YIELD MAXIMISATION OF BANANA (*Musa AAB group* 'Nendran') THROUGH ORGANIC AND INORGANIC MANURING

By

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THESIS

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DECLARATION

I hereby declare that this thesis entitled **"Yield Maximisation of Banana (*Musa AAB group* 'Nendran') through organic and inorganic manuring"** is a *bonafide* record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

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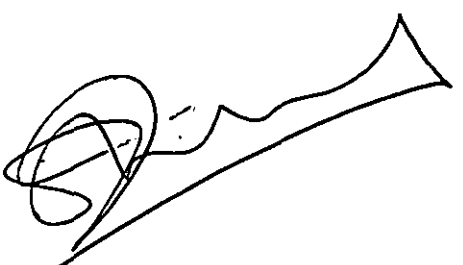

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LIST OF ABBREVIATIONS

g	-	Gram
kg	-	Kilogram
cm	-	Centimetre
m	-	Metre
t	-	Tonnes
%	-	Per cent
FAI	-	Fertilizer Association of India
SPB	-	State Planning Board
ha	-	Hectare
FYM	-	Farm Yard Manure
N	-	Nitrogen
P	-	Phosphorus
K	-	Potassium
GA	-	Giberellic Acid
ANOVA	-	Analysis of Variance
Cv	-	Cultivar
KCl	-	Potassium Chloride
TSS	-	Total Soluble Solids
lb	-	Pound
EC	-	Emulsifiable Concentrate
ppm	-	Parts per million
KAU	-	Kerala Agricultural University

INTRODUCTION

INTRODUCTION

Banana is one of the most important commercial fruit crops grown in India. It occupies an area of 4.19 lakh hectares, with an annual production of 99.35 lakh tonnes which corresponds to 9.75 per cent of total area and 24 per cent of the total production of fruit crops in India (FAI, 1996). It is grown in varying ecological conditions under different systems of production having regional preference for the cultivars. Banana is reported to be fourth most important global food commodity after rice, wheat and milk in terms of gross value of production.

In Kerala, banana occupies an area of 0.24 lakh ha with a production of 3.5 lakh tonnes (SPB, 1997). Among the different varieties of banana cultivated in Kerala, Nendran belonging to French plantain group is the most popular commercial variety grown in 23,850 hectares. It is used as a dessert and cooking variety and also forms the raw material for several processed foods such as flour, chips etc.

Inspite of predominance of banana as a fruit crop in Kerala, its productivity is very low. Field investigations revealed that banana farmers invariably apply larger quantities of fertilizers without any scientific basis. Lack of location and soil specific management practices and fertilizer

schedule has caused such a situation. Most of the farmers use factomphos as the fertilizer and poultry manure and FYM as the organic manures. Still yield level was found to be very low resulting on low net profit. Due to the use of factomphos, the crop receives very low amount of potassium. The disposal of banana pseudostem after the harvest pose a big problem. By converting this crop residue as value added vermicompost, organic manure requirement of the crop could be met and waste recycling and sustainability could be ensured. The present study was conducted to find out efficacy of different sources of organic and inorganic nutrients on productivity of Nendran banana. For better utilization of resource and to produce crops with less expenditure, integrated nutrient management is the best approach. Organic manures are not regarded as alternatives or substitutes for chemical fertilizers. Application of organic manure definitely benefits the soil in its structure, water holding capacity as well as nutritional status. Modern farming is quite rightly based on skillful use of all sources of plant food, organic and inorganic alike.

Several studies have brought out the beneficial effect of post shooting application of 2,4-D. The farmers in Vellayani region practise the urea tying in the peduncle to increase the bunch weight. The present study envisages to find out the efficacy of different sources of organic and inorganic nutrients for increasing the productivity of Nendran banana, the effect of post shooting application of urea and growth regulators on the bunch weight and overall yield of banana, to workout the benefit cost ratio by the integrated use of organic and inorganic fertilizers.


REVIEW OF
LITERATURE

REVIEW OF LITERATURE

One of the characteristics of high yield technology is the addition of heavy dose of fertilisers. Though several workers have studied the role of nutrition on other varieties of banana, informations on the nutritional aspects of 'Nendran' banana to maximise its yield is very much limited. The present investigation has been planned with main thrust on the integrated use of organic and inorganic manures. The important literature covering various aspects is briefly reviewed in this chapter.

Effect of nutrition of growth characters

2.1.1. Effect of nutrition on plant height and girth

Melin (1970) reported that a combination of KCl 2 kg plant^{-1} and N C 250 g plant^{-1} recorded marked increase in growth.

Herath *et al.* (1977) found that application of 3.3 tons of cattle manure acre^{-1} every 4 months or 6 gallons of cattle shed waste / mat every two weeks increased the height and girth of fruiting in ratoon banana.

In studies with cv. Giant Governor using various combinations and seperate nutrient levels of 0, 120 and 240 g N plant^{-1}, 0, 45 and 90g P plant^{-1} and 0, 240 and 480 g K plant^{-1}, Chattopadhyay and Bose (1986) reported significant increase in plant height and girth. Similar increase in plant height was reported by Lahav *et al.* (1981) with N (as urea) at 50 mg/litre.

Anjorin and Obigbesan (1984) found that the beneficial effect of N on early growth and development was evident only when moisture was not a limiting factor. Application of N upto 300 g plant^{-1} significantly increased plant height, pseudostem girth, pseudostem weight, leaf weight, while higher N rates (400 g N plant^{-1}) depressed all these parameters.

Obiefuna (1984a) found that delayed fertilizer application to plantains from first to six months after planting resulted in retarded growth (height and girth). Recovery from fertilizer stress was faster after earlier fertilizer application upto three months.

Sharma (1984) reported increased plant height and pseudostem girth using N at 250-500 g plant^{-1} as split dose or half as soil application and other half as foliar spray.

Baruah and Mohan (1985) observed that height and diameter of the pseudostem responded significantly to K with the highest effect at 250 g.

The cultivar used for the trial was Cavendish sub group 'Jahaji' and it was supplied with 130 g N and 13 g P plant^{-1}.

Reynolds and Langenegger (1985) concluded from trials on the response of Dwarf Cavendish bananas to limestone ammonium nitrate (LAN) applied at 0-800 g mat^{-1} year^{-1} that growth rate of plants receiving no LAN was much slower.

Shaikh *et al.* (1985) observed that NPK rates for optimising growth and yield is found to be 786 : 393 : 786 kg ha^{-1}.

In a study on the effect of different levels of potassium on banana (var. Robusta) under rainfed conditions at Chethalli, India, Mustaffa (1987) observed that application of Muriate of potash at 400 g K_2O plant^{-1} significantly increased height and circumference of the pseudostem.

Oubahou *et al.* (1987) observed increased plant height and pseudostem circumference when banana plants cv. Grand Naine (Giant Cavendish) were supplied with N at 225-425 g plant^{-1} and K_2O at 350-550 g plant^{-1}. There was positive correlation between K and the productivity index (Pseudostem circumference) and yield components (number of hands and number of fingers).

Sharma and Yadav (1987) concluded from trails that the best manurial practice for banana is to apply full organic manure and two split doses of chemical fertilizers by dibbling near the base of young suckers.

Dave *et al.* (1990) reported that application of 180 : 180 : 180 g of fertilizer plant^{-1} is recommended for banana in South Gujarath.

Hazarika and Mohan (1991) conducted trials with different levels of N (as urea) ranging from 0-200 g plant^{-1} applied in two equal split doses with a uniform dose of 40 g P_2O_5 + 300 g K_2O plant^{-1}. Highest plant height (164.11 cm) and pseudostem girth (64.47 cm) were obtained with 200 g N plant^{-1} applied in 3 equal split doses.

Bhargava *et al.* (1992) reported increased growth in banana plantation in red soils of Karnataka by potassium application at the rates of 0.2, 0.4 and 0.8 kg K_2O plant^{-1}.

Singh and Kashyap (1992) reported highest yield and pseudostem circumference with 400 g N plant^{-1}.

2.1.2. Effect of nutrition on leaf characters

Low rate of leaf production was noticed by Butler (1960) in bananas with reduction in levels of nitrogen. This was further proved by Battikah and Khalidy (1962). Arunachalam (1972) and Shanmugham and Velayudham (1972).

Lahav (1973) observed significant reduction in leaf size, longevity and leaf area with potassium starvation while Lacoevilhe (1973) clearly

indicated the influence of K application on the number of functional leaves.

Jambulingam *et al.* (1975) reported that in Robusta banana higher rates of K_2O significantly increased leaf area.

Kohli *et al.* (1985) reported significant increase in leaf area and leaf area index by N application from trials conducted in robusta bananas with 0, 150, 300, 450 and 750 g N plant^{-1} in 4 split doses and 50 g P_2O_5 and 250 g K_2O plant^{-1}.

Baruah and Mohan (1985) reported that number of leaves plant^{-1} increased with increasing K application.

In a study on the effect of different levels of potassium on banana (var. Robusta) under rainfed conditions at Chethalli, India Mustaffa (1987) observed that application of Muriate of potash at 400 g K_2O plant^{-1} significantly increased number of leaves and leaf area.

2.1.3. Effect of nutrition on flower initiation, flowering and crop duration

Reduction in cropping period with application of nitrogen was first reported by Croucher and Mitchell (1940). Earliness in flowering by two months was observed due to the effect of nitrogen. Shooting was hastened upto 20 per cent by nitrogen. The same was later confirmed by Stein Hausen (1957).

Martin Prevel (1966) observed earliness of the crop (Dwarf cavendish) due to N supply. Simmonds (1966) also reported that application of N hastened the shooting.

Singh *et al.* (1977) observed that higher levels of N, P and K (150g N, 90g P_2O_5, 170 g K_2O $plant^{-1}$ $year^{-1}$). Significantly shortened the time taken for flowering.

Nambiar *et al.* (1979) found that abundant supply of nitrogen at fifth month was found to be beneficial since the flower initiation in Nendran coincided with this month. The levels of nutrients tried were 225, 225 and 450 g of N, P_2O_5, and K_2O respectively $plant^{-1}$ $year^{-1}$. In rainfed 'palayamkodan' the duration of the crop was significantly increased by nitrogen (Valsamma Mathew, 1980).

Lahav *et al.* (1981) found that the flowering date could be advanced by applying a combination of KNO_3 + organic manure.

Obiefuna (1984b) observed that optimal dose of 300 g K $plant^{-1}$ reduced the time of harvest from planting by more than three months. High yield of plantains associated with heavy K application 2-3 months after planting could be achieved by timely application of smaller quantities of potassium at the 19/20th leaf stages when it is required most for floral initiation.

Sharma (1984) reported earlier flowering in trials with the cv. Basrai using N at 250-500 g plant^{-1} in a split dose or half the rate to the soil and the other half as a foliar spray.

Kohli *et al.* (1985) reported from trials in Robusta banana that plants receiving no N required highest number of days to reach flowering (378 days) while N fertilized plants required only 315 to 329 days to flower.

Anjorin and Obigbesan (1987) reported that N, P, K at 200, 66 and 166 g shoot^{-1} respectively reduced the number of days to flowering. Insufficient K led to lodging and delayed flowering Obiefuna and Onyele (1987).

Sharma and Yadav (1987) stated that to minimise wastage by nitrification and leaching, nitrogen should be applied in small doses at frequent intervals. Split dose of phosphate and potash has also been recommended. Trials have shown that the best practice is to apply full organic manure and two split doses of chemical fertilizers by dibbling near the base of young suckers.

Hemong *et al.* (1995) observed that supplying plantains with 18 tonnes of poultry manure ha^{-1} with or without a standard inorganic NPK fertilizer significantly reduced the number of days to 50 per cent flowering compared to unfertilized controls and plants supplied with inorganic NPK only.

2.1.4. Effect of nutrition on sucker production and sucker growth

Arunachalam (1972) found enhanced sucker production in all the varieties with 170 g N plant^{-1} with a reduction in cropping period.

Kohli *et al.* (1984) observed that suckering was reduced by low levels of nitrogen.

Baruah and Mohan (1985) in a trial on the effect of potassium on banana supplied with N at 130 g plant^{-1}, P at 13 g plant^{-1} and K at five levels found that the number of suckers produced by each plant was highest when K was at 330 g plant^{-1} and lowest at zero K.

2.1.5. Effect of Nutrition on Foliar Nutrient status

Hewitt (1955) estimated NPK concentration of 3rd, 5th and 7th leaf and suggested the 3rd leaf as standard sampling. He found that 2.6 per cent N, 0.45 per cent P_2O_5 and 3.3 per cent K_2O were the critical concentrations and that no increase in yield could be obtained by additional application of P_2O_5 and K_2O over and above their critical levels.

Hewitt and Osborne (1962) working in lacatan variety of banana observed that for securing high yields the leaf tissue should have 2.6 per cent nitrogen, 0.40 per cent P_2O_5 and 4.0 per cent K_2O respectively.

Fernandez and Garcia (1972) reported that N content of the first leaf was negatively correlated with girth at the floral emergence stage.

Lahav *et al.* (1978) reported that combined application of 24-0-24 NPK fertilizer was associated with a higher plant content of N, Ca, Mg, Mn and B whereas KNO_3 alone increased the K content. Organic manure had less influence on mineral content than the inorganic fertilizer tested.

Bhavani Sanker (1980) reported a critical leaf concentration in Nendran banana as 2.26 to 3.39 per cent N, 0.23 to 0.43 per cent P_2O_5, 3.18 to 3.47 per cent K_2O, 0.94 to 1.35 per cent Ca and 0.43 to 0.80 per cent Mg at shooting stage.

Kohli *et al.* (1984) observed a significant correlation between yield and leaf nitrogen at 16th leaf stage.

Kotur and Mustaffa (1984) reported that increasing the N rates significantly augmented leaf N and P contents but decreased K with no appreciable effect on Ca and Mg. A rate of 210.67 g N $plant^{-1}$ corresponding to 3.51 per cent leaf N produced the highest yield of 44.8 t ha^{-1}.

Fernandez and Fox (1985) concluded that K level in the leaf of less than 3.2 per cent and N level in the leaf of less than 2.6 per cent limited yields in banana.

Langenegger and Smith (1988) reported that highest yield corresponded to leaf lamina N concentration of 2.5-3.0 per cent.

Dave *et al.* (1990) found that the leaf content of N, P and K were closely related to the fruit yield, indicating that the fruit yield can be increased by increasing the nutrient use efficiency of the plant. Application of 180:180:180 N, P_2O_5 and K_2O were recommended for the banana crop in South Gujarath.

Gubbuk *et al.* (1991) in a trial using nitrogen at 0, 80, 160 or 320 gram per mat and FYM at 0, 75, 150 or 225 kg/mat in various combinations found that increasing rate of N reduced the foliar concentrations of N and K. Increasing FYM rates significantly increased the foliar K, Ca and Zn. In both cultivars Cavendish and Basrai used in the experiments, foliar N was highest with 225 kg mat^{-1}.

Miao *et al.* (1993) reported that application of K influenced the leaf contents of certain elements. The content of K, Mn and Zn on leaves were increased as K rates were increased whereas those of N, Fe, Ca and Mg were reduced.

EFFECT OF NUTRITION ON YIELD CHARACTERS OF BANANA

2.2.1. Effect of nutrition on bunch size, weight and yield of banana

Optimum fertilizer supply is essential to increase yield by increasing bunch weight and to improve the production of marketable

fruits. Croucher and Mitchell (1940) in a fertilizer experiment conducted in Jamaica with 'Gros Michel' banana found significant response to N. They have recorded increased plant growth and yield in certain areas by the application of P_2O_5 and K_2O along with N.

Steinhausen (1957) found that N promoted vegetative growth, increased the length of the bunch and number of hands.

Champion *et al.* (1958) reported that the yields of Robusta could be increased from 18-25 tonnes per hectare due to application of N at the rate of 100-200 kg ha^{-1} during the vegetative phase.

According to Srivastava (1981) heavier bunches was obtained in banana by using a mixture of 0.68 kg ammonium sulphate, 13.66 kg farm yard manure and 1.59 kg castor cake.

Wood (1939) recorded an increase in yield in banana by the application of farm yard manure and potash.

According to Twyford (1967) the amount of potash was always highest among the nutrients analysed. The potash content was 2.2 to 4.6 times higher than nitrogen content and critical manuring could be done on 4:1:14 ratio of N, P and K.

Bhan (1967) reported that under Indian conditions P and K have not produced any appreciable response in yield. In Maharashtra, N, K

and Farm Yard Manure failed to influence the production while P alone increased the yield.

Teotia *et al.* (1972) stated that 600 g super phosphate combined with 300 g ammonium sulphate and 300 g potassium sulphate plant^{-1} gave the highest yield in Cavendish banana.

Veeraraghavan (1972) reported highest yield both in number of fruits and weight by application of 228 g P_2O_5 in Nendran.

Shanmugham and Velayudham (1972) reviewed the fertilizer recommendations of banana in different states of India and found that a dose of 225 g each of N and K plant^{-1} year^{-1} was the best recommendation for Kerala soils. The amount of N, P_2O_5 and K_2O recommended for irrigated 'Nendran' banana in Kerala are 190:115:300 g plant^{-1} respectively and for rainfed palayankodan it is 100:200:400 g plant^{-1} of N, P_2O_5 and K_2O, for other varieties in general 160 g each of N, P_2O_5 and 320 g of K_2O are recommended to be applied plant^{-1} (KAU, 1996).

Ramaswamy and Muthukrishnan (1974) found highest response in terms of number of hands and fruits, weight of the hand and fruit with N at 170 g plant^{-1} . Studies by Pillai *et al.* (1977) at BRS Kannara indicated that Nendran banana required 191 g N and 301 g P_2O_5 and 300 g K_2O respectively for maximum yields.

Herath *et al.* (1977) found that application of 3.3 tons of cattle manure per acre every 4 months or 6 gallons of cattle shed waste mat^{-1}

every 2 weeks increased yields of banana cv. Embul from 6.287 t/acre in untreated controls to 6.563 and 6.442 t $acre^{-1}$ respectively. Both treatments increased the number of fruits $bunch^{-1}$.

Gopimony *et al.* (1979) found that in 'Zanzibar' variety of Nendran on additional dose of 500 g urea in five equal split doses of 100 g each at one week interval during the fifth month of planting resulted in an increase in bunch weight and number of fingers $bunch^{-1}$.

Manica *et al.* (1978) found that P at 300 g $plant^{-1}$ gave the best results with regard to bunch weight, number of hands and number of fingers $bunch^{-1}$.

Nambiar *et al.* (1979) reported that application of N and P_2O_5 each at 225 g $plant^{-1}$ and K_2O at 450 g $plant^{-1}$ in two split doses during 30th and 150th days after planting increased the bunch weight in Nendran.

Singh *et al.* (1979) in a trial with Basrai banana found that 150 g N $plant^{-1}$ gave the higher yields with better fruit quality.

Chattopadhyaya *et al.* (1980) found that in Giant Governer banana the yield rose to 31200 and 30880 kg ha^{-1} for the plant and ratoon crop respectively by increasing nitrogen dose upto 240 g $plant^{-1}$ annually.

Hernandez *et al.* (1981) found that N increased yield, hands and fruit number from an experiment on banana var. Giant Cavendish supplied with N at 0-300 g $plant^{-1}$ $year^{-1}$.

Nanjan *et al.* (1981) recommended a dose of 100 g N plant^{-1} for the cultivar Robusta under Periyar river command area in Tamil Nadu.

Pillai and Khader (1981) reported that 100 kg N ha combination with 40 kg P_2O_5 and 400 kg K_2O ha^{-1} produced the heaviest bunches (about 26 kg bunch^{-1}) in Robusta.

Mustaffa (1983) reported that 150 g N plant^{-1} applied to Hill bananas gave the highest yield.

Kohli *et al.* (1985) observed that dry matter production was greatest in response to 150-300 g N plant^{-1} which also resulted in the highest yield.

The most economical application for banana, cultivars : cavendish and Williams was 240 g calcium ammonium nitrate above which there was little response in a trial conducted by Langenegger (1984) cv. Williams gave higher yield ha^{-1} at this rate (37.3 t ha^{-1} compared with 33.7 t ha^{-1} for cavendish) but had slightly fewer hands bunch^{-1} and finger numbers in the third hand.

Kohli *et al.* (1985) reported highest yield in robusta banana supplied with 150 g N plant^{-1}. The trial was conducted using 0, 150, 300, 450, 600 or 750 g N plant^{-1} in 4 split doses and 50 g P_2O_5 and 250 g K_2O plant^{-1}.

Shaikh *et al.* (1985) reported that optimum NPK rates with regard to plant growth and yield were 786:393:786 kg ha^{-1} for banana.

Dagade (1986) recommended fertilizer rates for bananas as 100 g N, 40 g P_2O_5 and 100 g K_2O $plant^{-1}$.

Baghel *et al.* (1987) observed that number of hands $bunch^{-1}$ and number of fingers $bunch^{-1}$ were influenced by N level (100-400 g $plant^{-1}$) and the highest values were obtained with 400 g N $plant^{-1}$.

Mustaffa (1987) in a trial on Robusta under rainfed conditions observed highest fruit yield of 45.4 t ha^{-1} with 300 g K_2O $plant^{-1}$, 35% higher than in no potash treatment.

Obiefuna and Onyele (1987) reported annual application of 200 g N and 500 g K produced heaviest bunch weights and was the most economic.

Obiefuna *et al.* (1987) reported N, K treatments of 375-500 and 400-500 g $plant^{-1}$ were superior with bunch yields of 9.4 and 11.2 kg respectively in an experiment in banana plants cv. Grand Naine.

In studies conducted by Geetha (1988) in Nendran banana grown in rice fallows a linear increase in yield was obtained upto 400 g N and 600 g K_2O $plant^{-1}$.

Gomes *et al.* (1988) reported from trials that highest average bunch weight was obtained from plots receiving Farm Yard Manure + NPK.

Nair *et al.* (1990) obtained the highest yield by the application of N and K in six splits at the rate 400 g N and 600 g K_2O plant^{-1} in Nendran grown in rice fallows.

