MAXIMISATION OF PRODUCTIVITY BY RESCHEDULING THE NUTRIENT APPLICATION IN BANANA

(*Musa AAB group 'Nendran'*)

By

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THESIS

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Dedicated to
my beloved parents

DECLARATION

I hereby declare that this thesis entitled "Maximisation of productivity by rescheduling the nutrient application in banana (Musa AAB group 'Nendran')" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

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CERTIFICATE

Certified that this thesis entitled "Maximisation of productivity by rescheduling the nutrient application in banana (Musa AAB group 'Nendran')" is a record of research work done independently by Miss. DOVELYN PETERS. C under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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LIST OF ABBREVIATIONS USED IN THIS THESIS

l	litre
m	metre
cm	Centimetre
%	Percent
N	Normal
g	Gram
kg	Kilogram
t	tonnes
^{0}C	Degree Celsius
cv.	Cultivar
var.	Variety
LAI	Leaf Area Index
TSS	Total Soluble Solid
MAP	Month After Planting
ANOVA	Analysis of Variance
FAI	Fertilizer Association of India
SPB	State Planning Board
N	Nitrogen
P	Phosphorus
K	Potassium
KAU	Kerala Agricultural University
TNAU	Tamil Nadu Agricultural University
B:C ratio	Benefit : Cost ratio
ha	hectare
RBD	Randomised Block Design
G	Granular
DP	Dustable Powder
mg	milligram

INTRODUCTION

INTRODUCTION

Banana, one of the earliest crops cultivated by man remains to be the most important fruit crop, especially of the tropics and the fourth important global commodity in terms of the gross value of the produce after rice, wheat and milk products. Compared with the world production of other fruits, the production of banana is second only to grapes. The crop is grown extensively in India, Africa, Phillippines and other tropical countries for home consumption as well as for export.

The importance of growing bananas in a tropical country like India is much greater as it plays a vital role both in the domestic and international trade. The country contributes 11 per cent of world's production of bananas and ranks second among the banana producing countries of the world. The crop occupies an area of 4.19 lakh ha with an annual production of 99.35 lakh tonnes which corresponds to 24 per cent of the total production of fruit crops in India (FAI, 1996). Banana is the foremost major fruit crop of Kerala both in terms of area and production. The area under banana in Kerala is 0.24 lakh ha leading to a production of 3.5 lakh tonnes (SPB, 1997). 'Nendran' is the popular and commercially grown variety of banana in the state covering nearly 30 per cent of the total area under banana. 'Nendran' being a remunerative variety fetching a premium price has got various uses as the dessert and cooking variety and it is the principal raw material for several processed foods such as flour, chips etc. In the recent context of its export potential, especially to West Asian countries and the resultant large scale intensive cultivation, banana has acquired the commercial preposition.

Being a soil exhaustive crop, banana requires adequate quantities of nutrients throughout its growth period. Inspite of the predominance of banana as a fruit crop in Kerala its productivity is very low and the present nutrient recommendation is found to be insufficient to exploit its full potential. Nitrogen is the chief promoter of plant growth and hence it is essential to banana during early stages of crop growth especially when the meristem is developing. Being a mobile element timely application of nitrogen in small instalments is very important to correspond with the critical phases of growth. Similarly importance of potassium nutrition on banana is very well documented by several workers (Croutcher and Mitchell, 1940., Norris and Ayyar, 1942 and Rajeevan, 1985). Potassium proves to be the most important nutrient influencing both the quantitative and qualitative aspects of the crop and proper management of this nutrient has become pertinent to obtain high yield of quality fruits.

Field investigations revealed that banana farmers invariably apply larger quantities of fertilizers without any scientific basis. This is found to be much higher than the recommended dose as per POP. This has necessitated a reappraisal of the present fertiliser schedule for banana in order to exploit its full potential. Keeping this point in view, an experiment was conducted on nutrition of banana (*Musa* AAB group 'Nendran') with the following objectives of finding out the optimum fertilizer dose to maximise the productivity of banana and standardisation of the optimum frequency of fertilizer application for maximum yield.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Banana, one of the most important commercial fruit crops of Kerala, requires larger quantities of potassium, moderate quantities of nitrogen and relatively lower doses of phosphorus. Various experiments conducted in India and abroad showed that remarkable yield improvement in banana could be brought about by judicious and regular manuring.

The present experiment envisages to find out the most appropriate fertilizer dose and scheduling to maximise the productivity of banana var. Nendran. 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. A brief review of the literature relevant to the subject under study is detailed hereunder.

2.1 Relative importance of nutrients

Nitrogen and potassium requirements for banana in larger quantities have been reported as early as 1921 by Fawcett and later confirmed by Norris and Ayyar (1942). From the review of earlier works conducted on banana by Gandhi (1951), Osborne and Hewitt (1963) and Twyford (1967), it has been observed that phosphorus absorption by banana is less pronounced and has shown increased response for nitrogen and potassium.

Turner (1969) reported that banana requires high quantities of nitrogen and potassium and low quantity of phosphorus. The relative importance of nitrogen and potassium for maximising the yield of banana was reported by Ramaswamy and Muthukrishnan (1973).

Pillai *et al.* (1977) worked out the optimum dose of N and K_2O corresponding to maximum yield of fruit in 'Nendran' banana as 191 and 301 g $plant^{-1}$ respectively. However Nair *et al.* (1990) obtained the heaviest bunch with N and K at 400 g $plant^{-1}$ and 600 g $plant^{-1}$ respectively in six splits.

The package of practices recommendations by KAU (1996) for irrigated 'Nendran' banana in our state viz. 190:115:300g NPK $plant^{-1}$ also stresses the relative importance of N and K nutrition.

2.2 Vegetative characters as influenced by nutrient levels

2.2.1 Height and girth of pseudostem

2.2.1.1 Nitrogen

Nitrogen, the most important crop nutrient element, which is required throughout the crop growth period has marked influence on the vegetative characters. Battikhah and Khalidy (1962) observed increase in height of pseudostem with increase in nitrogen application in banana.

According to Garcia *et al*. (1976) excess nitrogen exerted a depressive effect on height and diameter of pseudostem of banana.

Ashok kumar (1977) and Valsamma Mathew (1980) observed significant increase in height and girth of pseudostem with higher levels of nitrogen. From the studies conducted by Anjorin and Obigbesan (1983) on 'Plantain', it was observed that nitrogen application upto 300 g plant^{-1} significantly increased plant height, pseudostem girth and pseudostem weight while higher rates (400 g plant^{-1}) depressed all these parameters. In a nutritional trial on 'Robusta' by Kohli *et al*. (1984) with six levels of nitrogen, plant height and pseudostem girth significantly increased with application of nitrogen.

Sharma (1984) in his studies on the effect of soil and foliar application of urea on the growth of banana cv. Basrai observed that plant height and pseudostem girth were highest in plants receiving 187.5 g N plant^{-1} applied to the soil + 187.5 g N plant^{-1} applied in 12 sprays at 2 weekly intervals.

In 'Dwarf Cavendish' banana, height and girth of pseudostem increased by application of nitrogen (Singh *et al*. 1990). Hazarika and Mohan (1991) observed increase in vegetative growth with increasing nitrogen levels (0 to 200 g plant^{-1}) in banana cv. Jahaji. Studies conducted by Singh and

Kashyap (1992) on 'Robusta' banana revealed that plant height was highest with 600 g N $plant^{-1}$ while pseudostem circumference was highest with 400 g N $plant^{-1}$.

Gubbuk *et al*. (1993) obtained highest growth rate of stems with 80 g N $plant^{-1}$ for 'Dwarf Cavendish' and 320 g N $plant^{-1}$ for 'Basrai'. Shawky *et al*. (1993) observed that vegetative growth increased with increasing nitrogen application in banana cv. Hindy plant.

2.2.1.2 Phosphorus

Phosphorus requirement of banana was much less compared to N and K as reported by Norris and Ayyar (1942) and Martin Prevel (1964). Jagirdar and Ansari (1966) found that in 'Basrai' banana stem girth showed an increase with phosphours application. Increase in pseudostem height was obtained with P_2O_5 application upto 60 g $plant^{-1}$ in 'Robusta' banana (Ramaswamy, 1976).

2.2.1.3 Potassium

Studies on K nutrition in rainfed banana cv. Palayankodan by Sheela (1982) revealed that the height of the pseudostem at late vegetative stage and shooting stage was influenced significantly by supply of potassium (0 to 600 g $plant^{-1}$).

Baruah and Mohan (1985) reported that height and diameter of the pseudostem responded significantly to K with the maximum effect at 250 g plant^{-1} in banana cv. Jahaji. Mustaffa (1987) opined that 400 g K_2O plant^{-1} significantly increased the height and circumference of pseudostem.

In banana cv. Nendran, Sumam George (1994) observed increased height and girth of pseudostem with increasing levels of potassium application at all growth stages. The effects were more pronounced from the shooting stage of the crop after it received the full dose of potash fertilizer.

In a study conducted on tissue cultured 'Nendran' banana at Vellayani, significant increase in height and girth of pseudostem was observed due to potassium application (Sheela, 1995). According to Sindhu (1997) height and girth of pseudostem showed an increasing trend with increase in the dose of potassium from 0 to 600 g plant^{-1} in Nendran.

2.2.1.4 Combined application of NPK

Pseudostem height was maximum with 180 g N plant^{-1} year^{-1} and 273.5 g K_2O plant^{-1} year^{-1} in 'Robusta' banana as reported by Kohli *et al*. (1976). In studies with banana cv. Basrai Dwarf, Singh *et al*. (1977) observed highest growth rate with N, P and K at the highest level viz. 150, 90 and 170 g plant^{-1} respectively.

According to Oubahou *et al.* (1987) N at 225 to 425 g plant^{-1} and P_2O_5 at 320 to 550 g plant^{-1} and K_2O at 320 to 550 g plant^{-1} increased height and pseudostem circumference of banana cv. Grande Naine when compared to no fertilizer treatments. In banana cv. Campierganj Local, Ram and Prasad (1989) obtained maximum plant growth with 300 g N, 120 g P_2O_5 and 200 g K_2O plant^{-1}.

Parida *et al.* (1994) observed increased plant height and stem girth in 'Robusta' banana with increasing rates of N (75 to 225 g plant^{-1}) P (0 to 60 g plant^{-1}) and K (75 to 225 g plant^{-1}). Application of nitrogen showed significant effect on height and girth of pseudostem.

2.2.2 Number of leaves and Leaf Area Index (LAI)

2.2.2.1 Nitrogen

According to Butler (1960) low rate of leaf production was noticed in bananas with reduction in levels of nitrogen. Kohli *et al.* (1985) reported that leaf area and leaf area index were significantly increased in 'Robusta' banana by nitrogen application. Singh *et al.* (1990) observed increase in leaf area index in 'Dwarf Cavendish' banana by application of nitrogen. In banana cv. Robusta, Singh and Kashyap (1992) obtained more number of leaves plant^{-1} with 400 g N plant^{-1}.

2.2.2.2 Phosphorus

Reports regarding the effect of phosphorus on the leaf characters are very meagre. However Shanmugavelu *et al*. (1992) reported the favourable influence of phosphorus fertilization on general vegetative growth of banana.

2.2.2.3 Potassium

Brezesowsky and Biesen (1962) reported increase in the number of leaves from the plots receiving the highest level of potassium. Yang and Pao (1962) observed that the number of functional leaves was not affected significantly by potassium in 'Fairyman' banana.

Ho (1968) reported that application of K at the early stage gave the largest number of leaves in banana cv. Fairyman.

Lacoevilhe (1973) clearly indicated that K application influenced the number of functional leaves. Jambulingam *et al*. (1975) reported that in 'Robusta' banana, higher rates of K_2O significantly increased the leaf area. Ramaswamy *et al*. (1977) in their studies with 'Dwarf Cavendish' obtained significant increase in leaf area with increasing rate of potassium upto a level of 450 g $plant^{-1}$.

Turner and Barkus (1980) found that low levels of K reduced 20% of the total leaf area produced but it had little effect on the rate of appearance of new leaves and relative leaf area production rate. According to Sheela (1982) higher levels of potassium application in 'Palayankodan' produced more leaf number and leaf area, but there was no significant difference in the total number of functional leaves and leaf area index, under different levels of K.

The number of leaves plant^{-1} in banana cv. Jahaji increased with increasing levels of K application and leaf area index showed significant difference after six months and at shooting by the higher levels of K (Baruah and Mohan, 1985). Mustaffa (1987) found significant increase in leaf number and leaf area in 'Robusta' banana through application of Muriate of Potash @ 400 g K_2O plant^{-1}.

According to Singh *et al.* (1990) potassium application did not favourably increase the leaf area index in 'Dwarf Cavendish' banana. Sumam George (1994) observed that total number of leaves and number of functional leaves showed an increasing trend with increase in levels of K applied at all growth stages of banana cv. Nendran, while significant variations observed only at the post shooting and bunch maturation stages.

2.2.2.4 Combined application of NPK

Chattopadhyay and Bose (1986) reported that application of NPK nutrients significantly increased the leaf number over the control. Parida *et al.* (1994) found that application of 225:60:225 g NPK plant^{-1} increased the number of leaves in 'Robusta' banana.

2.2.3 Duration from planting to shooting, shooting to harvest and planting to harvest

2.2.3.1 Nitrogen

In banana cv. Robusta, with 170 g N plant^{-1} inflorescence emergence was accelerated and the period till harvest was shortened by 29 days compared with plants receiving no nitrogen (Ramaswamy and Muthukrishnan, 1974b). In rainfed 'Palayankodan', the duration of the crop was significantly increased by nitrogen application as reported by Valsamma Mathew (1980). Sweidan *et al.* (1981) reported that N at 400 g plant^{-1} induced early differentiation and shortened the vegetative period in 'Dwarf Cavendish' banana.

According to Mustaffa (1983) supply of high nitrogen rates delayed maturity in 'Hill' banana and the optimal rate was worked out as 160 g N plant^{-1}. Sharma (1984) observed earliest flowering in banana cv. Basrai receiving 187.5 g N plant^{-1} applied to soil + 187.5 g N plant^{-1} applied in 12 sprays at 2 weekly intervals.

In studies with 'Robusta' banana, Kohli *et al.* (1985) observed that flowering was considerably delayed when no nitrogen was applied. Plants receiving no nitrogen required the highest number of days to reach flowering (379 days) while nitrogen fertilized plants required 315 to 329 days to flower. Singh *et al.* (1990) reported that nitrogen application in 'Dwarf Cavendish' banana reduced the number of days to harvest. According to Srikul and Turner (1995) application of 450 kg N ha^{-1} hastened the fruit maturation rate by 25 per cent.

2.2.3.2 Phosphorus

In 'Robusta' banana earlier flowering was observed with P_2O_5 at 60 g $plant^{-1}$ (Ramaswamy, 1976). Bellie (1987) studied the effect of increased doses of phosphorus on banana var. Nendran and observed early shooting and harvest with highest level of P_2O_5 (90 g $plant^{-1}$).

2.2.3.3 Potassium

Jambulingam *et al.* (1975) noticed earlier flowering and maturity with higher rates of K_2O application (above 360 g K_2O $plant^{-1}$).

In banana cv. Robusta, Vadivel and Shanmugavelu (1976) studied the effect of potassium on fruit bud initiation and differentiation and they observed that transition from vegetative to reproductive buds was delayed by foliar applied K upto 19 days but was not affected by soil applied K.

According to Sheela (1982) highest level of potassium induced early harvest of bunches in banana cv. Palayankodan. Application of 300 g K $plant^{-1}$ in 'Plantains' at 19/20th leaf stage (4-5 MAP) reduced the time of harvest from planting by more than 3 months (Obiefuna, 1984). Insufficient doses of K delayed flowering by 2-3 months in 'Plantain' (Obiefuna and Onyele, 1987).

2.2.3.4 Combined application of NPK

According to Singh *et al*. (1977) application of N, P and K at the highest rate viz. 150 g N $plant^{-1}$, 90 g P_2O_5 $plant^{-1}$ and 170 g K_2O $plant^{-1}$ reduced the number of days to flowering in banana cv. Basrai Dwarf. Lahav and Zamet (1982) observed that a N:K ratio of 1:6 delayed flowering in banana. In studies with 'Plantain', Anjorin and Obigbesan (1987) opined that application of N at 200 g $stool^{-1}$ along with 66 g P $stool^{-1}$ and 166 g K $stool^{-1}$ reduced the number of days to flowering.

According to Ram and Prasad (1989) higher NPK rates above 300:120:200 g NPK $plant^{-1}$ delayed flowering in banana cv. Campierganj Local. Parida *et al*. (1994) reported that increasing rates of NPK (N and K each at 75 to 225 g $plant^{-1}$ and P at 0 to 60 g $plant^{-1}$) reduced the number of days taken for shooting in 'Robusta' banana.

2.3 Yield and yield attributes as influenced by nutrient levels

2.3.1 Bunch characters

A positive correlation exists between the applied nutrients and yield as reported by many workers. (Butler, 1960., Osborne and Hewitt, 1963., Moreau and Robin, 1972 and Sheela, 1982).

Nitrogen

Croutcher and Mitchell (1940) observed increased yield due to the application of nitrogen in the var. Gros Michel under Jamaican conditions.

Ramaswamy and Muthukrishnan (1973) reported that the space between the first and second hands on the bunch was increased from 10 cm in the untreated plants to 14 cm when 170 g N $plant^{-1}$ was used in 'Robusta' banana. Ramaswamy and Muthukrishnan (1974a) obtained the maximum response in terms of hand and fruit number and bunch and hand weight with the same dose of nitrogen. According to Arunachalam *et al*. (1976) 170 g N $plant^{-1}$ was the optimum level in the Cavendish clones viz., 'Dwarf Cavendish', 'Giant Cavendish', 'Robusta' and 'Lacatan' bananas. Nitrogen application improved the bunch weight and fruit number in these clones.

Excess nitrogen exerted a depressive effect on the yield and yield components of banana grown on red soils of cuba. (Garcia *et al*. 1976).

Warner and Fox (1976) reported that 'Giant Cavendish' bananas produced more and heavier bunches at high nitrogen levels (280 to 360 g N $plant^{-1}$) than at low (40 g $plant^{-1}$) or medium (120 to 200 g $plant^{-1}$) levels.

According to Plessis *et al*. (1977) nitrogen application enhanced the yield in 'Dwarf Cavendish' bananas, the optimum rate being 440 g mat^{-1} $year^{-1}$. The number of hands per bunch and fingers per third hand were also increased by nitrogen.

Gopimony *et al*. (1979) studied the effect of top dressing with urea at flower initiation in 'Zanzibar' variety of banana. They found that an additional dose of 500 g urea in five equal doses of 100g each (One week interval) during fifth month of planting resulted in an increase in the bunch weight and number of fingers per bunch.

Chattopadhyay *et al*. (1980) found that in 'Giant Governor' banana the yield increased to 31200 and 30880 kg ha^{-1} for the plant and ratoon crop respectively due to increment in nitrogen dose upto 240 g $plant^{-1}$ annually. According to Nanjan *et al*. (1980) best results were obtained with 100 g N per plant crop and 200 g for the ratoon while for cv. Vayal Vazhai 100 g N was sufficient for both crops in Periyar river command area.

In banana cv. Palayankodan Valsamma Mathew (1980) observed maximum yield at 200 g N plant^{-1} and they worked out the optimum and economic dose of nitrogen as 204.6 and 96 g plant^{-1} respectively. Hernandez *et al.* (1981) observed increased yields, hands and fruit number through application of N at 100 g plant^{-1} year^{-1} in banana var. Giant Cavendish.

In banana cvs. Robusta and Giant Cavendish, Holder and Gumbs (1983) obtained the highest yield at 840 kg N ha^{-1}. Mustaffa (1983) obtained the highest yield in 'Hill' banana through application of higher nitrogen rates (250 g N plant^{-1}) and the optimal rate was worked out as 150 g N plant^{-1}.

A rate of 210.67 g N plant^{-1} produced the highest yield (44.8 t ha^{-1}) in 'Robusta' banana as reported by Kotur and Mustaffa (1984). According to Sharma (1984) highest bunch weight and number of fruits bunch^{-1} were obtained in banana cv. Basrai receiving 187.5 g N plant^{-1} applied to Soil + 187.5 g N. plant^{-1} applied in 12 sprays at 2 week interval. Anjorin and Obigbesan (1987) reported that N at 400 g stool^{-1} markedly depressed yield in 'Plantain'.

Hegde (1988) observed that increasing nitrogen application from 100 to 200 g plant^{-1} in 'Robusta' significantly increased fruit yield from 45.3 to 49.3 t ha^{-1}.

According to Mustaffa (1988b) highest yields (47.42 t ha^{-1}) in 'Robusta' banana were obtained through application of nitrogen at 150 g $plant^{-1}$. Corrales Garriga *et al*. (1989) also observed that N at 150 g $plant^{-1}$ increased yield (27.3t ha^{-1}) and number of fruits $bunch^{-1}$ compared with 21.9 t ha^{-1} in control plots receiving no nitrogen in the case of banana clone 'Ciencia'.

Hazarika and Mohan (1991) obtained highest number of fingers $bunch^{-1}$ (127.83) bunch weight (20.94 kg $plant^{-1}$) and yield (64.47 t ha^{-1}) with 160 g N $plant^{-1}$ in banana cv. Jahaji. According to Singh and Kashyap (1992) highest yield (69.32 t ha^{-1}), number of hands $bunch^{-1}$ and number of fingers $bunch^{-1}$ were obtained with 400 g N $plant^{-1}$ in banana cv. Robusta.

Gubbuk *et al*. (1993) observed highest growth rate of fingers with 80 g N mat^{-1} for 'Dwarf Cavendish' and 320 g N mat^{-1} for 'Basrai'. Ray and Yadav (1994) obtained the highest yields (92.6 t ha^{-1}) in banana cv. Basrai with annual application of 250 g N $plant^{-1}$. They found that fruit yields declined with higher rates of nitrogen. Sindhu Prabhakar (1996) obtained the highest bunch weight and number of hands $bunch^{-1}$ with 200 g N $plant^{-1}$.

2.3.1.2 Phosphorus

Bhan and Majumdar (1956) reported that P_2O_5 did not show any significant effect on yield and maturity of banana.

According to Valmayer *et al*. (1965) and Nambisan *et al*. (1980) individual effect of phosphorus in improving the yield of bananas was not much significant. Number of hands bunch^{-1} and bunch weight increased upto 60 g P_2O_5 plant^{-1} as reported by Ramaswamy (1976). Kohli *et al*. (1985) obtained the highest yield in 'Robusta' banana with 50 g P_2O_5 plant^{-1}.

2.3.1.3 Potassium

Beneficial effect of potassium on yield of bunches has been reported by many workers (Osborne and Hewitt, 1963 and Jagirdar and Ansari, 1966). In banana cv. Americani yields rose with increasing K applications, the highest increase of 93 per cent being in response to the highest dose (1350 kg K_2O ha^{-1}) (Moreau and Robin, 1972). Ramaswamy *et al*. (1977) worked out the optimum rate of potassium in 'Dwarf Cavendish' banana as 450 g plant^{-1} which produced significant increase in bunch yield, number of hands bunch^{-1} and number of fruits bunch^{-1}.

Garcia *et al*. (1979) obtained the highest yield in banana grown on red soils of Cuba through application of 750 g K_2O plant^{-1} with an average bunch weight of 38.7 kg. Low K supply considerably reduced the bunch weight and various yield components in banana (Turner and Barkus, 1980).

According to Sheela (1982) the optimum level of potassium for maximising the yield of banana var. Palayankodan was 600 g $plant^{-1}$ and bunch characters viz. length of bunch, number of hands, weight of hands, number of fingers were significantly increased by increasing levels of potassium. Garita and Jaramillo (1984) found that 750 kg K_2O ha^{-1} $year^{-1}$ resulted in highest yield in banana cv. Giant Cavendish.

Obiefuna (1984) in studies with 'Plantains' worked out the optimal dose of potassium as 300 g $plant^{-1}$ and observed significant increase in bunch weight (73.9%), number of marketable fingers (33.7%) and finger weight per plant over the control when applied at 19/20th leaf stage (4-5 MAP). Super optimal K application applied at this growth stage significantly decreased the yield of 'Plantain'. Mustaffa (1987) obtained highest fruit yield of 45.4 t ha^{-1} at 300 g K_2O $plant^{-1}$ in 'Robusta' banana.

In 'Dwarf Cavendish' banana, highest yield (45.18 t ha^{-1}) was obtained with 300 g K_2O $plant^{-1}$ (Yadav *et al*. 1988). Sindhu (1997) reported that application of 450 g K_2O $plant^{-1}$ in 'Nendran' banana increased the number of fingers $bunch^{-1}$, number of hands $bunch^{-1}$ and weight of hand and recorded a maximum bunch weight of 11.12 kg.

2.3.1.4 Combined application of NPK

Increased yields were obtained by the application of N, P and K in combination in bananas. Bhangoo *et al*. (1962) found out that a 350, 160, 180 formulation of N, P_2O_5 and K_2O

greatly increased yields, bunch weight and number of hands per bunch. According to Sarma and Roy (1972) the highest yields came from the two higher fertilizer rates (Double and triple doses of 300 kg N, 160 kg P_2O_5 and 160 kg K_2O ha^{-1}) in banana cv. Jahaji.

