unit area and maximum economic returns. The study also reveal that 133 per cent of recommended dose of nutrients (400 : 153 : 600 g NPK pit^{-1}) is required when farmyard manure @ 15 kg pit^{-1} or banana pseudostem @ 20 kg pit^{-1} is used as organic source. When vermicompost is used @ 5 kg pit^{-1} the recommended nutrient dose (300 : 115 : 450 g NPK pit^{-1}) is sufficient. Moreover this nutrient schedule is economically viable and helpful in maintaining soil fertility.

Appendices

APPENDIX – I

Weather parameters during the cropping period

Month and year	RH (%)	Temperature (°C)		Sunshine hours	Rainfall (mm)	Number of rainy days	Evaporation (mm)
		Maximum	Minimum				
Oct-02	94.1	30.1	23.3	4.6	416.5	25	2.7
Nov-02	95.9	30.2	23.4	4.0	95.5	13	2.1
Dec-02	90.4	30.9	21.5	5.8	3.2	1	2.8
Jan-03	93.0	31.5	21.4	8.5	1.6	1	3.6
Feb-03	93.9	31.7	22.8	8.5	68.3	3	3.8
Mar-03	91.7	32.5	23.5	8.8	69.0	6	4.2
Apr-03	89.8	32.8	24.7	7.6	80.2	7	4.0
May-03	87.8	32.6	25.5	7.2	179.3	11	3.5
Jun-03	88.8	31.6	24.4	6.2	193.6	14	3.9
Jul-03	90.0	30.5	23.8	5.2	126.6	19	3.2
Aug-03	93.2	30.9	24.3	6.0	100.5	15	3.9
Sep-03	85.8	31.4	23.9	9.1	10.3	4	4.8
Oct-03	92.9	30.4	23.6	5.8	515.9	15	3.0
Nov-03	93.7	30.5	23.2	4.5	169.4	15	2.5
Dec-03	93.8	31.2	21.6	8.2	0	0	3.2
Jan-04	94.4	31.5	21.7	9.0	6.8	1	3.6
Feb-04	94.1	32.2	22.1	9.4	0.4	1	4.2
Mar-04	90.6	33.1	24.1	7.5	1.2	1	4.6
Apr-04	88.2	33.3	24.9	8.0	126.9	10	4.5
May-04	91.5	31.0	23.9	5.3	447.6	19	3.1

APPENDIX - II

Soil moisture content and water holding capacity (WHC) of the experimental field

Treatments	Soil moisture content at monthly intervals (%)																		WHC (%)
	Nov. 2002	Dec. 2002	Jan. 2003	Feb. 2003	Mar 2003	Apr 2003	May 2003	June 2003	July 2003	Aug. 2003	Sept 2003	Oct. 2003	Nov. 2003	Dec. 2003	Jan 2004	Feb 2004	Mar 2004	Apr 2004	
p_1c_0	7.7	10.0	9.0	10.5	7.4	10.1	10.6	12.3	15.6	11.6	7.4	17.8	13.6	8.9	8.8	8.2	7.8	15.3	23.5
p_1c_1	12.7	10.5	9.7	11.8	9.4	11.8	14.3	13.8	14.3	12.9	9.4	11.1	12.9	8.5	9.0	8.9	7.8	10.3	21.5
p_1c_2	13.9	9.3	8.6	11.6	10.7	9.9	11.3	12.6	14.8	11.9	10.7	11.6	13.2	9.8	9.3	9.3	9.0	12.8	22.6
p_1c_3	8.2	11.5	6.9	9.7	8.1	9.9	9.7	13.2	16.4	12.6	8.1	12.6	11.4	9.0	7.4	8.4	7.9	10.9	22.9
p_2c_0	9.0	10.8	6.5	6.2	9.2	11.9	12.0	14.8	14.6	12.1	9.2	10.4	10.8	8.3	8.0	11.2	10.8	13.7	21.8
p_2c_1	10.3	7.7	5.8	12.6	12.3	11.9	11.2	12.6	15.4	11.8	12.5	9.3	9.9	9.2	6.2	7.9	7.7	12.0	20.9
p_2c_2	10.7	12.4	7.1	13.8	12.6	11.4	10.9	12.4	13.9	10.7	11.6	11.9	10.6	9.3	8.5	9.9	9.9	12.3	20.2
p_2c_3	11.8	9.8	9.2	12.6	12.0	12.6	10.6	14.3	15.9	12.1	11.1	11.1	11.5	9.8	9.2	10.1	9.8	12.5	22.4
Experiment II	7.2	10.3	6.6	8.4	9.1	10.6	8.7	12.9	13.2	12.6	8.9	12.8	11.9	8.4	7.8	8.4	8.6	11.3	21.2

APPENDIX - III

Cost of cultivation of banana under different planting pattern and intercrops (first crop)

Treatments	Cost of cultivation (Rs.)
p_1c_0	97455
p_1c_1	101707
p_1c_2	109635
p_1c_3	149665
p_2c_0	94050
p_2c_1	100033
p_2c_2	1113000
p_2c_3	163482

APPENDIX – IV

Cost of cultivation of banana under different planting pattern and intercrops (second crop)

Treatments	Cost of cultivation (Rs.)
p_1c_0	87455
p_1c_1	91707
p_1c_2	99635
p_1c_3	89665
p_2c_0	80712
p_2c_1	86701
p_2c_2	97968
p_2c_3	83510

APPENDIX – V

Cost of cultivation of banana with different nutrient levels and organic sources (first crop)

Treatments	Cost of cultivation (Rs.)			
	Excluding treatment	Fertilizer	Organic sources	Total
f_1o_1	72800	15000	6250	94050
f_1o_2	72800	15000	40000	127800
f_1o_3	72800	15000	0	87800
f_2o_1	72800	20500	6250	99550
f_2o_2	72800	20500	40000	133300
f_2o_3	72800	20500	0	93300
f_3o_1	72800	25545	6250	104595
f_3o_2	72800	25545	40000	138345
f_3o_3	72800	25545	0	98345

APPENDIX - VI

Cost of cultivation of banana with different nutrient levels and organic sources (second crop)

Treatments	Cost of cultivation (Rs.)			
	Excluding treatment	Fertilizer	Organic sources	Total
f_1o_1	52802	15000	6250	74052
f_1o_2	52802	15000	40000	107802
f_1o_3	52802	15000	0	67802
f_2o_1	52802	20500	6250	79552
f_2o_2	52802	20500	40000	113302
f_2o_3	52802	20500	0	73302
f_3o_1	52802	25545	6250	84597
f_3o_2	52802	25545	40000	118347
f_3o_3	52802	25545	0	78347

APPENDIX - VII

Market price of the produce

Produce	Market price (Rs.)
Banana var. Nendran	13/ kg
Cucumber	6/kg
Amaranthus	7/kg
Colocasia	12/kg
Chittaratha	18/kg of dried produce
Sucker	4/plant