Hazarika and Mohan (1991) reported that yield attributing characters and yield increased with increasing N application upto 160 g plant^{-1} in a trial using banana cv. Jahaji (Musa AAA group, Cavendish sub group) highest number of fingers bunch^{-1} (127.83), bunch weight (20.94 kg plant^{-1}) and yield (64.47 t ha^{-1}) were obtained with 160 g N plant^{-1} applied in 3 equal split doses.

Pandit *et al.* (1992) reported from a fertilzer trial using Dwarf Cavendish banana that highest yield (35.0 tonnes ha^{-1}) and number of hands bunch^{-1} were achieved by applying 400 g ammonium sulphate + 300 g single super phosphate + 250 g Muriate of potash stool^{-1}.

Natesh *et al.* (1993) in a trial a split application of fertilizers in banana Musa AAB, 'Nendran' indicated that recommended dose of fertilizers viz., 190:115:300 K_2O g plant^{-1} year^{-1} when applied in four splits had favourable effect on yield than when the same dose was applied in two splits.

Hemong *et al.* (1995) observed higher yield (10.2 t ha^{-1}) compared with 7.2 t ha^{-1} in unfertilized controls in trial with 18.0 t poultry manure only treatment.

2.2.2. Effect of Nutrition on fruit characters

According to Srivastava (1961) larger fingers was obtained in banana by using a mixture of 1.5 lb ammonium sulphate, 30 lb farm yard manure and 3.5 lb caster cake.

Leigh (1969) reported that increasing supplies of potassium increased finger weights, rind thickness, finger length and circumference. Application of 204 kg K_2O $acre^{-1}$ $annum^{-1}$ in three of four splits was recommended.

According to Veeraraghavan (1972) significant increase in the number and weight of fruits in 'Nendran' bananas was obtained with 228 g N, 228 g P_2O_5 and 456 g K_2O $plant^{-1}$ $year^{-1}$.

Ramaswamy and Muthukrishnan (1974b) got the highest response in terms of weight of hands and fruits with 170 g N $plant^{-1}$.

Number of hands $bunch^{-1}$, bunch weight, fruit size and volume increased upto 60 g P_2O_5 $plant^{-1}$ according to Ramaswamy (1976).

Hernandez *et al.* (1981) found that N had no effect on fruit length, diameter and weight from an experiment on banana var. Giant Cavendish supplied with N at 0-300 g $plant^{-1}$ $year^{-1}$ with P and K at 50 and 300 g $plant^{-1}$ $year^{-1}$ as P_2O_5 and K_2O respectively.

Obiefuna (1984b) in a trial using six levels of K (100-600 g K $plant^{-1}$ as muriate of potash, zero K-control) found that an optimal dose

and total sugar content also increased with increasing doses of K_2O. While acidity was reduced, sugar / acid ratio increased, ascorbic acid content also increased with higher levels of potash (Vadivel and Shanmugavelu, 1978).

Singh *et al.* (1974) studied the effect of nutrients on fruit quality of Robusta banana and reported an appreciable improvement in fruit qualities with different potassium combinations.

Chattopadhyay *et al.* (1980) reported from studies in cv. Giant governor that total sugar content in fruits varied in particular, with deficient N and K levels. Acidity of fruits showed a reduction with an increased in K level.

Mustaffa (1983) found from a spacing cum manurial that close spacing hastened maturity and improved fruit quality, but high N reversed this trend. The optimal rate was found to be 150 g N $plant^{-1}$.

Acidity of fruits decreased with increasing levels of potassium (Chattopadhyay and Bose, 1986).

Mustaffa (1987) reported that potassium improved the quality of the fruit by raising the total soluble solids (Brix) and ascorbic acid content and reduced the acidity.

Ram and Prasad (1988) reported maximum Tss (21.21%) with N : P_2O_5 : K_2O at 200 : 80 : 200 g while total sugar was highest (17.3%) with 300 : 120 : 100 g in a trial conducted on effect on N, P and K on fruit quality of banana cv. Campiergang Local (Musa AAB).

Hegde and Srinivas (1991) reported that increasing levels of potassium increased TSS but decreased pulp/peel ratio.

Sheela (1982) also obtained beneficial effects on TSS, reducing sugar, total sugars, sugar / acid ratio and acidity with higher doses of potash.

Pandit *et al.* (1992) reported highest total sugar content and lowest acidity in Dwarf Cavendish banana by applying 400 g ammonium sulphate + 300 g single super phosphate + 250 g Muriate of potash $stool^{-1}$.

2.2.4. Benefit cost ratio

According to Jagirdar and Ansari (1966) in 'Basrai' variety of banana receiving 96 lb/acre of K_2SO_4 alone gave the highest yield in terms of bunch weight, number of fingers per unit area and highest monetary returns per lb of fertilizer applied.

Ramanathan *et al.* (1973) found that 55 g N $plant^{-1}$ as ammonium chloride or ammonium sulphate was sufficient to get profitable yield to Poovan.

Sharma and Roy (1973) found that 320 kg P_2O_5 ha^{-1} gave the greatest profit when applied in combination with 600 kg N and 320 kg K_2O.

Chundawat *et al.* (1983) in a four season trial with cv. Basrai using N derived from 8 different sources found that urea + castor cake 1:1 was the most economical. This treatment gave an average yield of 50.5 t ha^{-1} and a gross income of Rs. 27,797 ha^{-1} compared with the lowest income of Rs. 23,058 ha^{-1} after treatment with ammonium sulphate.

Langenegger (1984) found that 240 g calcium ammonium nitrate $plant^{-1}$ was the most economical application for cavendish, William cultivars.

Bellie (1987) found that a fertilizer dose of 150 g N, 90 g P_2O_5 and 300 g K_2O $plant^{-1}$ in three split during third, fifth and seventh month increased the net income per hectare from Nendran banana.

Effect of growth regulators on yield, fruit characters and quality

Tomi *et al.* (1970) reported pulp percentage and soluble solid content at both room temperature and 55°F increased with storage duration and were highest with fruits sprayed with 2,4-D at 10 ppm during flowering.

Lockaed (1975) reported that Ethrel sharply reduced stem growth and also decreased yield. These adverse effects are largely ascribed to

high concentration used (500 and 1000 ppm) ABA and Alar inhibited growth slightly and increased yields.

Venkatarayappa *et al.* (1976) reported that tying urea at the rachis promoted the yield of bunch and hand because of availability of urea in aqueous form at later stages and for prolonged period.

Sampaio *et al.* (1977) found no effect when GA at 50-200 ppm was applied at inflorescence emergence, when the bunch development was completed and again 30 days later on the number of hands $bunch^{-1}$, the number of fruits per hand or on the length of fruits.

Annadurai and Shamungavelu (1978) in a trial with Ethrel at 250 or 500 ppm to three month old banana found retarded growth, delayed flowering and bunch weight was reduced by 51.8 per cent. bunch weight was greatest after treatment with ccc at 2000 ppm.

Deshmukh and Chakrawar (1980) reported ancymidel at 200 ppm, 2,45-T at 100 ppm or Racua at 100 ppm gave the best results with regard to advancing by 8-14 days and increasing the average weight and size of bunch and weight of fingers.

Mishra *et al.* (1981) reported that Giberellic acid increased the weight and volume of fingers in both young and old bunches, with the young bunches responding better.

Kohli and Reddy (1983) obtained best results for ripening, colour change, pulp structure and chemical composition with ethephon at 1000

ppm in a trial in which robusta hands each with 12 fingers, were dipped in Ethrel (Ethephon) at 200-250 ppm for 2 minutes.

Lahav and Gottreich (1984) reported ethephon can give an acceleration of ripening with a dose of 500 to 1000 ppm.

Parmar and Chundawat (1984) found that spraying with GA (100 ppm) NAA (100 ppm) or 1 per cent mineral oil increased the yield as did sleeving with blue polythene. Spraying with ethephon (250 ppm) and sleeving hastened fruit ripening whereas treatment with GA, NAA, Kinetin (20 ppm), mineral oil at 0.5 per ent delayed it. Sleeving gave the best fruiting quality, followed by treatment with GA.

Tadros *et al.* (1984) found from trials with cv. Hindy, GA_3 at 10-50 ppm increased finger weight and size and bunch weight but delayed maturity. GA_3 had little effect on pulp peel ratio and TSS.

Chattopadhyay and Jana (1985) reported that NAA at 100 ppm applied at either five months and seven months after planting gave the highest yield 42.7 t ha^{-1} with 36.2 t ha^{-1} in the control and 23.2 t ha^{-1} from plants treated with ethephon. Ethrel at 100-400 ppm, cycocel at 500-1500 ppm or NAA at 25-100 ppm had no marked effect on fruit quality.

Satyanarayana (1985) reported that 2,4-D at 25 ppm and GA_3 at 2000 ppm significantly improved fruit size and weight, bunch weight and

Tss. 2,4-D at 50 ppm had negative effects. In summer experiments GA_3, even at 1000 ppm, improved yields but 2,4-D at 25 ppm had adverse effects.

Burgohain and Shanmugavelu (1986) reported that a 23 per cent bunch weight increase resulted from attaching 10 gms of urea in polythene bag to the cut stalk immediately below the banana bunch two days after the male bud was removed in banana variety Vayal Vazha (ABB).

MATERIALS AND METHODS

MATERIALS AND METHODS

This investigation carried out at the Instructional farm attached to the College of Agriculture, Vellayani envisages the possibility of maximising the yield of banana, *Musa* (AAB group) 'Nendran' through an integrated use of organic and inorganic manures. The materials used and the methods adopted for study are briefly described below.

3.1. Experimental site

The experiment was conducted at the Instructional farm, College of Agriculture, Vellayani, located at 8.5° N latitude and 76.9° E longitude at an altitude of 26 m above mean sea level.

3.2. Soil

The soil of the experimental area was sandy clay loam. The data on physico-chemical properties of the soil are given below. Soil samples were collected from the site before the start of the experiment air-dried in shade, gently powdered with a wooden plank and passed through 2 mm sieve.

A. Mechanical composition

Sl. No.	Parameters	Content in Soil (%)	Method used
1.	Coarse sand	56.50	International pipette method (Gupta and Dakshinamoorthy, 1980)
2.	Fine sand	16.10	
3.	Silt	20.35	
4.	Clay	5.80	
5.	Soil type	Loamy sand	

B. Chemical composition

Sl. No.	Parameters	Content kg ha^{-1}	Rating	Method used
1.	Available N	177.8	Low	Alkaline potassium permanganate method (Subbiah & Asija, 1956)
2.	Available P_2O_5	40.0	Medium	Bray colorimetric method (Jackson, 1973)
3.	Available K_2O	125.0	Low	Ammonium acetate method (Jackson, 1973)
4.	pH	5.8	Acidic	1:2.5 soil solution ratio using pH meter (Jackson, 1973)

3.3. Climate

The experiment was conducted during the period from January 1995 to November 1995. The data on various weather parameters (Monthly rainfall, maximum temperature, minimum temperature and relative humidity) during the cropping period are presented in Appendix 1.

3.4. Seed material

Healthy seed materials were collected from farmer's field in Neyyattinkara and Nagercoil. The variety selected was 'Nendran' coming under the subgroup 'plantain' with 'AAB' genome.

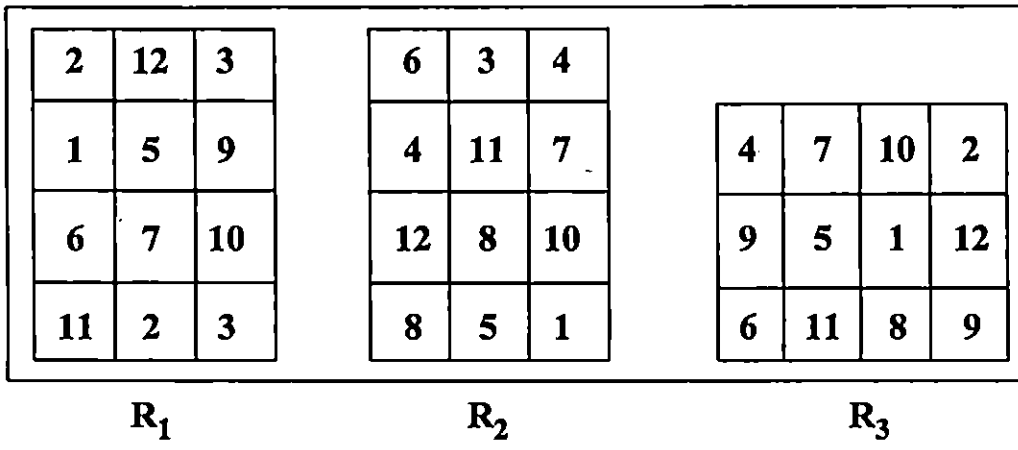
3.5. Field preparation and planting

Land was ploughed twice, weeds were removed, clods broken and levelled. Pits were taken as per lay out plan. Suckers of uniform weight and age were selected and dipped in cow dung slurry and treated with 0.2 per cent BHC and dried in sun for three days and stored in shade for 15 days before planting.

3.6. Experimental design and lay out

Lay out plan of the experiment is presented in the next page.

LAY OUT PLAN



Treatments

(A) Levels of organic manures

M_1 - FYM 10 kg plant^{-1}

M_2 - PM 5 kg plant^{-1}

M_3 - NC 5 kg plant^{-1}

M_4 - VC 5 kg plant^{-1}

(B) Post shoot application

P_1 - 2,4-D 10 ppm spray

P_2 - Urea one per cent spray

P_3 - Tying urea 15 g

Treatment combinations

T_1 - M_1P_1 - 10 kg FYM + RF + 2,4-D 10 ppm spray

T_2 - M_1P_2 - 10 kg FYM + RF + urea 1% Spray.

T_3 - M_1P_3 - 10 kg FYM + RF + Tying urea 15 g.

T_4 - M_2P_1 - 5 kg PM + RF + 2, 4D 10 ppm spray.

T_5 - M_2P_2 - 5 kg PM + RF + urea 1% spray.

T_6 - M_2P_3 - 5 kg PM + RF + Tying urea 15 g.

T_7 - M_3P_1 - 5 kg NC + RF + 2, 4D 10 ppm spray.

T_8 - M_3P_2 - 5 kg NC + RF + urea 1% spray.

T_9 - M_3P_3 - 5 kg NC + RF + Tying urea 15 g.

T_{10} - M_4P_1 - 5 kg VC + RF + 2,4-D 10 ppm spray.

T_{11} - M_4P_2 - 5 kg VC + RF + urea 1% spray.

T_{12} - M_4P_3 - 5 kg VC + RF + Tying urea 15 g.

Design : Factoral RBD

No. of replication : 3

RF - Recommended KAU Package of Practices inorganic fertilizer recommendation for banana variety - Nendran (190 : 115 : 300 g plant^{-1}) NPK

PM - Poultry Manure NC - Neem Cake VC - Vermi Compost

Total number of treatments : 12.

Spacing : 2 x 2 m.

Variety : *Musa* (AAB group) 'Nendran'.

Plot size : 8 x 8 m.

Number of plants per plot : 16.

3.7. Fertilizer application

The levels of N, P and K were supplied through nitrogen in 6 splits first as basal (40g plant^{-1}) and then one, two, four, five and six months after planting at 30 g plant^{-1}. Phosphorus was applied in two splits, first as basal (65 g plant^{-1}) and the second (50 g plant^{-1}), one month after planting. Potassium was applied in five equal splits (60 g plant^{-1}), first as basal and then one, two, four and five months after planting. Urea (46 per cent N), Mussoorie 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.

3.8. Organic manure application

Organic manure viz., FYM at the rate of 10 kg plant^{-1}, poultry manure at the rate of 5 kg plant^{-1}, vermicompost at the rate of 5 kg plant^{-1} and neem cake at the rate of 5 kg plant^{-1} were applied as basal as per the treatments.

3.9. Post shooting application

After the emergence of flower the whole bunch was sprayed with 2,4-D 10 ppm, urea 1 per cent spray and the peduncle is tied with 15 g urea after the removing the male flowers as per the treatments.

3.10. Maintenance of the crop

During the dry period, life irrigation was given to the plant once in three days with 40 litres of water per plant. Periodic desuckering were done throughout the cropping period.

3.11. Plant protection measures

The major pest observed in the field was leaf eating caterpillar, *Spodoptera* sp. which was effectively controlled by spraying 0.1 per cent Malathion (50 per cent EC) during first week of February and March.

After 5-6 months, the lower leaves were cut and removed as a prophylatic measure to prevent the incidence of sigatoka disease. One per cent Bordeaux mixture was sprayed on first week of May controlling the disease.

Kokkan infested plants were cut and removed and suckers were crushed and buried away from the experimental site.

Harvest of bunch was done at the mature stage. The maturity was judged by visual observation.

3.12. Biometric characters

3.12.1. Height of the plant

Height of the plant was measured from the base of the stem at the soil level to the axil of the youngest leaf at fifth month and at flowering.

3.12.2. Girth

Girth of the pseudostem at 20 cm height above the soil were measured using a flexible measuring tape at fifth month, at flowering and at harvest.

3.12.3. Functional leaf area (m^2)

The leaf area was calculated using the equation developed by Murray (1960).

$$LA = L \times W \times 0.8$$

LA = Leaf Area per leaf.

L = Length of lamina.

W = Width of lamina

The length of lamina was measured from the base of the leaf to the tip and width at the broadest part of the lamina. The sum of the area of all the functional leaves in a plant was then computed at different growth stages and taken as total leaf area.

3.12.4. Leaf area duration

The leaf area duration (LAD) was computed from the formula proposed by Turner (1980).

LAD = Time from shooting to harvest x Leaf area of last 3 leaves.

3.12.5. Crop duration

a. From planting to shooting

Number of days taken from planting to shooting was recorded.

b. From shooting to harvest

Number of days taken to harvest after emergence of bunch was recorded.

3.13. Foliar nutrient status

The third leaf from apex was cut and the middle lamina was collected at harvest stage for analysis of nitrogen, phosphorus and potassium.

Nitrogen was estimated by modified microkjeldahl method (Jackson, 1973). Phosphorus content was estimated colorimetrically after wet digestion of the sample using 2:1 mixture of nitric acid and perchloric acid by vanadomolybo phosphoric yellow colour method and read in a Baush and Lomb spectronic 20 spectrometer (Jackson, 1973).

Total potash content of the plant was estimated by using the flame photometer method (Jackson, 1973).

3.14. Bunch characters

3.14.1. Bunch weight

The mean weight of bunch of four observational plants after harvest was recorded in kilogram.

3.14.2. Number of hands per bunch

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

3.14.3. Number of fingers per bunch

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

3.14.4. Number of fingers in second hand

The number of fingers in the second hand was recorded.

3.14.5. Length of bunch (cm)

Length of the bunch was measured from the point of attachment of first hand to that of the last hand of the observational plants and mean values recorded.

3.14.6. Fruit characters (Mature)

The middle finger in the top row of the second hand designated by Gottriech *et al.* (1964) was taken as the index finger for studying the fruit characters.

Weight of the index finger was taken as the mean finger weight. Length and girth were measured using fine thread and scale. Length was measured from the tip of the finger to the point of attachment of the peduncle and girth of the finger was recorded at the middle portion.

3.14.6.1. Weight of finger

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

3.14.6.2. Length and girth of fruit

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

3.14.7. Volume of finger

Volume of finger was estimated by water displacement method and expressed in cm^3.

3.14.8. Dry weight of pulp and peel

The dry weight of pulp, peel were recorded and expressed in grams.

3.15. Fruit characters (Ripe)

3.15.1. Weight of finger, pulp and peel

The weight of finger, weight of pulp and weight of peel of the fully ripened sample fruits were recorded and expressed in grams.

3.15.2. Pulp / Peel ratio

The rate of the peel and pulp of ripe fruits were taken seperately and the ratio worked out.

3.16. Sensory evaluation

Rank means for the taste and texture of fruits were recorded.

3.17. Quality of fruits

The fully ripe index fingers collected from bunches of different treatments were used for quality analysis. Known weight of samples taken from three portions (top, middle and bottom) of sample fruit were macerated in a blender and made up to a known volume. Aliquots taken from this were used for the analysis of the following characters of the fruit.

3.17.1. Total soluble solids (TSS)

This was represented in per cent and measured by using a pocket refractometer.

3.17.2. Acidity

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

3.17.3. Total sugars

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

described by Ranganna (1977) on fresh weight basis. Samples consisted of 25 g of fresh fruit material made upto 250 ml with distilled water.

3.17.5. Non-reducing sugars

Non-reducing sugar content was computed using the following formula.

Non-reducing sugars = Total sugars – Reducing sugars (Ranganna, 1977).

3.17.6. Ascorbic acid

Ascorbic acid was estimated as per the method suggested by Ranganna (1977). A sample of 25 g of fresh fruit made up to 250 ml with 3% oxalic acid was used for estimation.

3.17.7. Starch

A known weight of sample was hydrolysed to glucose and estimated by titration with Fehling solution to find out the starch content as per method described by A.O.A.C (1965).

3.17.8. 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.

3.17.9. 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).

3.17.10. Sensory evaluation of ripe fruit

The fruit samples from each treatment plot were evaluated for their organoleptic qualities by selecting five judges. These judges were selected as panel members through the triangle test as suggested by Mahony (1985). The fruit samples were tested for their overall acceptability by the sensory evaluation with due emphasis on the attributes taste and flavour. (Score card is shown in Appendix 3). Scores for overall acceptability was obtained by determining the average mean score for each characters.

3.18. Soil analysis

Soil samples were taken from the experimental area before and after the experiment. The air-dried soil samples were analysed for available N, available P and available K contents.

Available N content was estimated by alkaline potassium permanganate method (Subbiah and Asija, 1956).

Available P content by Bray's colorimetric method (Jackson, 1973) and available K by ammonium acetate method (Jackson, 1973).

3.19. Economics

The economics of production was worked and based on various input cost as per norms and rates of Instructional Farm of the College of Agriculture, Vellayani prevailing at the time of cultivation and benefit cost ratio was worked out as follows.

Net Return Rs. ha^{-1} = Gross income – cost of cultivation.

Benefit / Cost ratio= Gross income / Cost of cultivation.