Veeraraghavan (1972) reported significant increase in number of fruits in 'Nendran' banana with application of 8:8:16 mixture to supply 228 g N, 228 g P_2O_5 and 456 g K_2O $plant^{-1}$ $year^{-1}$. The highest yield in 'Robusta' banana were obtained with 180 g N, 155 g P_2O_5 and 186.75 g K_2O $plant^{-1}$ $year^{-1}$. (Kohli *et al*. 1976). Application of P_2O_5 @ 60 g $plant^{-1}$ along with 170 g N $plant^{-1}$ and 450 g K_2O $plant^{-1}$ increased the number of hands $bunch^{-1}$ as well bunch weight in 'Robusta' banana as reported by Ramaswamy (1976).

The results of the study conducted by Pillai *et al*. (1977) on 'Nendran' banana at BRS, Kannara revealed that N and K exerted a significant positive influence on fruit number and bunch weight and they obtained the highest yield (9.72 kg $bunch^{-1}$) with 191 g N and 301 g K_2O $plant^{-1}$. Randhawa and Iyer (1978) found that a fruit yield of 45 t ha^{-1} could be obtained by the application of 180 g N in combination with 100 g P_2O_5 and 225 g K_2O $plant^{-1}$ in 'Robusta' banana.

Highest yield (43-44 t ha^{-1}) in 'Robusta' banana were obtained with 180 g N $plant^{-1}$ and 108 g P_2O_5 $plant^{-1}$ (Kohli *et al.* 1980). In studies with 'Robusta' bananas, Pillai and Khader (1980) reported that heaviest bunches (26 kg $bunch^{-1}$) were obtained with 100 kg N, 40 kg P_2O_5 and 400 kg K_2O $acre^{-1}$. According to Lahav and Zamet (1982) a N:K ratio of 1:6 resulted in the highest number of bunches ha^{-1} in banana. Shaikh *et al.* (1985) worked out the optimum NPK rates for highest yield in 'Basrai' banana as 786:393:786 kg ha^{-1}.

Chattopadhyay and Bose (1986) reported that NPK at 240:90:480 g $plant^{-1}$ gave the maximum fruit yield (58.5 t ha^{-1}) in the plant and ratoon crop. According to Obeifuna and Onyele (1987) demand for K is double that of N. An annual application of 200 g N and 500 g K $plant^{-1}$ produced the heaviest bunch weight and was the most economic dose in 'Plantains'.

Study conducted by Oubahou *et al.* (1987) on banana cv. Grande Naine revealed that NK treatments of 375 to 500 g and 400 to 550 g $plant^{-1}$ were superior to other treatments with bunch yield of 9.4 and 11.2 kg respectively. Ray *et al.* (1988) reported that N and K were more effective than P in improving the yield and the highest doses of 225 g each $plant^{-1}$ gave the best results.

Highest yields in banana var. Harichal were obtained with N and P at the higher rates (0.18 kg $plant^{-1}$ and 0.26 kg plant^{-1} respectively) (Upadhyay, 1988). In trials conducted on banana cv. Campierganj Local, Ram and Prasad (1989) obtained maximum bunch weight and yield with 300 g N, 40 g P_2O_5 and 100 g K_2O plant^{-1} . Highest bunch yield (12.02 kg) in 'Nendran' banana was obtained with 400 g N and 600 g K_2O plant^{-1} (Nair *et al*. 1990).

According to Singh *et al*. (1990) fruit yield and bunch weight in 'Dwarf Cavendish' banana were increased both by N and K application. Annual application of 614 kg N and 450 kg K_2O ha^{-1} appeared to be the most economic from cost benefit analysis. Pandit *et al*. (1992) reported that highest yield (35 t ha^{-1}) and number of hands bunch^{-1} in 'Dwarf Cavendish' banana were obtained with 400 g ammonium sulphate, 300 g superphosphate and 250 g muriate of potash stool^{-1}. The unfertilized controls yielded 7.89 t ha^{-1} and 3.3 hands bunch^{-1}.

In ratoon crop of banana cv. Mysore, bunch weight increased as NPK rate was increased and highest yield was obtained at the highest NPK rate (Pradeep *et al*. 1994).

2.3.2 Fruit characters

2.3.2.1 Nitrogen

Fruit characters of bananas were significantly influenced by nitrogen application. In a study conducted by

Ramaswamy and Muthukrishnan (1973), the length and circumference of the Robusta fruit at harvest increased to 21.26 cm and 11.47 cm respectively with 170 g N plant^{-1} compared with 16.31 cm and 8.66 cm where no nitrogen was used. According to Plessis *et al*. (1977), average fruit size was slightly reduced by nitrogen application.

Hernandez *et al*. (1981) did not observe any significant influence on fruit length, diameter and weight in 'Giant Cavendish ' banana with 100 g N plant^{-1} year^{-1}. However Corrales Garriga *et al*. (1989) noticed significant increase in the length of fruit with 150 g N plant^{-1} in banana clone 'CEMSA 3/4'.

Srikul and Turner (1995) obtained significant increase in the relative fruit growth rate of cv. Williams by 7 per cent with 450 kg N ha^{-1}. Fruit length and fruit volume was maximum in Rasthali banana with 200g N plant^{-1} while 250 g N plant recorded the maximum fruit mid circumference (Sindhu Prabhakar, 1996).

2.3.2.2 Phosphorus

Reports on the influence of phosphorus on the fruit characters are very few. Ramaswamy (1976) obtained significant increase in fruit size and volume with 60 g P_2O_5 plant^{-1} in banana cv. Robusta. In a trial conducted by Venkatarayappa *et al*. (1978) fruit volume and weight were remarkably increased by spraying potassium dihydrogen phosphate

2.3.2.3 Potassium

Increased dose of potassium exerted a favourable effect of nearly every feature of fruit growth as reported by Yang and Pao (1962). Average weight of finger increased due to potassium application by 15-25 per cent during the first year and by 27-48 per cent in second year. Thickness and weight of peel and length and girth of fruits were also increased due to potassium application.

Leigh (1969) observed increase in finger weight, length and circumference of fingers and rind thickness with increasing supplies of potassium in banana. Significant increase in the size of fruits at harvest was obtained with higher levels of K in banana cv. Dwarf Cavendish (Ramaswamy, 1971).

In var. Robusta Singh *et al*. (1972) noticed significant increase in weight, volume and density of fruit with application of potassium. Studies by Venkatarayappa *et al*. (1978) revealed that the application of potassium at the post shooting stage significantly increased the weight and length to girth ratio of fruits in both 'Giant Cavendish' and 'Dwarf Cavendish' banana.

According to Ramaswamy *et al*. (1977) significant increase in size of fruit at harvest was obtained with increasing rate of potassium upto a level of 450 g $plant^{-1}$ in

'Dwarf Cavendish' banana. The dry matter production of fruits was reduced by 79 per cent in var. Williams due to low rate of supply of potassium (Turner and Barkus, 1980). Girth and weight of finger affected by levels of potassium in banana var. Palayankodan (Sheela, 1982). Obiefuna (1984) obtained 44.2 per cent increase in finger weight over the control in 'Plantains' by the application of 300 g K_2O $plant^{-1}$ at floral initiatiion stage.

Hegde and Srinivas (1991) reported significant increase in finger weight at 300 g K_2O $plant^{-1}$ in bananas. Baruah and Mohan (1992) noticed significant increase in the length and circumference of the finger by increasing rate of potassium application in 'Dwarf Cavendish' banana. Highest fruit weight in banana was obtained with an annual rate of 720 kg K_2O ha^{-1} (Lopez Morales, 1994).

According to Sumam George (1994) length, girth and weight of index finger showed an increasing trend with increase in rates of potassium application upto 225 g $plant^{-1}$ in 'Nendran' banana. Sindhu (1997) observed that application of 450 g K_2O $plant^{-1}$ increased the weight, length and girth of finger in banana cv. Nendran.

2.3.2.4 Combined application of NPK

Hewitt and Osborne (1962) reported that in the presence of adequate N and P it was possible to double the weight of fruits by the application of potassium. Veeraraghavan (1972) obtained significant increase in weight of fruits in banana cv. Nendran with application of 456 g K_2O plant^{-1} along with 228 g each of N and P_2O_5. Average fruit weight was increased both by N and K application (Singh *et al*., 1990). Pathak *et al*. (1992) revealed that application of 300 g K_2O plant^{-1} along with 300 g N was the most effective in increasing the size and weight of fingers in banana cv. Harichal.

2.4 Quality characters as influenced by nutrient levels

2.4.1 Nitrogen

Nitrogen significantly influences the quality of fruits as evident from the following reports. Chattopadhyay *et al*. (1980) observed significant increase in the total and reducing sugar content of 'Cavendish' banana fruits by application of nitrogen. Similar results were obtained in rainfed banana var. Palayankodan by Valsamma Mathew (1980). According to Mustaffa (1983) high nitrogen rates (above 250 g N plant^{-1}) decreased fruit quality in 'Hill' banana. Nair (1988) reported that the total soluble solid content of fruits were significantly increased in 'Nendran' by application of 300 g N plant^{-1}. Sindhu Prabhakar (1996) noticed a gradual increase in acidity and ascorbic acid content with increasing levels of nitrogen in 'Rasthali' banana.

2.4.2 Phosphorus

So far no studies have been reported regarding the individual effect of phosphorus on the quality characters of fruit.

2.4.3 Potassium

A number of studies on the effect of potassium on the quality characters have been reported by many workers. According to Chu (1961) K fertilizing greatly improved fruit quality and storage life. In an experiment conducted by Ho (1968) in Taiwan, increasing supplies of K_2O improved the fruit conditions as observed after 20 days of storage.

According to Von Uexkull (1970) potassium improved the sugar/acid ratio and the keeping quality of banana fruits by increasing the thickness and firmness of rind. Singh *et al*. (1972) also observed significant improvement in fruit quality by potassium application in banana.

Venkatarayappa *et al*. (1978) reported that acidity of the fruit was lowered with application of potassium in 'Cavendish' banana. Potassiun had pronounced effect on titrable acids and soluble solids of 'Robusta' banana (Jambulingam *et al*. 1975). Koen (1976) obtained high quality fruits with an annual application of 370 g potassium ammonium nitrate along with 450 g kcl plant^{-1}. Fruit quality was lowest with higher rate of application or when the latter was supplemented with 250 g magnesium sulphate.

In studies with 'Robusta' banana, Vadivel and Shanmugavelu (1978) observed significant increase in reducing sugars, non-reducing sugars and total sugars as well as total soluble solids with increase in levels of K_2O (upto 300 g $plant^{-1}$). Acidity was decreased while sugar/acid ratio was enhanced. Fruit ascorbic acid content also slightly increased with K_2O application.

Zehler *et al*. (1981) reported the positive influence of potassium in improving the storage properties of banana fruit as well sugar/acid ratio. Studies conducted by Sheela (1982) revealed that total soluble solids, total sugar, reducing sugars, sugar/acid ratio and acidity were beneficially affected with increasing levels of potassium in banana cv. Palayankodan. Baruah and Mohan (1986) also observed that increasing levels of potassium significantly increased the total soluble solids, sugar/acid ratio and lowered the acidity in banana cv. Jahaji.

Acidity of fruits decreased with increasing levels of potassium in 'Dwarf Cavendish' banana as reported by Chattopadhyay and Bose (1986). Although not significant high rates of potassium application to banana cv. Umalag reduced the sugar contents (Fabregar, 1986).

Mustaffa (1987) reported that potassium improved the quality of the fruit by raising the total soluble solids and ascorbic acid content and reducing the acidity in banana var. Robusta. At high K level (400 g K_2O plant^{-1}) acidity was reduced in 'Hill' banana (Mustaffa, 1988a).

In a report Von Uexkull and Bosshart (1987) stated that potassium improved the shelf life of the banana fruit by increasing the firmness of the pulp. Martin-Prevel (1989) reported that banana fruits receiving high rates of potassium exhibited high pulp/peel ratio. According to Tandon and Sekhon (1988) potassium improves the quality, flavour, sweetness and keeping quality of fruits.

Samra and Quadar (1990) revealed that soil and foliar application of K increased total and reducing sugars. Sumam George (1994) studied the effect of potash application on the quality parameters in banana cv. Nendran and the results indicated that potassium application increased the total and non-reducing sugar content and shelf life of fruits. Reducing sugar showed a decreasing trend and pulp/peel ratio showed a steady increasing trend with increasing levels of potassium application.

According to Sheela (1995) increasing K levels increased sugar/acid ratio and lowered acidity in tissue cultured 'Nendran' banana.

Quality characters of the fruit namely total soluble solids, total sugars, non reducing sugars, sugar/acid ratio, pulp/peel ratio and shelf life showed significant positive trend and acidity and reducing sugar showed significant negative trend with increasing levels of potassium in banana var. Nendran (Sindhu, 1997).

2.4.4 Combined application of NPK

There are several reports on the combined effect of nitrogen, phosphorus and potassium on fruit quality. Teotia *et al.* (1972) did not get any marked effect on quality of fruits by different levels of N, P and K in banana var. Cavendish. In banana cv. Basrai Dwarf fruit quality was improved through application of 150 g N plant^{-1}, 90 g P_2O_5 plant^{-1} and 170 g. K_2O plant^{-1} as reported by Singh *et al.* (1977).

Rajeevan (1985) studied the effect of split application of NPK fertilizer in banana cv. Palayankodan. Among the physical/characters of fruits only the pulp/peel ratio (by weight) differed significantly between the treatments. The quality in terms of chemical characters like total sugars and reducing sugar showed significant difference.

In banana cv. Campierganj Local maximum TSS (21.21%) was obtained with $N:P_2O_5:K_2O$ at 200:80:200 g plant^{-1} and total sugar was highest (17.3%) with 300:120:100 g NPK plant^{-1} (Ram and Prasad, 1988). According to Upadhyay (1988) fruit quality was best with N, P and K each at the lower rate in banana cv. Harichal.

Hegde and Srinivas (1991) observed that increasing levels of nitrogen increased the total soluble solids while increasing levels of potassium improved total soluble solids, but decreased pulp/peel ratio in bananas.

2.5 Effect of split application of fertilizers

Time of application of fertilizer is an important factor in determining the yield of the crop and for better results the fertilizers are to be applied during the early stages of growth (Summerville, 1944). The importance of split application of fertilizer has been pointed out in earlier periods by Alexandrowitz (1955) and Dugain (1959). Nitrogen fertilizers were applied in two to twelve instalments in banana by Dugain and he reported that fractional application of nitrogen was more beneficial than frequent application in large quantities.

Osborne and Hewitt (1963) recorded highest yield in rainfed banana when nitrogen was applied in three splits a year. Different levels of split application were recommended for different nutrients by Ho (1968). He recommended five split applications of nitrogen, two split applications of phosphorus and three split applications of potassium for maximisation of yield in banana.

Shanmugam and Velayudham (1972) reported that potassium could be applied in three split doses viz., first, third and fifth month after planting along with nitrogen in Tamilnadu. They opined that fertilizers did not help to increase the yield of banana if applied after the sixth month. Veeraraghavan (1972) recommended two split application of fertilizers during second and fourth month after planting in banana. var. Nendran. In Assam three split applications of fertilizers were given to banana cv. Jahaji (Sarma and Roy, 1972).

Ramaswamy and Muthukrishnan (1974b) recommended two split application of fertilizers in the third and fifth month after planting in var. Robusta. Echeverri Lopez and Garcia (1976) found that two split application of fertilizers was effective and economic in banana cv. Dominico.

Veerannah *et al*. (1976) reported that nitrogen and potassium were absorbed more in the preflowering stage in 'Robusta' but in equal quantities before and after flowering in 'Poovan'. Pillai *et al*. (1977) followed two equal split applications of N, P_2O_5 and K_2O at 70-80 days and 110, 120 days after planting in banana cv. Nendran. Split application of fertilizers increased the total soluble contents of 'Robusta' banana as reported by Vadivel and Shanmugavelu (1978).

Gopimony *et al*. (1979) suggested application of an additional dose of 500 g urea in five equal split doses at one week interval during fifth month of planting for obtaining higher yields in 'Zanzibar' variety of banana. Studies conducted by Nambiar *et al*. (1979) on the effect of split application of fertilizers on banana var. Nendran at BRS, Kannara revealed that average bunch weight was greatest with two split doses applied at 30 and 150 days after planting.

Pillai and Khader (1980) adopted three split applications during 50, 80 and 120 days after planting in 'Robusta'. Chundawat *et al*. (1982) recommended three split application of fertilizers within six months of planting 'Basrai' banana under South Gujarat conditions.

Garita and Jaramillo (1984) suggested potassium application in five equal splits year^{-1} for 'Giant Cavendish' banana. According to Kotur and Mustaffa (1984) application of nitrogen in two split doses, fifth and eight month after planting was found to be effective in 'Robusta' banana.

Studies by Obiefuna (1984) revealed that the highest yield of 'Plantain' associated with heavy application of K_2O, two to three times after planting could be achieved by timely application of K_2O at the 19th/20th leaf stage when it requires more potassium for its floral initiation. Rajeevan (1985) reported that by suitably splitting recommended dose of fertilizer, a 17 per cent increase in yield was obtained in banana var. Palayankodan.

Bellie (1987) found that a fertilizer dose of 150:90:300 g NPK plant^{-1} applied in three splits during third, fifth and seventh month increased the net income ha^{-1} from 'Nendran' banana. Sharma and Yadav (1987) recommended application of fertilizers in two split doses for banana. Nitrogen and potassium were applied at varying intervals usually four to six times annually for nitrogen and one or two times for potassium (Stover and Simmonds, 1987).

Best results were obtained in banana with application of potassium in three splits (Yadav *et al*. 1988). Nair *et al*. (1990) obtained the heaviest bunch yield with six split applications of N and K in 'Nendran' grown in rice fallows. Hazarika and Mohan (1991) recommended application in three equal split doses [three and five months after planting and at the flower tip emergence stage (peeping stage)] for higher growth and yield in banana cv. Jahaji.

Rajeevan and Mohanakumaran (1992) reported that application of 3/4th of the dose (200:200:400 g NPK plant^{-1} year^{-1}) in the second month and 1/4th of the dose in the sixth month, improved the yield of banana cv. Mysore upto 17.76 per cent over the control wherein the above dose was applied in two equal splits in the second and fourth month of planting.

Natesh *et al.* (1993) reported that application of the recommended fertilizer rates (190:115:300 g NPK $plant^{-1}$ $year^{-1}$) in four splits (2, 4, 6 and 8 months after planting) increased banana cv. Nendran yield parameters compared with the same rates applied in two splits (two and four months after planting).

Ray and Yadav (1994) recommended seven split applications of nitrogen in banana cv. Basrai. They observed that seven split application of N upto 10 months after planting was more beneficial than the conventional 3-4 applications upto 5-6 MAP because each dressing of N was only effective for 2 months.

According to Sindhu Prabhakar (1996) four split applications of nitrogen (30, 75, 120 and 165 days after planting) was found effective for 'Rasthali' banana.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was carried out to find out the optimum dose of inorganic fertilizer and their frequency of application to maximise the production of banana. The materials and methods used for the study are detailed hereunder

3.1 Experimental site

The experiment was conducted at the Instructional Farm attached to the College of Agriculture, Vellayani. The farm is located at 8.5° N latitude and 76.9° E longitude and at an altitude of 29 m above mean sea level.

3.2 Soil

The soil of the experimental area comes under the textural class of sandy clay loam. It belongs to the taxonomic class kaolinitic isohypothermic family of Rhodic Haplustox. The important chemical properties of the soil are presented in Table 1.

Table 1 Chemical properties of the soil at the experimental site

Constituent	Content in soil	Rating	Method used
Organic carbon (%)	0.43	Low	Walkley and Black's rapid titration method (Jackson, 1973)
Available N (kg ha^{-1})	206.98	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 (kg ha^{-1})	24	Medium	Bray colorimetric method (Jackson, 1973)
Available K_2O (kg ha^{-1})	112	Low	Ammonium acetate method (Jackson, 1973)
pH	4.95	Acidic	1:2.5 soil solution ratio using pH meter with glass electrode (Jackson, 1973)

3.3 Season

The experiment was conducted from December 1995 to September 1996.

3.4 Climate

The experimental site enjoys a humid tropical climate. The data on various weather parameters (monthly rainfall, maximum temperature, minimum temperature and relative humidity) during the cropping period are presented in Appendix I. The mean maximum and minimum temperature during the cropping period were 31.6°C and 21.8°C respectively. Total rainfall received during the period was 83.1 cm. The crop was raised as an irrigated crop with a frequency of irrigation once in 2 days at the rate of 40 l of water per plant.

3.5 Cropping history of the field

The land was left fallow prior to the commencement of the trial before which it had been cropped with banana.

3.6 Variety

The variety selected for the study was 'Nendran', the most popular dual purpose commercial cultivar of Kerala. It comes under the sub group 'Plantain' with 'AAB' genome. 'Nendran' is mainly grown as an irrigated crop in the state.

3.7 Preparation of the planting material

Suckers of uniform weight and age (3 months old) were selected from a disease free area and pseudostems were cut at a length of about 15-25 cm from the corm. Old roots were removed and the rhizomes were dipped in cowdung slurry, dried in sun for 3 days and stored in shade for 15 days before planting

3.8 Field preparation and planting

The land was prepared by digging once. Raised beds were taken with channels all around for proper drainage and pits of size 50 cm^3 were dug on these beds at a spacing of 2 x 2 m. Suckers were planted upright in the centre of pits with 5 cm of pseudostem remaining above the soil level.

3.9 Experimental design and layout

The experiment was laid out in Factorial RBD. The lay out plan of the experiment is presented in Fig. 1. The details of the layout are as follows.

Design	:	Factorial RBD (3x4+2)
Total No. of treatments	:	14
No. of replications	:	2
Spacing	:	2x2 m
No. of plants/plot	:	16
Plot size	:	8x8 m^2
Variety	:	'Nendran'
Treatments		
Levels of NPK	:	Three
L_1	:	190:115:300 g NPK $plant^{-1}$
L_2	:	380:115:600 g NPK $plant^{-1}$
L_3	:	570:115:900 g NPK $plant^{-1}$

Fig. 1 Layout of the experimental field (Factorial RBD)

N

T_{10}	T_4	T_1	T_6	T_9	T_3	T_{12}	T_8	T_{11}	T_{13}	T_2	T_5	T_{14}	T_7	R_1
T_2	T_{11}	T_5	T_8	T_{14}	T_7	T_{13}	T_6	T_1	T_9	T_3	T_{10}	T_4	T_{12}	R_2

R_1 : Replication I
R_2 : Replication II

T_1 - L_1F_1	T_5 - L_2F_1	T_9 - L_3F_1	T_{13} - A_1
T_2 - L_1F_2	T_6 - L_2F_2	T_{10} - L_3F_2	T_{14} - A_2
T_3 - L_1F_3	T_7 - L_2F_3	T_{11} - L_3F_3	
T_4 - L_1F_4	T_8 - L_2F_4	T_{12} - L_3F_4	

Frequency of application : Four

F_1 - Three splits 2nd, 4th and 6th month after planting

F_2 - Six splits as per package of practices recommendation of KAU (at planting, one, two, four, five MAP and just after complete emergence of bunch)

F_3 - Two splits as per package of practices recommendation of KAU (two and four months after planting)

F_4 - N + K_2O as equal splits once in 21 days from first month onwards upto seventh month after planting. P_2O_5 as 2 equal splits at the time of planting and one month after planting.

Additional Treatments

A_1 - Farmer's practice (Factamphos 1 kg + 500 g K_2O plant^{-1} after shooting)

A_2 - NPK based on soil test values

FYM was applied as basal @ 10 kg plant^{-1} in all treatment plots and P_2O_5 was applied in two splits, first as basal and the second, one month after planting for all the treatments except T_{13} and T_{14}. The levels of NPK for T_{14} was fixed as 190:69:300 g plant^{-1} based on soil test values as per the adhoc system followed in Kerala.

Plate No. 1

An overview of the experimental field


KAU-PG PROJECT

Treatment combinations

Treatment combinations = 3x4+2 = 14

The treatment combinations are as follows

T_1	-	L_1F_1	T_5	-	L_2F_1	T_9	-	L_3F_1
T_2	-	L_1F_2	T_6	-	L_2F_2	T_{10}	-	L_3F_2
T_3	-	L_1F_3	T_7	-	L_2F_3	T_{11}	-	L_3F_3
T_4	-	L_1F_4	T_8	-	L_2F_4	T_{12}	-	L_3F_4
T_{13}	-	A_1						
T_{14}	-	A_2						

The details of split application of fertilizers are given in Appendix II.

3.10 Fertilizer application

Urea (46% N), Superphosphate (16% P_2O_5) and Muriate of potash (60% K_2O) were used as the sources of N, P and K respectively except for T_{13}. Factamphos 20:20:0:15 and Muriate of potash were used for T_{13}. Fertilizers were applied 60-75 cm around the plant.

3.11 Maintenance of the crop

Hand weeding was done as and when required. Channels were cleared before the onset of rain to facilitate smooth drainage of excess water. Periodic desuckering were done throughout the cropping period. Inorder to prevent wind damage all the plants in the experimental field were tied together with rope.

3.12 Plant protection measures

'Bunchy top' which is the major disease of 'Nendran' was effectively managed by the selection of disease free suckers from disease free plantations as well as through the application of Phorate (10% G) for the control of the vector. Captafol was sprayed at 0.3 per cent concentration for control of sigatoka leaf spot. Aldrin 5 per cent DP was applied at 50 g pit^{-1} before planting against rhizome weevil. Spodoptera infestation during early stages of crop growth was effectively controlled by spraying Quinalphos at 0.05 per cent concentration.