3.20. Statistical analysis

The data generated through factorial Randomised block Design were subjected to analysis of variance (ANOVA) technique (Panse and Sukhatme, 1967). Sensory evaluation of the ripe fruits of various treatments were analysed statistically using non parametric method of analysis - Kruskal Wallis test (Sidney and John Castellan, 1988).

RESULTS

RESULTS

The experiment was conducted at College of Agriculture, Vellayani. The experimental data was subjected to statistical analysis to bring out the effects of different sources of organic and inorganic nutrients on the growth, yield and quality of banana var. 'Nendran'. The results obtained are presented in this chapter.

4.1. Plant height

The mean data on plant height recorded at different growth stages such as fifth month, at flowering and at harvest are presented in Table 1.

At fifth month the effect of manurial treatments were significant, on the height of plants. The level of poultry manure, at five kg plant^{-1} recorded the maximum height of 308.49 cm at fifth month which was significantly more than the other three levels. At flowering stage, the effect of manures on plant height was significant. The level poultry manure, 5 kg plant^{-1} recorded the maximum height of 321.4 cm and was significantly more than heights recorded under other levels.

Thus it was observed throughout the experimental period the level poultry manure, five kg plant^{-1} was significantly superior to other manurial

Table 1. Effect of treatments on plant height at 5th month, flowering

Treatments	Plant height (cm)	
	Fifth month	Flowering
M_1	291.41	304.97
M_2	308.49	321.40
M_3	287.47	303.64
M_4	272.97	299.36
$F_{3,22}$	4.96**	6.87**
SE ±	6.554	3.689
CD(0.05)	19.225	10.821
P_1	291.03	311.21
P_2	287.21	297.63
P_3	291.81	313.18
$F_{2,22}$	0.19	7.02
SE ±	5.6762	3.1950
CD(0.05)	16.649	9.371
M_1P_1	329.37	335.00
M_1P_2	265.37	274.26
M_1P_3	278.67	305.63
M_2P_1	308.73	323.63
M_2P_2	309.23	324.57
M_2P_3	307.50	316.00
M_3P_1	260.16	292.03
M_3P_2	296.43	302.50
M_3P_3	305.80	316.40
M_4P_1	265.83	294.16
M_4P_2	277.80	289.20
M_4P_3	275.27	314.70
$F_{11,22}$	4.50**	8.80**
SE ±	11.352	6.370
CD(0.05)	33.298	18.743

** Significant at 1% level

treatments. There was no significant effect by different Post shooting application.

The interaction effect of treatments showed significant influence on the plant height during all stages of observation. The treatment farm yard manure 10 kg plant^{-1} and 2,4-D 10 ppm spray showed maximum interaction effect in all three growth stages.

4.2. Girth

The mean data on the girth of plants recorded at the three stages of crop growth namely at fifth month, at flowering and at harvest are presented in Table 2.

Perusal of the data revealed that the effect of four doses of manure on the girth of the plant was not significant in any of the stages. Though not significant, the levels of neem cake, five kg plant^{-1} recorded the maximum girth (57.83cm), while vermicompost, five kg plant^{-1} registered the lowest girth (54.95cm) at harvest.

The post shooting treatments also did not significantly influence plant girth. But urea 1 per cent spray recorded the maximum girth, while 2,4-D 10 ppm spray recorded the lowest girth in all the stages of growth.

Table 2. Effect of treatments on girth at 5th month, flowering and harvest

Treatments	Girth (cm)		
	Fifth month	Flowering	Harvest
M_1	49.26	52.08	55.76
M_2	48.52	53.60	56.51
M_3	50.87	54.62	57.83
M_4	47.33	51.60	54.95
$F_{3,22}$	1.43	1.56	1.02
SE ±	1.237	1.123	1.211
CD(0.05)	3.628	3.294	3.552
P_1	48.72	52.69	55.72
P_2	49.19	53.25	56.56
P_3	49.07	52.93	56.51
$F_{2,22}$	0.05	8.12	0.20
SE ±	1.0711	0.9725	1.0488
CD(0.05)	3.14	2.853	3.076
M_1P_1	49.95	52.68	56.72
M_1P_2	47.86	51.85	54.22
M_1P_3	49.95	51.52	56.36
M_2P_1	48.03	52.02	53.77
M_2P_2	49.62	54.35	57.72
M_2P_3	47.92	54.42	58.05
M_3P_1	49.98	54.38	57.29
M_3P_2	52.01	55.55	59.35
M_3P_3	50.61	53.92	56.84
M_4P_1	46.92	51.68	55.09
M_4P_2	47.25	51.25	54.97
M_4P_3	47.82	51.87	54.78
$F_{11,22}$	0.23	0.24	0.64
SE ±	2.142	1.945	2.098
CD(0.05)	6.284	5.705	6.153

The interaction effects also did not significantly influence plant girth.

4.3. Functional Leaf Area

The effect of treatments on functional leaf area is presented in Table 3.

The manurial treatments had significant effect on functional leaf area during fourth month. Maximum leaf area during fifth month was recorded by vermicompost at the rate of five kg plant^{-1}, while the lowest was farm yard manure at the rate of 10 kg plant^{-1} and it progressively increased from farm yard manure at the rate of 10 kg plant^{-1} upto vermicompost at the rate of five kg plant^{-1}. At harvest stage, maximum leaf area was noticed in farm yard manure at the rate of 10 kg plant^{-1} and lowest at vermicompost at the rate of five kg plant^{-1}. A declining trend from poultry manure at the rate of five kg plant^{-1} upto vermicompost at the rate of five kg plant^{-1} was also observed in functional leaf area.

In the case of post shooting application the treatments did not significantly influence the functional leaf area. The interaction effects were not significant.

4.4. Crop duration

The mean duration in number of days recorded at three stages namely planting to shooting, shooting to harvest and planting to harvest are presented on Table 4.

Table 3. Effect of treatments on functional leaf area and leaf area duration

Treatments	Functional leaf area (m^2 $plant^{-1}$)			Leaf area duration
	Fifth month	Flowering	Harvest	
M_1	4.002	9.271	5.721	212.897
M_2	4.887	9.060	3.826	250.968
M_3	4.989	10.440	3.115	238.438
M_4	5.118	10.275	2.862	183.621
F(3,22)	3.09*	1.88	20.52**	4.05**
SE ±	0.2879	0.5078	0.2853	14.8135
CD(0.05)	0.8445	1.4894	0.8370	43.4490
P_1	4.771	9.589	3.961	242.222
P_2	4.878	9.879	3.653	211.719
P_3	4.599	9.817	4.029	210.502
F	0.32	0.1199	0.66	1.96
SE ±	0.2494	0.4398	0.2471	12.83
CD(0.05)	0.7314	1.2899	0.7248	37.63
M_1P_1	3.602	9.578	6.222	247.733
M_1P_2	4.054	9.188	5.910	172.597
M_1P_3	4.350	9.048	5.030	218.360
M_2P_1	5.288	8.516	3.823	322.070
M_2P_2	4.664	10.498	3.662	191.678
M_2P_3	4.710	8.167	3.994	239.158
M_3P_1	5.080	9.771	3.507	233.477
M_3P_2	5.358	10.343	2.301	270.810
M_3P_3	4.529	11.206	3.538	211.027
M_4P_1	5.112	10.493	2.294	165.607
M_4P_2	5.437	9.485	2.740	211.794
M_4P_3	4.806	10.848	3.553	173.463
F	0.6175	1.11	1.58	3.05
SE ±	0.4988	0.8795	0.4942	25.6577
CD(0.05)	1.4629	2.5797	1.4496	75.2560

* Significant at 5% level ** Significant at 1% level

Table 4. Effect of treatments on crop duration from planting to shooting shooting to harvest and planting to harvest

Treatments	Duration from		
	Planting to shooting (days)	Shooting to harvest (days)	Planting to harvest (days)
M_1	188.44	74.89	263.33
M_2	177.89	88.11	266.00
M_3	182.78	80.67	263.44
M_4	191.33	71.56	262.89
F	1.92	3.16*	0.57
SE ±	4.313	4.082	1.865
CD(0.05)	12.651	11.973	5.470
P_1	180.67	83.42	264.08
P_2	185.17	79.42	264.58
P_3	189.50	73.58	263.08
F	1.3979	1.9567	0.2236
SE ±	3.7354	3.5351	1.6152
CD(0.05)	10.9562	10.3689	4.7375
M_1P_1	175.67	84.33	260.33
M_1P_2	202.67	65.00	267.67
M_1P_3	187.00	75.33	262.33
M_2P_1	166.00	101.67	267.67
M_2P_2	185.00	75.66	260.67
M_2P_3	182.67	87.00	269.67
M_3P_1	185.00	82.33	267.33
M_3P_2	173.67	91.00	264.67
M_3P_3	189.67	68.67	258.44
M_4P_1	196.00	65.33	261.33
M_4P_2	179.33	86.00	265.33
M_4P_3	198.67	63.33	262.00
F	2.333	3.000	1.9617
SE ±	7.4707	7.0702	3.2304
CD(0.05)	21.9124	20.7378	9.4751

* Significant at 5% level

Verification of the data shows that the manurial levels had no significant influence on the duration in the initial stage of planting to shooting and planting to harvest stage, while the duration from shooting to harvest was significantly influenced by manurial levels. Poultry manure, 5 kg plant^{-1} recorded the longest duration of 88.11 days which was superior to neem cake 5 kg plant^{-1} (80.67 days) and vermicompost 5 kg plant^{-1} registered the shortest duration of 71.56 days for the period from shooting to harvest.

The post shooting treatments did not significantly influence the duration of the crop at all the three stages.

The interaction effect on duration of the crop was not significant.

4.5. Leaf Area Duration (Table 3).

The manurial treatments significantly influenced the leaf area duration with poultry manure at the rate of five kg plant^{-1} recording maximum value of 250.96. Neem cake five kg plant^{-1}, vermicompost at the rate of five kg plant^{-1} and farm yard manure at the rate of 10 kg plant^{-1} were on par.

4.6. Foliar Nutrient Status

Nitrogen

The mean data on nitrogen content of the leaf are presented in Table 5.

Table 5. Effect of treatments on foliar nutrient status - Nitrogen

Treatments	Nitrogen (%)		
	Fifth month	Flowering	Harvest
M_1	1.47	2.21	2.65
M_2	2.36	2.82	2.85
M_3	2.57	3.14	2.90
M_4	2.56	2.88	2.79
F	18956.79**	7255.962**	522.5**
SE ±	3.7758	4.6119	4.7761
CD(0.05)	0.0111	0.0135	0.0140
P_1	2.232	2.78	2.766
P_2	2.246	2.80	2.901
P_3	2.241	2.720	2.723
F	4.6973	116.7554	502.1352
SE ±	3.2699	3.9940	4.1362
CD(0.05)	0.00959	0.0171	0.0121
M_1P_1	1.43	2.21	2.62
M_1P_2	1.47	2.17	2.58
M_1P_3	1.52	2.25	2.74
M_2P_1	2.38	2.92	2.80
M_2P_2	2.36	2.88	3.10
M_2P_3	2.34	2.66	2.65
M_3P_1	2.55	3.10	2.84
M_3P_2	2.60	3.28	3.11
M_3P_3	2.56	3.04	2.75
M_4P_1	2.57	2.88	2.79
M_4P_2	2.55	2.85	2.81
M_4P_3	2.55	2.90	2.76
F	25.6865	152.5121**	303.4415**
SE ±	6.5399	7.9881	8.2724
CD(0.05)	0.0192	0.0234	0.0243

** Significant at 1% level

The manurial treatment had significant effect on foliage N during fifth month. Neem cake at the rate of five kg plant^{-1} recorded a maximum of 2.57 per cent and minimum of 1.47 per cent was recorded with farm yard manure, 10 kg plant^{-1}.

Perusal of the data showed that during flowering stage also, the manurial treatments had significant effect with maximum value of 3.14 per cent recorded for neem cake, five kg plant^{-1}.

The post shooting treatments also significantly influenced foliage nitrogen and the values ranged from 2.80 to 2.72 per cent, the maximum being with urea one per cent spray.

The interaction effect of treatments also had significant influence on foliage N with the maximum of 3.28 per cent recorded for neem cake five kg plant^{-1} and urea one per cent spray during the flowering stage which was superior than other interaction effect.

The manurial treatments had significant influence on foliage nitrogen during harvest stage with a maximum of 2.90 per cent recorded with the level of neem cake, five kg plant^{-1}. The foliage content showed an increasing trend with growth stages, and the maximum value at harvest stage.

The post shooting treatments also significantly influenced the foliage nitrogen with maximum of 2.90 per cent recorded with level urea one per cent spray. All treatments were significantly different.

The interaction effect of treatments also showed significant effect on foliage nitrogen with a maximum of 3.11 per cent recorded for neem cake five kg plant^{-1} and urea one per cent spray.

Phosphorus

The mean data on phosphorus content of leaf are presented in Table 6. The manurial treatments had significant effect on foliar phosphorus content during fifth month with maximum of 0.314 per cent recorded with poultry manure, five kg plant^{-1}.

The post shooting treatments did not significantly influence the P content of leaf during fifth month. The values ranged from 0.292 per cent with level 2,4-D 10 ppm spray to 0.285 per cent with level urea one per cent spray.

The interaction effect of treatments also did not significantly influence the phosphorus content of leaf during the fifth month.

Verification of data showed that during flowering stage also, the manurial treatments significantly influenced the foliar phosphorus content with the maximum value of 0.254 per cent recorded for level vermicompost, five kg plant^{-1}.

The post shooting treatments did not significantly influence foliar phosphorus content. All post shooting treatments were on par with the

Table 6. Effect of treatments on foliage nutrient status - Phosphorus

Treatments	Phosphorus (%)		
	Fifth month	Flowering	Harvest
M_1	0.271	0.229	0.219
M_2	0.314	0.249	0.252
M_3	0.292	0.239	0.253
M_4	0.278	0.254	0.237
F	65.35**	7.945**	10.017**
SE ±	2.3291	3.8672	4.9865
CD(0.05)	0.0068	0.0113	0.0146
P_1	0.292	0.243	0.241
P_2	0.285	0.241	0.242
P_3	0.289	0.245	0.238
F	2.741	0.314	0.161
SE ±	2.0170	3.3491	4.3185
CD(0.05)	0.0059	0.0098	0.0126
M_1P_1	0.273	0.232	0.237
M_1P_2	0.268	0.232	0.217
M_1P_3	0.271	0.225	0.205
M_2P_1	0.317	0.255	0.257
M_2P_2	0.302	0.248	0.245
M_2P_3	0.323	0.245	0.253
M_3P_1	0.295	0.233	0.248
M_3P_2	0.293	0.233	0.258
M_3P_3	0.288	0.252	0.253
M_4P_1	0.283	0.252	0.222
M_4P_2	0.278	0.252	0.247
M_4P_3	0.273	0.258	0.242
F	2.499	1.140	2.147
SE ±	4.0341	6.6982	8.6369
CD(0.05)	0.0118	0.0196	0.0253

** Significant at 1% level

maximum value of 0.245 per cent recorded with a treatment of tying urea 15 g.

The interaction effect of treatments did not significantly influence foliar phosphorus content. All post shooting treatments were on par with the maximum value of 0.245 per cent recorded with tying urea 15 g.

The interaction effect of treatments did not significantly influence the phosphorus content during flowering stage. However, maximum value of 0.258 per cent was observed with vermicompost five kg plant^{-1} and tying urea 15g..

The manurial treatments had significant effect on foliage phosphorus content during harvest stage. Maximum value of 0.253 per cent was recorded with level neem cake, five kg plant^{-1} and minimum of 0.219 with farm yard manure, 10 kg plant^{-1}. Neem cake at the rate of five kg plant^{-1} was on par with poultry manure at the rate of five kg plant^{-1}.

The post shooting treatments and interaction effect did not significantly influence the foliage phosphorus content during the harvest stage.

Potash

The mean data on potash content of leaf are presented in Table 7.

Table 7. Effect of treatments on foliar nutrient status - Potash

Treatments	Potash (%)		
	Fifth month	Flowering	Harvest
M_1	2.634	1.899	2.439
M_2	3.320	2.100	2.699
M_3	3.022	2.163	2.706
M_4	2.830	1.853	2.520
F	807.3295**	17.9843**	6.5827**
SE ±	1.0283	3.5593	5.1778
CD(0.05)	0.0301	0.1044	0.1518
P_1	3.065	1.958	2.550
P_2	2.957	2.034	2.658
P_3	2.833	2.020	2.565
F	170.7405	1.7511	1.6863
SE ±	8.9050	3.0824	4.4841
CD(0.05)	0.0261	0.0904	0.1315
M_1P_1	2.850	2.000	2.693
M_1P_2	2.747	1.710	2.207
M_1P_3	2.307	1.987	2.417
M_2P_1	3.543	1.940	2.303
M_2P_2	3.243	2.143	2.933
M_2P_3	3.173	2.217	2.860
M_3P_1	3.023	2.057	2.663
M_3P_2	3.010	2.260	2.727
M_3P_3	3.033	2.173	2.727
M_4P_1	2.843	1.833	2.540
M_4P_2	2.830	2.023	2.763
M_4P_3	2.817	1.703	2.257
F	71.4946**	6.7539**	9.5538**
SE ±	1.7810	6.1649	8.9683
CD(0.05)	0.0522	0.1808	0.2630

** Significant at 1% level

The manurial treatments significantly influenced the foliage potash content. All manurial treatments differed significantly with the maximum value 3.32 per cent recorded with poultry manure at the rate of five kg plant^{-1} during fifth month.

The interaction effect of treatments also significantly influenced the potash content with the maximum value of 3.543 per cent recorded for poultry manure five kg plant^{-1} and 2,4-D 10 ppm spray during fifth month.

During flowering stage also, the manurial treatments significantly influenced the foliar potash content with the maximum value 2.163 per cent recorded with neem cake, five kg plant^{-1}.

The post shooting treatments did not significantly influence the foliar potash content. All treatments were on par. The maximum value 2.034 per cent was recorded with urea one per cent spray.

The interaction effect of treatments significantly influenced the foliage K content maximum value 2.26 per cent was observed with neem cake five kg plant^{-1} and urea one per cent spray.

During harvest stage manurial treatments significantly, influenced foliage potash content. Maximum value recorded was 2.706 per cent with neem cake, five kg plant^{-1} which was on par with poultry manure, five kg plant^{-1}.

The post shooting treatments did not significantly influence the foliage potash content. The urea one per cent spray recorded maximum value of 2.658 per cent which was on par with tying urea 15 g and 2,4-D 10 ppm spray.

The interaction effect of treatments significantly influenced the foliage potash content. Maximum value 2.933 per cent was recorded with poultry manure five kg plant^{-1} and urea one per cent spray and minimum value of 2.207 per cent recorded with farm yard manure 10kg plant^{-1} and urea 1 per cent spray.

4.7. Bunch characters

The mean data on bunch characters are presented in Table 8. The manurial treatments significantly influenced weight of bunch, with a maximum of 11.39 kg recorded with level M_2 poultry manure 5 kg plant^{-1}. The post shooting treatments did not significantly affect bunch yield. However, highest weight of 10.91 kg was recorded with 2,4-D 10 ppm spray. The interaction effect did not significantly influence the bunch weight.

The number of hands and number of fingers in second hand were not influenced by manurial, post shooting treatments and interaction effect.

The total number of fingers were also not significantly influenced by treatments. However, in the case of manurial treatments, the total number of fingers was higher with poultry manure five kg plant^{-1}.

Table 8. Effect of treatments on bunch characters of banana var. Nendran

	Wt. of bunch (kg)	No. of hands bunch^{-1}	No. of fingers in second hand	No. of fingers bunch^{-1}	Length of bunch (cm)
M_1	10.67	4.33	9.33	41.78	38.17
M_2	11.39	4.78	9.67	43.44	39.93
M_3	10.36	4.67	9.78	40.44	36.11
M_4	10.17	4.11	9.44	40.59	36.56
F	6.77**	1.22	2.05	4.80	77.31
SE ±	0.2065	0.2763	0.3252	1.4327	0.2064
CD(0.05)	0.606	0.810	0.954	4.202	0.605
P_1	10.91	4.17	9.50	40.08	38.55
P_2	10.77	4.92	9.00	42.42	40.15
P_3	10.26	4.33	9.42	38.83	37.74
F	3.65	2.71	0.91	2.15	47.14
SE ±	0.1798	0.2393	0.286	1.241	0.1788
CD(0.05)	0.5245	0.7017	0.826	3.639	0.5244
M_1P_1	11.23	5.0	10.33	45.67	38.91
M_1P_2	10.80	5.00	8.66	47.00	39.88
M_1P_3	9.97	4.33	9.00	32.67	33.64
M_2P_1	11.53	4.33	9.00	42.67	38.36
M_2P_2	11.27	5.33	9.00	43.67	41.60
M_2P_3	11.37	4.66	10.33	44.00	39.83
M_3P_1	10.47	4.66	9.66	38.33	41.88
M_3P_2	10.83	5.00	10.33	44.33	41.95
M_3P_3	9.77	4.33	9.33	38.67	40.00
M_4P_1	10.40	4.33	9.00	33.67	35.03
M_4P_2	10.16	4.33	8.00	34.67	37.17
M_4P_3	9.93	4.00	9.00	40.00	37.48
F	0.82	1.63	1.76	3.95	45.12**
SE ±	0.358	0.479	0.563	2.4816	0.3575
CD(0.05)	1.0490	1.404	1.652	7.2786	1.0487

** Significant at 1% level

The interaction effect of treatments significantly influenced the length of bunch, with a maximum of 41.95 cm recorded for neem cake five kg plant^{-1} and urea one per cent spray.

The maximum length of bunch of 31.93 cm of manurial treatments was observed with poultry manure five kg plant^{-1} and for post shooting treatments 40.15 cm with urea one per cent bunch spray.

4.8. Fruit characters (Mature)

The mean data on fruit characters (mature) are presented in Table 9. The manurial treatments significantly influenced the fruit weight with the maximum value of 241.44 g recorded for poultry manure, five kg plant^{-1}.

The post shooting treatments did not significantly influence the fruit weight. However, though not significant, 2,4-D 10 ppm spray recorded maximum weight.

The interaction effect of treatments did not significantly influence the fruit weight.