3.13 Observations recorded

3.13.1 Vegetative characters

3.13.1.1 Height of the plant

Height of the plant was measured from the ground level to the base of the unopened leaf at fifth month, at flowering and at harvest and recorded in cm.

3.13.1.2 Girth of the plant

The girth of the plant was measured at 10 cm above ground level at fifth month, at flowering and at harvest and recorded in cm.

3.13.1.3 Number of leaves

Number of green leaves capable of photosynthesis were counted at fifth month, at flowering and at harvest.

3.13.1.4 Leaf Area Index (LAI)

Leaf area Index was determined at fifth month, at flowering and at harvest using the following formula suggested by Watson (1952).

$$LAI = \frac{\text{Leaf area per plant}}{\text{Area occupied per plant}}$$

Leaf area was measured using the following model developed by Robinson and Nel (1988)

LA = 0.83 LxB where

LA = Leaf area per leaf

L = Leaf length

B = Leaf breadth

3.13.1.5 Duration from planting to shooting

Duration from planting to shooting was recorded from the date of planting to visual bunch emergence and expressed in days.

3.13.1.6 Duration from shooting to harvest

Duration from shooting to harvest was recorded from the date of visual bunch emergence to the date of harvest and expressed in days.

3.13.1.7 Duration from planting to harvest

Duration from planting to harvest was recorded from the date of planting to harvest and expressed in days.

3.13.2 Bunch characters

Bunches were harvested when fully mature as indicated by the disappearance of angles from fingers (Simmonds, 1959).

The following observations were made on bunch characters

3.13.2.1 Number of hands

The number of hands in each bunch was noted.

3.13.2.2 Number of fingers bunch^{-1}

The number of fingers in each of the bunches were counted and values recorded.

3.13.2.3 Number of fingers in second hand

No. of fingers in second hand (from the base of the bunch) was recorded.

3.13.2.4 Length of bunch

Length of bunch was measured from the point of attachment of first hand to that of last hand and expressed in cm.

3.13.2.5 Compactness of bunch

Compactness of bunch is computed by measuring the average distance separating nodes and recorded in cm.

3.13.2.6 Weight of bunch

Weight of bunch including the portion of the peduncle upto the first scar (exposed outside the plant) was recorded in kilograms.

3.13.3 Fruit characters (mature)

The middle fruit in the top row of the second hand (from the base of the bunch) was selected as the representative finger or index finger (Gottriech *et al*. 1964).

3.13.3.1 Weight of finger

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

3.13.3.2 Length, girth and volume of finger

Length of finger was measured from the tip of the finger to the point of attachment to the peduncle and girth of the finger was recorded at the middle portion using a fine thread and scale and expressed in cm. Volume of finger was estimated by water displacement method and expressed in cm^3.

3.13.3.3 Dry weight of pulp, peel and total dry weight

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

3.13.4 Fruit characters (ripe)

The fruits collected from well ripe bunches were selected. The middle fruit in the top row of the second hand was again selected as the representative sample.

3.13.4.1 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.

3.13.4.2 Pulp/Peel ratio

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

3.13.5 Quality analysis of fruit

3.13.5.1 Quality attributes of mature fruit

3.13.5.1.1 Starch

The mature finger after removal of peel was dried at 70°C in an oven, powdered and this was used for the analysis of starch (AOAC, 1965) and values expressed as percentage on dry weight of fruits.

3.13.5.2 Quality attributes of ripe 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 viz. top, middle and bottom of sample fruit were macerated in a blender and made upto a known volume. Aliquots taken from these made up fruit samples were used for the analysis of the following constituents of the fruit viz. ascorbic acid, acidity, total sugar, reducing sugars and non reducing sugars.

3.13.5.2.1 Total soluble solids (TSS)

Macerated fruit samples were taken and total soluble solid content was determined using a pocket refractometer and expressed as percentage (Ranganna, 1977).

3.13.5.2.2 Ascorbic acid

Ascorbic acid content was estimated as per the method suggested by Ranganna (1977). The result was expressed as mg/100 g of fresh fruit sample.

3.13.5.2.3 Acidity

Titrable acidity was determined following the procedure proposed by Ranganna (1977). An aliquot from the sample was titrated against 0.1 N NaoH and the acidity values were expressed as per cent anhydrous citric acid.

3.13.5.2.4 Total sugars

Total sugar content was determined as per the method described by Ranganna (1977) and was expressed as percentage on fresh weight basis.

3.13.5.2.5 Reducing sugars

The reducing sugars of the samples were determined as per the method described by Ranganna (1977) as percentage on fresh weight basis.

3.13.5.2.6 Non-reducing sugars

The non-reducing sugars of the samples were determined as per the method described by Ranganna (1977) as percentage on fresh weight basis.

3.13.5.2.7 Sugar/acid ratio

Sugar/acid ratio was arrived at by dividing the total sugars with titrable acidity.

3.13.5.2.8 Shelf life of fruits

The number of days taken from harvest to the development of black colour in the peel was recorded to determine the shelf life or storage life of fruits at room temperature (Stover and Simmonds, 1987).

3.13.6 Sensory evaluation of ripe fruit

The fruit samples from each treatment plot were evaluated for their organoleptic qualities by selecting ten 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 such as taste, texture and lump formation. (Score card is shown in Appendix III). Scores for over all acceptability was obtained by determing the average mean score for each character.

3.13.7 Foliar nutrient status at harvest

The middle lamina of third fully opened leaf counted from the tip of the plant was taken (Twyford and Walmsley, 1973) and oven dried to constant weight at 70°C, ground in a Wiley mill and analysed for the N, P and K contents and the results were expressed as percentage on dry weight basis. The methods adopted for the chemical analysis are described below.

Sl.No.	Estimated character	Methods followd
1	N	Modified microkjeldahl method (Jackson, 1973)
2	P	Vanadomolybdo phosphoric yellow colour method using Klett Summerson photoelectric colorimeter (Jackson, 1973)
3	K	Flame photometry (Jackson, 1973)

3.13.8 Soil analysis

Soil samples were collected before planting and after harvest. Composite sample from each treatment plot was airdried, gently powdered, passed through a 2 mm sieve and analysed for available N, available P, and available K as per the methods described earlier.

3.13.9 Incidence of pests and diseases

The various diseases and pests observed in the crop were recorded as and when they appeared. Sigatoka scoring was carried out as per the method suggested by Suharban (1977). (Appendix IV). The per cent infection index was worked out using the following formula described by Singh (1984).

$$\text{Per cent infection index} = \frac{\text{Sum of all disease ratings} \times 100}{\text{Total number of ratings} \times \text{Maximum disease grade}}$$

3.13.10 Economics of production

The economics of cultivation was worked out considering the cost of cultivation and income derived from the plant with respect to all treatments. It was calculated as per the norms and rates fixed by the Instructional farm, College of Agriculture, Vellayani.

$$\text{Benefit/Cost ratio} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.13.11 Statistical analysis

The experimental data were analysed statistically by applying the technique of analysis of variance as per the lay out of the experiment (Panse and Sukhatme 1967). CD values are provided in the table wherever significant differences were observed among treatments. Sensory evaluation of the ripe fruits of various treatments were analysed statistically using nonparametric method of analysis - Kruskal Wallis test (Sidney and John Castellan, 1988).

RESULTS

RESULTS

An experiment was conducted to find out the optimum fertilizer schedule for maximisation of productivity of banana (*Musa* AAB group 'Nendran'). The experimental data was subjected to statistical analysis to bring out the effects of levels of NPK and frequency of their application on the growth, yield and quality of banana var. Nendran. The results obtained are presented in this chapter.

4.1 Vegetative characters

4.1.1 Height of the plant

The average height of the plant at three stages of growth viz. fifth month, flowering and harvest are presented in Table 2. The results revealed that levels of NPK, frequency of application and their interaction effects had significantly influenced the height of the plant at all the three stages.

Application of 380:115:600 g NPK plant^{-1} (L_2) recorded a maximum height of 244.38 cm at fifth month and was significantly superior to L_1 (190:115:300 g NPK plant^{-1}) and L_3 (570:115:900 g NPK plant^{-1}), the latter two being statistically on par. At flowering, tallest plants (300.40 cm) were produced by L_2 level which was significantly superior to L_3 and L_1. L_1 recorded the lowest plant height (275.25 cm) which was statistically on par with L_3. The height of the plant did not

Table 2 Effect of fertilizer treatments on the height and girth of pseudostem of banana var. Nendran

Fertilizer treatments	Height of the plant			Girth of the plant		
	At 5th MAP (cm)	At flowering (cm)	At harvest (cm)	At 5th MAP (cm)	At flowering (cm)	At harvest (cm)
L_1	230.65	275.25	280.04	49.96	54.25	55.06
L_2	244.38	300.40	303.56	52.84	57.95	58.56
L_3	229.04	275.42	277.56	48.46	53.90	54.44
SE±	1.267	3.200	2.974	0.997	1.045	0.974
CD(0.05)	3.872	9.773	9.086	3.045	3.192	2.975
F_1	229.30	277.75	282.30	49.04	53.83	54.58
F_2	249.20	299.90	301.80	54.00	59.07	59.83
F_3	231.80	280.80	283.75	49.19	54.42	55.08
F_4	228.38	276.20	280.30	49.46	54.16	54.58
SE±	1.463	3.694	3.434	1.151	1.206	1.125
CD(0.05)	4.471	11.285	10.492	3.517	3.686	3.436
L_1F_1	231.50	277.00	284.90	47.63	54.38	55.25
L_1F_2	235.00	286.30	290.80	51.75	55.88	57.00
L_1F_3	233.40	272.00	274.00	51.50	54.50	55.25
L_1F_4	222.80	265.80	270.50	49.00	52.25	52.75
L_2F_1	232.30	281.10	285.00	51.00	55.13	55.75
L_2F_2	278.10	331.50	332.50	60.63	65.50	66.25
L_2F_3	237.00	301.50	304.80	48.63	54.50	55.25
L_2F_4	230.10	287.30	292.00	51.13	56.68	57.00
L_3F_1	224.30	275.10	277.00	48.50	52.00	52.75
L_3F_2	234.50	282.10	282.30	49.65	55.84	56.25
L_3F_3	225.20	269.00	272.50	47.45	54.25	54.75
L_3F_4	232.30	275.50	278.50	48.25	53.55	54.00
SE±	2.535	6.398	5.949	1.994	2.090	1.948
CD(0.05)	7.744	19.546	18.172	-	-	-
Treatment means	234.68	283.70	287.05	50.43	55.36	56.02
A_1	227.00	267.30	272.00	48.50	52.15	52.75
A_2	219.10	260.15	266.00	47.30	52.88	53.50

show any noticeable improvement after flowering. Hence height at harvest showed a similar trend as in flowering with the maximum height (303.56 cm) being recorded at L_2.

Fertilizer application in six splits (F_2) recorded significantly higher plant height at all the three growth stages compared to other split applications. The height produced by two splits (F_3), three splits (F_1) and ten splits (F_4) were statistically on par.

Interaction between level of NPK and frequency of application of nutrients was found significant at all growth stages.

At fifth month, six splits application at L_1 level recorded a plant height of 233.40 cm which was comparable with two and three splits and significantly superior to ten splits. Six splits application at L_2 was found to be the best which showed significant difference in plant height from other splits which were on par. Six splits and ten splits at L_3 level produced comparable plant heights (234.5 cm and 232.30 cm respectively) and were significantly superior to two and three splits.

Six splits at L_1 level produced the tallest plants (286.30 cm) during flowering and was statistically on par with two and three splits and significantly superior to ten splits.

Significantly higher plant heights (331.50 cm) were recorded by six splits at L_2 level compared to other splits which were on par. However the different frequencies of fertilizer application did not show any marked differences in height at L_3 level during this flowering stage.

Height of the plant at harvest showed a similar trend as in flowering with maximum response being observed in six splits application at L_2 level.

Results presented in Table 2 showed that six splits application at L_2 significantly increased plant height at all the three stages while differential response was observed at L_1 and L_3 with different frequencies of application. This treatment combination (L_2F_2) was significantly superior to the two additional treatments viz. farmer's practice (A_1) and NPK based on soil test value (A_2).

The mean of these factorial treatment combinations were found to be significantly superior to the additional treatments (A_1 and A_2) at all the three stages. However A_1 and A_2 themselves showed significant variation in plant height only at the fifth month, with higher plant height being recorded by A_1 (227.00 cm).

4.1.2 Girth of the plant

Table 2 presents the average girth of the plant at three stages of growth viz. fifth month, flowering and harvest.

Different levels of NPK and frequency of application had significantly influenced the girth while their interactions had no significant effect on plant girth at all stages.

At all the three stages of growth, plant girth (52.84 cm, 57.95 cm and 58.56 cm respectively) was highest at L_2 level. Girth recorded by L_2 level at fifth month was on par with L_1 and significantly superior to L_3. However at flowering and harvest stages L_2 level was significantly superior to other levels of NPK. L_1 and L_3 recorded lower plant girths at all growth stages compared to L_2.

Among the different frequencies of application tested, six splits was found to be beneficial producing the highest girth at all the three stages (fifth month, flowering and harvest). The corresponding values recorded were 54.00 cm, 59.07 cm and 59.83 cm respectively. Six splits was significantly superior to other splits which were statistically on par.

The additional treatments A_1 and A_2 could not produce much significant variations in girth between themselves as well as over the mean of other treatment combinations at all growth stages.

4.1.3 Number of leaves

The average number of leaves at fifth month, at flowering and at harvest are furnished in Table 3.

Table 3 Effect of fertilizer treatments on number of leaves and Leaf Area Index (LAI) of banana Var. Nendran

Fertilizer treatments	Number of leaves			Leaf Area Index		
	At 5th MAP (cm)	At flowering (cm)	At harvest (cm)	At 5th MAP (cm)	At flowering (cm)	At harvest (cm)
L_1	12.41	12.80	3.74	2.18	2.29	0.62
L_2	13.00	13.41	3.99	2.32	2.75	0.64
L_3	12.18	12.76	3.41	1.98	2.21	0.59
SE±	0.791	0.145	0.145	0.108	0.069	0.021
CD(0.05)	-	0.444	0.444	-	0.214	-
F_1	12.50	12.81	3.62	2.16	2.35	0.59
F_2	13.02	13.53	3.94	2.45	2.76	0.69
F_3	12.23	12.85	3.75	1.97	2.47	0.60
F_4	12.38	12.76	3.55	2.03	2.08	0.59
SE±	0.914	0.168	0.168	0.125	0.087	0.024
CD(0.05)	-	0.514	-	-	0.246	0.074
L_1F_1	12.50	12.75	3.53	2.11	2.26	0.59
L_1F_2	12.63	13.00	3.95	2.53	2.47	0.69
L_1F_3	12.00	12.93	3.75	2.02	2.34	0.59
L_1F_4	12.50	12.53	3.75	2.08	2.09	0.59
L_2F_1	12.75	12.88	3.83	2.24	2.56	0.59
L_2F_2	14.13	14.75	4.25	2.86	2.55	0.71
L_2F_3	13.00	13.00	4.00	2.07	2.88	0.65
L_2F_4	12.13	13.00	3.80	2.10	2.01	0.62
L_3F_1	12.25	12.80	3.50	2.13	2.23	0.57
L_3F_2	12.30	12.85	3.63	1.96	2.27	0.68
L_3F_3	11.68	12.63	3.50	1.81	2.19	0.57
L_3F_4	12.50	12.75	3.00	1.92	2.14	0.57
SE±	1.582	0.291	0.291	0.216	0.139	0.042
CD(0.05)	-	-	-	-	0.427	-
Treatment means	12.53	12.99	3.72	2.15	2.41	0.62
A_1	11.84	12.00	2.68	1.76	1.95	0.41
A_2	11.50	11.75	2.50	1.69	1.76	0.34

At fifth month levels of NPK revealed no significant influence on number of leaves. However levels of NPK exhibited a profound influence on the number of leaves at flowering and harvest stages. Maximum number of leaves was produced at L_2 level in both these stages. At flowering stage L_2 level was significantly superior to other levels of NPK while at harvest stage it was found to be on par with lowest level of NPK (L_1). In both these stages highest level of NPK (L_3) produced the lowest number of leaves (12.76 and 3.41 respectively).

Frequency of application showed marked effect on the number of leaves only at the flowering stage. Application of fertilizer in six splits recorded the maximum number of leaves (13.53) at flowering stage and was significantly superior to other splits which were statistically on par.

Interaction effects were found to be not significant at all the three stages with regard to the number of leaves produced.

In all the three stages of growth the mean of the two additional treatments (A_1 and A_2) produced significantly lower number of leaves compared to mean of twelve treatments while there was no significant difference in the number of leaves produced between A_1 and A_2.

4.1.4 Leaf Area Index (LAI)

Table 3 gives the average values of the LAI recorded at fifth month, at flowering and at harvest.

Leaf Area Index (LAI) recorded at fifth month and at harvest stages were not positively influenced by levels of NPK. However, levels of NPK significantly influenced the LAI at flowering stage. L_2 level produced the maximum LAI (2.75) at flowering stage which was significantly superior to L_1 and L_3. LAI was lowest (2.21) at the highest fertilizer dose (L_3) which was statistically on par with the lowest fertilizer dose (L_1).

LAI at flowering and harvest stages were significantly influenced by the different frequencies of application. In both these stages, fertilizer application in six splits was found to be more effective in producing the highest LAI (2.76 and 0.69 respectively) and was significantly superior to all other split applications. At flowering stage, two and three splits were found to be on par and significantly superior to ten splits. However at harvest stage, no significant difference in LAI was observed among two, ten and three splits.

Interaction effects were found significant only at the flowering stage. No significant difference in LAI was observed at L_1 and L_3 levels by the different freqencies of application at this stage. Two splits application at L_2 level produced the highest LAI (2.88) which was comparable with three splits and six splits. This treatment combination was significantly superior to ten splits application at L_2 level.

As in the case of number of leaves, the mean of additional treatments (A_1 and A_2) recorded a significantly lower LAI compared to all other treatment combinations at all the three growth stages. These growth stages also did not show any significant variation in LAI between A_1 and A_2.

4.1.5 Duration from planting to shooting

Observations on the average number of days taken from planting to shooting are given in Table 4.

Both levels of NPK and frequency of application exhibited a significant influence on the number of days to shooting while interaction effects did not show any influence on this character.

Plants which received double the dose of fertilizer recommended by KAU (L_2) had taken minimum number of days to shooting (184.06 days) and was significantly different from other fertilizer levels.

Early shooting was found to be induced by the fertilizer application in six splits (181.83 days). Other

Table 4 Effect of fertilizer treatments on duration from planting to shooting, shooting to harvest and planting to harvest in banana var. Nendran

Fertilizer treatments	Duration from		
	Planting to shooting (Days)	Shooting to harvest (Days)	Planting to harvest (Days)
L_1	190.06	83.41	273.46
L_2	184.06	84.53	268.59
L_3	192.84	87.32	280.16
SE$\pm$	1.025	0.575	1.507
CD(0.05)	3.129	1.755	4.602
F_1	191.092	85.71	276.80
F_2	181.83	83.92	265.74
F_3	191.33	84.09	275.43
F_4	191.70	86.63	278.33
SE$\pm$	1.183	0.663	1.739
CD(0.05)	3.614	2.027	5.314
L_1F_1	191.50	84.25	275.75
L_1F_2	184.75	82.38	267.13
L_1F_3	190.13	81.00	271.13
L_1F_4	193.85	86.00	279.85
L_2F_1	187.90	85.25	273.15
L_2F_2	173.10	83.13	256.23
L_2F_3	188.50	82.88	271.38
L_2F_4	186.75	86.88	273.63
L_3F_1	193.88	87.63	281.50
L_3F_2	187.63	86.25	273.88
L_3F_3	195.38	88.40	283.78
L_3F_4	194.50	87.00	281.50
SE$\pm$	2.049	1.149	3.013
CD(0.05)	-	-	-
Treatment means	188.99	85.09	274.07
A_1	195.63	88.63	284.25
A_2	199.83	90.38	290.20

split applications which were on par among themselves exhibited a significant variation in the number of days taken for shooting from six splits.

There was no significant difference in the number of days taken for shooting between the mean of additional treatments (A_1 and A_2) and mean of twelve treatments as well as among themselves.

4.1.6 Duration from shooting to harvest

The mean values of the number of days from shooting to harvest are furnished in Table 4. The number of days to harvest was favourably influenced by different levels of NPK and frequency of application but their interactions had no pronounced effect. The plants which had received the lowest level of nutrients (L_1) had taken the minimum number of days to harvest (83.41 days) and were statistically on par with L_2. Highest dose of fertilizer had prolonged the fruit maturity period (87.32 days).

There was no significant difference in the number of days to harvest among six, two and three splits, the minimum number of days being recorded by six splits (83.92 days). Three splits was in turn statistically on par with ten splits.

The factorial treatment combinations had taken minimum number of days (85.09 days) compared to mean of additional treatments (A_1 and A_2) which themselves did not show any significant variation in the number of days to shooting.

4.1.7 Duration from planting to harvest

Table 4 presents the mean value of the duration from planting to harvest.

Levels of NPK and frequency of application had exerted a strong positive influence on the total crop duration while the interaction effects did not show any significant variation with respect to this character

All the three levels of NPK differed significantly from each other in the number of days taken from planting to harvest. Among the levels of NPK, L_2 level had taken the minimum number of days to harvest (268.59 days) while application of the highest level of NPK (L_3) had delayed the crop duration by 11.57 days compared to L_2.

Application of fertilizers in six splits had significantly advanced the crop duration by 11 days (265.74 days) compared to other splits. No significant difference in the number of days to harvest was observed among other splits (two, three and ten splits).

The additional treatments (A_1 and A_2), recorded a significantly higher total crop duration (287.23 days) compared to the mean of treatment combinations. However no significant difference in total crop duration was observed between A_1 and A_2.

4.2 Bunch characters

Table 5 presents the average values of number of hands, number of fingers, number of fingers in second hand, length of bunch, compactness of bunch and weight of bunch as influenced by different levels of NPK and frequency of application and their interaction effects.

4.2.1 Number of hands

The number of hands was favourably influenced by frequency of application. However levels of NPK and interaction effects did not show any significant variation in the number of hands.

Among the frequency of applications, maximum number of hands (4.92) was recorded by six splits and was significantly superior to other splits which were statistically on par.

The number of hands recorded by the mean of the additional treatments (A_1 and A_2) was significantly lower (4.22) compared to the mean of treatment combinations while A_1 and A_2 did not show any significant variation among themselves.

Table 5 Effect of fertilizer treatments on bunch characters of banana Var. Nendran

	No.of hands	No.of fingers	No.of fingers in second hand	Length of Bunch (cm)	Compactness of Bunch (cm)	Weight of Bunch (kg)
L_1	4.57	42.18	9.63	51.93	7.30	9.82
L_2	4.77	46.49	9.84	54.35	7.03	10.42
L_3	4.60	42.68	9.59	50.35	7.25	9.61
SE±	0.078	0.874	0.123	0.937	0.228	0.194
CD(0.05)	-	2.669	-	2.863	-	0.593
F_1	4.52	40.52	9.50	50.62	7.21	9.47
F_2	4.91	47.71	10.08	56.38	7.28	11.20
F_3	4.57	43.71	9.58	51.22	6.98	9.61
F_4	4.58	43.18	9.58	50.62	7.30	9.54
SE±	0.090	1.009	0.142	1.082	0.264	0.224
CD(0.05)	0.276	3.082	0.432	3.306	-	0.685
L_1F_1	4.48	41.18	9.50	50.59	7.11	9.40
L_1F_2	4.83	44.57	10.00	54.50	7.13	11.00
L_1F_3	4.52	43.60	9.50	52.03	7.17	9.60
L_1F_4	4.47	39.36	9.50	50.60	7.81	9.30
L_2F_1	4.50	41.63	9.50	51.03	6.96	9.55
L_2F_2	5.19	52.44	10.38	60.00	7.76	12.50
L_2F_3	4.70	45.04	9.75	53.38	6.79	9.82
L_2F_4	4.69	46.84	9.75	53.00	6.60	9.82
L_3F_1	4.57	38.76	9.50	50.25	7.56	9.45
L_3F_2	4.73	46.12	9.88	54.65	6.96	10.10
L_3F_3	4.51	42.50	9.50	48.25	6.98	9.40
L_3F_4	4.58	43.35	9.50	48.25	7.50	9.50
SE±	0.156	1.747	0.245	1.874	0.457	0.389
CD(0.05)	-	-	-	-	-	-
Treatment means	4.65	43.78	9.69	52.21	7.19	9.95
A_1	4.29	32.75	9.25	42.25	7.61	6.82
A_2	4.15	31.50	9.25	42.05	7.40	6.68

4.2.2 Number of fingers bunch^{-1}

The average values of the number of fingers bunch^{-1} presented in the Table 5 revealed that levels of NPK and frequency of application had strongly influenced the number of fingers. Interaction effects did not exhibit any significant variation in number of fingers bunch^{-1}.

Number of fingers bunch^{-1} was found to be the highest (46.49) at L_2 level which was significantly superior to L_3 and L_1 which were on par.

Fertilizer applied in six splits recorded the maximum number of fingers bunch^{-1} (47.71) which was significantly superior to other splits. Number of fingers was found to be the lowest at three splits which was statistically on par with ten splits. Ten splits was in turn found to be statistically on par with two splits.

The factorial treatment combinations recorded a significantly higher number of fingers bunch^{-1} (43.78) compared to the two additional treatments. However farmers practice (A_1) and NPK based on soil test values (A_2) did not differ significantly with regard to the number of fingers bunch^{-1}.

4.2.3 Number of fingers in second hand

Unlike the total number of fingers bunch^{-1}, significant difference in the number of fingers in second hand

Plate No. 2

Treatment T_6 (360:115:600 g NPK $plant^{-1}$ in six splits)

171216

was noticed only at different frequencies of application. Levels of NPK and interaction effects were not statistically significant.

Maximum number of fingers in the second hand (10.08) was recorded by six splits and was significantly superior to other splits which were statistically on par.

Significant difference in the number of fingers in the second hand was observed between the mean of twelve treatment combinations and the two additional treatments (A_1 and A_2, while the additional treatments showed no significant differences between themselves.

4.2.4 Length of bunch

Levels of NPK and frequency of application had exerted a marked influence on the length of bunch while the interaction effects did not show much variation in bunch length.

L_2 level produced the maximum bunch length of 54.35 cm which was statistically on par with L_1 level. L_3 and L_1 levels were found to be statistically on par, the lowest bunch length being recorded by L_3 (50.35 cm).

Among split applications, six splits was significantly superior to other splits, which recorded a

Plate No.3

Treatment T_{13} (Farmer's practice)


T13

maximum bunch length of 56.38 cm. No significant difference in bunch length was observed among other split applications.

Significant increase in bunch length was observed by the factorial treatment combinations over the two additional treatments (A_1 and A_2). However these additional treatments recorded no significant variation in bunch length betweem themselves.

4.2.5 Compactness of bunch

No significant difference in bunch compactness was observed by different levels of NPK, frequency of application and their interaction effects. Also there was not much significant variation in bunch compactness between factorial treatment combinations and the two additional treatments (A_1 and A_2) as well as between A_1 and A_2.

4.2.6 Weight of bunch

Bunch weight was significantly influenced by levels of NPK and frequency of application while interaction effects did not show any significant variation in bunch weight.

Application of 380:115:600 g NPK plant^{-1} (L_2) recorded the highest bunch weight (10.42 kg) and was significantly superior to the other levels of NPK which were statistically on par. Bunch weight was lowest (9.61 kg) at the highest level of NPK (L_3).

Plate No.4

Treatment T_{14} (NPK based on soil test values)


T14

Fertilizer application in six splits recorded the highest bunch weight (11.20 kg) and was significantly superior to the other splits which were statistically on par. On an average the bunch weight recorded by other splits was 9.4 kg.

The twelve treatment combinations recorded a mean significantly higher bunch weight (9.95 kg) compared to the mean of two additional treatments (6.75 kg). However no significant difference in bunch yield was observed between the two additional treatments. The bunch weights recorded by L_2F_2, L_1F_2 and L_3F_2, were 12.50 kg, 11.00 kg and 10.10 kg respectively whereas A_1 and A_2 recorded lover bunch weights of 6.8 kg and 6.7 kg. Thus the treatment combinations gave significantly higher bunch weight compared to A_1 and A_2.

4.3 Fruit characters (mature)

The average values of the weight of finger, length of finger, girth of finger, volume of finger, dry weight of pulp, dry weight of peel and total dry weight of finger are furnished in Table 6.

4.3.1 Weight of finger

The average weight of finger was favourably influenced by levels of NPK and frequency of application. However the interaction effects were not statistically significant.

Table 6 Effect of fertilizer treatments on fruit characters (mature) of banana var. Nendran

Fertilizer treatments	Weight of finger (g)	Length of finger (cm)	Girth of finger (cm)	Volume of finger (cm^3)	Dry weight of pulp (g)	Dry weight of peel (g)	Total dry weight (g)
L_1	208.06	19.84	13.73	205.81	53.98	8.07	62.05
L_2	243.63	21.33	14.31	239.19	62.64	9.60	72.23
L_3	204.44	19.89	13.74	201.50	53.13	8.23	61.36
SE±	1.466	0.269	0.140	1.758	0.580	0.174	0.747
CD(0.05)	4.479	0.820	0.428	5.371	1.772	0.532	2.281
F_1	210.83	19.56	13.86	207.71	53.76	8.28	62.04
F_2	238.58	21.79	13.98	234.46	62.51	9.33	71.83
F_3	213.58	20.18	13.99	211.04	56.03	8.35	62.38
F_4	211.83	19.88	13.89	208.79	54.03	8.57	64.66
SE±	1.693	0.310	0.162	2.030	0.669	0.201	0.862
CD(0.05)	5.172	0.947	-	6.202	2.047	0.614	2.634
L_1F_1	199.00	19.00	13.50	197.50	51.84	7.61	59.45
L_1F_2	233.25	21.00	14.13	231.13	60.12	8.94	69.06
L_1F_3	202.50	20.30	13.60	199.38	52.00	8.17	60.17
L_1F_4	197.50	19.05	13.71	195.25	51.95	7.57	59.52
L_2F_1	232.50	19.44	14.06	227.63	56.69	9.10	65.79
L_2F_2	265.00	23.75	14.70	258.00	71.71	10.27	81.98
L_2F_3	239.00	20.88	14.38	237.00	63.95	9.55	73.50
L_2F_4	238.00	21.25	14.10	234.13	58.20	9.47	67.67
L_3F_1	201.00	20.25	14.00	198.00	52.77	8.13	60.89
L_3F_2	217.50	20.63	13.13	214.25	55.69	8.77	64.47
L_3F_3	199.25	19.35	14.00	196.75	52.13	8.00	60.13
L_3F_4	200.00	19.34	13.85	197.00	51.93	8.03	59.95
SE±	2.932	0.537	0.280	3.516	1.160	0.348	1.494
CD(0.05)	-	-	-	-	3.545	-	4.562
Treatment means	218.71	20.35	13.93	215.50	56.58	8.63	65.21
A_1	187.50	18.28	13.05	184.75	50.06	7.35	57.41
A_2	166.75	18.20	12.50	164.25	45.35	6.81	52.16

The highest weight of finger (243.63g) was observed at L_2 level which was superior to other levels of NPK. Application of the highest level of NPK (L_3) had significantly reduced the weight of finger which was statistically on par with L_1. (208.06 g).

Weight of finger was maximum (238.58g) at six splits which was significantly different from other splits. Three splits recorded the lowest weight of finger (210.83g) which was statistically on par with ten splits (211.83 g) and two splits (213.58 g).

The mean of farmers practice (A_1) and fertilizer applied based on soil test values (A_2) showed significantly lower finger weight (177.13g) compared to the mean of treatment combinations. Among the two additional treatments, significantly higher finger weight (187.50 g) was recorded by farmers practice (A_1). L_2F_2 recorded a finger weight of 265 g. The finger weights corresponding to L_2F_3 and L_2F_4 were 239 and 238 g respectively. All the treatment combinations gave significantly higher finger weights compared to A_1 and A_2.

4.3.2 Length of finger

Both levels of NPK and frequency of application had exhibited strong positive influence on the length of finger while the interaction effects did not show much significant variation in finger length.

Application of 380:115:600 g NPK $plant^{-1}$ (L_2) has recorded the highest finger length (21.33 cm) which was superior to other levels of NPK. L_3 and L_1 levels were found to be statistically on par, with the lowest finger length being recorded by L_1 (19.84 cm).

Among the split applications, maximum finger length (21.79 cm) was observed by six splits which was significantly superior to other splits. All the other split applications were found to be statistically on par.

The mean of factorial treatment combinations were found to record a significantly higher finger length (20.35 cm) compared to the mean of additional treatments (A_1 and A_2). However no significant difference in finger length was observed between A_1 and A_2.

4.3.3 Girth of finger

Girth of finger was favourably influenced by levels of NPK. However no significant variation in girth of finger was observed by frequency of application and interaction effects.

L_2 level had significantly increased the girth of finger (14.31 cm) compared to other levels of NPK. Minimum girth of finger was observed at L_1 level (13.73 cm) which was statistically on par with L_3 (13.74 cm).

The mean of additional treatments showed a significantly lower girth (12.78 cm)compared to mean of twelve treatment combinations (13.93 cm). Meanwhile A_1 and A_2 themselves did not show any significant variation in girth of finger.

4.3.4 Volume of finger

Both levels of NPK and frequency of application exhibited a marked influence on the finger volume whereas the interaction effects were not statistically significant.

Finger volume was greatest (239.19 cm^3) at L_2 level which was significantly different from other levels of NPK. However no significant variation in finger volume was observed between L_1 and L_3 levels, with lowest finger volume (201.50 cm^3) being recorded by the highest level of NPK (L_3).

Highest finger volume (234.46 cm^3) was observed at six split application of fertilizer which was significantly superior to other splits. No significant difference in finger volume was observed among the other split applications.

Significant difference in volume of finger was observed between mean of treatment combinations and mean of additional treatments (A_1 and A_2), with lowest value being observed by the mean of A_1 and A_2 (174.5 cm^3). Farmers practice (A_1) recorded a significantly higher finger volume (184.75 cm^3) compared to A_2 (164.25 cm^3)

4.3.5 Dry weight of pulp

Pulp dry weight was favourably influenced by levels of NPK, frequency of application and their interaction effects.

Maximum pulp dry weight (62.64 g) was noticed at L_2 level, which showed significant variation from other levels of NPK. L_1 and L_3 levels were statistically on par, the highest level (L_3) recorded the lowest pulp dry weight (53.13g).

Fertilizer application in six splits recorded the highest pulp dry weight (62.51 g) which was significantly superior to other splits. Pulp dry weight was lowest at three splits which was statistically on par with ten splits. Ten splits in turn was statistically on par with two splits.

Interaction between levels of NPK and frequency of application was found statistically significant. In the lowest level of NPK tried (L_1) six splits was found to be the best producing the highest pulp dry weight (60.12 g) compared to other splits which were statistically on par. However at the higher level of NPK (L_2), six splits and two splits recorded significantly higher pulp dry weight compared to other split applications. Six splits at L_3 level was equally effective as three splits in producing higher pulp dry weights (55.69 g and 52.77 g respectively). At this level ten splits recorded the lowest pulp dry weight (51.39 g) which was statistically on par with two splits and three splits.

Table 6 revealed that six splits application at L_2 and L_1 level were found to produce significantly higher pulp dry weights while differential response was observed at L_3 level.

These factorial treatment combinations recorded a significantly higher pulp dry weight (56.58 g) compared to the two additional treatments (A_1 and A_2). The additional treatments also showed significant variation among themselves. Among these two additional treatments A_1 was found to be the best which recorded significantly higher pulp dry weight (50.06g).

4.3.6 Dry weight of peel

Levels of NPK and frequency of application exerted a marked influence on peel dry weight, while interaction effects were not statistically significant.

Among the levels of NPK, L_2 recorded the maximum peel dry weight (9.60 g) which was significantly superior to other levels of NPK. L_1 level recorded the lowest peel dry weight (8.07 g) which was statistically on par with L_3.

In the case of frequency of application six splits was found to be the best which produced significantly higher peel dry weight (9.33 g) compared to other splits. No significant variation in peel dry weight was observed among the other splits.

Peel dry weight was found to be higher in factorial treatment means compared to mean of additional treatments (A_1 and A_2), while A_1 and A_2 themselves did not show any significant variation in peel dry weight.

4.3.7 Total dry weight

Total dry weight of finger was significantly influenced by levels of NPK, frequency of application and their interaction effects.

Total dry weight of finger was found to be the highest (72.23g) at L_2 level which was significantly superior to other levels of NPK. L_1 and L_3 levels were statistically on par, with the lowest dry weight (61.36 g) being recorded at the highest level of NPK (L_3).

Among the frequencies of application, six splits was found to be the best (71.83g) and was significantly superior to other splits which were statistically on par.

Six splits application at L_1 and L_2 levels were found to result in significant increase in total dry weight of finger. However at the highest level of NPK (L_3), no significant difference in the total finger dry weight was observed by the different frequencies of application. At the lowest level of NPK (L_1), three splits recorded a significantly lower total finger dry weight (59.52g) which was on par with ten splits and two splits. Three splits recorded a lower finger dry weight (65.79 g) at L_2 level which was on par with ten splits.

The factorial treatment combinations recorded a significantly higher total finger dry weight (65.21 g) compared to mean of additional treatments (A_1 and A_2). Between the two additional treatments, A_1 was found to be significantly superior to A_2.

4.4 Fruit characters (Ripe)

Table 7 presents the average values of the weight of finger, weight of pulp, weight of peel and pulp/peel ratio.

4.4.1 Weight of Finger

Levels of NPK, frequency of application and their interaction effects exhibited a strong positive influence on the average weight of ripe fingers.

Statistical scrutiny of the data revealed that the weight of ripe finger was maximum (205.82g) at L_2 level. Lowest finger weight (171.28 g) was recorded at the highest level of NPK (L_3). All the three levels of NPK differed significantly from each other in the case of finger weight.

Fertilizer application in six splits significantly increased the finger weight (206.42 g) compared to other

Table 7 Effect of fertilizer treatments on fruit characters (ripe) of banana var. Nendran

Fertilizer treatments	Weight of finger (g)	Weight of pulp (g)	Weight of peel (g)	Pulp/peel ratio
L_1	176.55	140.71	35.85	3.93
L_2	205.82	156.78	49.04	3.20
L_3	171.28	124.49	46.79	2.67
SE±	1.485	1.185	0.587	0.044
CD(0.05)	4.537	3.620	1.793	0.134
F_1	174.56	133.27	41.29	3.25
F_2	206.42	159.90	46.52	3.47
F_3	180.49	134.69	45.80	3.02
F_4	176.74	134.78	41.96	3.32
SE±	1.715	1.368	0.678	0.051
CD(0.05)	5.239	4.180	2.070	0.154
L_1F_1	167.08	131.03	36.05	3.63
L_1F_2	203.25	163.30	39.95	4.09
L_1F_3	171.20	135.25	35.95	3.76
L_1F_4	164.68	133.25	31.43	4.24
L_2F_1	188.50	142.20	46.31	3.07
L_2F_2	233.50	182.85	50.85	3.59
L_2F_3	203.67	152.03	51.64	2.95
L_2F_4	197.62	150.27	47.36	3.17
L_3F_1	168.10	126.59	41.51	3.08
L_3F_2	182.50	133.75	48.75	2.73
L_3F_3	166.60	116.80	49.80	2.35
L_3F_4	167.91	120.83	47.09	2.55
SE±	2.971	2.370	1.174	0.087
CD (0.05)	9.074	7.240	3.586	0.267
Treatment				
Means	184.55	140.66	43.89	3.26
A_1	154.50	120.50	34.00	3.55
A_2	139.75	112.50	27.25	4.13

splits. Lowest finger weight (174.56 g) was recorded by three splits which was statistically on par with ten splits. Ten splits in turn was found to be on par with two splits.

Interaction effects were statistically significant with regard to weight of finger (ripe).

Ten splits, three splits and two splits application at the lowest level of NPK (L_1) were statistically on par and recorded significantly lower finger weights compared to six splits. At L_2 level six splits recorded the highest finger weight (233.50 g) compared to other splits. Two splits and ten splits were on par and lowest finger weight was recorded by three splits (188.50 g) at this level. At the highest level of NPK (L_3), three splits, ten splits and two splits recorded comparable finger weights and was significantly inferior to six splits (182.50 g).

Six splits application had significantly increased the weight of fingers (ripe) at all the three levels of NPK viz. L_1, L_2 and L_3 compared to other splits. On the whole the treatment combination viz. six splits application at L_2 level was found to be the best in producing higher finger (ripe) weights and was significantly superior to all other treatment combinations as well as the two additional treatments (A_1 and A_2).

Significant difference in finger weight was observed between mean of factorial treatment combinations and mean of additional treatments (A_1 and A_2). Comparatively lower finger weights were recorded by mean of A_1 and A_2 (147.13 g). A_2 recorded a significantly lower finger weight (139.75g) compared to A_1.

4.4.2 Weight of pulp

Pulp weight was also positively influenced by levels of NPK, frequency of application and their interaction effects.

The pulp weight recorded by all the three levels of NPK showed significant variation from each other, with the highest pulp weight (156.78 g) being recorded by L_2. The highest level of NPK (L_3) recorded the lowest pulp weight (124.49g).

Among the different split applications, maximum pulp weight was recorded by six splits (159.90g) and was significantly superior to other splits which were on par.

Interaction effect was found statistically significant. Six splits application of L_1 and L_2 produced significantly higher pulp weights compared to other split applications while differential response was observed at the highest level of NPK (L_3) with different frequencies of application.

Six splits at L_1 recorded significantly higher pulp weight (163.30g) compared to other splits which were statistically on par. At L_2 level maximum pulp weight of 182.65g was recorded by six splits which showed significant variation from other splits. Three splits recorded the lowest pulp weight (142.20 g) at this level which was statistically on par with ten splits which in turn was on par with two splits. Six splits and three splits application at the highest level of NPK (L_3) produced comparable pulp weights and showed significant variation from two splits. Two splits and ten splits were statistically on par.

L_2F_2 combination was observed to be the best in producing the maximum pulp weight which was significantly superior to all other treatment combinations as well as the two additional treatments (A_1 and A_2).

The mean of twelve treatment combinations recorded a higher pulp weight (140.66 g) which was significantly superior to the two additional treatments (A_1 and A_2). A_1 recorded a pulp weight of 120.60 g which was significantly higher than the mean pulp weight recorded by A_2.

4.4.3 Weight of peel

Levels of NPK, frequency of application and their interaction effects exhibited a strong positive influence on the peel weight.

The peel weight recorded by all the three levels of NPK showed significant variation from each other. Peel weight was maximum(49.04 g) at L_2 level and minimum (35.85 g) at L_1 level.

Fertilizer application in six splits recorded a higher peel weight (46.52 g) which was statistically on par with two splits and significantly superior to other splits. Peel weight was lowest at three splits (41.29g) which was statistically on par with ten splits.

Interaction between levels of NPK and frequency of application was statistically significant. Significantly higher peel weights (39.95 g) were recorded by six splits application at L_2 level which showed significant variation from the other splits. At this level, two splits and three splits were statistically on par. However at higher levels of NPK (L_2) two splits recorded comparable peel weights with six splits and showed significant variation from other splits. Two splits was on par with ten splits which in turn was on par with three splits. At the highest level of NPK (L_3), three splits recorded significantly lower peel weight (41.51 g) compared to other split applications which were statistically on par.

On the whole L_1F_4 recorded the lowest peel weight (31.43 g) which was significantly different from all other treatment combinations.

The twelve treatment combinations differed significantly in peel weight from the mean of additional treatments (A_1 and A_2), higher peel weight (43.89g) being recorded by mean of treatment combinations. Between A_1 and A_2, A_2 recorded the lowest peel weight (27.25 g).

4.4.4 Pulp/peel ratio

Pulp/peel ratio of ripe fruits was significantly influenced by levels of NPK, frequency of application and their interaction effects.

Highest pulp/peel ratio (3.93) was recorded at the lowest level of NPK (L_1). Application of the highest level of NPK (L_3) had significantly reduced the pulp/peel ratio (2.67). The pulp/peel ratio recorded by the different levels of NPK showed significant variation from each other.

Maximum pulp peel ratio was observed at six splits (3.47) which was statistically on par with ten splits. Ten splits was in turn statistically on par with three splits. Fertilizer application in two splits recorded significantly lower pulp/peel ratio (3.02) compared to other splits.

Interaction effects between levels of NPK and frequency of application were statistically significant. The different frequencies of application showed differential response in pulp/peel ratio at all the three levels of NPK.

Ten splits at the lowest level of NPK (L_1) recorded higher pulp/peel ratio (4.24) which was statistically on par with six splits. These split applications were significantly superior to other splits. At L_2 level six splits was found to produce significantly higher pulp/peel ratio (3.59 g) compared to other splits. However at the highest level of NPK (L_3) , three splits produced the highest pulp/peel ratio (3.06) which showed significant difference from other splits. Six splits and ten splits were on par at this level.

The mean of the pulp/peel ratio recorded by the two additional treatments (A_1 and A_2) was significantly superior to the mean of all treatment combinations. Significant variation in pulp/peel ratio was between among A_1 and A_2, with a higher pulp/peel ratio being recorded by A_2 (4.13).

4.5 Quality characters

Table 8 presents the mean data on the quality characters of fruit as influenced by different levels of NPK and frequency of application. The characters studied were starch content, total soluble solids, ascorbic acid, acidity, total sugars, reducing sugars, non reducing sugars, sugar/acid ratio and shelf life.

Table 8 Effect of fertilizer treatments on quality characters of fruits of banana var. Nendran

Fertilizer treatments	Quality attributes of: Mature fruit		Ripe fruits						
	Starch (%)	TSS (%)	Ascorbic acid (mg/100g	Acidity (%)	Total sugars (%)	Reducing sugars (%)	Non reducing sugars (%)	Sugar/ acid ratio	Shelf life (days
L_1	55.60	30.42	14.85	0.59	21.44	13.42	8.02	36.66	8.33
L_2	60.88	29.50	14.38	0.63	20.22	15.22	4.99	32.19	7.25
L_3	56.17	28.73	14.26	0.65	19.20	16.28	2.90	29.73	6.17
SE±	1.466	0.248	0.312	0.01	0.469	0.352	0.29	0.718	0.149
CD(0.05)	4.477	0.759	-	0.029	1.434	1.075	0.892	2.193	0.456
F_1	62.51	29.51	14.40	0.62	20.01	15.15	4.85	32.50	7.48
F_2	60.31	29.58	14.58	0.61	20.48	14.69	5.79	33.99	7.20
F_3	53.24	29.33	14.26	0.64	19.87	15.43	4.44	31.41	7.02
F_4	54.14	29.77	14.75	0.62	20.78	14.63	6.15	33.54	7.29
SE±	1.693	0.287	0.360	0.011	0.542	0.406	0.337	0.829	0.172
CD(0.05)	5.170	-	-	-	-	-	1.030	-	-
L_1F_1	61.76	30.13	14.51	0.60	20.56	14.31	6.25	34.49	8.20
L_1F_2	54.27	30.15	14.99	0.56	21.23	13.08	8.16	37.91	8.35
L_1F_3	50.96	30.30	14.44	0.60	21.05	14.11	6.94	35.08	8.25
L_1F_4	55.43	31.10	15.48	0.595	22.92	12.17	10.75	39.16	8.50
L_2F_1	61.49	29.40	14.35	0.63	19.88	15.13	4.75	31.66	7.25
L_2F_2	64.83	29.80	14.45	0.62	20.95	14.50	6.45	33.76	7.25
L_2F_3	64.03	29.20	14.20	0.64	19.75	15.95	3.80	30.87	7.00
L_2F_4	53.19	29.60	14.50	0.63	20.30	15.30	5.00	32.47	7.50
L_3F_1	64.29	29.00	14.35	0.63	19.60	16.00	3.56	31.35	7.00
L_3F_2	61.84	28.80	14.29	0.64	19.25	16.50	2.75	30.30	6.00
L_3F_3	44.75	28.50	14.14	0.67	18.82	16.23	2.59	28.28	5.80
L_3F_4	53.81	28.60	14.26	0.66	19.12	16.40	2.72	29.01	5.88
SE±	2.932	0.497	0.624	0.019	0.939	0.704	0.584	1.436	0.298
CD (0.05)	8.955	-	-	-	-	-	1.784	-	-
Treatment Means	57.55	29.55	14.50	0.62	20.29	14.97	5.31	32.86	7.25
A_1	59.66	30.05	16.23	0.56	21.20	14.40	6.70	37.73	8.00
A_2	40.78	30.15	14.54	0.58	21.95	12.65	9.30	37.86	8.50

4.5.1 Quality attributes of mature unripe fruit

4.5.1.1 Starch content

Different levels of NPK, frequency of application and their interaction effects had pronounced effect on the starch content of mature unripe fruits.

Application of 380:115:600 g NPK plant^{-1} (L_2) had recorded the highest starch content (60.88%) which was significantly superior to other levels of NPK. L_1 level recorded the lowest value (55.60%) which was statistically on par with L_3 level.

Fertilizer application in three splits had produced the maximum starch content (62.51%) which was found to be statistically on par with six splits (60.31%). Both these split applications were significantly superior to other splits. Two splits and ten splits had recorded the lowest value of starch content which were statistically on par.

In the case of interaction effects differential response was observed in the starch content of mature unripe fruit with different frequencies of application at all the three levels of NPK.

Three splits at L_1 level recorded higher starch contents (61.76%) which was on par with ten and six splits and significantly different from two splits. However ten and six splits application at this level were on par with two splits. Six, two and three splits at L_2 level recorded comparable values for starch content (64.83%, 64.03% and 61.49% respectively). Among these split applications, six and two splits showed significant variation from ten splits while three splits was on par with ten splits. However at L_3 level three splits recorded higher starch content (64.29%) which was on par with six splits and significantly different from other splits. Two splits was in turn on par with ten splits.

On the whole, percentage of starch in mature fruit was higher for the treatment combinations L_2F_2, L_2F_3, L_3F_1, L_3F_2, L_2F_1 and L_2F_1 which were on par among themselves and showed significant difference from other treatment combinations as well as the two additional treatments (A_1 and A_2).