Length of fruit was significantly influenced by manurial treatments with maximum value of 25.12 cm with neem cake, five kg plant^{-1}.

In the case of post shooting treatments, urea one per cent spray recorded the maximum length of 23.49 cm. All post shooting treatments differed significantly.

Table 9. Effect of treatments on fruit characters (Mature)

Treatments	Fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Volume of fruit (cm^3)	Dry wt. of pulp (g)	Dry wt. of peel (g)
M_1	167.78	20.30	13.38	207.22	61.74	5.13
M_2	241.44	25.12	14.08	234.78	71.93	3.65
M_3	222.11	23.33	13.84	226.44	46.13	3.09
M_4	216.67	22.11	13.17	210.78	61.41	4.18
F	4.50*	635.48**	38.61**	1.18	20.02**	720.04**
SE ±	14.773	8.0565	6.759	11.968	2.378	3.227
CD(0.05)	43.3309	0.2363	0.1982	35.1022	6.9735	0.0946
P_1	224.75	22.48	13.49	231.83	60.90	4.230
P_2	198.92	23.49	13.76	219.75	57.41	4.050
P_3	212.33	22.18	13.60	207.83	62.59	3.762
F	1.0198	97.4285	5.6395	1.34	1.6494	71.44
SE ±	12.7939	6.9771	5.8542	10.3643	2.0590	2.7950
CD(0.05)	37.5254	0.2046	0.1717	30.3999	6.0392	0.0819
M_1P_1	168.33	18.37	13.27	199.00	62.64	5.78
M_1P_2	171.66	22.20	13.60	211.67	61.10	5.17
M_1P_3	163.33	20.33	13.27	211.00	61.49	4.45
M_2P_1	250.00	22.20	13.73	248.67	76.26	3.66
M_2P_2	247.67	26.13	13.96	257.67	62.84	3.34
M_2P_3	226.67	21.67	13.83	198.00	76.69	3.95
M_3P_1	251.00	25.70	14.08	241.33	43.26	2.88
M_3P_2	177.33	24.97	14.13	213.33	44.04	3.43
M_3P_3	238.00	24.70	14.05	224.66	51.08	2.97
M_4P_1	229.67	23.67	12.87	238.33	61.47	4.60
M_4P_2	199.00	20.67	13.27	196.33	61.65	3.67
M_4P_3	221.33	22.00	13.27	197.67	61.15	3.67
F	0.6682	175.5598**	1.0765	0.9913	1.05	68.53**
SE ±	25.5877	0.1395	0.1171	20.7287	4.1180	5.5900
CD(0.05)	75.0508	0.4093	0.3434	60.7988	12.0785	0.1639

* Significant at 5% level ** Significant at 1% level

The interaction effect also significantly influenced the length of fruits with the maximum value of 26.13 cm for poultry manure five kg plant^{-1} and urea one per cent spray. poultry manure five kg plant^{-1} and urea one per cent spray was superior to all other interaction effects.

Girth of fruit was significantly influenced by the manurial treatments, with maximum girth of 14.08 cm recorded by poultry manure, five kg plant^{-1}.

The post shooting treatments did not significantly affect the girth of fruit. However, the level urea 1 per cent spray recorded the maximum girth of 13.76 cm.

The interaction effect did not significantly influence the girth of fruit.

The manurial treatments, post shooting treatments and interaction effect did not significantly influence the volume of fruit.

The manurial treatments significantly influenced the dry weight of pulp. Maximum dry weight of 71.93 g in the case of pulp was recorded with the poultry manure, five kg plant^{-1}.

The post shooting treatments did not influence the dry weight of pulp. However, the highest value of 62.59 g was observed with the tying urea 15 g. The interaction effects were not significant.

The dry weight of peel was significantly influenced by manurial treatments. Maximum weight of 5.13 g was recorded for farm yard manure, 10 kg plant^{-1}.

In the case of post shooting treatments there was no significant effect on dry weight of peel.

The interaction effect of treatments was found to have significant effect on dry weight of peel with the maximum value of 5.78 g for farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray. farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray was found to be superior than other interaction effects.

4.9. Fruit Character (Ripe)

The mean data on fruit character (Ripe) are recorded on Table 10. The effect of manurial treatments on the weight of pulp was significant. The poultry manure, five kg plant^{-1} recorded the maximum value of 177.88 g which was significantly more than other three levels.

The post shooting treatments also had significant influence on weight of pulp, with the urea one per cent spray showing a maximum weight of 171.93 g. All the treatments showed significantly difference.

The interaction effect on weight of pulp was significant. Maximum weight of the pulp 217.36 g was noticed with poultry manure

Table 10. Effect of treatments on fruit character (Ripe)

Treatments	Weight of pulp (g)	Weight of peel (g)	Weight of finger (g)	Pulp/peel ratio (by wt.)
M_1	156.13	73.48	229.61	2.139
M_2	177.88	72.67	250.55	2.451
M_3	147.09	80.42	227.51	1.927
M_4	166.30	69.97	236.27	2.407
F(3,22)	268.84**	21.92**	36.14**	156.87**
SE ±	0.8085	0.9504	1.7124	1.9565
CD(0.05)	2.3715	2.7876	5.0227	5.7384
P_1	160.85	82.79	243.64	2.011
P_2	171.93	77.35	249.28	2.230
P_3	152.77	62.27	215.04	2.452
F	188.61**	166.78**	149.93**	170.06**
SE ±	0.7002	0.8231	1.4830	1.6944
CD(0.05)	2.0538	2.4141	4.3498	0.0497
M_1P_1	158.15	75.83	233.98	2.127
M_1P_2	158.80	73.77	232.57	2.152
M_1P_3	151.43	70.85	222.28	2.138
M_2P_1	201.15	73.69	274.84	2.730
M_2P_2	217.36	94.50	311.86	2.311
M_2P_3	115.12	49.81	164.93	2.312
M_3P_1	109.08	96.53	205.61	1.129
M_3P_2	172.75	82.19	254.94	2.101
M_3P_3	159.44	62.54	221.98	2.550
M_4P_1	175.02	85.11	260.13	2.056
M_4P_2	138.79	58.92	197.71	2.355
M_4P_3	185.09	65.89	250.98	2.809
F	745.71**	65.17**	236.59**	155.38**
SE ±	1.4004	1.6461	2.9660	3.3887
CD(0.05)	4.1075	4.8282	8.6996	0.0994

** Significant at 1% level

five kg plant^{-1} and urea one per cent spray treatment and minimum was recorded with neem cake five kg plant^{-1} and 2,4-D 10 ppm spray treatment. poultry manure five kg plant^{-1} and urea 1 per cent spray was superior than all other interaction effect.

The weight of peel was also significantly influenced by the manurial treatments. Perusal of the data showed maximum weight of 80.42 g for neem cake, five kg plant^{-1} level.

The post shooting treatments also significantly influenced the weight of peel with maximum value of 82.79 recorded with 2,4-D 10 ppm spray level.

The interaction effect also were found to be significant with the maximum of 96.53g with neem cake 5kg plant^{-1} and 2,4-D 10 ppm spray treatment. Neem cake five kg per plant and 2,4-D 10 ppm spray and poultry manure five kg plant^{-1} and urea one per cent spray were on par.

The weight of finger was found significantly influenced by manurial treatments with the maximum value of 250.10g for poultry manure, five kg plant^{-1}.

The post shooting treatments also significantly influenced weight of finger. Urea one per cent spray recorded the maximum weight of 249.28 g.

The interaction effect was significantly influenced the weight of finger with the maximum value of 311.86 g for poultry manure five kg plant^{-1} and urea one per cent spray which was superior than all other interaction effect.

The pulp-peel ratio of ripe fruit were significantly influenced by manurial treatments with the maximum value of 2.451 recorded with poultry manure, five kg plant^{-1}.

The post shooting treatments significantly influenced pulp-peel ratio. tying urea 15 g recorded the maximum value of 2.452. The treatments 2,4-D 10 ppm spray, urea one per cent spray and tying urea 15 g were on par.

The interaction effects were found to be significantly different with maximum value of 2.809 for vermicompost five kg plant^{-1} and tying urea 15g. Vermicompost five kg plant^{-1} and tying urea 15 g was on par with poultry manure five kg plant^{-1} and 2,4-D 10 ppm spray.

4.10. Soil N, P and K

The mean data on soil N, P and K after the experiment are presented in Table 11. The manurial treatments significantly influenced available N content of soil with the highest value of 224.64 kg ha^{-1}. recorded by farm yard manure, 10 kg plant^{-1}. The post shooting application also showed significant influence on available N content

Table 11. Effect of different treatments on soil N, P and K

Treatments	Available N kg ha^{-1}	Available P kg ha^{-1}	Available K kg ha^{-1}
M_1	224.64	42.57	206.73
M_2	218.19	41.06	188.51
M_3	216.14	43.60	174.91
M_4	216.20	45.61	181.91
$F_{3,22}$	23.51**	109.51**	5.78**
SE ±	0.828	0.183	5.682
CD(0.05)	2.429	0.536	16.664
P_1	222.12	43.35	186.08
P_2	210.94	42.67	194.40
P_3	223.31	43.61	183.57
F	90.63**	9.41**	1.32
SE ±	0.7171	0.1581	4.9203
CD(0.05)	2.103	0.4638	14.4318
M_1P_1	234.27	42.02	191.60
M_1P_2	204.47	42.77	233.60
M_1P_3	235.19	42.93	195.00
M_2P_1	217.89	41.01	189.13
M_2P_2	210.67	41.43	189.13
M_2P_3	225.98	40.74	187.26
M_3P_1	221.45	43.75	173.80
M_3P_2	216.50	41.37	171.67
M_3P_3	210.47	45.68	179.27
M_4P_1	214.88	46.61	189.80
M_4P_2	212.10	45.13	183.20
M_4P_3	221.16	45.09	172.73
F	37.55**	16.14**	1.74
SE ±	1.4342	0.3163	9.8407
CD(0.05)	4.2065	0.9276	28.8635

** Significant at 1% level

with a maximum of 223.31 kg ha^{-1} recorded for tying urea 15 g. The interaction effect of treatment showed significant influence on available N content of soil after the experiment. The effect of manurial treatments on available P content of soil were significant. The maximum value of 45.61 kg ha^{-1}. was recorded with the level vermicompost, five kg $plant^{-1}$. The post shooting application significantly influenced the content of soil P. The highest value was obtained with tying urea 15 g.

The interaction effect of treatments also had significant influence on soil P, recording a maximum of 46.61 kg ha^{-1}. recorded for vermicompost five kg $plant^{-1}$ and 2,4-D 10 ppm spray.

The manurial treatments influenced the available K. The maximum value of 206.73 kg ha^{-1} was recorded for the level farm yard manure, 10 kg $plant^{-1}$. The post shooting treatments and interaction effect did not significantly influence the available soil K.

4.11. Quality attributes

The mean data on quality attributes are presented in Table 12. The manurial treatments significantly influenced the TSS of fruit with maximum value 26.11 per cent noticed with farm yard manure, 10 kg $plant^{-1}$ level.

The post shooting treatments did not influence the TSS of fruit. However, maximum value of 25.46 was noticed with level tying urea 15 g which was on par with urea one per cent spray.

Table 12. Effect of treatments on quality attributes

Treatments	Tss of fruit (%)	Acidity (%)	Total sugar (%)	Reducing sugar (%)	Non reducing sugar (%)	Ascorbic acid mg/100g	Starch (%)	Sugar acid ratio	Shelf life (days)
M_1	26.11	0.47	22.58	9.55	13.04	9.357	61.48	48.04	7.44
M_2	24.72	0.41	18.62	8.38	0.26	11.355	75.26	45.41	7.56
M_3	25.10	0.43	18.68	7.67	11.01	12.840	72.82	43.44	8.00
M_4	24.81	0.46	19.69	9.04	10.64	9.347	71.80	42.80	8.78
F	14.97**	0.9233	233.99**	38.79**	39.59**	116.8171**	2.57	76.9213**	2.33
SE ±	0.1648	3.0989	0.1215	0.1309	0.1970	1.5703	3.7918	0.7451	0.3964
CD(0.05)	0.4833	0.0909	0.3564	0.3839	0.5778	0.0046	11.1217	2.1854	1.1626
P_1	24.73	0.48	20.70	8.61	12.08	10.58	72.31	43.12	7.67
P_2	25.37	0.44	18.95	8.12	10.83	10.56	72.28	43.06	8.25
P_3	25.46	0.42	20.06	9.23	10.80	11.04	66.43	47.76	7.92
F	7.6624	1.37	70.04**	24.29	18.67**	40.700**	1.06	42.31**	0.73
SE ±	0.1427	2.684	0.1052	0.1133	0.1706	1.3599	3.2838	0.6453	0.3433
CD(0.05)	0.4185	0.0787	0.3086	0.3324	0.5004	0.0039	9.6317	1.8926	1.0069
M_1P_1	26.63	0.517	25.833	10.07	15.77	9.467	69.80	49.67	7.33
M_1P_2	25.47	0.363	19.760	8.92	10.84	9.351	69.21	53.40	8.33
M_1P_3	26.23	0.540	22.156	9.65	12.51	9.254	45.43	41.02	6.67
M_2P_1	21.70	0.367	18.193	7.41	10.78	11.361	75.43	49.16	6.33
M_2P_2	26.43	0.523	18.616	7.96	10.65	11.322	74.76	35.60	8.00
M_2P_3	26.03	0.343	19.060	9.73	9.33	11.382	75.58	56.05	8.33
M_3P_1	25.66	0.520	18.440	7.38	11.06	12.107	73.15	35.46	8.00
M_3P_2	25.17	0.340	19.227	7.76	11.46	12.206	72.84	56.55	8.33
M_3P_3	24.47	0.433	18.373	7.87	10.50	14.207	72.47	42.72	7.66
M_4P_1	24.93	0.520	20.317	9.57	10.74	9.367	70.84	39.07	9.00
M_4P_2	24.40	0.520	18.203	7.85	10.35	9.352	72.30	35.00	8.33
M_4P_3	25.10	0.363	20.55	9.71	10.84	9.323	72.25	57.08	9.00
F	14.97*	3.60*	62.78**	10.98**	14.47	50284.67	1.148	79.11**	1.25
SE ±	0.2854	5.3676	0.2104	0.2267	0.3412	2.71996	6.5676	1.2905	0.6866
CD(0.05)	0.8370	0.1574	0.6172	0.6648	1.0008	0.0079	19.2634	3.7852	2.0138

* Significant at 5% level ** Significant at 1% level

The interaction effect of treatments were found to be significant with farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray recording a maximum of 26.63 which was on par with poultry manure 5kg plant^{-1} and urea 1 per cent spray, farm yard manure 10kg plant^{-1} and tying urea 15 g and poultry manure 5kg plant^{-1} and tying urea 15 g.

The manurial treatments did not significantly influence the acidity of fruit. However, highest value of 0.47 for acidity was recorded with farm yard manure, 10 kg plant^{-1}.

The post shooting treatments also did not significantly influence the acidity. All the treatments were on par.

The interaction effect significantly influenced the acidity of fruit with maximum value of 0.54 recorded for farm yard manure 10kg plant^{-1} and tying urea 15 g and lowest value of 0.34 for neem cake five kg plant^{-1} and urea one per cent spray. Farm yard manure 10kg plant^{-1} and tying urea 15 g was on par with farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray, poultry manure five kg plant^{-1} and urea one per cent spray, neem cake five kg per plant and 2,4-D 10 ppm spray, vermicompost five kg plant^{-1} and 2,4-D 10 ppm spray, vermicompost five kg plant^{-1} and urea one per cent spray and neem cake five kg plant^{-1} and tying urea 15 g.

The manurial treatments significantly influenced the total sugar content with maximum value of 22.58 recorded with farm yard manure,

10 kg plant^{-1}. Farm yard manure, 10 kg plant^{-1} was superior. Neem cake, five kg plant^{-1} and poultry manure, five kg plant^{-1} were on par.

The post shooting treatments also significantly influenced total sugar content with maximum of 20.70 per cent observed with level 2,4-D 10 ppm spray.

The interaction effect of treatments also significantly influenced the total sugar content with maximum value of 25.83 observed for farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray which was superior to all the other interaction effect.

In the case of reducing sugar, maximum value of 9.55 per cent was recorded with farm yard manure, 10 kg plant^{-1}. All treatments differed significantly.

The post shooting treatments did not significantly influence the reducing sugar.

The interaction effect of treatments significantly influenced the reducing sugar with a maximum value 10.07 per cent recorded with farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray and minimum value 7.38 per cent with neem cake five kg plant^{-1} and 2,4-D 10 ppm spray. Farm yard manure 10kg plant^{-1} and 2,4-D 10 ppm spray was found to be on par with poultry manure five kg plant^{-1} and tying urea 15 g,

vermicompost five kg plant^{-1} and tying urea 15 g, farm yard manure 10kg plant^{-1} and tying urea 15 g and vermicompost five kg plant^{-1} and 2,4-D 10 ppm spray.

The non reducing sugar content was significantly influenced by the manurial treatments. With a maximum value of 13.04 observed with farm yard manure, 10 kg plant^{-1} (FYM 10 kg plant^{-1}).

The post shooting treatments also significantly influenced Non-reducing sugar content with a maximum value of 12.08 observed with 2,4-D 10 ppm spray.

The interaction effect of treatments did not significantly influence the non reducing sugar content.

The manurial treatments had significant influence on ascorbic acid content with a maximum value of 12.840 recorded with neem cake, five kg plant^{-1}.

The post shooting treatments also significantly influenced the ascorbic acid content. Maximum value of 11.04 was recorded with tying urea 15 g.

The interaction effect of treatment also had significant influence on ascorbic acid content. The highest value of 14.207 was observed with neem cake five kg plant^{-1} and tying urea 15 g which was superior to other interaction effects.

In the case of starch content, the manurial treatments did not have any significant effect. However, the maximum value of 75.26 was observed with the level poultry manure, five kg plant^{-1}.

The post shooting treatment and interaction effect of treatments did not have any profound influence on starch content of fruits.

The manurial treatments had significant influence on sugar acid ratio of fruits. The maximum value of 48.04 was recorded for FYM, five kg plant^{-1} which was on par with neem cake, five kg plant^{-1}.

The post shooting treatments also significantly influenced the sugar acid ratio, with the highest value of 47.76 recorded for tying urea 15 g. All post shooting treatments differed significantly.

The interaction effect of treatments also significantly influenced the sugar acid ratio. The maximum value of 56.55 was recorded for neem cake at the rate of five kg plant^{-1} and urea one per cent spray and the minimum of 35.00 for vermicompost five kg plant^{-1} and urea one per cent spray. poultry manure five kg plant^{-1} and tying urea 15 g was on par with neem cake five kg plant^{-1} and urea one per cent spray.

In the case of shelf life of fruits, the manurial treatments did not have any significant affect. The maximum value of 8.78 was observed for the level vermicompost, five kg plant^{-1} which was on par with neem cake, five kg plant^{-1}.

Table 13. Sensory evaluation of ripe fruits (Rank means) of banana var. Nendran

Treatments	Rank means	
	Taste	Texture
1.	32	47.4
2.	32	30.0
3.	32	30.0
4.	26	30.0
5.	20	18.6
6.	32	30.0
7.	32	30.0
8.	32	30.0
9.	32	30.0
10.	32	30.0
11.	32	30.0
12.	32	30.0
Critical values	21.65	21.65

Table 14. Economics of production (ha^{-1})*

Treatments	Total yield (kg ha^{-1})	Income from bunches (Rs.)	Total cost of cultivation (Rs.)	Net profit (Rs.)	B : C ratio
T_1	28,075	2,52,675	1,03629.25	1,49045.75	2.44
T_2	27,000	2,43000	1,04050.00	1,38950.00	2.34
T_3	24,925	2,24325	1,04153.75	1,20171.25	2.15
T_4	28,825	2,59425	1,24879.25	1,34545.75	2.08
T_5	28,175	2,53575	1,25300.00	1,28275.00	2.02
T_6	28,425	2,55825	1,25403.75	1,30421.25	2.04
T_7	26,175	2,35575	1,56129.25	7,9445.75	1.51
T_8	27,075	2,43675	1,56550.00	8,7125.00	1.56
T_9	24,425	2,19825	1,56656.75	6,3171.25	1.40
T_{10}	26,000	2,34000	9,7379.25	1,36620.75	2.40
T_{11}	25,400	2,28600	9,7800.00	1,30800.00	2.33
T_{12}	24,825	2,23425	9,7903.75	1,25521.25	2.28

* Data statistically not analysed wage rate - Rs. 80 day^{-1}

Cost of inputs

Urea	Rs. 3.32 kg^{-1}
Mussorie phosphate	Rs. 2.101 kg^{-1}
MOP	Rs. 5.25 kg^{-1}
FYM	Rs. 2.50 kg^{-1}
Neem cake	Rs. 5.00 kg^{-1}
Poultry Manure	Rs. 2.50 kg^{-1}
Vermicompost	30 Ps kg^{-1}

Cost of produce - Rs. 9.00 kg^{-1}

In the case of post shooting application also there was no significant influence on shelf life of fruits.

The interaction effects of treatments also did not have any profound influence on the shelf life of fruit.