Starch content recorded by the mean values of the two additional treaments (A_1 and A_2) was significantly inferior (50.22%) compared to the mean of all the twelve treatment combinations (57.55%). Also significant variation in starch content was observed between A_1 and A_2, with the highest value of starch content being recorded by A_1 (59.66%). Among the treatment combinations, the starch percentage recorded by L_3F_3 was lower compared to farmer's practice (A_1) and those recorded by L_1F_2, L_1F_4, L_1F_4, L_2F_4 and L_1F_3 and L_1F_3 were comparable with A_1.

4.5.2 Quality attributes of ripe fruits

4.5.2.1 Total soluble solids (TSS)

Total soluble solid content of ripe fruits was favourably influenced by levels of NPK, while frequency of application and interaction effects did not show any marked influence on TSS content of ripe fruits.

TSS content was highest (30.19%) at the lowest NPK level (L_1) which was significantly superior to L_2 and L_3 levels. Lowest TSS content (28.73%) was recorded at the highest NPK level (L_3).

No significant difference in TSS was observed between mean of all the twelve treatment combinations and mean of additional treatments (A_1 and A_2) and also between mean values of A_1 and A_2.

4.5.2.2 Ascorbic acid

Levels of NPK, frequency of application and interaction effects did not exert any marked influence on the ascorbic acid content of ripe fruits

The mean of two additional treatments did not show any significant difference in ascorbic acid content when compared to the mean of all treatment combinations. There was also no significant difference in ascorbic acid content between the two additional treatments (A_1 and A_2).

4.5.2.3 Acidity

Levels of NPK exhibited a profound influence on the acidity of fruits. However acidity was not significantly influenced by frequency of application and interaction effects.

Highest level of NPK (L_3) recorded the highest value for acidity (0.65%) which was statistically on par with L_2 level. Lowest value for acidity (0.59%) was noticed at the lowest level of NPK (L_1) which showed significant variation from other levels of NPK.

A significantly lower value for acidity (0.57%) was recorded by the mean of additional treatments (A_1 and A_2) compared to mean of twelve treatment combinations. However no significant difference in acidity was observed between the two additional treatments.

4.5.2.4 Total sugars

Total sugar content of fruits was significantly influenced by levels of NPK while frequency of application and interaction effects did not show any significant influence on total sugar content.

Total sugar content was highest (21.44%) at the lowest level of NPK (L_1) which was statistically on par with L_2 level and significantly superior to L_3 level. L_3 level recorded the lowest value (19.20%) for total sugar.

Total sugar content of the fruit did not show much significant variation between mean of treatments combinations and mean of additional treatments (A_1 and A_2) and also between A_1 and A_2.

4.5.2.5 Reducing sugars

Reducing sugar content was not positively influenced by frequency of application and interaction effects, while levels of NPK exerted a strong positive influence on this parameter.

Reducing sugar content was highest at L_3 level (16.28%) which was statistically on par with L_2 level and significantly different from L_1 level.

Significant difference in reducing sugar content value was observed between mean of twelve treatments and mean of additional treatments. Meanwhile A_1 and A_2 did not show any significant difference between themselves.

4.5.2.6 Non-reducing sugars

Levels of NPK, frequency of application and interaction effects favourably influenced the non reducing sugars content of fruit.

Non reducing sugars content recorded by the three levels of NPK showed significant variation from each other, with the maximum value (8.02%) being recorded by L_1.

Application of fertilizers in ten splits recorded a higher non reducing sugars content (6.15%) which was statistically on par with six splits but significantly superior to three splits. Fertilizer application in two splits recorded a lower nonreducing sugars content value of (4.44%) which was statistically on par with three splits.

Interaction effects were found statistically significant. Differential response in non reducing sugars value were observed with different frequencies of application at varying levels of NPK. Comparatively higher non-reducing sugars were observed with two and ten splits at $L_1$and L_2 level.

Ten splits application at L_1 level recorded significantly higher nonreducing sugars (10.75%) compared to other splits. This was followed by six splits (8.16%) which was on par with two splits. Two splits was in turn on par with three splits. Comparable non reducing sugars value were observed by six, two and three splits at L_2 level and the corresponding values were 6.45%, 5.00% and 4.75% respectively. Ten and three splits were also on par with two splits. However at the highest level of NPK (L_3) no significant variation in non reducing sugars content was observed with different frequencies of application.

On the whole the treatment combination L_1F_4 (190:115:300 g NPK plant^{-1} in ten splits) recorded the highest non reducing sugars which was significantly superior to all other treatment combination as well as the two additional treatments (A_1 and A_2).

A significantly higher non reducing sugar content was recorded by the mean of additional treatments (7.99%) compared to mean of twelve tratment combinations. A_2 recorded a significantly higher non reducing sugar content (9.30%) compared to A_1.

4.5.2.7 Sugar/acid ratio

Significant positive influence on the sugar/acid ratio was observed by different levels of NPK. However, frequency of appication and interaction effects had no marked effect on sugar/acid ratio.

The lowest level of NPK (L_1) resulted in the maximum sugar/acid ratio (36.66) which was significantly superior to other levels. The other levels of NPK also showed significant variation from each other. The lower sugar/acid ratio was produced at the highest level of NPK (L_3).

The mean value of the two additional treatments (A_1 and A_2) had recorded a significantly higher sugar/acid ratio (37.80) compared to mean of twelve treatment combinations while the additional treatments did not show any significant variation between themselves.

4.5.2.8 Shelf life

Levels of NPK had exerted a strong positive influence on the shelf life of fruits. However frequency of application and interaction effects did not show any significant influence on shelf life.

Application of lowest level of NPK (L_1) had prolonged the keeping quality of fruits (8.33 days) which was significantly superior to other levels. Highest level of NPK (L_3) had produced the lowest shelf life (6.17 days). Shelf life recorded by all the three levels of NPK were significantly different from each other.

The average number of days of shelf life recorded by the twelve treatments was significantly lower (7.248 days) compared to mean of two additional treatments (A_1 and A_2). However the shelf life of fruits did not show much significant variation between A_1 and A_2.

4.6 Sensory evaluation of ripe fruits

The fruit samples were evaluated for their organo-leptic qualities and the rank means for the attributes tested viz. taste, texture and lump formation are presented in Table 9.

Table 9 Sensory evaluation of ripe fruits (Rank means) of banana var. Nendran

Treatments	Taste	Texture	Lump formation	Overall acceptability
T_1	147.60	161.90	147.60	164.78
T_2	150.80	167.40	150.80	153.08
T_3	138.00	181.30	138.00	178.68
T_5	198.90	161.70	198.90	177.98
T_5	149.80	151.30	149.80	165.85
T_6	115.85	139.90	115.85	135.40
T_7	136.55	135.00	136.55	129.83
T_8	115.85	129.30	115.85	125.25
T_9	145.35	129.10	145.35	138.95
T_{10}	132.10	118.70	132.10	121.03
T_{11}	54.30	51.70	54.30	16.15
T_{12}	105.50	118.70	105.50	111.35
T_{13}	188.20	161.70	188.20	183.95
T_{14}	188.20	159.30	188.20	164.75
Critical values	50.188	50.188	50.188	50.188

4.6.1 Taste

T_4 (190:115:300 g NPK plant^{-1} in ten splits) recorded the highest rank mean (198.90) which was statistically on par with T_{13}, T_{14}, T_2 and T_5 and significantly superior to other treatments. Treatments T_{13}, T_{14}, T_2, T_5, T_1 and T_9 were also found to be on par. Lowest rank mean (54.30) was observed by T_{11} which was significantly inferior to all other treatments. T_{12} also recorded lower rank mean (105.50) and was statistically on par with T_8, T_6, T_{10}, T_7, T_3, T_9, T_1, T_5 and T_2.

4.6.2 Texture

Good textured fruits were observed with T_3 which recorded a higher rank mean (181.30) and was statistically on par with T_2, T_1, T_4, T_{13}, T_{14}, T_5, T_6, T_7 and significantly superior to other treatments. Treatments T_2 was in turn statistically on par with T_1, T_4, T_{13}, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{12}. Treatment T_{11} produced poor textured fruits which was significantly inferior to all other treatments.

4.6.3 Lump formation

Lump formation was found to be minimum in T_4 which had recorded the highest rank mean and was statistically on par with T_2, T_5, T_1 and T_9. T_{11} recorded the lowest rank mean (54.30) which was significantly inferior to other treatments.

T_{12} also recorded a lower rank mean which was statistically on par with T_8, T_6, T_{10}, T_7, T_3, T_9, T_1, T_5 and T_2.

Regarding overall acceptability, T_{13} was found to record the highest rank mean (183.16) which was statistically on par with T_3, T_4, T_5, T_1, T_{14}, T_2, T_9, T_6. T_3 was on par with T_7 also. T_5 was found to be on par with T_7, T_8 and T_{10}. Poor quality fruits with significantly lower acceptability was produced with T_{11}.

4.7 Foliar nutrient status at harvest

Table 10 revealed that the nitrogen, phosphorus and potassium content of the third leaf at harvest was not positively influenced by levels of NPK, frequency of application and their interaction effects.

The mean value the two additional treatments (A_1 and A_2) did not show any significant variation from the mean of treatment combinations with regard to the nitrogen and phosphorus content of leaves. However the mean value of the additional treatments (A_1 and A_2) recorded a significantly lower potassium content (1.06%) compared to mean of twelve treatments.

Also no significant difference was observed in the nitrogen and potassium content of leaves between A_1 and A_2. Meanwhile A_2 recorded a significantly lower phosphorus content (0.28%) compared to A_1.

Table 10 Effect of fertilizer treatments on foliar nutrient status at harvest of banana var. Nendran

Fertilizer treatments	Nitrogen (%)	Phosphorus (%)	Potassium (%)
L_1	2.08	0.33	1.63
L_2	2.03	0.43	2.32
L_3	1.93	0.42	2.29
SE±	0.048	0.028	0.204
CD(0.05)	-	-	-
F_1	1.95	0.38	1.58
F_2	1.98	0.39	2.26
F_3	2.08	0.40	2.26
F_4	2.04	0.41	2.22
SE±	0.055	0.033	0.235
CD(0.05)	-	-	-
L_1F_1	2.13	0.31	1.28
L_1F_2	1.88	0.26	1.50
L_1F_3	2.09	0.39	2.26
L_1F_4	2.24	0.39	1.48
L_2F_1	1.89	0.38	1.47
L_2F_2	2.09	0.51	2.58
L_2F_3	2.19	0.44	2.06
L_2F_4	1.94	0.40	3.18
L_3F_1	1.84	0.45	2.00
L_3F_2	1.97	0.39	2.70
L_3F_3	1.97	0.39	2.46
L_3F_4	1.94	0.44	2.00
SE±	0.096	0.057	0.408
CD(0.05)	-	-	-
Treatment means	2.01	0.39	2.08
A_1	2.00	0.48	1.16
A_2	1.82	0.28	0.96

4.8 Soil nutrient status after harvest

Table 11 furnishes the available N, available P_2O_5 and available K_2O content of the soil after harvest.

4.8.1 Available N

Levels of NPK, frequency of application and their interaction effects had significantly influenced the available nitrogen content of soil at harvest.

Available N content of soil was highest at L_3 level (275.78 kg ha^{-1}). N content of soil at all the levels of NPK showed significant difference from each other. Lowest soil nitrogen was observed at L_2 level (253.86 kg ha^{-1}).

No significant difference in the available soil nitrogen content was observed among ten splits, six splits and two splits. However fertilizer application in three splits recorded a significantly lower soil nitrogen content (253.28 kg ha^{-1}) compared to other splits.

Interaction effects were significant with regard to avvailble soil nitrogen content after harvest. Differential responses were observed in the available soil nitrogen content after harvest with different frequencies of application at all the three levels of NPK.

Table 11 Effect of fertilizer treatments on soil nutrient status after harvest of banana var. Nendran

Fertilizer treatments	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (Kg ha^{-1})
L_1	262.39	46.11	176.78
L_2	253.85	54.74	275.69
L_3	275.78	47.42	306.81
SE±	2.424	3.103	7.110
CD(0.05)	7.405	-	21.721
F_1	253.28	59.82	272.88
F_2	265.66	37.32	240.92
F_3	265.70	50.90	220.20
F_4	271.38	49.69	278.36
SE±	2.799	3.583	8.211
CD(0.05)	8.551	10.945	25.082
L_1F_1	241.47	61.10	188.16
L_1F_2	260.50	30.00	141.12
L_1F_3	273.22	58.95	147.84
L_1F_4	274.35	36.42	230.00
L_2F_1	261.22	56.10	295.68
L_2F_2	253.97	43.61	288.96
L_2F_3	239.90	64.95	255.02
L_2F_4	260.29	54.30	263.08
L_3F_1	257.15	62.30	334.80
L_3F_2	282.51	38.30	292.68
L_3F_3	283.96	30.70	257.74
L_3F_4	279.50	58.40	342.00
SE±	4.848	6.206	14.222
CD(0.05)	14.810	18.956	43.443
Treatment means	264.00	49.42	253.09
A_1	230.49	59.10	370.00
A_2	174.38	44.20	87.50

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Ten, two and six splits application at lowest level of NPK (L_1) recorded comparable values in the available soil nitrogen content after harvest. The corresponding figures were 274.35 kg ha^{-1}, 274.35 kg ha^{-1} and 260.50 kg ha^{-1} respectively. These values were significantly superior to three splits. Highest available soil nitrogen content at L_2 level was observed with three splits (261.22 kg ha^{-1}) which was on par with ten and six splits and significantly superior to two splits. Six splits and two splits were on par at this level. At the highest level of NPK (L_3) two, six and ten splits were statistically on par and significantly superior to three splits.

The mean of treatment combinations showed a significantly higher available soil nitrogen content (264.00 kg ha^{-1}) compared to mean of additional treatments (A_1 and A_2). Also significant variation in soil nitrogen content was observed between A_1 and A_2, with a comparatively higher soil nitrogen content (230.49 kg ha^{-1}) being recorded by A_1.

4.8.2 Available P_2O_5

Levels of NPK did not exert any significant positive influence on the P_2O_5 content after harvest, while frequency of application and interaction effects exhibited a strong positive influence on the phosphorus content.

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Among the split applications of N and K fertilizer, three, two and ten splits were found to be statistically on par and showed significant variation in P_2O_5 content from six splits. The corresponding values for three, two and ten splits where 59.82 kg ha^{-1}, 50.90 kg ha^{-1} and 49.69 kg ha^{-1} respectively.

Interaction between levels of NPK and frequency of application was found significant. At all the three levels of NPK differential responses were observed in available P_2O_5 content after harvest with different frequencies of application.

Three and two split at L_1 level recorded higher P_2O_5 content after harvest which were on par and showed significant variation from other splits. Ten and six splits were statistically on par, with lower P_2O_5 content being observed at six splits (30.00 kg ha^{-1}). Two, three and ten splits at L_2 level recorded comparable available P_2O_5 values viz. 64.95 kg ha^{-1}, 56.10 kg ha^{-1}, and 54.30 kg ha^{-1} respectively. Ten splits at this level was on par with six splits. At the highest level of NPK (L_3) three and ten splits were on par and significantly different from other splits six and two splits at this level recorded lower P_2O_5 values which were on par.

No significant difference in P_2O_5 content was observed between treatment means and mean of the two additional treatments and also between A_1 and A_2.

4.8.3 Available K_2O

The available potassium content of the soil was favourably influenced by different levels of NPK, frequency of application and their interaction effects.

The highest K_2O content in the soil (306.81 kg ha^{-1}) was noticed at the highest level of NPK (L_3). The K_2O content observed at different NPK levels showed significant variation among themselves, with lowest value (176.780 kg ha^{-1}) being recorded by the lowest level of NPK (L_1).

Application of fertilizer in ten splits recorded a significantly higher K_2O content (278.36 kg ha^{-1}) which was statistically on par with three splits and significantly different from other splits. A lower level of potassium content in soil (220.20 kg ha^{-1}) was observed by two splits which was statistically on par with six splits.

Interaction was observed between levels of NPK and frequency of application. L_1 and L_3 levels showed similar response in available soil K_2O content after harvest with different frequencies of applcation. However L_2 levels showed no response to frequency of application.

Ten splits recorded higher values for available K_2O content after harvest (230.00 kg ha^{-1}) at L_1 which was on par with three splits. Three splits was in turn on par with two splits. Six splits recorded the lowest K_2O content (141.12 kg ha^{-1}) at this level which was on par with two splits. No significant variation in available K_2O content was observed with different frequencies of application at L_2 level. Ten splits and three splits recorded higher available K_2O values (342.00 kg ha^{-1} and 334.80 kg ha^{-1} respectively) at L_3 level which were on par. Three splits was in turn on par with six splits. Two splits recorded the lowest K_2O content (257.74 kg ha^{-1}) which was on par with six splits.

The mean of twelve treatment combinations recorded a significantly higher K_2O content (253.09 kg ha^{-1}) compared to mean of the two additional treatments (A_1 and A_2). The two additional treatments (A_1 and A_2) also showed significant variation between themselves with the highest content being recorded by A_1 (370.00 kg ha^{-1}).

4.9 Incidence of pest and diseases

The incidence of pseudostem weevil was negligible. No incidence of bunchy top disease and rhizome weevil were observed in the experimental field. The only major incidence observed was Sigatoka leaf spot.

Table 12 furnishes the data on Sigatoka leaf spot incidence. Levels of NPK and frequency of application showed significant variation on the incidence of sigatoka leaf spot while interaction effects were not significant.

Table 12 Effect of fertiliser treatments on the incidence of Sigatoka leaf spot in banana var. Nendran

Treatments	Per cent infection index
L_1	13.24
L_2	15.14
L_3	15.78
SE±	0.405
CD(0.05)	1.236
F_1	12.58
F_2	15.56
F_3	16.28
F_4	14.46
SE±	0.467
CD(0.05)	1.428
L_1F_1	12.35
L_1F_2	12.75
L_1F_3	14.03
L_1F_4	13.83
L_2F_1	12.58
L_2F_2	16.90
L_2F_3	16.45
L_2F_4	14.63
L_3F_1	12.80
L_3F_2	17.04
L_3F_3	18.35
L_3F_4	14.94
SE±	0.810
CD(0.05)	-
Treatment means	14.72
A_1	13.87
A_2	12.40

Sigatoka leaf spot incidence was observed to be highest (15.782%) at the highest level of NPK (L_3) which was statistically on par with L_2. Leaf spot incidence was significantly lower (13.24%) at the lowest level of NPK (L_1).

Per cent leaf spot infection was highest (16.28%) at two splits which was statistically on par with six splits. Six splits was in turn on par with ten splits. Significantly lower level of infection was noticed at three splits (12.58%).

The mean of twelve treatment combinations differed significantly from the mean of additional treatments (A_1 and A_2), with comparatively lower infection being recorded by the latter. However the additional treatments did not show any significant variation between themselves.

4.10 Economics of Production

The details of economics of production (Benefit Cost Ratio) are furnished in table 13.

T_2 recorded the highest benefit cost ratio (2.46) followed by T_6 (2.45). Lowest Benefit Cost ratio was recorded by T_{13} (1.57) followed by T_{14} (1.63). The highest net profit of Rs.189460 was realised ha^{-1} in T_6 followed by T_2, T_3, T_7 and T_1. T_{13} recorded the lowest net profit (Rs.69160).

Table 13 Economics of production (ha^{-1})*

Treatments	Total income (Rs.)	Total cost of cultivation (Rs.)	Net profit (Rs.)	B:C ratio
T_1	255000	118624	136376	2.15
T_2	295625	120049	175576	2.46
T_3	260625	118149	142476	2.21
T_4	253135	121949	131176	2.08
T_5	258750	128260	130490	2.02
T_6	320000	130540	189460	2.45
T_7	265375	127500	137875	2.08
T_8	265500	133580	131920	1.99
T_9	256250	137612	118638	1.86
T_{10}	272500	140462	132038	1.94
T_{11}	255000	136662	118338	1.87
T_{12}	257500	144262	113238	1.78
T_{13}	190375	121215	69160	1.57
T_{14}	186875	114668	72207	1.63

* Data statistically not analysed

Wage rate - Rs. 95 day^{-1}

Cost of inputs

- Farmyard manure - Rs. 0.68 kg^{-1}
- N (Urea) - Rs. 7.40 kg^{-1}
- N (Factamphos) - Rs.15.80 kg^{-1}
- P_2O_5 - Rs.13.80 kg^{-1}
- K_2O - Rs. 7.00 kg^{-1}

Cost of produce - Rs.10.00 kg^{-1}

DISCUSSION

DISCUSSION

Banana though occupies the second position in the total fruit production of our country (Tajuddin *et al*. 1996), it caters to meet the fruit requirement of the people throughout the year unlike the other seasonal fruits like mango. Among the different varieties cultivated, Nendran being highly remunerative has become the leading commercial variety of banana in Kerala.

Among the factors which influence the production potential of banana, fertilizer nutrients play a vital role. Crop removal to the extent of 300 kg N, 80 kg P_2O_5 and 800 kg K_2O from a hectare of land has been reported by Veeraraghavan (1972). Hence adequate supply of nutrient becomes a prerequisite for efficient banana production.

Apart from the quantity of fertilizers applied, the time of application, especially during the early stages of growth, is an important factor (Summerville, 1944). Greater requirements of nutrients especially of nitrogen and potassium and their split applications have been emphasised by several workers (Fawcett, 1921., Norris and Ayyar, 1942., Alexandrowitz, 1955 and Dugain, 1959). Though there are reported evidences to show that fertilizers applied in two splits have been found to be beneficial for optimum yield (Pillai *et al*. 1977., Valsamma Mathew, 1980 and Sheela, 1982), the increased split applications also had an impact on the yield and yield attributes of banana. For instance it has been recommended to apply the prescribed dose of fertilizer (190:115:300 g NPK $plant^{-1}$ $year^{-1}$) in two splits and has further advocated to increase the number of splits from two to six wherever the cost is affordable (KAU, 1996).

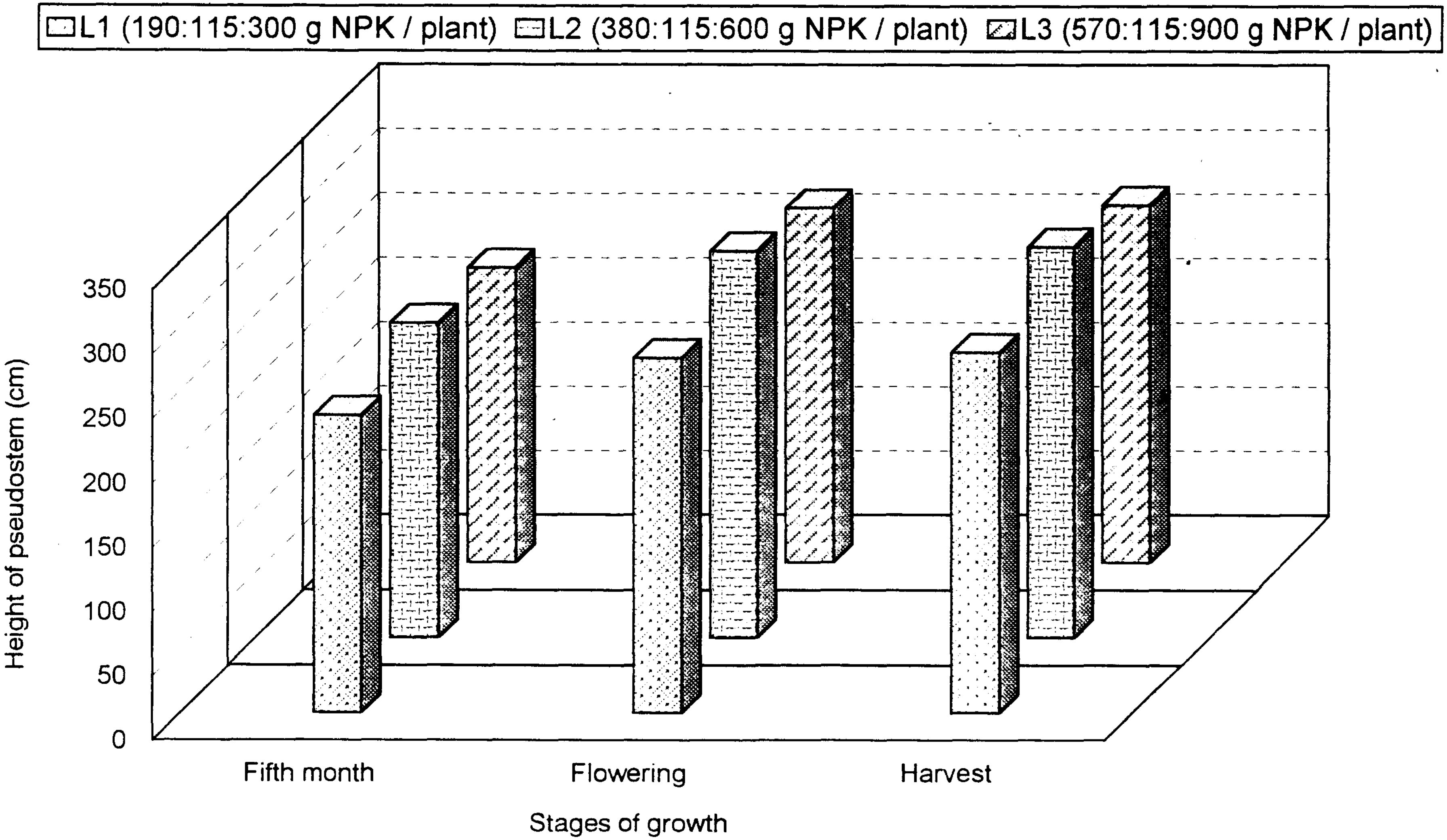
From the cultivator's point of view the present recommendation is found to be inadequate to achieve the maximum yield potential of 'Nendran' banana. The present investigation is envisaged to ascertain the impact of increased level of nutrients and increased frequency of application over the present recommendation in maximising the productivity of 'Nendran' banana. The results obtained in the present study are discussed below.

5.1 Vegetative characters

5.1.1 Height and girth of pseudostem

In banana the height and girth of the pseudostem are the important parameters to judge the vigour of the plant (Simmonds, 1987). The results of the present studies (Fig. 2 and 3) revealed that L_2 level (380:115:600 g NPK $plant^{-1}$) exerted a significant influence on the plant height and girth at all the three stages of growth (fifth month, flowering and harvest) compared to other levels of NPK. This may be

Fig. 2 Effect of levels of NPK on height of pseudostem of banana var. Nendran

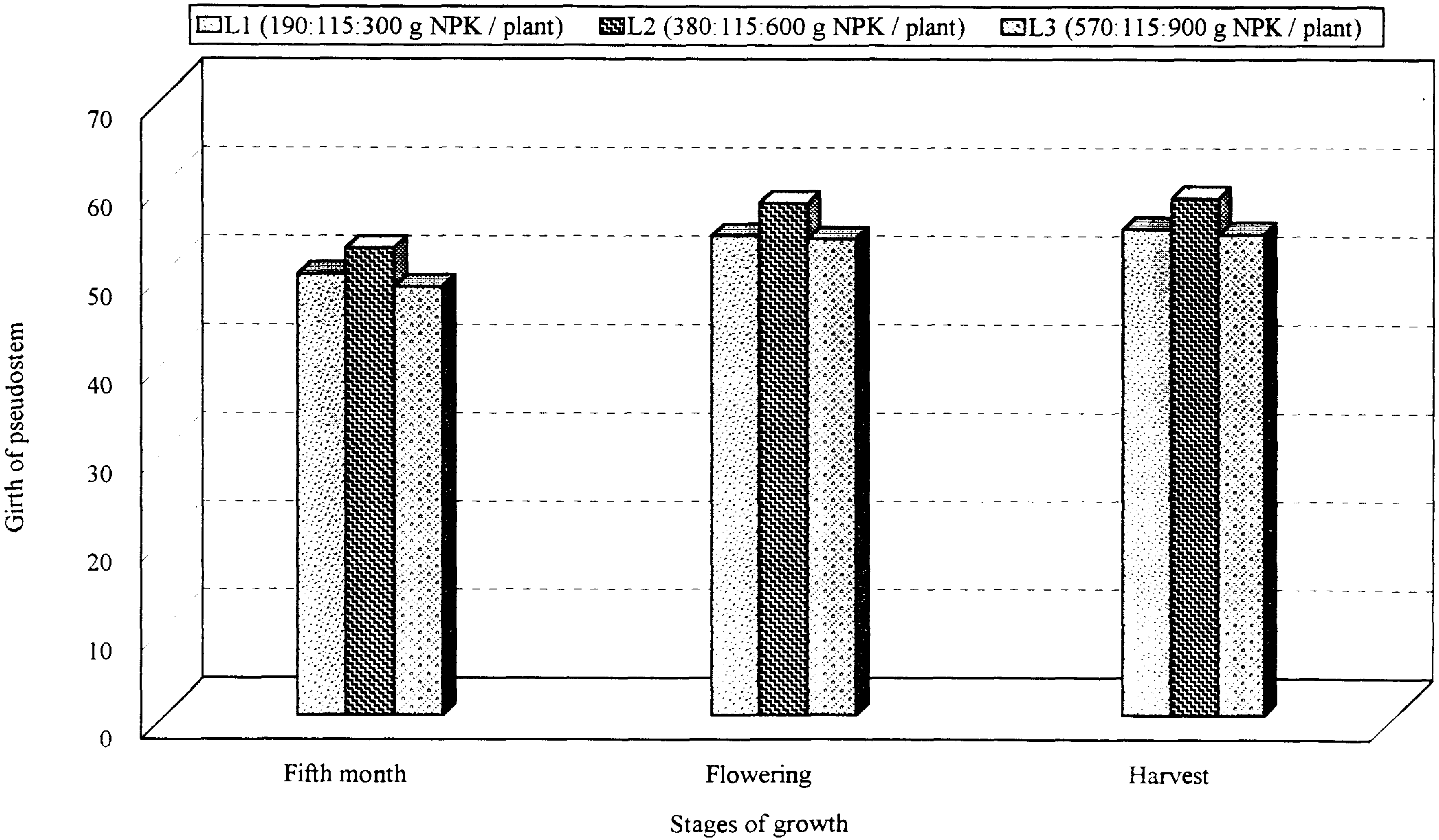


attributed to the role of nitrogen on the vegetative characters of the plant at higher levels (L_2). Sheela (1996) reported that significant increase in height of pseudostem in 'Nendran' banana noticed from the fifth month after planting with nitrogen and potassium application might be due to the increased hormonal activity at the flower initiation stage which occurred at that stage.

It may be noted that increase in plant height and girth was observed with increase in levels of N and K upto L2 level and thereafter it showed a declining trend. Here the plants showed maximum response to L_2 level of nutrients which provided adequate supply of nitrogen and potassium to the plant. The satisfactory rate of photosynthesis and meristematic activity under adequate supply of N and K would have contributed for the increase in plant height and girth under higher levels of N and K (L_2). The uptake of nutrients, more specifically N, ultimately leads to the formation of complex intragenous substances such as proteins, aminoacids etc. to build up new tissues (Clay pool, 1936 and Childers, 1966).

Increase in height and girth of pseudostem with increasing levels of nitrogen was reported by Ashok kumar (1977) and Valsamma Mathew (1980).

Fig. 3 Effect of levels of NPK on girth of pseudostem of banana var. Nendran



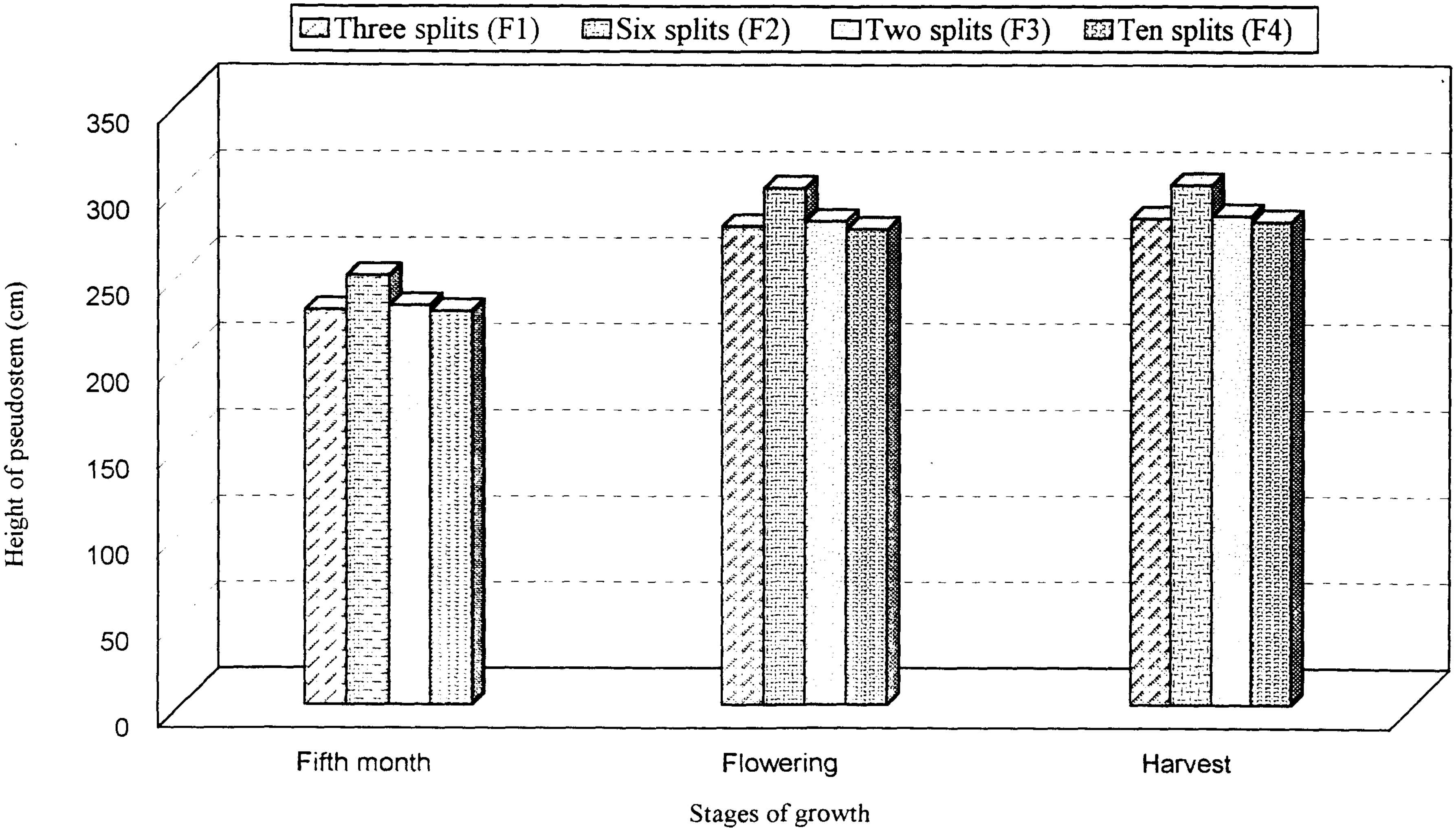
Oubahou and Dafiri (1987) highlighted the role of potassium on the height and pseudostem circumference in banana. Sindhu (1997) observed significant increase in height and girth of pseudostem at bunch maturation and harvest stage with increasing levels of K (0 to 600g plant^{-1}) in 'Nendran' banana.

However higher levels (L_3) above the apparently optimum level of N and K (L_2) have significantly reduced the plant height and girth. According to Anjorin and Obigbesan (1983) significant reduction in height and girth of pseudostem of bananas was observed at higher levels of nitrogen.

Reduction in height and girth may be attributed to the diminishing role of excess nitrogen. Also relatively high phosphorus status of soil and poor phosphorus feeding ability of banana might have resulted in the low efficiency of nitrogen fertilizer at higher levels and resulted in reduced vegetative growth. Reduced growth due to excessive quantities of N in the presence of P and K was also reported by Du Plessis (1982).

Among the different split applications, six splits was found to be the best which recorded the highest plant height and girth at all the three stages of growth viz. 5th month, flowering and harvest (Fig. 4 and 5). Banana crop requires more quantity of nitrogen during the early stages of growth before, during and just after flowering especially at the time of flower bud initiation. This would explain the

Fig. 4 Effect of frequency of application on height of pseudostem of banana var. Nendran



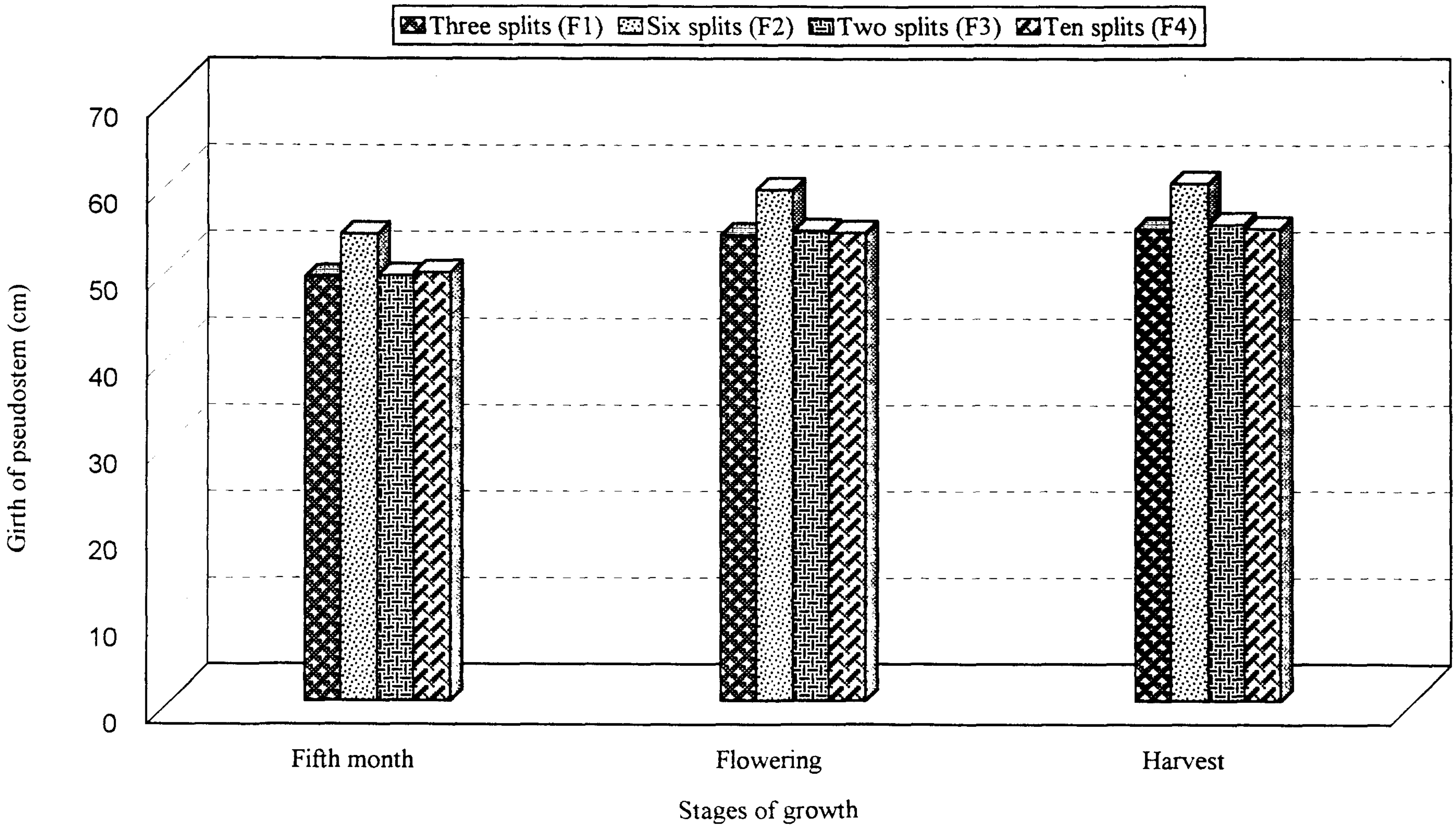
better effect in six splits where the nutrient application is well distributed compared to two splits and three splits. Summerville (1944) opined that the time of application is an important factor and for better results the fertilizers are to be applied during the early stages of growth. Increase in pseudostem height of bananas due to split application of nutrients have been reported by Battikhah and Khalidy (1962), Nambiar *et al*. (1979) and Rajeevan (1985). Veerannah *et al*. (1976) reported that nitrogen and potassium are absorbed more in pre flowering stages in 'Robusta' banana.

However increasing the number of splits above six did not show any marked improvement on plant height and girth. This may be due to the fact that plants might have received only lesser quantity of nutrients during the early stages of plant growth because of the diversion of the portion of total nutrient to later part of the growth stage when the plants had attained the maximum height and girth.

Interaction effects of nutrient levels and frequency of application were found to be significant on height of the plants while it was not significant on plant girth.

Though the increase in plant height between fifth month and flowering are marginal, the treatments had profound influence on these values. On the whole, application of 380:115:600 g NPK $plant^{-1}$ in six splits produced the highest

Fig. 5 Effect of frequency of application on girth of pseudostem of banana var. Nendran



plant height which was significantly superior to all other treatments including the two additional treatments (A_1 and A_2). At L_2 level time interval between fifth and sixth split is comparatively shorter compared to L_1 level due to early shooting observed by six splits at L_2 level, which implies more nitrogen availability within shorter period of time and resulted in marginal increase in height of pseudostem. But similar effect at highest level (L_3) was found to be absent probably due to poor response to supra-optimal levels of nitrogen.

At flowering the lowest height recorded by lowest level of NPK (L_1) in ten splits was statistically on par with L_3 at all the splits tried and lowest level applied in two splits and three splits and L_2 level in three splits.

The height and girth of the plant did not show any marked improvement after flowering stage. The plants have attained the maximum height and girth at the flowering stage itself and hence the application of fertilizer after the flowering stage could not produce any marked increment in height and girth. This is mainly because there is little height and girth increase on post-shooting phase due to termination of growth and leaf production in banana.

5.1.2 Number of leaves and LAI

5.1.2.1 Number of leaves

The importance of functional leaves and their increased photosynthetic efficiency contributing to ultimate yield has been emphasized in the fertilizer experiments conducted in India and elsewhere.

The functional leaves was positively influenced by the different levels of NPK at the flowering and harvest stage. During the early stage (fifth month) the number of leaves was not very much influenced by levels of NPK. Increasing the levels of nutrients have not contributed much for the production of functional leaves upto fifth month. So during this stage, leaf production which is the result of the physiological function of banana is not altered by the supply of nutrients at different levels.

There are reports showing the influence of N and K on the number of leaves. Venkatesam *et al*. (1965) observed increase in the number of leaves with increase in nitrogen level. Significant influence of potassium on number of leaves was reported by Lacoevilhe (1973).

In the present study, increase in levels of N and K had a positive impact on the number of leaves upto L_2. The increased vigour and meristematic activity of the plants brought about as a result of supply of adequate quantities of nutrients at this level (L_2) might be the reason for increased leaf number. The influence of mineral nutrition on the rate of leaf production was reported by Murray (1960).

Highest level of N and K (L_3) has resulted in the production of lesser number of leaves which was found to be statistically on par with lowest level tried (L_1). Nair (1988) also observed significant reduction in the number of leaves produced at higher levels of nitrogen in 'Nendran' banana. Production of lesser number of leaves at L_3 level might have resulted from the lesser uptake of nutrients from a soil with relatively high phosphorus status and supplied with higher amounts of N and K.

Reduction in the number of leaves observed at harvest stage might be due to non production of new leaves after flowering stage and senescence of leaves already produced. Significant difference in the number of leaves recorded at the harvest stage by the different NPK levels clearly indicated the positive influence of the levels of NPK on leaf senescence. More number of leaves was retained at L_2 level while at highest level (L_3) number of leaves recorded was lower compared to L_2 and was statistically on par with L_1. The leaf senescence may normally be due to physiological maturity. However higher incidence of sigatoka leaf spot might have also resulted in early senescence. Hence both physiological maturity and sigatoka leaf spot incidence were significantly influenced by levels of NPK.

The different frequencies of application had a positive impact on the functional leaves recorded at the flowering stage only. Maximum number of leaves was produced when fertilizers were applied in six splits. Increase in the number of leaves produced with increased number of split applications have been reported by Battikhah and Khalidy (1962) and Rajeevan (1985). Increasing the number of splits beyond six had no significant effect on number of leaves produced. Hence it is evident that small instalments of nitrogen and potassium application throughout the initial stages and during the flower bud initiation stages have got a profound influence on the number of leaves produced. The rate of leaf production varies in different growth phases of the banana plant (Stover and Simmonds, 1987). The fertilizer application in the present studies might have contributed to active leaf production in the vegetative phase. At harvest stage, no significant difference in the number of leaves was observed by the different frequencies of application. This clearly indicated that leaf senescence due to physiological maturity and sigatoka leaf spot, was not at all affected by different frequencies of application.

Interaction effect did not show any significant variation in the number of leaves at all the three stages of growth (fifth month, flowering and harvest).

5.1.2.2 Leaf Area Index

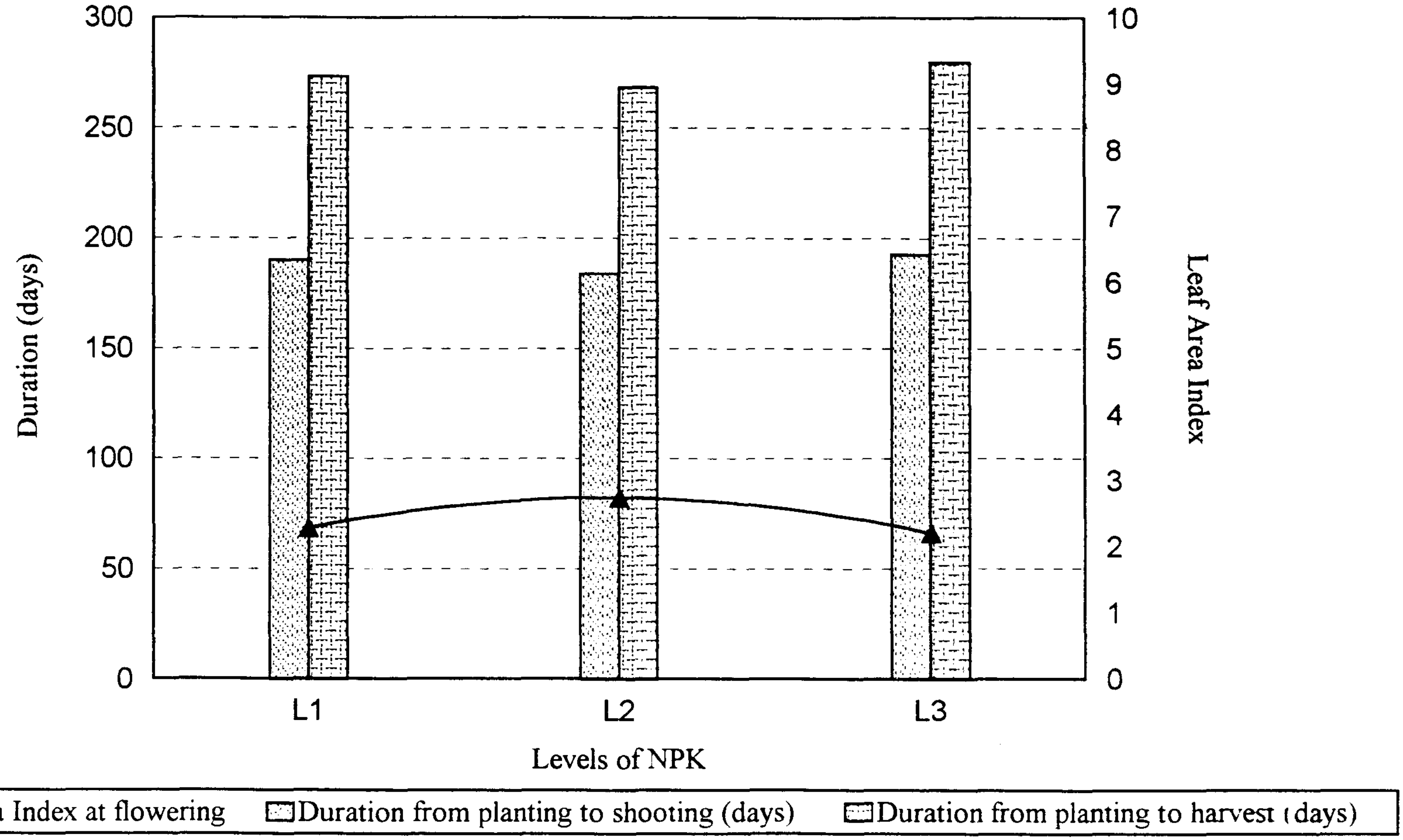
When the LAI recorded at three stages (fifth month, flowering and harvest) were compared, it was observed that LAI recorded at the fifth month and harvest was not significantly influenced by NPK levels, frequency of application and their interaction effects. At flowering stage, different levels of NPK, frequency of application and their interactions have brought about significant difference in LAI.

Increase in LAI was noticed with increase in nutrient application upto L_2 level at flowering stage (Fig. 6). Since a similar trend was observed in the case of functional leaves it could be inferred that higher LAI may be due to increase in number of functional leaves as well as leaf area.

Balakrishnan (1980) observed that high LAI coincides with the stages of growth when the plant produced high leaf number and leaf area. Kohli *et al*. (1985) observed significant increase in LAI of 'Robusta' banana by application of nitrogen. According to Singh *et al*. (1990), LAI of 'Dwarf Cavendish' banana was increased by application of nitrogen but not by potassium. In the present experiment, highest LAI observed at L_2 level might be due to enhanced production of leaves with comparatively higher leaf area due to optimum supply of nutrients especially nitrogen.