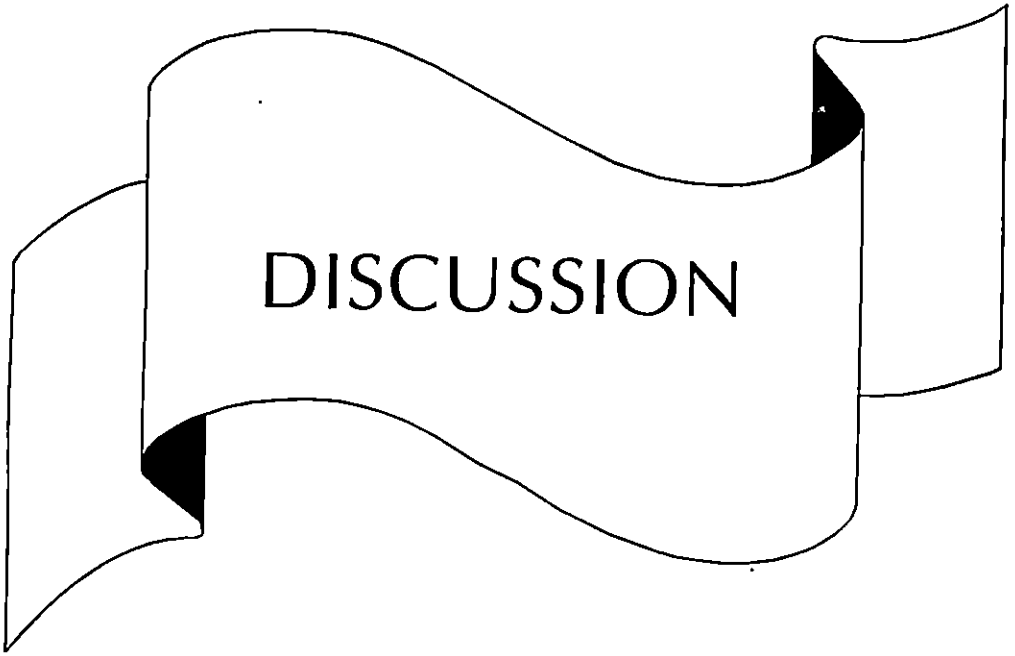
4.12. Sensory evaluation

The taste of fruit in the case of all treatments were similar. The texture of banana under treatment one been superior to that of treatment five. But it remained the same with other treatments. In the case of flavour and colour, the judges, did not find any marked difference between the treatments (Table 13).

4.13. Economics of production

The details of economics of production (Benefit cost ratio) are furnished in Table 14.

T_1 recorded the highest benefit cost ratio (2.44) as furnished in Table followed by T_{10} (2.40). Lowest benefit cost ratio was recorded by T_9 (1.40) followed by T_7 (1.51). The highest net profit of Rs. 1,49,045 was realised ha^{-1} in T_1 followed by T_2, T_{10}, T_4 and T_{11}. T_9 recorded the lowest net profit (Rs. 63,171,25).


DISCUSSION

DISCUSSION

Banana is one of the important tropical fruit crops of the world. It is commercially grown from the equator to a latitude of 30 or more.

The present investigation were designed to find out efficacy of different sources of organic and inorganic nutrients for increasing the productivity of Nendran banana, the effect of post shootinging application of urea and growth regulators on the bunch weight. The results obtained are discussed below.

5.1. Growth characters

The growth characters viz., plant height, girth of pseudostem and leaf characters are presented in Fig. 1, 2 and 3.

The height of plant was significantly influenced by the sources of organic manures. Maximum height was noticed by plots treated with poultry manure from fifth month onwards. The enhanced height in these plants might be due to higher nutrient content in the poultry manure. This result is in conformity with the findings of Iyengar *et al.* (1984). A combination of FYM at the rate of 10 kg^{-1} plant along with 2,4-D 10 ppm gave an appreciable increase in plant height. At low concentration of

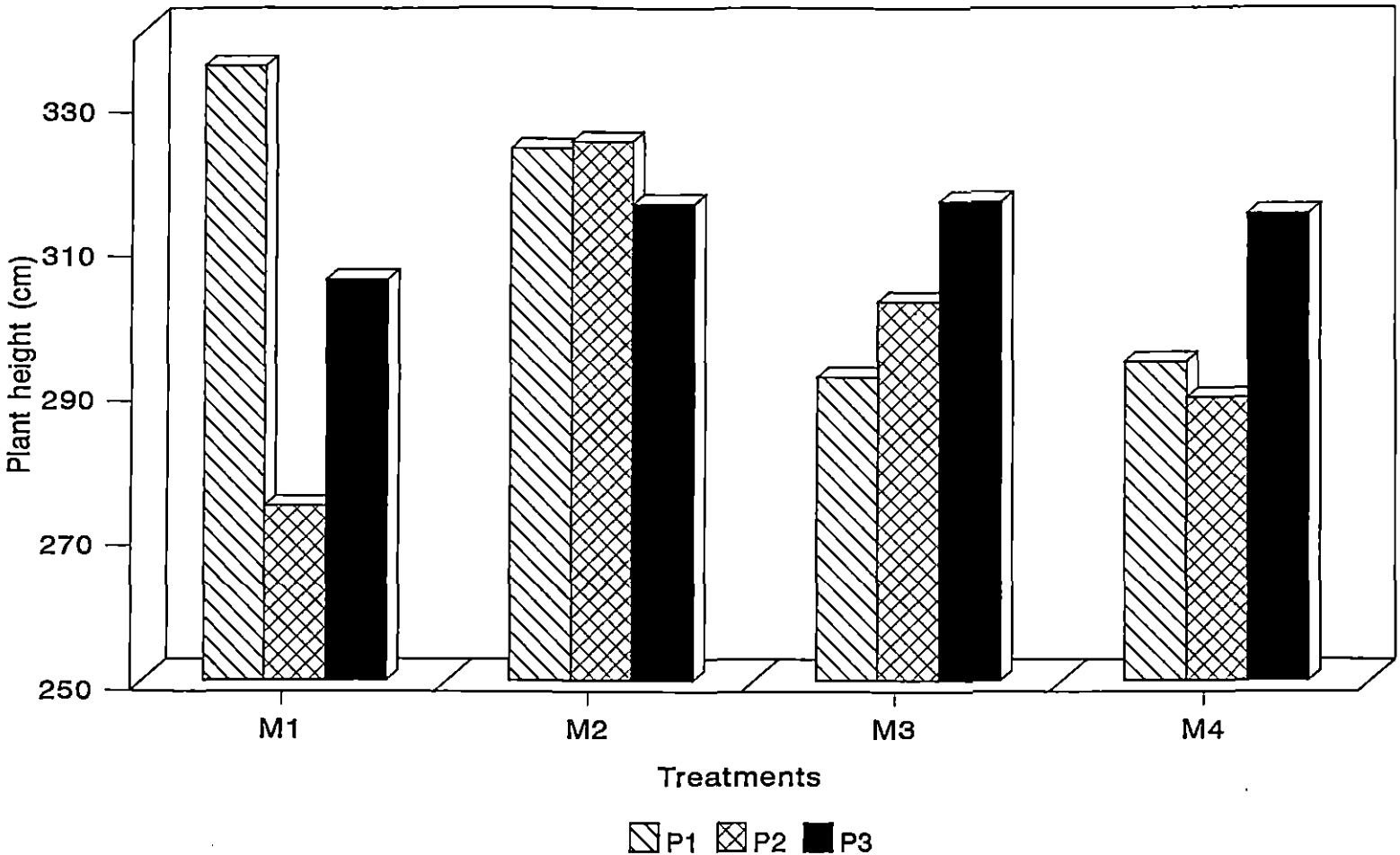


Fig. 1. Interaction effect of treatment on plant height at flowering of banana var. Nendran

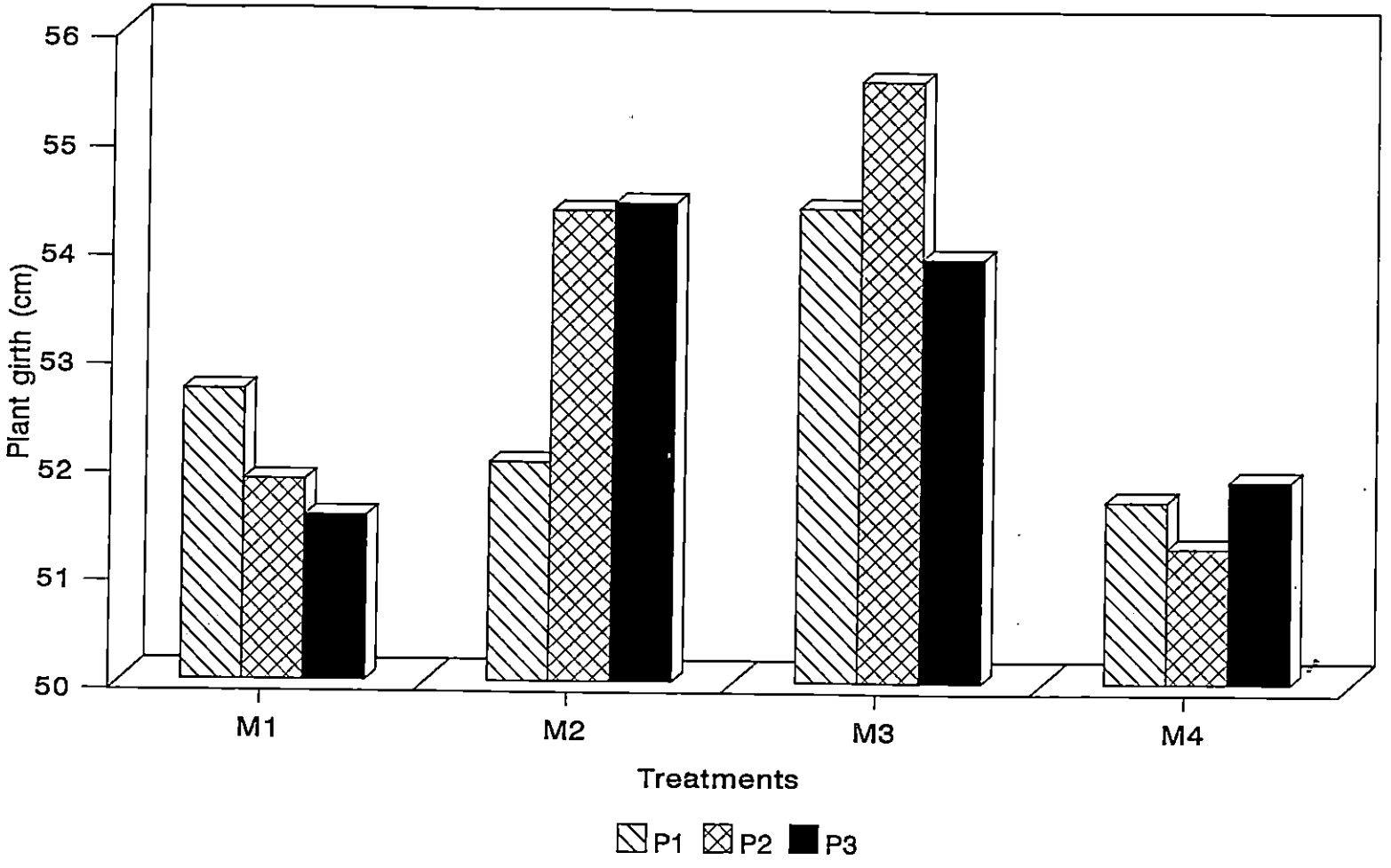


Fig. 2. Interaction effect of treatment on plant girth at flowering of banana var. Nendran

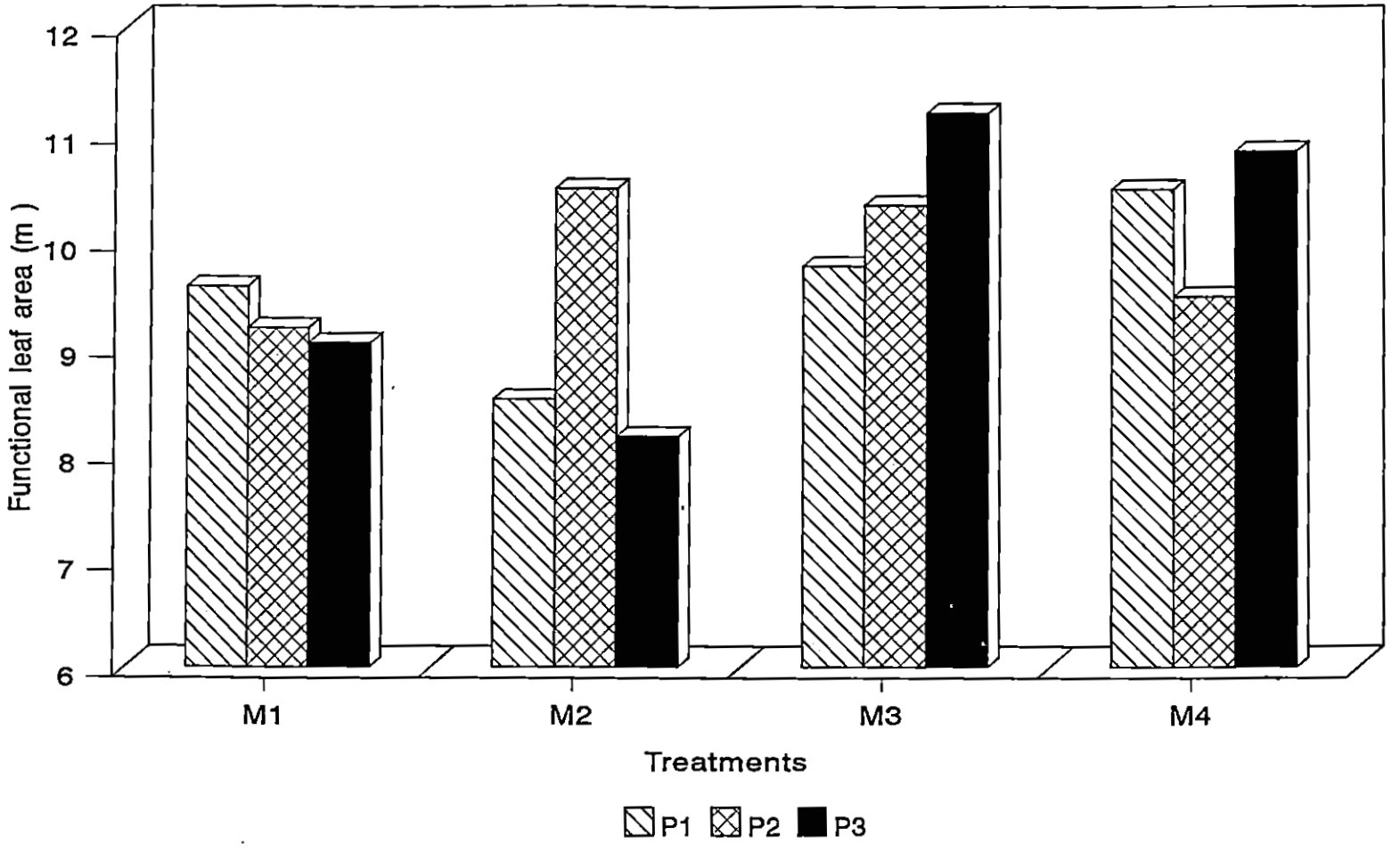


Fig. 3. Interaction effect of treatments on functional leaf area at flowering

2,4-D, the hormonal effect might have promoted plant height. A similar trend in plant height was reported by Herath *et al.* (1977).

The girth of pseudostem in banana is considered as an index for plant vigour. A comparison of organic sources indicated that neem cake applied at the rate of 5 kg plant^{-1} recorded greater girth. Apart, from the nutrient content, the retension capacity of nutrients especially nitrogen to a prolonged period and its balance availability might have resulted in girth maximisation in this treatment.

Simmonds (1966) opined that banana growth is a function of the number of leaves produced and its area. A fixed number of leaf emerges prior to flowering in most of the cultivars of banana (Summerville, 1944, Champion, 1963 and Wardlaw, 1972). Though the girth which is an indicator of plant vigour is not found to be affected by the treatment effect and interaction effect, the leaf area was significantly influenced by different manurial treatments. In the present experiment the leaf area showed considerable variations with the age of the plant. Vermicompost treated plant produced higher leaf area in the earlier part and the trend was reversed with FYM in the later part of the plant growth. These variations might be due to the variation, in the availability and retension of nutrients at different stages of plant growth.

5.2. Crop duration

The time taken from flowering to harvest was influenced by the treatments. In general a healthy plant, receiving proper nutrient showed

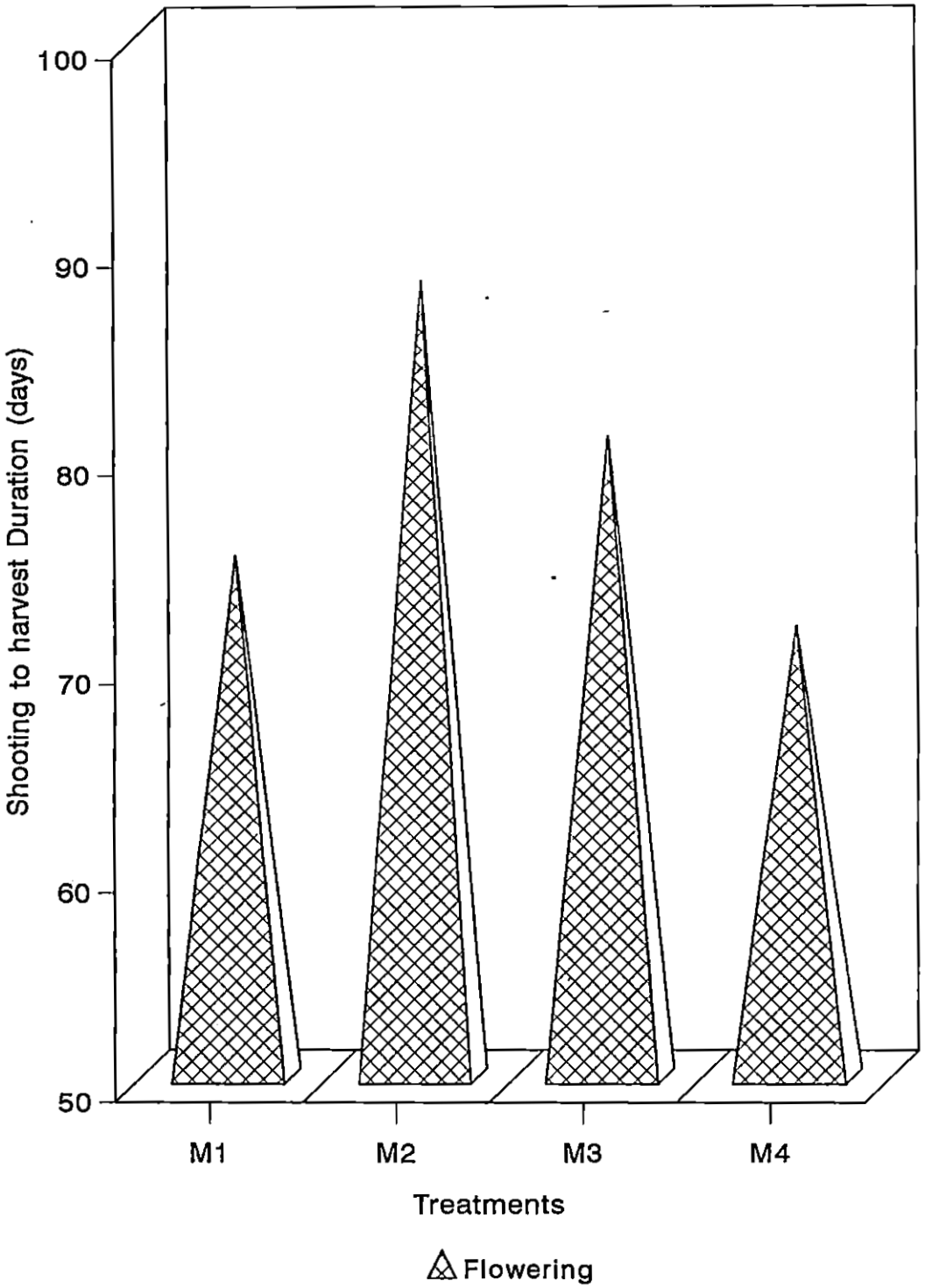


Fig. 4. Effect of manurial treatments on duration from shooting to harvest

earliness in flower emergence. The poultry manure treated plots had a profound increase in time taken for maturity from flowering (Fig. 4). The increment in time might have given the plant for better bulking of finger, by greater transmission of photosynthates from source to sink. Early harvest was noticed in plots treated with FYM at the rate of 10 kg per plant and 2,4-D 10 ppm spray. Similar trend was observed with N application in 'Robusta' banana by Kohli *et al.* (1985).

5.3. Foliar nutrient status

The foliar nutrient status are presented in Fig. 5, 6 and 7.

The results of leaf analysis indicated a precise inter relationship between the amount of nutrients added to the soil and its utilization by the crop. It also served as a diagnostic tool in understanding the inner physiology of the plant at various phases of growth of banana (Hewitt, 1955 and Turner and Barker, 1970).

The foliage N content was maximum during flowering and harvest stage with a dose of 5 kg^{-1} plant of neem cake. Apart from the nutrient content, the retension capacity of nutrients might have resulted in higher leaf content of N. Similar trend in foliage N content was reported by Kotur and Mustaffa (1984).

In the case of foliage P content it was noticed that it declined with increase in growth period with minimum at the time of harvest.