At the highest level of NPK (L_3), LAI was lowest which was statistically on par with the lowest level. The number of leaves recorded at flowering stage also observed a similar trend. Hence significant reduction in LAI observed at

Fig. 6 Effect of levels of NPK on Leaf Area Index (LAI) at flowering, Duration from planting to shooting and planting to harvest in banana var. Nendran



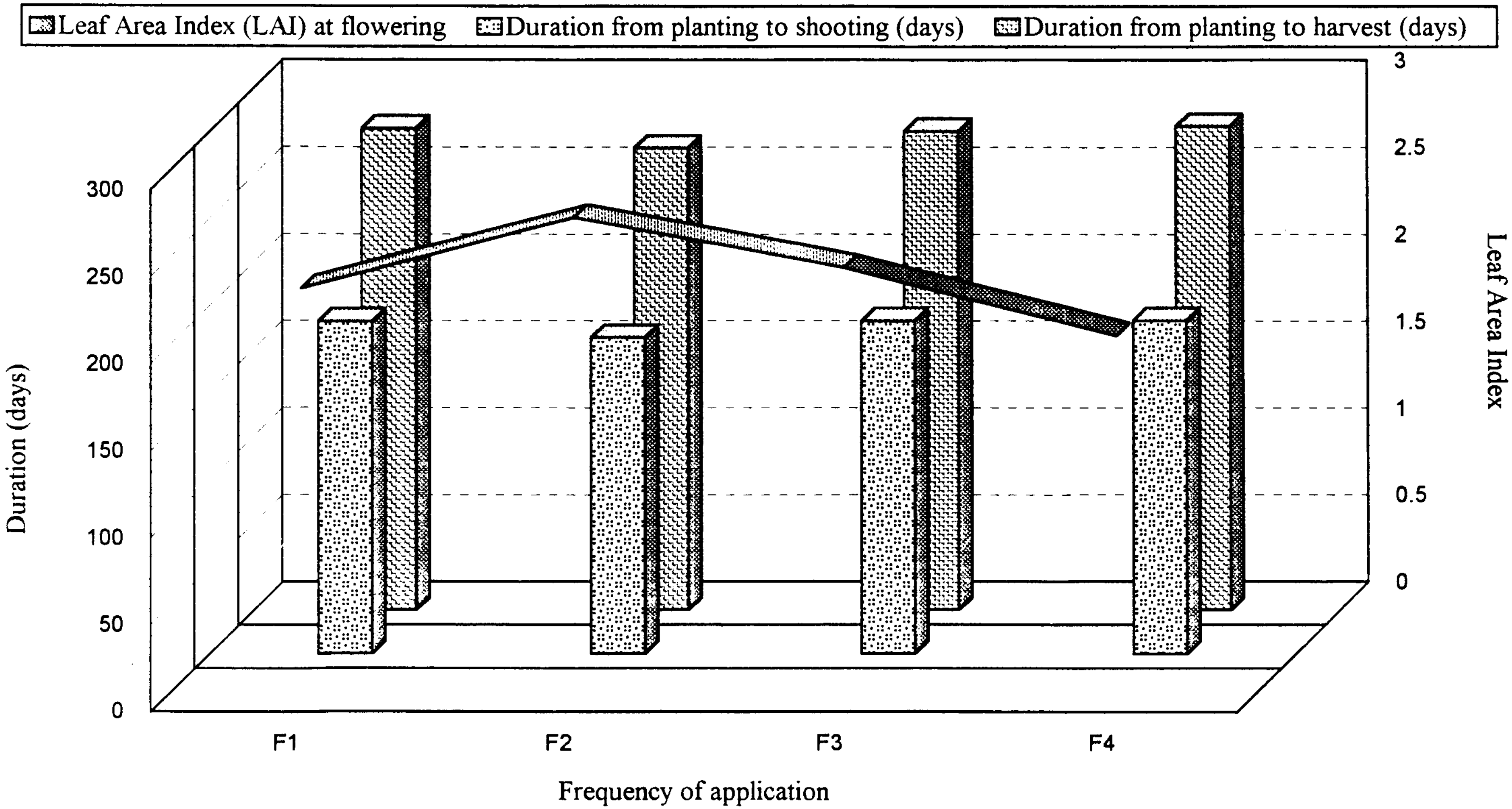
L1 - 190:115:300 g NPK / plant L2 - 380:115:600 g NPK / plant L3 - 570:115:900 g NPK plant highest levels might be due to the production of lesser number of leaves under excess quantities of N and K. Production of comparatively lesser number of leaves at lowest level (L_1) might have resulted in the lower LAI at this level. According to Lahav (1972) in potassium deficient banana plants, the leaves were small and their longivity shorter, thus reducing the total foliage area. Sumam George (1994) opined that as only the functional leaves were considered for determining the leaf area their lower number along with decreased leaf size might have contributed for the decrease in leaf area at lower levels of potassium supply.

With regard to the LAI recorded by different split application of nutrients, six splits had recorded the maximum LAI during flowering stage (Fig. 7). Highest LAI observed in six splits may be attributed to the increased production of leaves and increased leaf area due to well distributed application of nutrients during the period in which physiology of the plant is very much influenced by growth factors.

Increase in leaf area by split application of nutrients has been reported by Battikhah and Khalidy (1962). Contrary to this Rajeevan (1985) reported that leaf area was not influenced significantly by different split applications.

Increasing the number of splits above six have markedly reduced the LAI. This may be attributed to lesser

Fig. 7 Effect of frequency of application on Leaf Area Index (LAI) at flowering, Duration from planting to shooting and planting to harvest in banana var. Nendran



F1 - Three splits
F2 - Six splits
F3 - Two splits
F4 - Ten splits

production of leaves with reduced leaf size under supply of relatively lower dose of N and K during the early stages of the crop growth in ten splits. According to Stover and Simmonds (1987) the width of leaf varies in different growth stages of banana plant. More leaf area can be expected towards middle of vegetative phase.

At flowering stage, interaction effects were significant. Maximum LAI was observed at double the recommended dose of N and K (L_2) in two splits which was statistically on par with three splits and six splits at L_2 level and six splits at L_1 level. Since the number of leaves at flowering stage was not significantly influenced by interaction effects, the positive effect of interaction on LAI could only be attributed to the increased leaf area by these treatments.

At harvest stage the LAI was influenced only by the different frequencies of application tested. It may be noted that total number of functional leaves have reduced from flowering to harvest stage due to drying by senescence and leaf spot infestation and was influenced by levels of NPK. The reason for the nonsignificance in the LAI value observed at different levels of NPK may be due to the fact that increased levels of N and K could not produce any significant variation in the leaf area of the available leaves at harvest.

Fertilizer application in six splits recorded the highest LAI at harvest stage. This may be attributed to the increased number of leaves and leaf area during mid vegetative phase due to supply of optimum quantities of N and K during early stages of growth especially at flower bud initiation stage. The higher number of splits over and above the six splits were statistically on par with the lesser number of splits.

5.1.3 Duration from planting to shooting, shooting to harvest and planting to harvest

Different levels of NPK and frequency of application had significantly influenced the number of days taken for shooting, harvesting and total crop duration. However interaction effects were not significant.

Early shooting was observed at L_2 level (Fig. 6). This might be due to the enhanced vigour of the plant which was inturn indicated by the better vegetative growth observed at this level due to supply of optimum quantities of N and K. Venkatesam *et al*. (1965) opined that more vigorous plants took comparatively lesser time to shooting. The promotive effect of nitrogen in hastening the flowering has been reported by Chattopadhyay *et al*. (1980) and Kohli *et al*. (1985). Owing to the earlier production of leaves with larger leaf area and better disposition for photosynthetic activity, the required "net assimilation" presumably reached early in plants receiving higher dose of nitrogen which hastened the process of initiation and emergence of inflorescence (Parida *et al*. 1994).

For bunch maturation, lesser number of days were taken by the lowest level of N and K (L1) and was statistically on par with L_2 level. From this it can be inferred that optimum quantities of N and K has advanced the physiological maturity of the crop.

The role of nitrogen on inducing early flowering and harvesting were emphasized by several workers. Ramaswamy and Muthukrishnan (1974b) highlighted the influence of nitrogen on accelerating the inflorescence emergence and shortening the number of days to harvest. The role of nitrogen on inducing early differentiation and reducing the vegetative period when supplied with 400 g N $plant^{-1}$ in 'Dwarf Cavendish' banana was emphasized by Sweidan *et al*. (1981).

Apart from nitrogen the higher levels of potassium might have contributed much to advance flowering and harvesting. This view was corraborated by Jambulingam *et al*. (1975) who observed earlier flowering and maturation with K_2O application (above 360 g $plant^{-1}$).

The total crop duration was observed to be lowest at L_2 level (Fig. 6) and this was mainly due to early shooting observed at this level. However highest levels of N and K (L_3) have delayed flowering, harvesting and hence total crop duration. Delay in flowering and harvesting at higher levels might be due to supraoptimal levels of nitrogen diverting carbohydrate into vegetative growth and lowering the levels of other nutrients in the vegetative tissue (Black, 1965). Confirmatory results were also reported as early as 1989 by Ram and Prasad who observed delayed flowering with higher NPK rates in banana cv. Campierganj Local. Hence it is evident that a combination of N and K in balanced proportion is found to be necessary for enhancing the crop growth. The importance of optimum quantities of N and K on crop growth have been highlighted by many workers (Croutcher and Mitchell, 1940., Summerville, 1944 and Bhangoo *et al*. 1962).

The significant effect of reducing the number of days to shooting and to harvest was noticed in N and K applied in six splits (Fig. 7). This enabled an assured supply of optimum quantities of N and K at the critical stages of crop growth especially during the earlier stages and flower bud initiation stage during which it needs the nutrients most. Positive response of split application in hastening shooting has been reported by Sharma (1984) and Rajeevan (1985).

The positive effect of six splits in reducing the number of days taken from shooting to harvest was found to be on par with two splits and ten splits. There are reports on the influence of nitrogen on reducing the number of days to harvest (Ramaswamy and Muthukrishnan, 1974a).

It is evident that reduction in total duration of the crop was mainly the result of reduction in number of days to shooting which was explained by the significant effect produced by the six splits.

In confirmity with the effect on number of leaves and other vegetative characters, maximum number of splits reduced the availability of required nutrients during the earlier growth stages leading to delayed shooting and delayed harvesting.

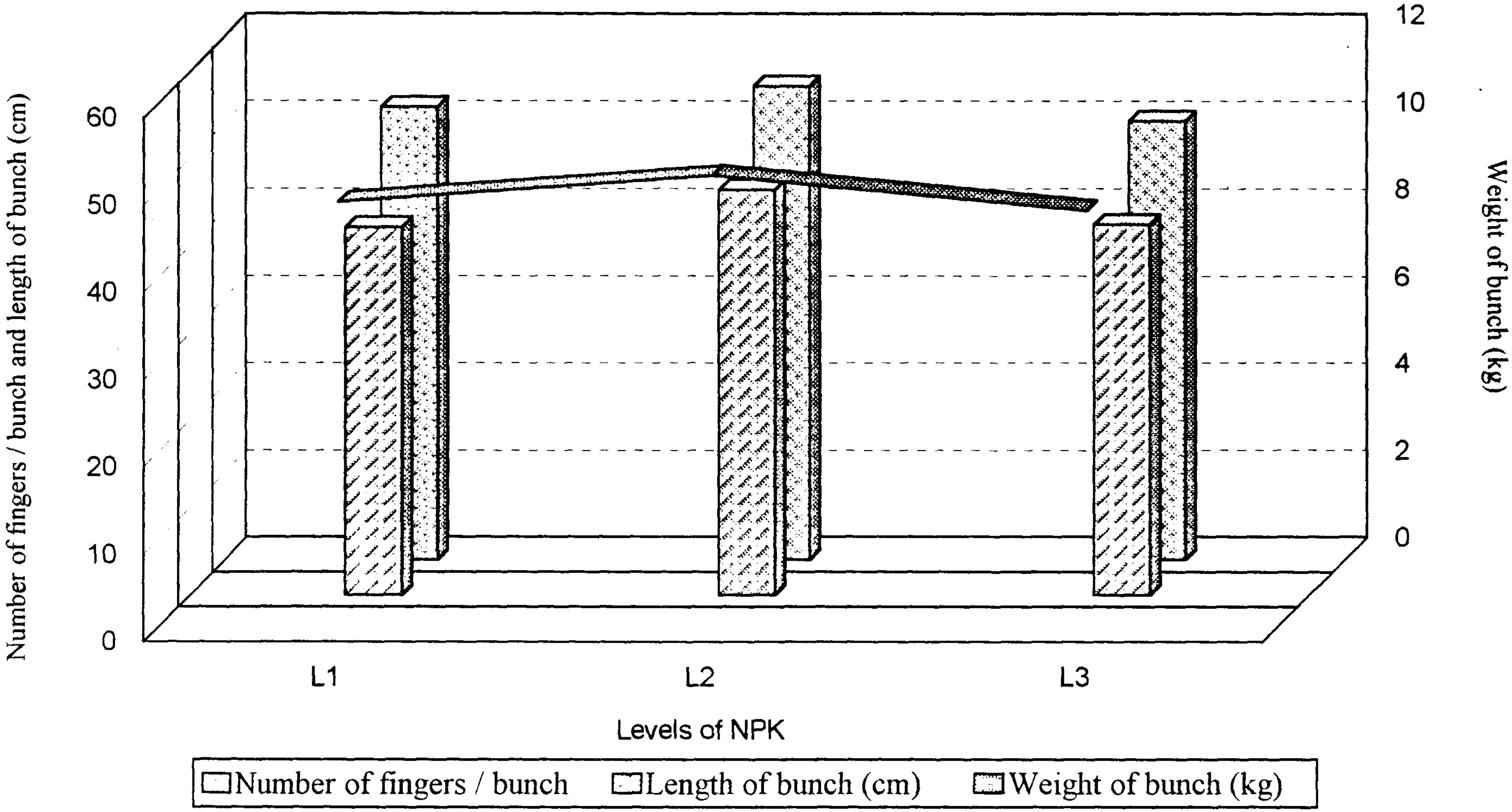
5.2 Yield and yield attributes

In banana, the characters viz. number of hands, number of fingers bunch^{-1}, weight of hand and length, girth and weight of individual fingers are considered as determinants of yield (Stover and Simmonds, 1987).

5.2.1 Bunch characters

Among the different bunch characters studied, number of fingers bunch^{-1} and length of bunch were significantly influenced by levels of NPK (Fig. 8). However levels of NPK did not exert any positive impact on number of hands and compactness of bunch.

Fig. 8 Effect of levels of NPK on the number of fingers / bunch, length and weight of bunch in banana var. Nendran



L1 - 190:115:300 g NPK / plant L2 - 380:115:600 g NPK / plant L3 - 570:115:900 g NPK / plant

The number of fingers $bunch^{-1}$ and bunch length showed an increasing trend with increase in levels of N and K upto L_2 level. Improved vegetative characters particularly more number of leaves produced at this level 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 the L_2 level. It is obvious that a longer bunch is capable of carrying more number of fingers compared to a shorter bunch. It can also be inferred that by this level of application plant was able to attain required fertilizers at the critical periods of growth.

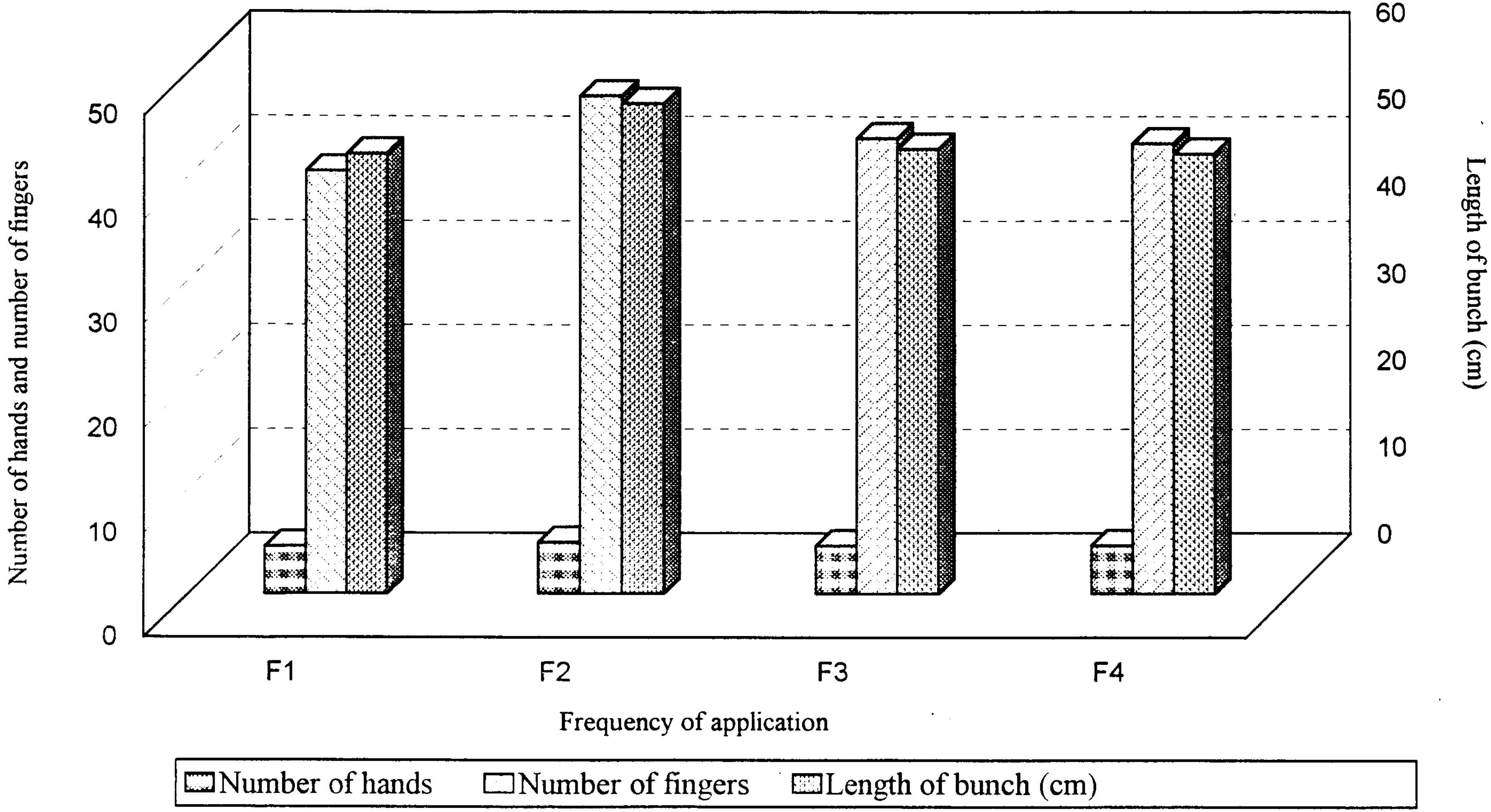
The influence of nitrogen and potassium on the bunch characters were reported by several workers. Increase in number of fingers with increased nitrogen application has been reported by Mustaffa (1983). Chattopadhyay *et al.* (1980) reported that at 240 g N $plant^{-1}$, number of fingers was the highest. Contrary to this Nair (1988) reported that nitrogen had no significant influence on the number of fingers at maturity while higher levels of K_2O (600 g $plant^{-1}$) significantly increased the number of fingers.

Increasing the levels of N and K above the optimum level (L_2) had significantly reduced the number of fingers and bunch length. Excess quantities of N and K might have exerted a detrimental effect on bunch length and hence on the number of fingers produced. Moreover number of leaves produced was observed to be lower at higher levels of N and K which resulted in the reduction of the amount of photosynthates produced. This might have resulted in the reduction of bunch length and number of fingers produced. Similar results with excess nitrogen were reported by Rao (1978) and Natesh, (1987). They observed significant response of banana to nitrogen, but beyond a certain level the benefits were not found to be proportional.

However lowest level of N and K (L_1) recorded the minimum number of fingers which was on par with highest level (L_3). Lowest bunch length recorded at L3 was statistically on par with L_1. This was also reflected in the lesser number of functional leaves at the lowest level (L_1) leading to reduced photosynthetic efficiency. Malavolta *et al*. (1962) indicated reduced photosynthesis and increased respiration due to low levels of potassium. The translocation of photosynthates to the bunch is weakened by the reduced photosynthesis.

Frequency of application had significantly influenced the yield attributes like number of hands, number of fingers and bunch length (Fig. 9). Increasing the number of splits to six positively increased the number of hands, number of fingers and bunch length. Fertilizers received in small instalments especially during the flower bud initiation stage

Fig. 9 Effect of frequency of application on number of hands, number of fingers / bunch and length of bunch in banana var. Nendran



F1 - Three splits
F2 - Six splits
F3 - Two splits
F4 - Ten splits

have played a crucial role in deciding the number of hands, numbers of fingers bunch^{-1} hence the bunch length. Well distributed application of optimum quantities of N and K might have resulted in the significant increase of the above yield attributing characters. This finding is in confirmity with the results obtained by Natesh *et al.* (1993). They observed significant increase in the yield parameters with increase in number of splits (four splits) in the case of 'Nendran' banana.

However increasing the number of splits to ten had no favourable impact on increasing the number of hands, number of fingers bunch^{-1} and bunch length. Ten splits was found to be statistically on par with two splits and three splits. This implies that more nutrients in the two and three splits and less nutrients in the ten splits during the early stages of crop growth were found to be suboptimal when compared to six splits.

Even though levels of NPK and frequency of application individually influenced the bunch characters, their combinations were observed to be statistically nonsignificant.

5.2.2 Fruit characters (mature)

Levels of NPK exerted a strong positive influence on all the mature fruit characters recorded viz. weight, volume, length and girth of finger as well as pulp dry weight, peel dry weight and total dry weight of finger.

Significant improvement in the mature fruit characters were observed with increase in levels of N and K upto L_2. Production of more photosynthates by increased number of leaves and leaf area increased the translocation of carbohydrates from leaves to the fruit under optimum levels of N and K which might have contributed to the significant improvement of fruit characters. Nair (1988) observed significant increase in length of finger with 200 g N plant^{-1} while girth of finger was not significantly influenced by different levels of N and K.

The entire process of fruit growth and development in banana are mediated by an interplay of endogenous growth substances. According to Phillips (1970) fruit length and mid circumference have been associated with endogenous levels of IAA and gibberellins in parthenocarpic fruits like banana. Balanced supply of nutrients might have imparted a direct influence on the level of these endogenous growth substance.

A gradual decline in the fruit characters were observed when the N and K level was increased to L_3. It may be inferred that double the recommended dose of N and K was optimum and supply of N and K over and above this optimum level had not contributed any significant improvement in finger characters. The finger characters observed at L_3 level were comparable with those recorded at the lowest level. Reduction in finger characters might be due to lesser uptake of nutrients in the presence of excess quantities of N and K. The results were in confirmity with the findings by Natesh (1987) who observed that fruit weight could not be increased by fertilizers beyond a certain level.

In the case of frequency of application, six splits significantly increased all the finger characters recorded. Availability of sufficient quantities of N and K especially during the stages of floral primordial structure development and immediately after shooting might have contributed to the significant improvement of finger characters in the six splits. Higher number of leaves produced at six splits also have ensured the supply of ample quantities of photosynthates to the developing fingers as evident from the higher total finger dry weights recorded.

Increasing the number of splits beyond six splits did not contribute much for the enhancement of finger characters and those finger characters recorded from ten splits was almost similar to those observed at two and three splits. This reduction in finger characters at ten splits was mainly due to the reduced quantities of N and K during the critical periods and supply of nutrients in later stages when plant nutrient requirement is very low.

Interaction effects were found to be significant only on the pulp dry weight and total dry weight of finger. Pulp dry weight was found to be highest in six split application at L_2 level and far superior to all other treatments including the two additional treatments (A_1 and A_2). This was followed by three split application of the same level. Similar trends were observed in total dry weight. From this finding it may be inferred that total dry weight was mainly contributed by pulp dry weight and not by peel dry weight. There was no significant diference in peel dry weight among the treatments.

It was also observed that six splits was found to be beneficial in improving the pulp dry weight and hence the total finger dry weight at lower levels tried (L_1 and L_2). But at the highest level there was not much significant difference among the different split applications. This shows the poor response of banana to split application at the highest level of N and K.

Significantly lower pulp dry weight and total finger dry weight were recorded by the two additional treatments (Farmer's practice and NPK based on soil test values). This throws light on the fact that farmer's practice and NPK application based on soil test value had no significant effect on enhancing the finger characters (ripe).

5.2.3 Bunch yield

Different levels of NPK and frequency of application had produced significant increase in bunch weight (Fig.6 and 7).

Highest mean bunch weight was recorded at L_2 level (Fig. 8) which was significantly superior to the lowest level and highest levels. Since a similar trend was noticed in bunch characters and mature fruit character at this level the yield increase was mainly contributed by the improved values of these yield attributes.

Among the yield attributes, number of fingers might have contributed to higher yield. There are several reports confirming this view. Vijayaraghavakumar *et al*. (1984) based on their statistical studies on the influence of biometric characters on yield reported that number of fingers is having the maximum direct effect in culinary varieties of banana. The direct influence of number of fingers in yield improvement of 'Nendran' bananas have been reported by Kurian *et al*. (1985) in a study conducted at BRS, Kannara. Reports by Jagirdar and Ansari (1966) and Sheela (1982) are also in confirmity with the above results.

Among the morphological characters girth of pseudostem, number of functional leaves and LAI also might have contributed to increased bunch yield. These morphological characters were significantly higher at L_2 level. This was corraborated by the report of several workers. The girth of pseudostem at shooting was a determinant of yield as reported by Krishnan and Shanmugavelu (1983) and Rosamma and Namboothiri (1990).

Reports correlating leaf number, leaf area with bunch yield are innumerable. According to Venkatesam *et al*. (1965) since there could be no further leaf production after shooting the effective leaf area available for photosynthetic activity at shooting influences development of fruit and in turn on the gross yield. Positive and significant correlation between bunch yield and total leaf area at shooting stage in banana cv. Robusta as a consequence of enhanced photosynthesis was reported by Krishnan and Shanmugavelu (1983). Kothavade *et al*. (1985) observed that as the number of leaves plant^{-1} increased, the weight of the bunch had progressively increased. Sindhu Prabhakar (1996) observed a positive correlation between leaf area at flowering and bunch weight.