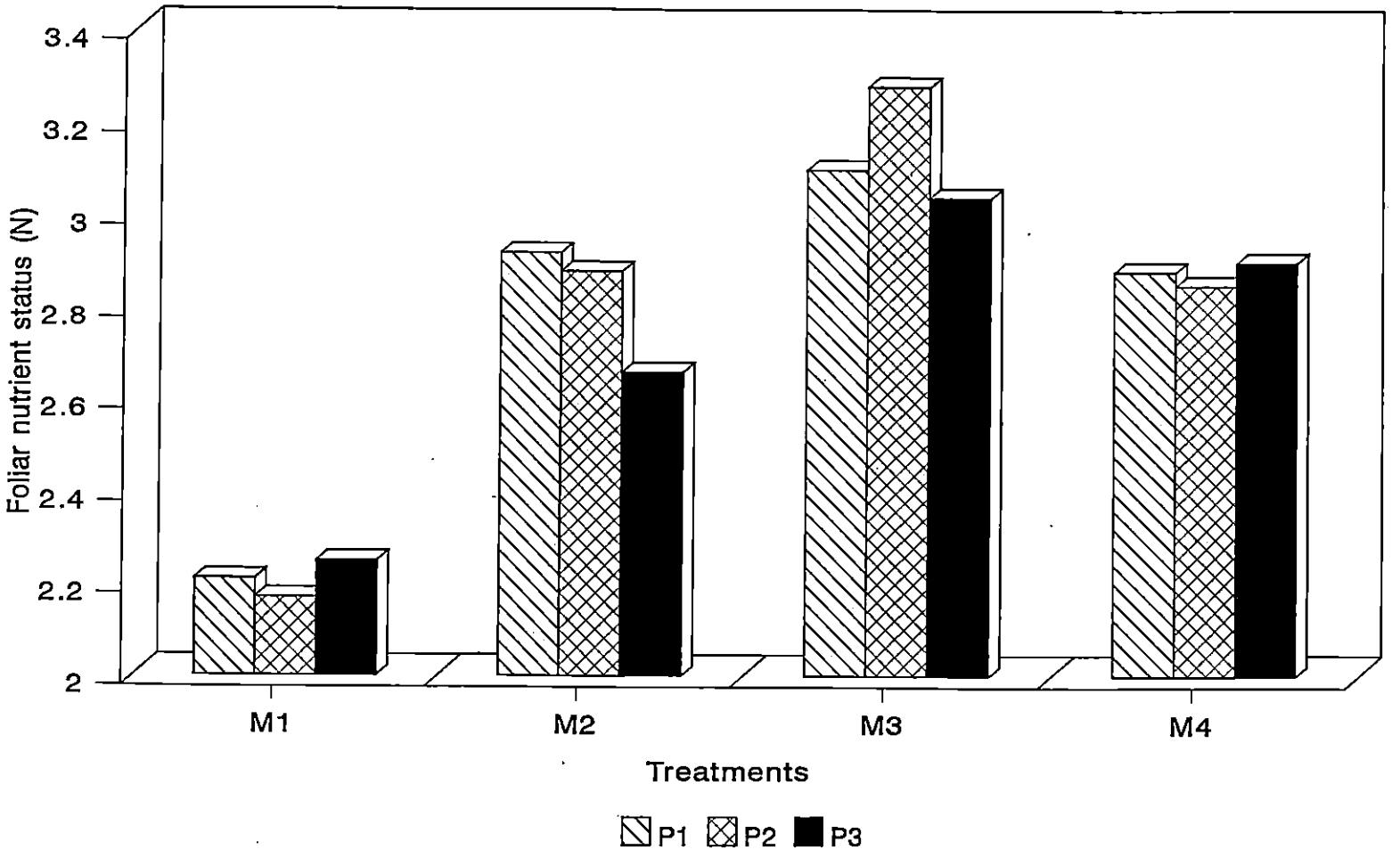


Fig. 5. Interaction effect of treatments on foliar nutrient status of N at harvest

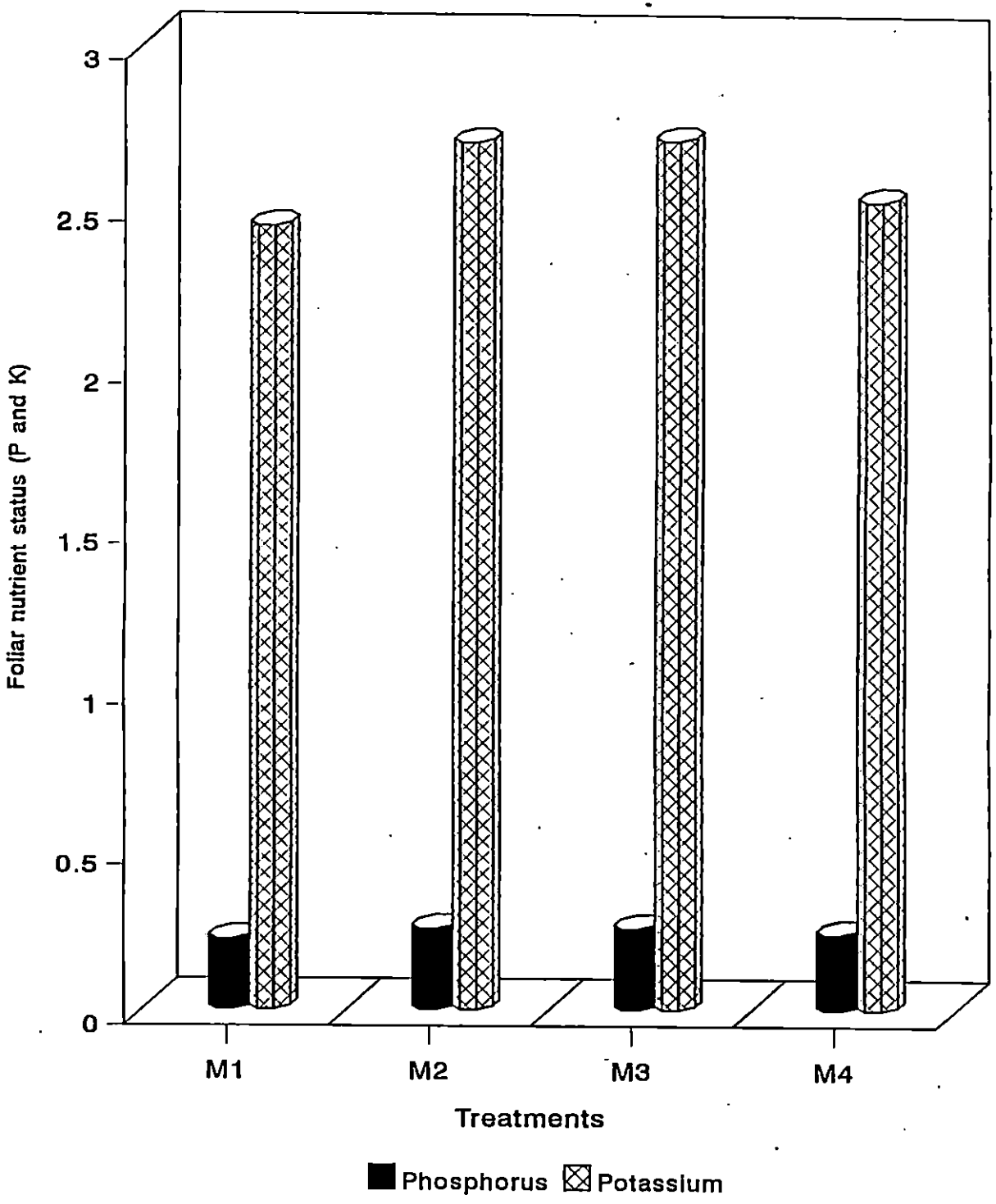


Fig. 6. Effect of manurial treatments on foliar nutrient status (P and K) at harvest

This might be due to P transmission from vegetative part for the development and bulking of fingers at later stage.. The leaf P content was higher with M_3 and M_2 treated plants. This might be due to the reduction of P fixation by formation of phosphohumic complex. Increase in leaf P with poultry manure was reported by Iyengar *et al.* (1984) in banana cv. Robusta. The P content on leaf showed an increasing trend with increased K availability. This might be due to the synergistic relation between K and P. Similar findings were reported by Lahav (1973), Turner and Barkus (1985) and Suman George (1994).

Among the nutrients, the concentration of K was highest in banana compared to N and P. The key role played by K in the synthesis of sugars and maintaining the water relations of the plant might be the cause for the requirement of this element in large quantities according to Martin Prevel (1962). Maximum content of K in leaf was recorded during the vegetative phase.

During flowering and harvest stages maximum K was noticed with M_3 and M_2 plots. The increase in the K_2O content might be due to higher uptake of K which could be the result of better physical and chemical properties by the poultry manure and neem cake treatments. The increase in tissue K concentration due to higher K availability was reported by Sheela (1982), Irizzary *et al.* (1988) and Sumam George (1994).

5.4. Bunch yield

In banana, the bunch characters viz., number of hands, number of fingers bunch^{-1}, weight of hand, length, girth and weight of individual fingers are considered as determinants of yield (Stover and Simmonds, 1987). In the present study it was noticed that all the yield attributing characters recorded the highest with poultry manure of 5 kg plant^{-1} (M_2). This might be due to higher availability of nutrients from this treatment. Among the morphological characters, the girth of the pseudostem at shooting was reported to be a determinant of yield by Rosamma and Namboothiri (1990). In the present study, also M_2 and M_3 registered higher girth of pseudostem at shooting stage which reflected a positive influence on different fruit characters. Among the different bunch characters studied weight of bunch and length of bunch were significantly influenced in this treatment. Though not significant higher number of fingers bunch^{-1} and length of bunch were influenced by poultry manure treatment. Improved vegetative characters particularly higher leaf area at this level especially at harvest stage might have resulted in the production of more photosynthates. The effect of increased photosynthetic efficiency was expressed in the higher bunch length and increased number of fingers bunch^{-1} recorded at M_2 level.

The other organic manures were on a par with each other on the production bunch yield. Thus the effectiveness of all the three source

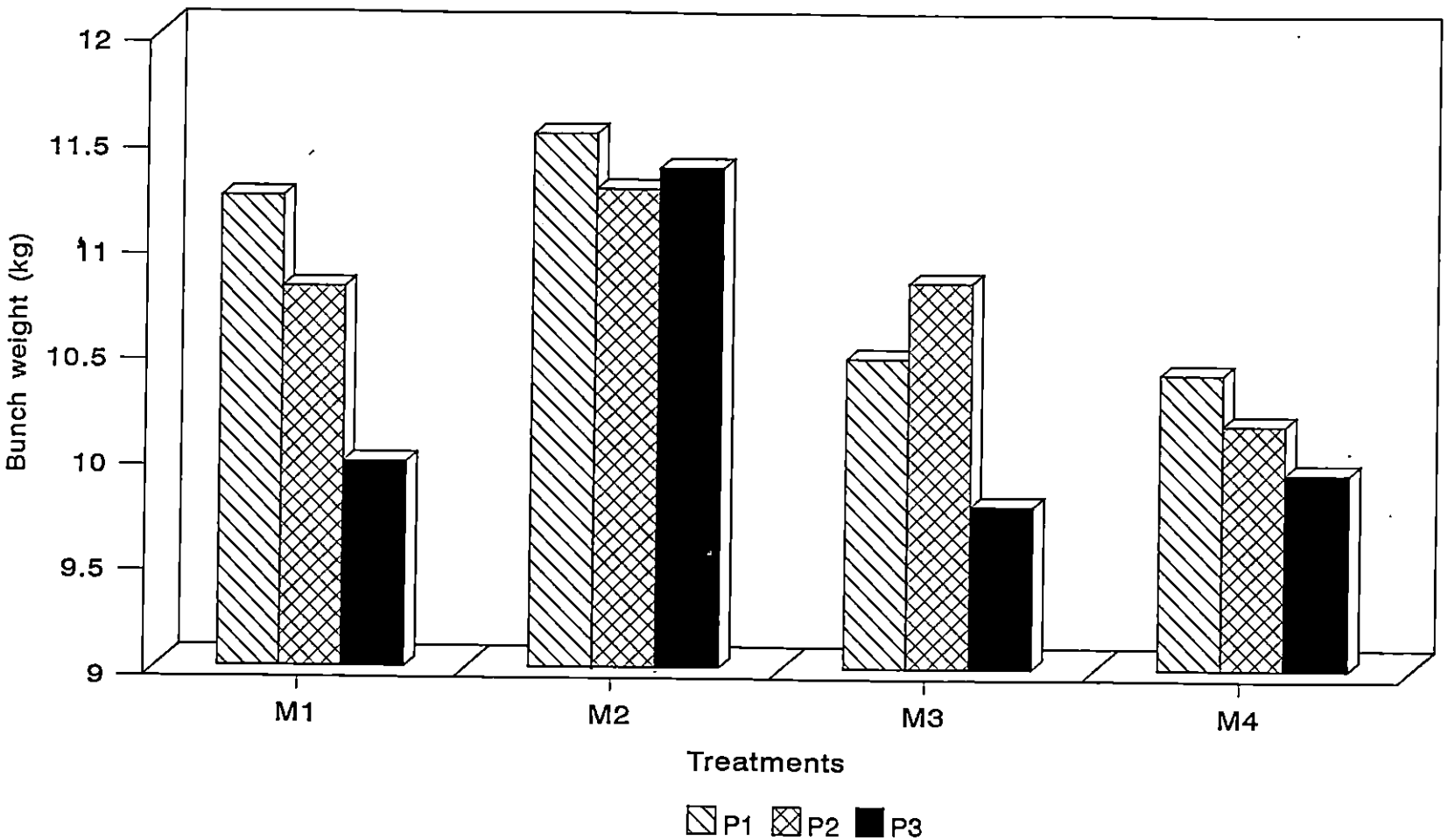


Fig. 8. Interaction effect of treatment on bunch weight of banana var. Nendran

are comparable and depending on this availability the present recommended of FYM (KAU, 1996) can be substituted by poultry manure or vermicompost at the rate of five kg plant^{-1}.

Lack of significant difference is due to low dose of 2,4-D. 2,4-D at higher concentration might have recorded more pronounced results. Similar trend was noticed in 'Nendran' with 2,4-D at 25 and 30 ppm by Aravindakshan (1981) and Chellapan (1983) on the bunch weight of banana.

In the case of interaction effect of treatments, though not significant the maximum weight of bunch was observed with M_2P_1 (Fig. 8). This might be due to effective diversion of nutrient especially P and K to the economic part and their higher availability due to better organic matter enrichment during flower bud initiation. Scope of yield increase by higher K availability were given by Baruah and Mohan (1992) and Sumam George (1994) in different cultivars of banana. Increase in number of fingers and yield of banana with increased nitrogen application has been reported by Mustaffa (1983). In other treatments, the higher levels of nutrients seem to have induced only vegetative growth and nutrient uptake without resulting in effective diversion of the same to the economic part.

5.5. Fruit characters (Mature, ripe)

Fruit characters mature and ripe are presented in Fig. 9 to Fig.12. Weight of finger and dry weight of pulp was significantly influenced by

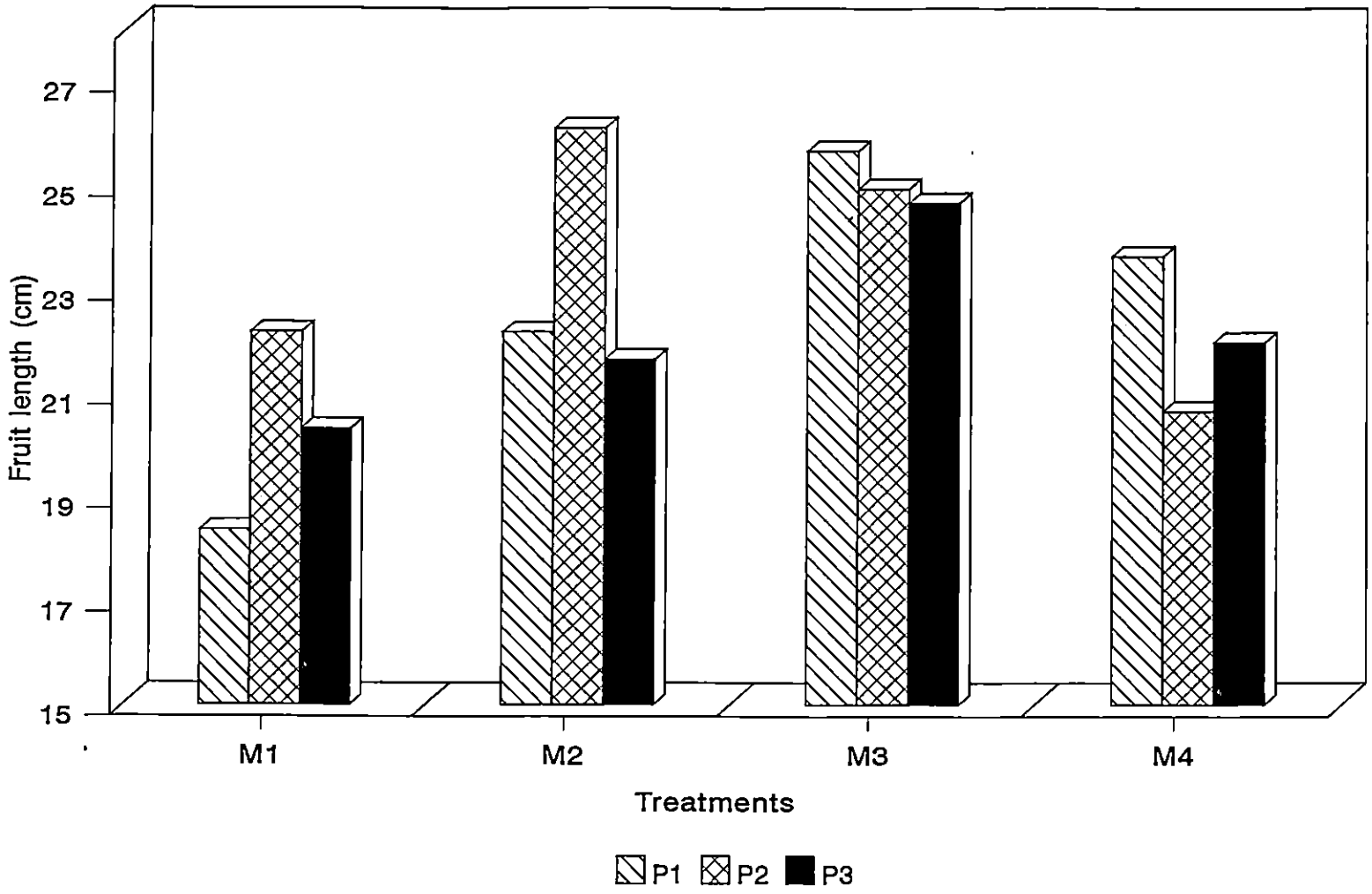


Fig. 9. Interaction effect of treatments on the length of fruit

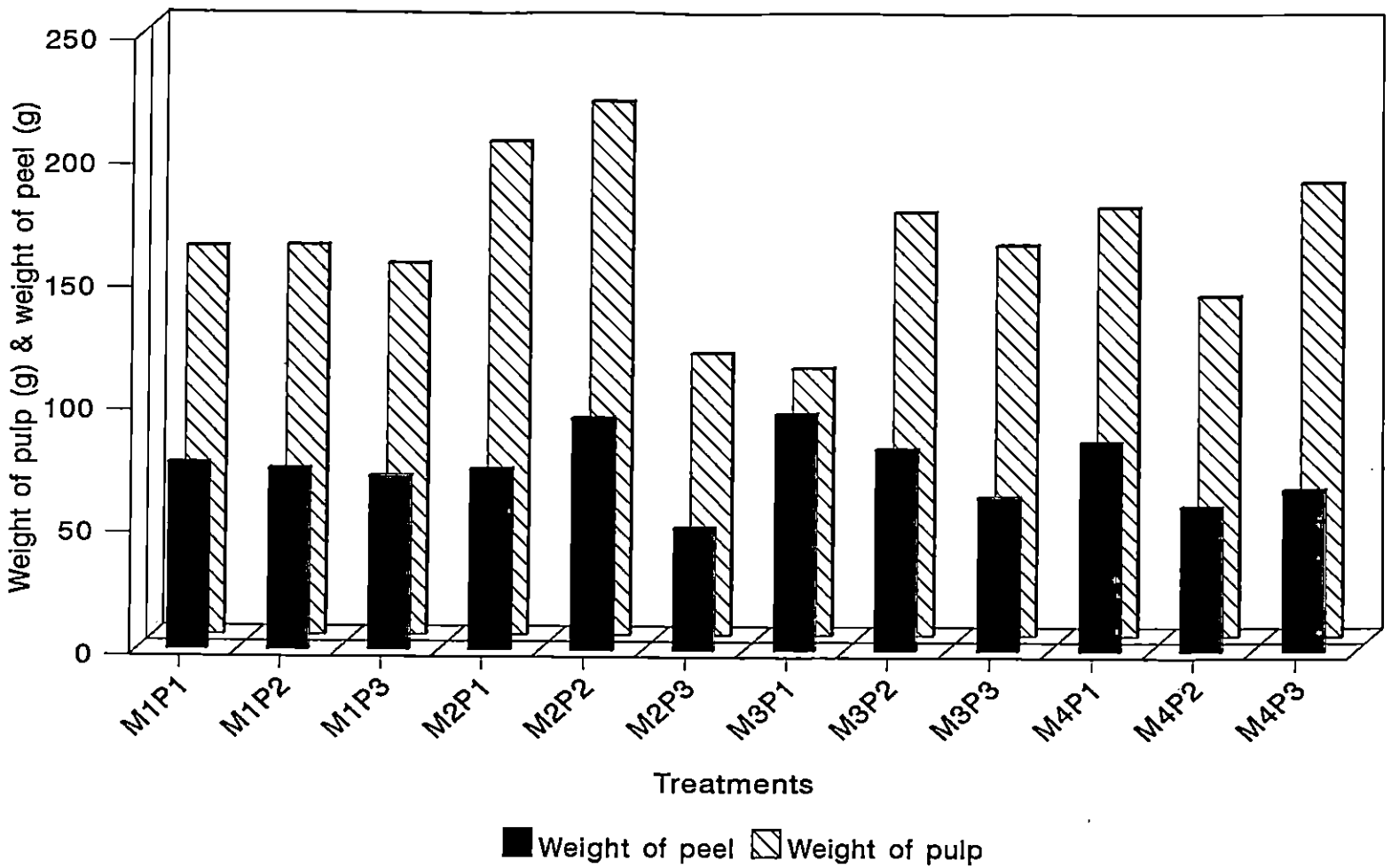


Fig. 10. Interaction effect of treatments on the weight of pulp and weight of peel

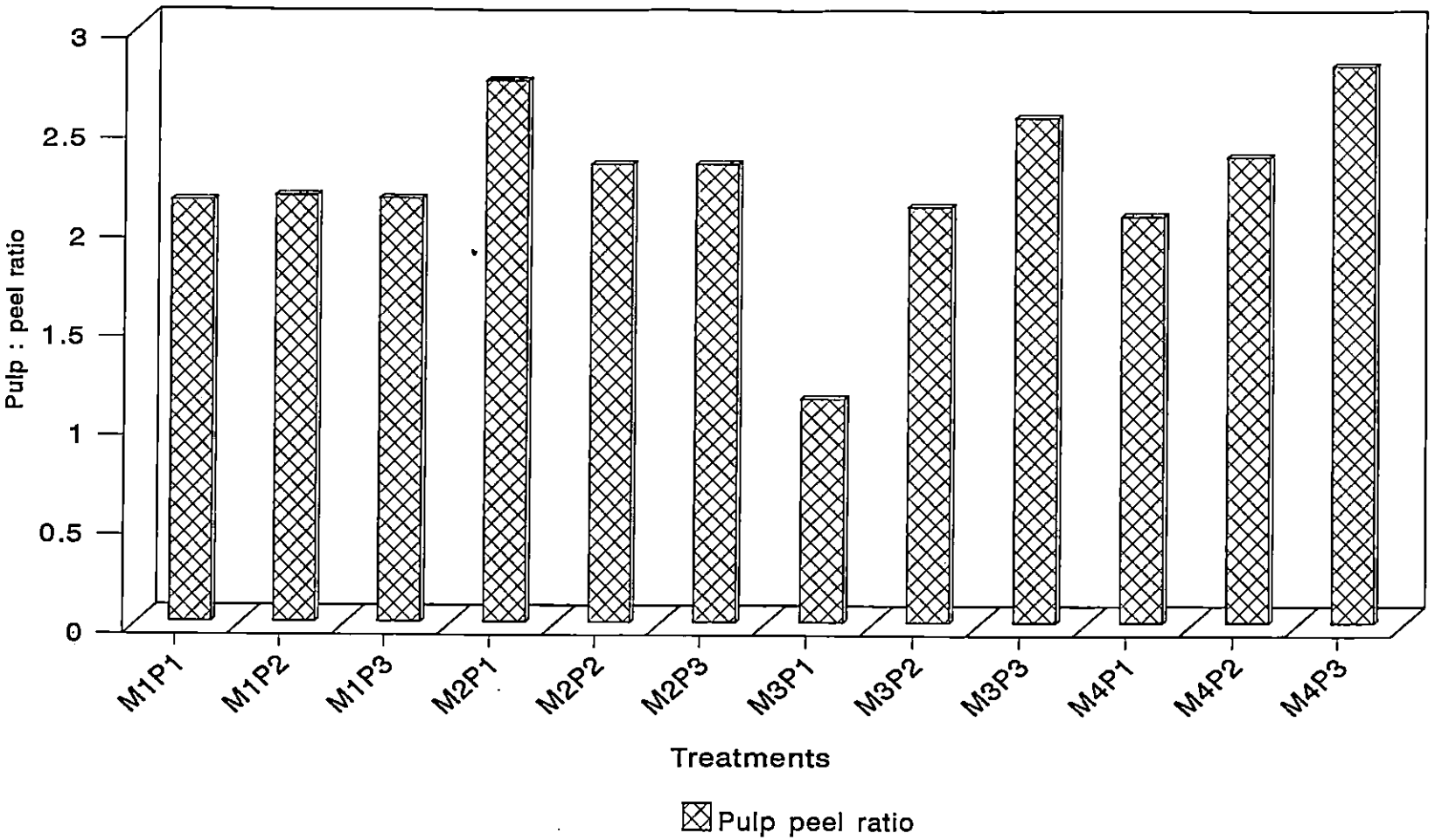


Fig. 11. Interaction effect of treatments on pulp / peel ratio

the application of poultry manure (M_2). Length of fruit and girth of fruit were influenced by the sources of organic manures. The package of practice recommendation (M_1) showed a reduction in these aspects compared to other sources. This might be due to better vegetative growth and nutrient availability to the plant reflected in the growth and yield attributing characters discussed earlier. Length of fruit was more with M_2 and M_3. This might be due to availability of nutrients from these treatments. Similar to length of fruit, girth was also influenced by M_3 which was on par with M_2 and M_4. This again might be a reflection of vegetative growth. It was also noticed that in M_1, there was a reduction in pulp weight which might be due to greater partition of dry matter to the peel. Higher pulp-peel ratio with six splits of recommended NPK was reported by Dovilyn peters (1997). In present experiment also balanced availability of nutrients in M_2, M_3 and M_4 might have resulted in better filling of pulp than M_1. From this we could infer that higher bunch weight by poultry manure is mainly contributed by better fruit characters than bunch characters especially weight of fruit, dry weight of pulp and length of fruit.

Among, the post shooting treatments the application of urea one per cent spray, recorded a marginal increase in most of the fruit characters. This might be due to the partial absorption of N by the active growing fingers. Similar results were reported by Venkatarayappa *et al.* (1978) with post shootinging spraying of urea. Among the interaction

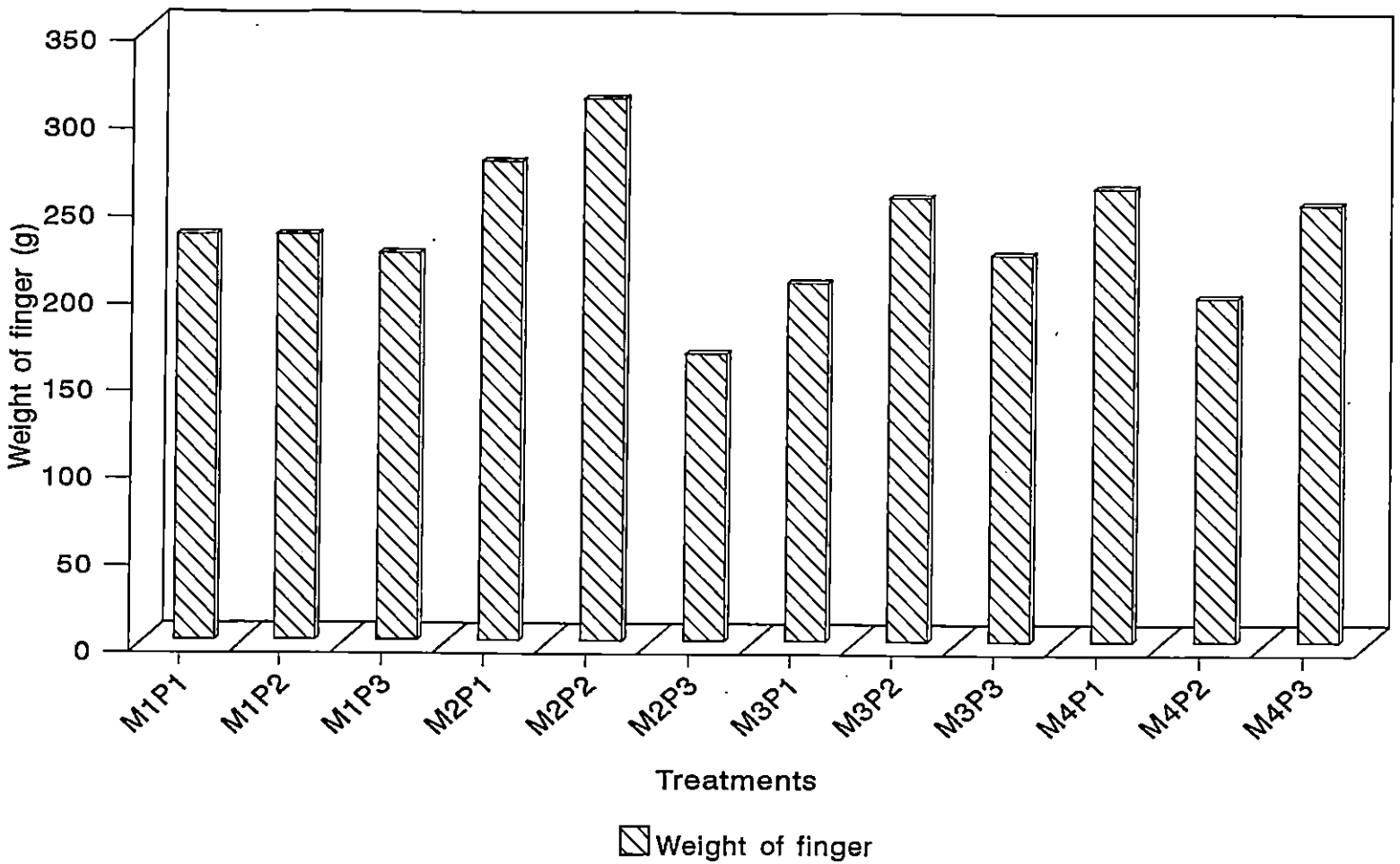


Fig. 12. Interaction effect of treatments on weight of finger

effect maximum length was noticed for M_2P_2 and this might be due to better availability of nutrients for filling up of pulp.

In the case of ripe fruit, marginal increase in most of the fruit characters was noticed with level M_2. This might be due to better availability of K and better physical and chemical property of soil with more of organic matter available during the fruit development stage. Higher pulp weight might be the consequence of satisfactory activity of the enzymes involved in starch and protein synthesis under adequate N and K levels (Sheela, 1982 and Martin Prevel, 1989). Peel weight was maximum with Neem cake 5 kg $plant^{-1}$, resulting in minimum pulp-peel ratio. This might be due to balanced N availability. Among the post shooting treatments higher weight of pulp and finger was observed with urea one per cent spray which might be due to its direct role in improving the pulp weight. Pulp-peel ratio was higher with urea tying 15 g on peduncle. Availability of urea in acqueous form at later stages and for a prolonged period tend to increase pulp-peel ratio by reducing thickness of peel. In the case of interaction effect, weight of pulp and weight of finger was higher with M_2P_2. Production of more photosynthates by higher leaf area at maturity stage might have increased the translocation of carhohydrates from leaves to fruit which might have contributed to significant improvement in fruit characters.

5.6. Fruit quality

The quality characters included in the present study were total soluble solids (TSS) ascorbic acid, acidity, total, reducing and non

reducing sugars, sugar / acid ratio and shelf life of ripe fruits as well as starch content of mature fruits. The above characters are presented in Fig. 13 to Fig. 15.

All the quality characters of the fruit except the non reducing sugar, starch and shelf life of fruits were significantly influenced by the treatments. According to Sheela (1995) quality of the fruits was best expressed in terms of high TSS, total and non reducing sugar, low acidity and high sugar / acid ratio when supplied with 200 g N.

Maximum TSS of fruit was observed with a combination of FYM at the rate of 5 kg plant^{-1} and 2,4-D 10 ppm spray. This might be due to the hormonal effect of 2,4-D and increased availability of macro nutrients from FYM. Pillai and Shanmugavelu (1978) observed fruit quality in 'Poovan' in terms of TSS was related with functional leaf area. In present study, functional leaf area was highest in FYM treated plots and was reflected in getting higher TSS.

Acidity was high in FYM treated plots and the maximum acidity for interaction was noticed with a combination of FYM and urea tying 15 g on peduncle. This might be due to increased availability of nutrients especially N. Sindu prabhakar (1996) observed increase in acidity with increased availability of nitrogen. In the case of interaction effect of treatments lowest value of acidity noticed with Neem cake. This might be due to increased availability of K from Neem cake. This reduction in

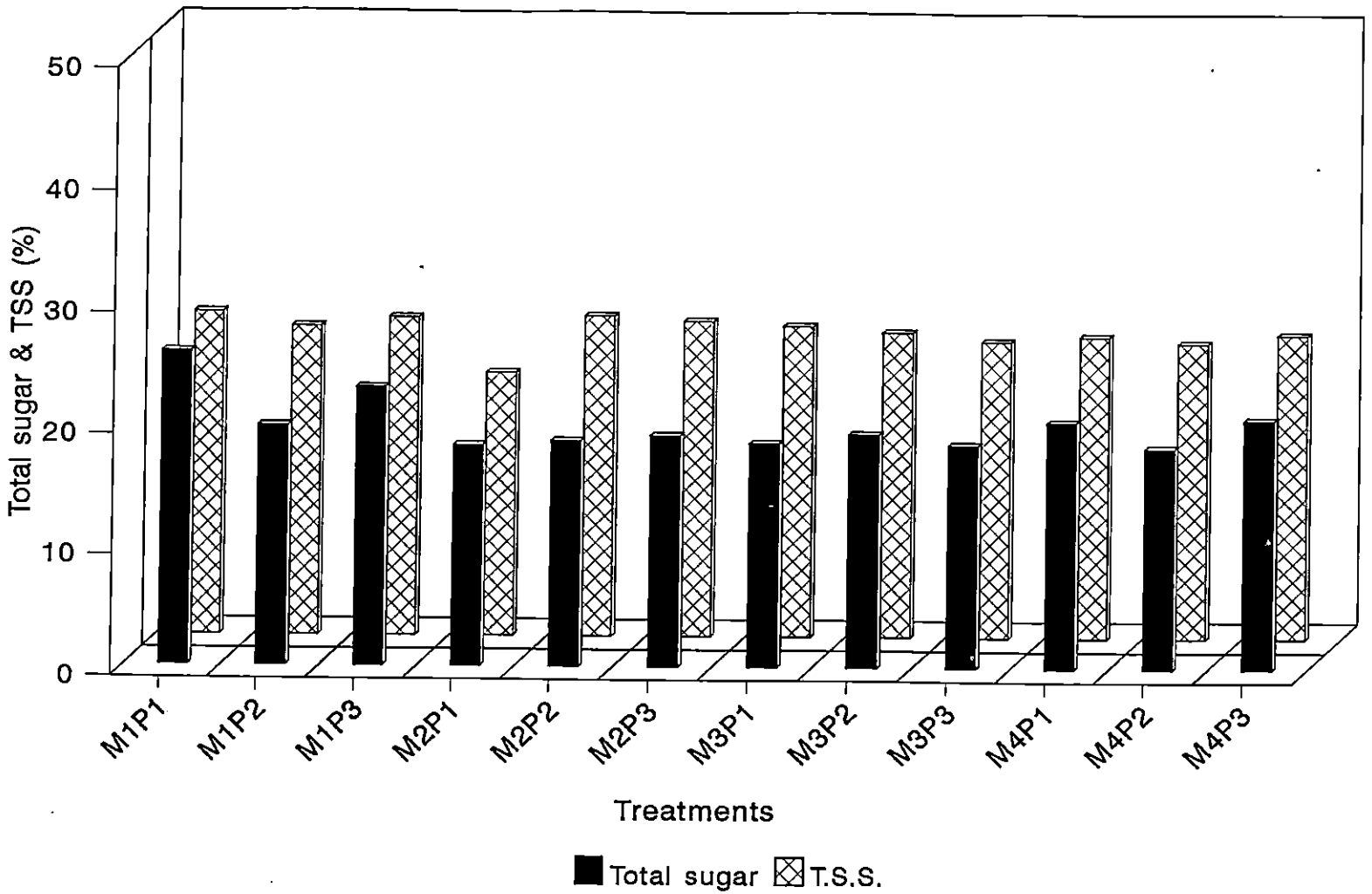


Fig. 13. Interaction effect of treatments on total soluble solids and total sugar content of ripe fruits

acidity with increasing K levels in the tissue was due to neutralisation of organic acids (Tisdale 1985).

The total and non reducing sugar was highest with FYM at the rate of 10 kg per plant (M_1). Increase in sugar observed might be due to respirational demand, adequate supply of nutrients, synthesis of invertase and starch splitting enzymes (Barnell, 1940). Reducing sugar was maximum with a combination of farm yard manure and 2,4-D 10 ppm spray. According to Nitos and Evans (1969) higher availability of N and K might have decreased the activity of sucrose. Synthetase and increased activity of hydrolytic enzymes such as amylase and saccharase. This led to accumulation of soluble carbohydrates especially monosaccharides and hence reducing sugar content was maximum.

The sugar-acid ratio was high with PM at 5 kg plant^{-1}. This was due to significant reduction in acidity with PM. Sugar-acid ratio was high with higher availability of K according to Vadivel and Shanmugavelu (1978) in banana cv. Robusta.

Shelf-life was highest with vermicompost at 5 kg plant^{-1}. This might be due to improved soil characteristics and better availability of nutrients especially K. There are reports on the effect of K on improving the storage life of banana as a result of increased thickness and firmness of rind (Van Uexkull, 1970). The level M_4 was on par with M_3. Martin-prevel (1989) observed an enhanced production of ascorbic acid under

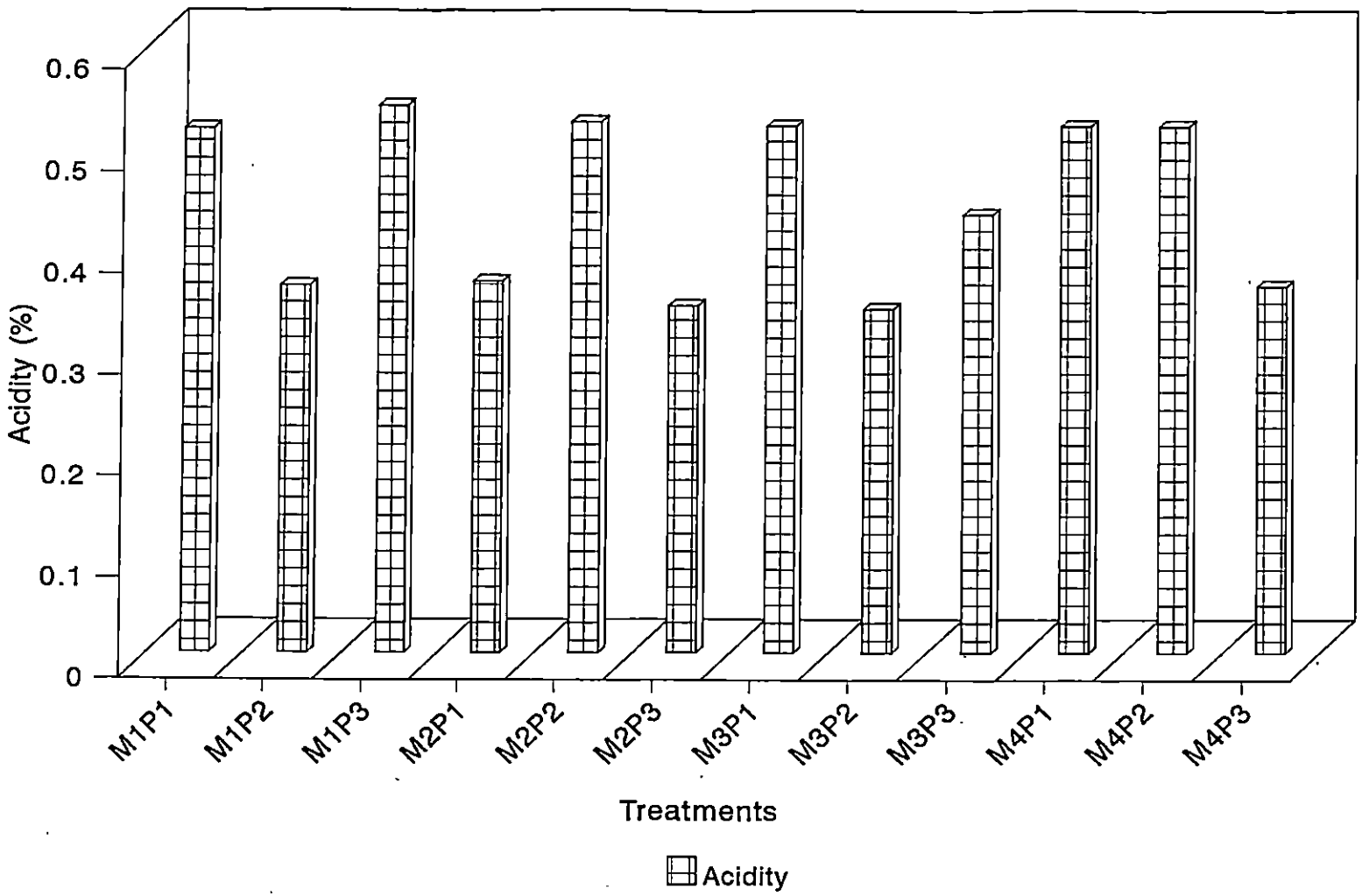


Fig. 14. Interaction effect of treatments on acidity of ripe fruits of banana var. Nendran

higher K level which was responsible for the slowing down of oxidation processes responsible for enzymatic browning on the peel of fruit.

5.7. Effect of different treatments on soil nutrient status

The soil chemical properties included in the study were available N, available P and available K. The available N content was high after the experiment than the initial available soil N for all manurial treatments with maximum value observed in plots treated with M_1 level. Lesser nitrogen content on plots treated with M_4, M_3 and M_2 levels might be due to higher uptake of nitrogen, in addition to the other nitrogen losses in the soil. The inorganic nitrogen added to all experimental plots may also enhance the nitrate nitrogen content of the soil, possibly due to conversion of applied mineral nitrogen through nitrification process (Krishnan, 1986). The soil characters are presented in Fig. 16.

The available P content is high in the soil even after harvest of banana. This may be due to build up of soil P due to application of manures. The available P content of soil is high even after harvest as the phosphatic fertilizers which are highly reactive are fixed in the soil and become immobile. Application of manures and fertilizers in a soil with relatively high available phosphorus status and high release of fixed phosphorus and the reduced uptake of phosphorus in the presence of N and K may be the reason for high phosphorus status in the soil after the experiment.

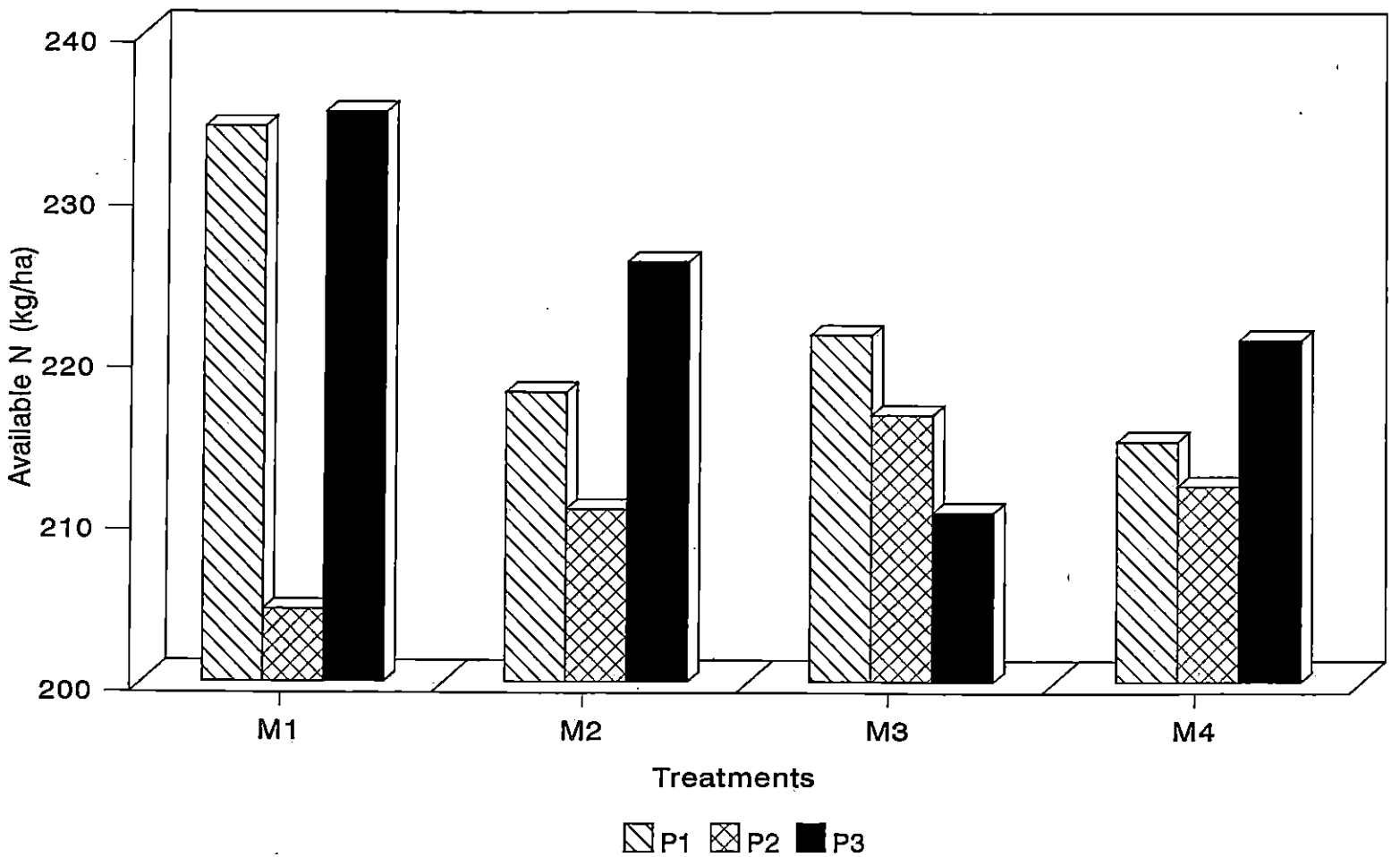


Fig. 16. Interaction effect of treatments on soil nutrient status (N) after harvest of banana var. Nendran

The available K content of soil after the experiment was higher compared to initial status. According to Sindu Prabhakar (1996) a marginal increase was noticed in available K content of the soil indicating better synergistic effect between N and available K.

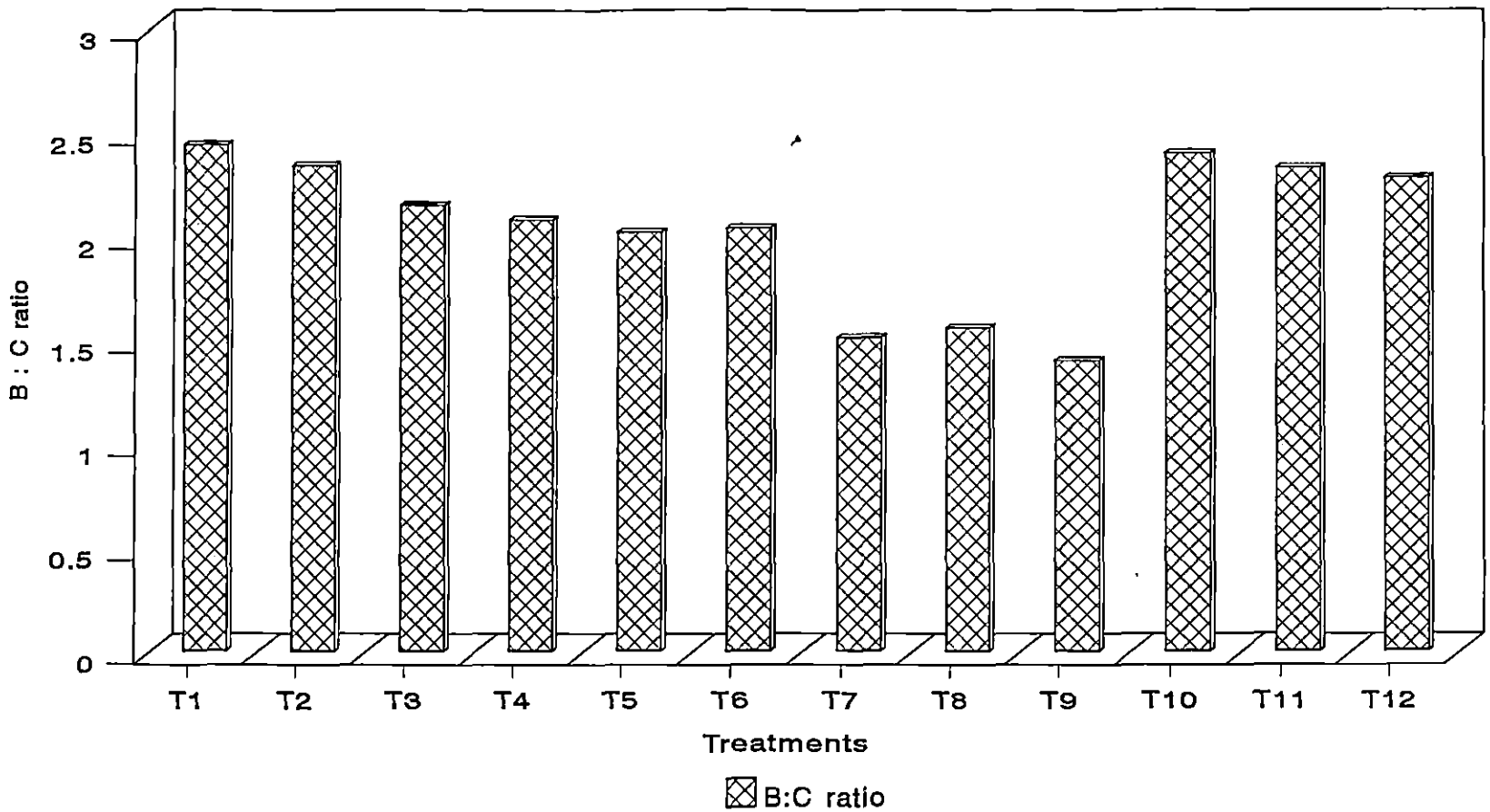
In the case of interaction effect, it was observed that available potassium status of the soil after harvest was relatively high. K availability is greatly influenced by clay content of soil and other factors which influence K fixation and release apart from the uptake of the crop.

5.8. Sensory evaluation of ripe fruits

Statistical scrutiny of the scores recorded for the sensory evaluation of ripe fruits of different treatment combinations revealed that the treatments did not significantly differ. In general, organic manuring improved quality of fruits.

5.9. Economics of production

The maximum net profit and benefit cost ratio was observed by T_1 (M_1P_1) (Fig. 17). This was due to comparatively higher bunch yield recorded at this level. The interaction effect of neem cake with post shooting treatments recorded lower profit and benefit cost ratio. This was due to the increased total cost of cultivation.



T1 - M1P1, T2 - M1P2, T3 - M1P3, T4 - M2P1, T5 - M2P2, T6 - M2P3,
T7 - M3P1, T8 - M3P2, T9 - M3P3, T10 - M4P1, T11 - M4P2, T12 - M4P3

Fig. 17. Effect of treatments on Economics of production

SUMMARY

SUMMARY

The present investigation on yield maximisation of banana, *Musa* (AAB group) 'Nendran' was undertaken in the instructional farm of College of Agriculture, Vellayani, Trivandrum during the period from January 1995 to November 1995. The main objective were to study effect of different combination of organic manures along with inorganic nutrients on biometric, yield and quality characters of irrigated 'Nendran' banana.

The soil of the experimental site belongs to the taxonomic class 'kaolinite Isohyperthermic Rhodic Haplustox' with a textural class of sandy clay loam. The biometric observations were carried out at the vegetative stage, flowering stage, bunch maturation stage and harvest stage.

The results of the investigation are briefly summarised below.

1. Height of the plant was maximum with poultry manure at the rate of 5 kg plant^{-1}. In all stages of growth, combination of farm yard manure at the rate of 5 kg plant^{-1} and 2,4-D 10 ppm spray produced taller plants.

2. Girth of plant was maximum with Neem cake at the rate of 5 kg per plant. Although not significant higher girth was recorded with a combination of Neem cake at 5 kg plant^{-1} and urea 1 per cent bunch spray.

3. Functional leaf area was maximum during fifth month with vermicompost at 5 kg plant^{-1}. Leaf area duration was maximum with poultry manure at 5 kg plant^{-1}.

4. The total crop duration was lowest in plots treated with vermicompost at 5 kg per plant. Longest duration was noticed in plots treated with poultry manure at 5 kg per plant. This increase in duration resulted in increased bulking of fruit and consequently higher bunch weight.

5. Manurial treatment had significant influence on the foliar leaf content of N with a maximum observed with Neem cake at 5 kg plant^{-1} at harvest stage.

6. Manurial treatment had significant influence on the foliar leaf content of P during harvest, with maximum value recorded with neemcake at 5 kg plant^{-1}, which was on par with poultry manure treatment.

7. The leaf content of K during harvest was maximum with neem cake at 5 kg plant^{-1}. A combination of poultry manure at 5 kg plant^{-1} and urea 1 per cent spray recorded maximum leaf content of K.

9. Length and girth of fruit, dry weight of peel, were significantly influenced among the fruit characters studied at maturity stage. Length of fruit was maximum with poultry manure at 5 kg plant^{-1}. The combination of poultry manure and urea 1 per cent spray recorded maximum length of fruit. Girth of fruit was maximum with level M_2. Dry weight of peel was maximum with FYM at the rate of 10 kg plant^{-1} and in the case of interaction FYM and 2,4-D 10 ppm spray recorded maximum dry weight of peel.

10. All the fruit characters at ripe stage, *viz.*, weight of pulp, weight of peel, weight of finger, pulp-peel ratio were significantly influenced by the treatments. Maximum weight of pulp and finger was observed with a combination of poultry manure and urea 1 per cent spray. Pulp peel ratio was maximum with poultry manure at 5 kg plant^{-1}.

11. Available NPK content of soil after harvest was higher compared initial soil test values. Highest available N and available K was observed in plots treated with FYM at 10 kg plant^{-1}. Highest available P was recorded with plots treated with vermicompost at the rate of 5 kg plant^{-1}.

12. High total soluble solids were obtained with FYM at 10 kg plant^{-1}. Low acidity were recorded with poultry manure at 5 kg plant^{-1}. Longer shelf life was recorded with vermicompost and 2,4-D spray (M_4P_1) which was on par with (M_4P_3). Total sugar was maximum with a combination of FYM at 5 kg plant^{-1} and 2,4-D 10 ppm spray.

13. Sensory evaluation of fruits revealed that all the treatment combination produced fruit with similar taste. Texture of fruits from FYM treated plots was superior to other treatments.

14. Maximum benefit cost ratio was recorded by FYM and 2,4-D 10 ppm spray which was followed by vermicompost and 2,4-D 10 ppm spray. The highest net profit was realised ha^{-1} in T_1 and lowest in T_9.

From the findings of the present investigation, it is seen that poultry manure at 5 kg plant^{-1} along with KAU package of practice recommendation for inorganic nutrients gives maximum yield. The effectiveness of other three sources are comparable and depending on its availability the present recommended dose of FYM can be substituted by poultry manure at 5 kg plant^{-1} or vermicompost at 5 kg plant^{-1}. Among the post shoot treatments 2,4-D 10 ppm spray recorded higher bunch weight.

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* Originals not seen

APPENDICES

Appendix - 1

Weather Data

Month 1995	Temperature °C Maximum	Minimum	Rainfall (mm)	Relative Humidity (%)
January	31.30	22.60	8.40	77.00
February	31.98	23.14	...	72.54
March	32.74	23.73	5.00	71.48
April	32.44	24.89	137.40	76.50
May	31.52	24.84	365.20	78.32
June	30.15	24.43	228.60	84.08
July	28.85	23.91	143.70	82.16
August	29.16	24.06	58.80	83.68
September	29.50	24.05	83.50	86.27
October	30.52	24.05	113.90	79.10
November	30.41	23.40	246.30	81.19
December	31.50	20.03	...	81.32

Appendix - 2

Cost of cultivation for different treatments in banana (ha^{-1})

Details	T_1			T_2			T_3			T_4			T_5			T_6	
	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)
1. Clearing of land	60		4800	60		4800	60		4800	60		4800	60		4800	60		4800
2. Earthing up	50		4000	50		4000	50		4000	50		4000	50		4000	50		4000
3. Making irrigation and drainage channels	40		3200	40		3200	40		3200	40		3200	40		3200	40		3200
4. Taking pits	65		5200	65		5200	65		5200	65		5200	65		5200	65		5200
5. Planting materials	2500		5000	2500		5000	2500		5000	2500		5000	2500		5000	2500		5000
6. Planting	20		1600	20		1600	20		1600	20		1600	20		1600	20		1600
7. Irrigation after planting for one months (once in 3 days)	100		8000	100		8000	100		8000	100		8000	100		8000	100	8000	
8. Cost of fertilizer																		
a. Urea - Rs. 3.32/kg		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428
b. Mp - Rs. 2.101 kg		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75
c. MOP - Rs. 5.25/kg	FYM 25MT	1250	6562.50 10000	FYM 25MT	1250	6562.50 10000	FYM 25MT	1250	6562.50 10000	PM 12.5MT	1250	6562.50 31250	PM 12.5MT	1250	6562.50 31250	PM 12.5MT	1250	6562.50 31250

Details	T_1			T_2			T_3			T_4			T_5			T_6		
	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)
9. Fertilizer application																		
i. At planting	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
ii. Manure application	10		800.00	10		800.00	10		800.00	10		800.00	10		800.00	10		800.00
iii. 1 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
iv. 2 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
v. 4 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
vi. 5 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
After complete flowering	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
10. Auxin or urea spraying / urea tying	10		800.00	15		1200 20.75	10		1200 124.50	10		800	15		1200 20.75	15		1200 124.50
11. Irrigation after 6 fertilizer application	30		2400.00	30		2400.00	30		2400.00	30		2400.00	30		2400.00	30		2400.00
12. Irrigation during summer months (once in 2 days for 2 months)	200		16,000	200		16,000	200		16,000	200		16,000	200		16,000	200		16,000
13. Clearing of channels	6		480	6		480	6		480	6		480	6		480	6		480
14. Weeding	50		4000	50		4000	50		4000	50		4000	50		4000	50		4000
15. De-suckering	5		400	5		400	5		400	5		400	5		400	5		400
16. Propping	20		1600	20		1600	20		1600	20		1600	20		1600	20		1600
17. Cost of proppig material Rs. 5 plant^{-1}			12,500			12,500			12,500			12,500			12,500			12,500
18. Harvesting and transporting of bunches	75		6000	75		6000	75		6000	75		6000	75		6000	75		6000
Total expenditure			1,03629.25			1,04050.00			1,04153.75			1,24879.25			1,25300.00			1,25403.75

Appendix - 2 (Contd...)

Cost of cultivation for different treatments in banana (ha^{-1})

Details	T_7			T_8			T_9			T_{10}			T_{11}			T_{12}	
	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)
1. Clearing of land	60		4800	60		4800	60		4800	60		4800	60		4800	60		4800
2. Earthing up	50		4000	50		4000	50		4000	50		4000	50		4000	50		4000
3. Making irrigation and drainage channels	40		3200	40		3200	40		3200	40		3200	40		3200	40		3200
4. Taking pits	65		5200	65		5200	65		5200	65		5200	65		5200	65		5200
5. Planting materials	2500		5000	2500		5000	2500		5000	2500		5000	2500		5000	2500		5000
6. Planting	20		1600	20		1600	20		1600	20		1600	20		1600	20		1600
7. Irrigation after planting for one months (once in 3 days)	100		8000	100		8000	100		8000	100		8000	100		8000	100	8000	
8. Cost of fertilizer																		
a. Urea - Rs. 3.32/kg		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428		1032.5	3428
b. Mp - Rs. 2.101 kg		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75		1437.5	3018.75
c. MOP - Rs. 5.25/kg	NC 12.5MT	1250	6562.50 62500	NC 12.5MT	1250	6562.50 62500	NC 12.5MT	1250	6562.50 62500	VC 12.5MT	1250	6562.50 3750	VC 12.5MT	1250	6562.50 3750	VC 12.5MT	1250	6562.50 3750

Details	T_1			T_2			T_3			T_4			T_5			T_6		
	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)	No. of lab. @ Rs.80/-	Qty.	Amount (Rs.)
9. Fertilizer application																		
i. At planting	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
ii. Manure application	10		800.00	10		800.00	10		800.00	10		800.00	10		800.00	10		800.00
iii. 1 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
iv. 2 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
v. 4 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
vi. 5 MAP	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
After complete flowering	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00	8		640.00
10. Auxin or urea spraying / urea tying	10		800.00	15		1200 20.75	10		1200 124.50	10		800	15		1200 20.75	15		1200 124.50
11. Irrigation after 6 fertilizer application	30		2400.00	30		2400.00	30		2400.00	30		2400.00	30		2400.00	30		2400.00
12. Irrigation during summer months (once in 2 days for 2 months)	200		16,000	200		16,000	200		16,000	200		16,000	200		16,000	200		16,000
13. Clearing of channels	6		480	6		480	6		480	6		480	6		480	6		480
14. Weeding	50		4000	50		4000	50		4000	50		4000	50		4000	50		4000
15. De-suckering	5		400	5		400	5		400	5		400	5		400	5		400
16. Propping	20		1600	20		1600	20		1600	20		1600	20		1600	20		1600
17. Cost of proppig material Rs. 5 plant^{-1}			12,500			12,500			12,500			12,500			12,500			12,500
18. Harvesting and transporting of bunches	75		6000	75		6000	75		6000	75		6000	75		6000	75		6000
Total expenditure			1,56129.25			1,56550.00			1,56656.75			97,379.25			97,800.00			97,903.75

Appendix - 3

Sensory evaluation of the attributes (organoleptic evaluation)

Evaluation card for triangle test

In the triangle test, three sets of sugar solution of different concentrations were used of which two solutions were identical. The panel members were asked to identify the sugar solution of different concentrations.

Name of the products : Sugar solution

Note : of the three samples given, identify the odd sample

Sl. No.	Code No. of Samples	Code No. of the identical sample	Code No. of the odd sample
1.	XYZ		
2.	ABC		
3.	PQR		

Score Card

Criteria

1.	Taste	Excellent	—	5
		Very good	—	4
		Good	—	3
		Fair	—	2
		Poor	—	1
2.	Flavour	Very pleasant	—	5
		Pleasant	—	4
		Neither pleasant nor unpleasant	—	3
		Not pleasant	—	1
3.	Colour	Very acceptable	—	5
		Acceptable	—	4
		Slightly acceptable	—	3
		Neither acceptable nor unacceptable	—	2
		Unacceptable	—	1
4.	Texture	Soft	—	5
		Neither hard nor soft	—	4
		Hard	—	3
		Very hard	—	2
		Brittle	—	1

YIELD MAXIMISATION OF BANANA (*Musa AAB group* 'Nendran') THROUGH ORGANIC AND INORGANIC MANURING

By

BAIJU. B. R.

ABSTRACT OF A THESIS

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VELLAYANI, THIRUVANANTHAPURAM

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ABSTRACT

An experiment was conducted at the Instructional farm attached to College of Agriculture, Vellayani during January 1995 to November 1995 with the objective of finding out the different sources of organic and inorganic nutrients for increasing the productivity of Nendran banana, the effect of post shooting application of urea and growth regulators on the bunch weight and to work out the benefit cost ratio by the integrated use of organic and inorganic fertilizers. Four levels of manures and three levels of post shooting treatments were tried in RBD with 3 replications.

The results of the study revealed that application of poultry manure at the rate of five kg plant^{-1} increased total crop duration. Farm yard manure at the rate of 10 kg plant^{-1} and 2,4-D 10 ppm spray recorded maximum height at all stages.

Bunch yield was maximum of (11.39 kg) with poultry manure at 5 kg plant^{-1}. Highest bunch weight was recorded by 2,4-D 10 ppm spray and total number of fingers with urea 1 per cent spray.

Among the ripe fruit characters, highest pulp / peel ratio was with poultry manure at the rate of five kg plant^{-1} eventhough higher finger weight, pulp weight and lower peel weight were recorded with poultry manure at the rate of five kg plant^{-1}. Application of urea one per cent spray increased weight of finger.

Among the quality attributes, higher values for TSS were noticed with level M_1. Lowest value for acidity was observed for five kg poultry manure and tying urea 15 g. Total sugar was high with 10 kg farm yard manure and 2,4-D 10 ppm spray and non reducing sugar was high with level farm yard manure at 10 kg plant^{-1}. Sugar-acid ratio was low for vermicompost at the rate of five kg plant^{-1}. Sensory evaluation revealed that all treatments produced fruits with similar taste, flavour and colour.

N content of index leaf showed significant variation at harvest with maximum value recorded with neem cake at the rate of five kg plant^{-1}. P content of leaf was maximum with level neem cake five kg plant^{-1} and minimum with level farm yard manure 10 kg plant^{-1}. The K content of leaf was maximum with neem cake level five kg plant^{-1} among manurial treatment.

When the economics of production was worked out, it was observed that a combination of farm yard manure at 10 kg plant^{-1} and 2,4-D 10 ppm spray (M_1P_1) recorded the highest benefit cost ratio. The highest net profit of Rs. 1,49,045 was realised per hectare in farm yard manure at 10 kg plant^{-1} and 2,4-D 10 ppm spray.

The present study revealed that application of poultry manure at five kg plant^{-1} and 2,4-D 10 ppm spray was beneficial for better growth, yield and quality of fruit in 'Nendran' banana.