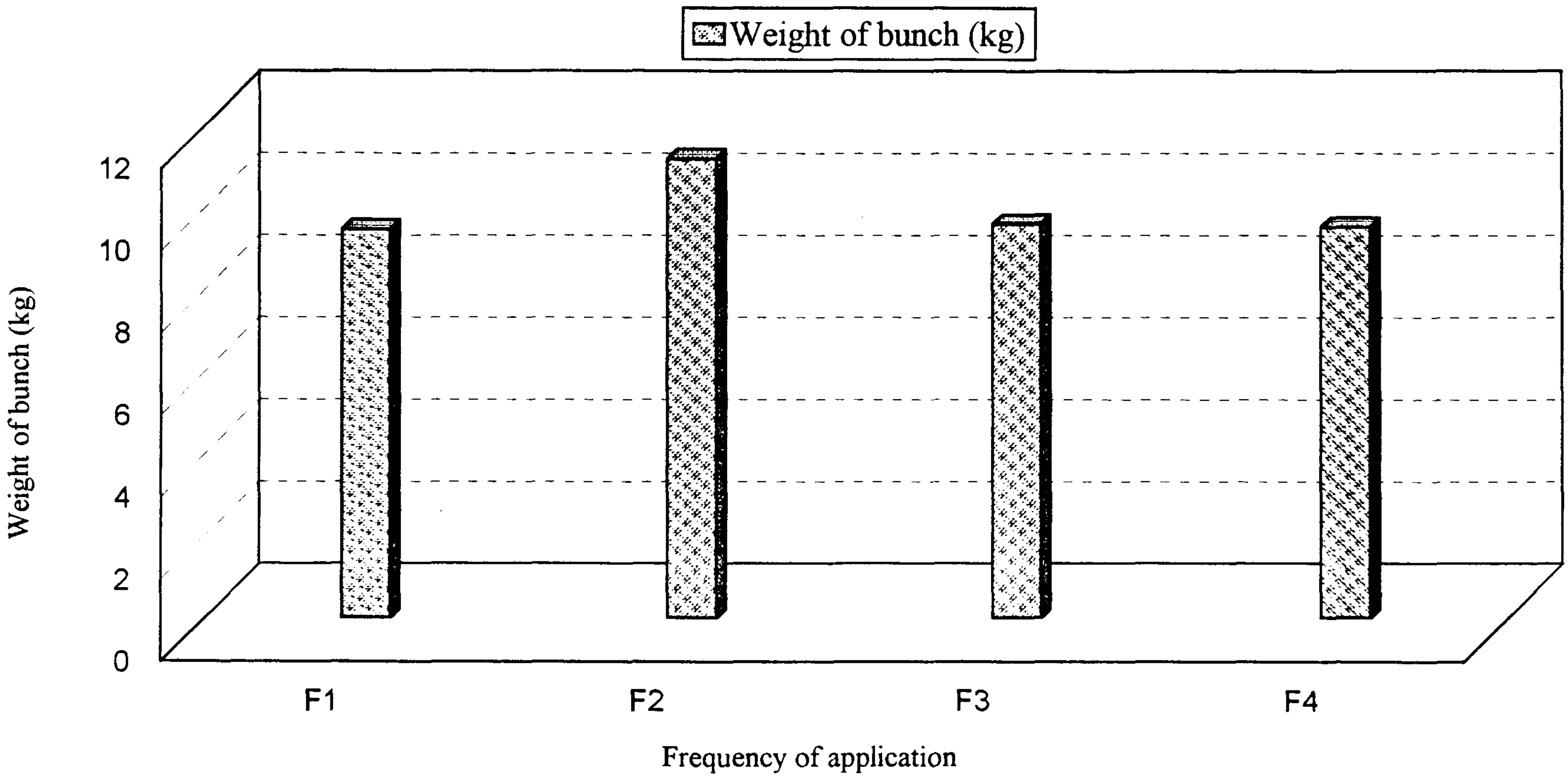
Apart from nitrogen, optimum quantities of K in the presence of phosphorus might have contributed to the significant improvement of vegetative characters, bunch characters and fruit characters which in turn resulted in increased bunch weight. The effect of nitrogen in presence of phosphorus and potassium in increasing the number of fingers and thereby enhancing the weight of bunches has been reported by Sunder Singh (1972). Requirement of higher quantites of potassium compared to nitrogen for increased yield have been emphasized by many workers (Pillai and Khader, 1980, Chattopadhyay and Bose, 1986 and Obiefuna and Onyele, 1987). Nair (1988) obtained the highest bunch yield with a combination of 400 g N plant^{-1} and 600 g K_2O plant^{-1} and this was in confirmity with the results obtained in the present study.

Hence it is evident that nitrogen alone could not produce yield improvement in banana but a combination of N and K in balanced proportion is necessary for enhancing the yield as reported by several workers (Croutcher and Mitchell, 1940, Summerville, 1944, Bhangoo *et al*. 1962 and Lin *et al*. 1962).

Application of higher quantities of N and K over and above the optimum level caused a gradual decline in yield. This was in confirmity with the findings of Sheela (1995). Excess quantities of N and K might have resulted in reduced uptake resulting in the reduction of number of fingers, number of hands, weight of finger and other yield attributes thereby contributing to reduced yield.

Fertilizer application in six splits was found to produce significantly higher bunch weight compared to other splits (Fig.10). Early phases of growth are critical for later development and it is advisable that minerals are made adequately available at the time of planting and initiation of flowers. Availability of nutrients during the periods when there was rapid differentiation of the meristem into various floral primordial structures which determine the bunch length, number of hands, number of finger, length of finger etc. might

Fig. 10 Effect of frequency of application on weight of bunch of banana var. Nendran



F1 - Three splits F2 - Six splits
F3 - Two splits F4 - Ten splits

be the reason for higher significant yield improvement in six splits. Increasing the number of splits beyond six was not effective in improvement of yield. The yields recorded at ten splits was statistically on par with three splits and two splits, with lowest yield being recorded by three splits. Murrary (1960) and Shanmugam and Velayudam (1972) opined that fertilizers did not help in increasing the yield if applied after six months. Interaction effects were not statistically significant. However the maximum bunch weight was recorded by L_2 level in six splits.

5.3 Fruit characters (ripe)

Weight of finger, pulp weight, peel weight and pulp peel ratio of ripe fingers were significantly influenced by levels of NPK, frequency of application and their interaction effects.

L_2 level recorded significantly higher finger weight, pulp weight and peel weight while pulp/peel ratio was highest at the lowest level. Even though L_2 recorded a higher pulp weight compared to the lowest level (L_1), the higher pulp/peel ratio observed at L_1 level was due to the lower peel weight recorded by the same. However L_1 and L_2 recorded significantly higher pulp weights compared to L_3 and hence higher pulp/peel ratio over L_3. 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). According to Hegde and Srinivas (1991) a reduction in pulp/peel ratio could be observed with increase in K content in tissues, indicating thickening of the peel in relation to pulp.

Among split applications, six splits recorded a higher pulp/peel ratio which was statistically on par with ten splits. Fertilizer application in two splits recorded the lowest pulp/peel ratio. Higher pulp/peel ratio in six splits may be solely due to higher pulp weight recorded at six splits. Supply of fractional quantities of N and K during early stages as well as supply of N after flowering might have resulted in the increased activity of enzymes involved in starch synthesis and thereby resulted in higher pulp weight. Weight of finger was also significantly higher at six splits.

Among interaction effects with regard to finger weight and pulp weight, double the recommended dose of N and K in six splits was found to be significantly superior to other treatments. In the case of pulp/peel ratio, lowest level of N and K (L_1) in ten splits recorded the lowest value which was statistically on par with six splits at the same level. This might be due to the lowest peel weight recorded by these treatments.

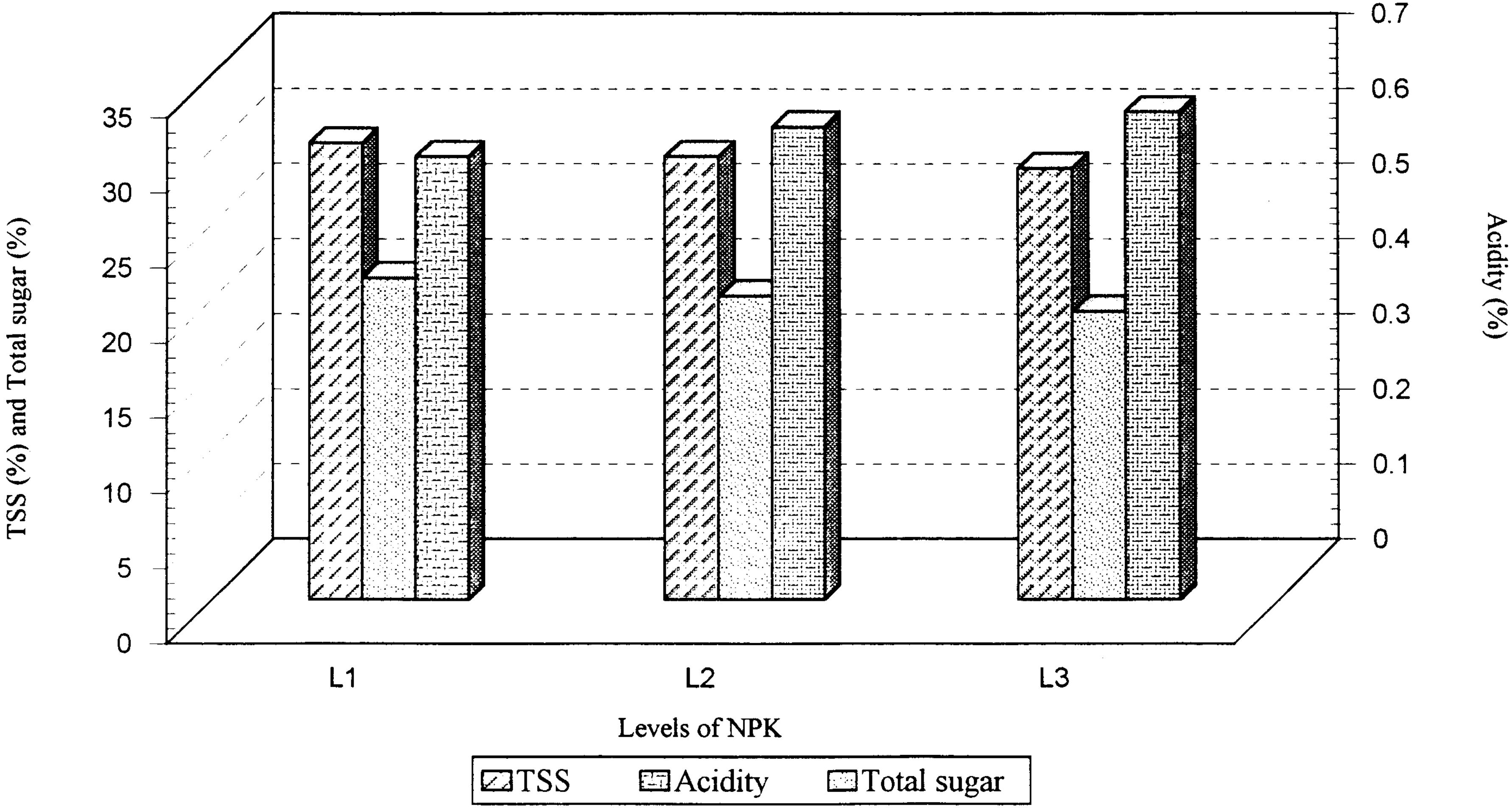
5.4 Quality characters

The quality characters included in the present study were total soluble solids, ascorbic acid content, acidity, total, reducing and non-reducing sugars, sugar/acid ratio and shelf life of ripe fruits as well as starch content of mature fruit.

All the quality characters of the fruit except the ascorbic acid content were significantly influenced by levels of NPK. 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. A decrease in quality was noticed when N levels higher than 200 g plant^{-1} was tried. In the present study also TSS, total and non-reducing sugars, sugar/acid ratio and shelf life showed a decreasing trend while acidity and reducing sugar showed an increasing trend with increase in levels of NPK.

Total soluble solids (TSS) was also highest at the lowest level of NPK (L_1) and showed a gradual decline with increase in levels of NPK (Fig. 11). This was in accordance with the findings of Mustaffa (1983), Reddy (1992) and Sindhu Prabhakar (1996) where they observed a slight decline in TSS with increase in nitrogen dose. Ram and Prasad (1989) reported higher levels of TSS with 200 g N plant^{-1}.

Fig. 11 Effect of levels of NPK on Total soluble solids (TSS), acidity and total sugar content of ripe fruits of banana var. Nendran



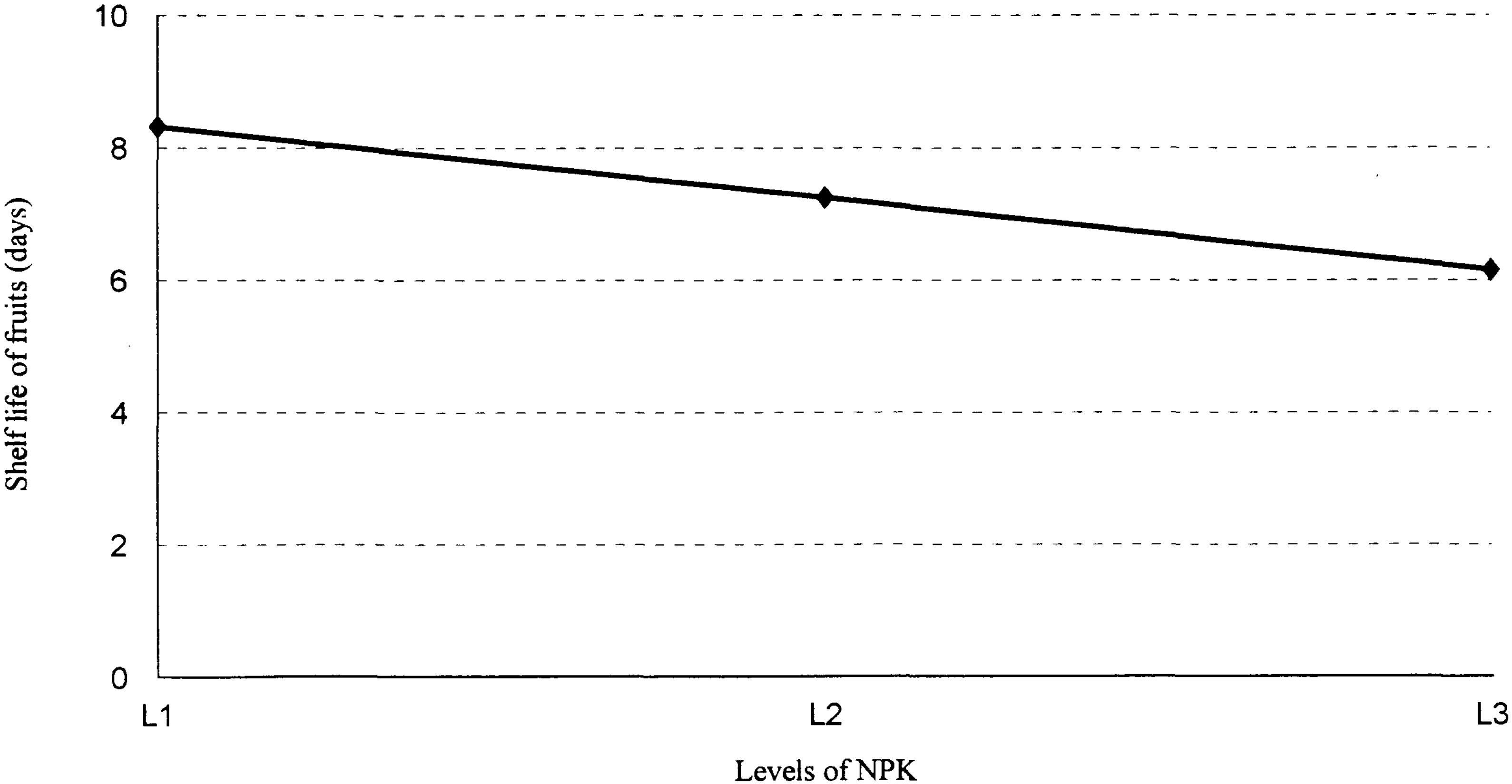
L1 - 190:115:300 g NPK / plant L2 - 380:115:600 g NPK / plant L3 - 570:115:900 g NPK / plant

Reduction of acidity in fruits receiving the lowest level of N and K (L_1) (Fig. 11) might be due to the neutralisation of organic acids with increased K^+ level in the tissues (Tisdale and Nelson, 1993). Sindhu Prabhakar (1996) observed a gradual increase in acidity with increasing levels of nitrogen.

Content of total and non-reducing sugars was the highest at the lowest level of NPK (L_1) (Fig.11). Increase in sugars observed might be due to respirational demand, adequate supply of nutrients, synthesis of invertase and starch splitting enzymes (Barnell, 1940). Reducing sugar was lowest at L_1 level and showed an increasing trend with increase in levels of N and K. According to Nitsos and Evans (1969) higher levels 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 carbohydrate especially monosaccharides and hence reducing sugar content was maximum. On the otherhand an adequate supply of NPK ensured optimal functioning of sucrose synthetase and suppression of hydrolytic enzymes leading to greater quantity of sugars in the proplastids.

Sugar/acid ratio was highest at L_1 level. This was due to significant reduction in acidity at this level. Shelf life was highest at lowest level of NPK and decreased with increase in levels of N and K (Fig. 12). Higher sugar/acid

Fig. 12 Effect of levels of NPK on shelf life of fruits of banana var. Nendran



L1 - 190:115:300 g NPK / plant L2 - 380:115:600 g NPK / plant L3 - 570:115:900 g NPK / plant

ratio noted at this level might have increased the storage life. 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 (Von Uexkull, 1970).

Starch content of mature fruit was highest at L_2 level. Beyond this level starch content showed a gradual decline and was comparable with lowest level. A similar trend was noticed in the weight of finger. Hence it may be inferred that the increased starch content might have contributed to the increased weight of finger thereby resulted in significant improvement of bunch yield at this level (L_2).

Among the quality attributes only the starch content of mature fruit and non reducing sugar content of ripe fruits were positively influenced by frequency of application. Rajeevan (1985) reported significant difference among treatments for total sugars and reducing sugars by split application. However, Natesh (1987) did not observe any significant variation in quality characters of fruits by split application.

Starch content was highest at three splits which was comparable with six splits. Both the splits were significantly superior to other splits. Lowest starch content was recorded at ten splits. From this it may be inferred that increasing the number of splits above ten was not effective in increasing the starch content. Application of fertilizers during early stages of crop growth in small instalments have significantly contributed to higher accumulation of carbohydrates in fruits. However Nair (1988) did not observe any significant variation in starch content of mature fruit by split application.

So optimum time of application of nutrient is only important for increasing the yield level. All other quality attributes were not at all influenced by split application. This implies that time of application of nutrients is a minor factor in increasing the quality characters.

The non reducing sugar content was found to be highest at ten splits which was on par with six plits. Lowest value for non reducing sugar content was recorded at two splits. It may be noted that increase in number of splits increased the non-reducing sugar content of the fruit.

Interaction effects were statistically significant with regard to starch content of mature fruit and non-reducing sugar content of ripe fruits. Lowest starch content was recorded at two splits applications of the highest level (L_3). Non reducing sugar content was highest at ten splits application of the lowest level of N and K (L_1) which was significantly different from other treatments.

5.5 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 differed significantly in their organoleptic qualities viz. taste, texture and lump formation.

Fruits with comparatively lower lump formation and better taste were observed at ten split application of the lowest level of N and K (T_4). It was also noted that this treatment was statistically on par with T_{13}, T_{14}, T_2 and T_5 with regard to taste and on par with T_2, T_5, T_1 and T_9 with regard to lump formation. From this we could infer that the lowest dose of N and K applied in ten splits which implies well distributed application of lesser quantity of nutrients from planting to about 7th month (after fruit formation) have been able to produce tastier fruits with relatively lower lump formation.

Plants which received the highest level of nutrients in two splits (T_{11}) recorded lower score values for taste, texture and lump formation.

Regarding overall acceptability T_{13} was found to be superior. Poor quality fruits with significantly lower acceptability was produced by T_{11}.

It may be noted that even though yield level was found to increase with higher level (L_2), the quality characters showed a gradual decline. Poor quality fruits with lower acceptability were produced at highest level of N and K.

5.6 Foliar nutrient status at harvest

The levels of NPK, frequency of application and interaction effects did not show any significant variation in nitrogen, phosphorus and potassium content of third leaf at harvest.

5.7 Soil nutrient status after harvest

5.7.1 Available nitrogen

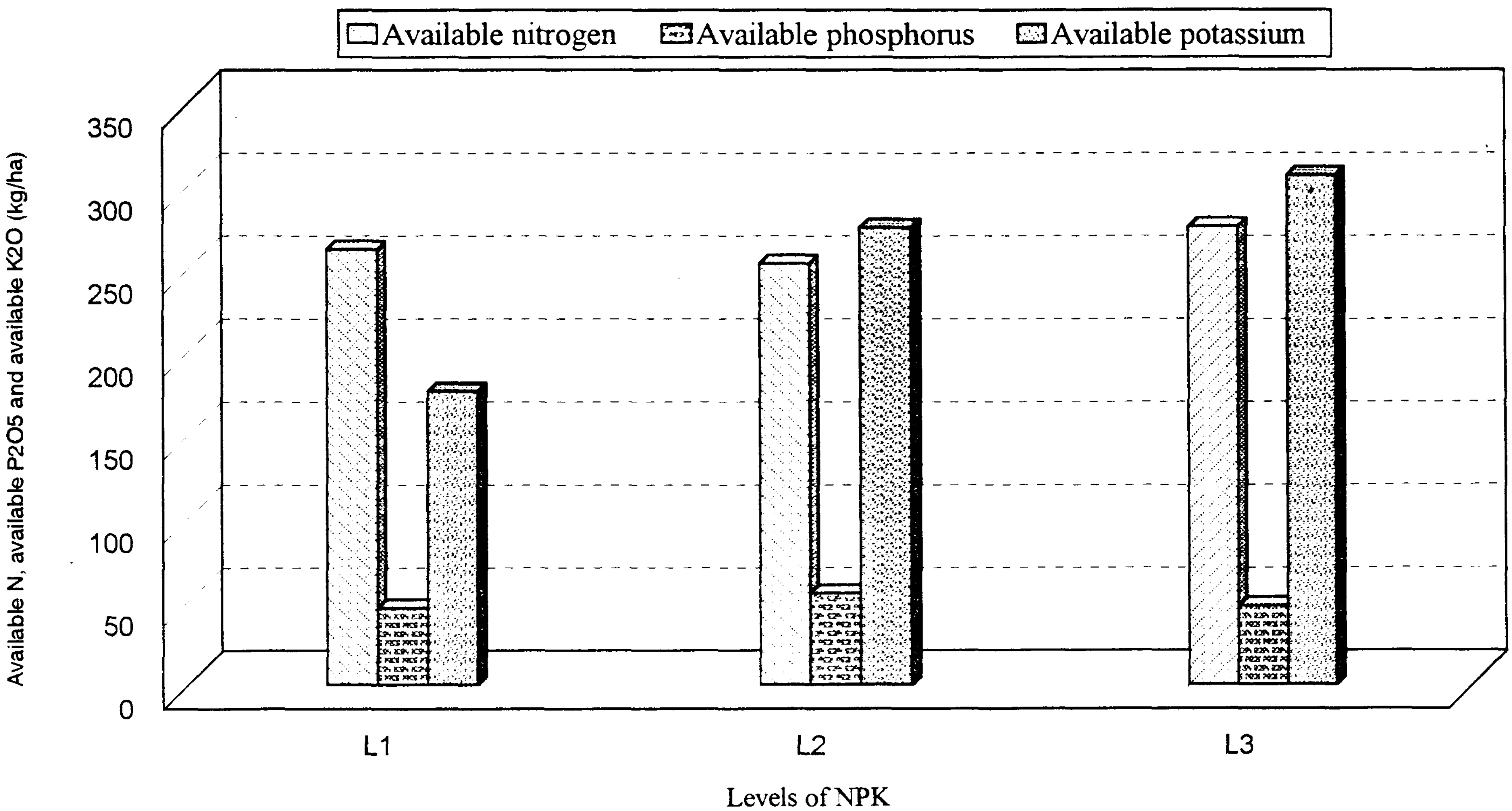
The results revealed that levels of NPK, frequency of application and interaction effects significantly increased the available nitrogen status of the soil after harvest compared to initial status.

Chakraborty (1979) reported that continuos addition of nitrogenous fertilizers lead to build up in the available nitrogen status of the soil. According to Minhar and Bora (1982) an increase in the rate of applied nitrogen (along with P and K) was associated with an increase in build up of total and available nitrogen. Increase in rate of inorganic nitrogen added may also enhance the nitrate nitrogen content of the soil possibly due to conversion of applied mineral nitrogen through nitrification process (Krishnan, 1986 and Yadav and Singh, 1991).

Lesser nitrogen content in the L_2 level (Fig. 13) may be mainly due to the higher uptake of nitrogen in addition to the other nitrogen losses in the soil and was reflected in the increaed yield observed at this level. Similarly at highest level of nutrients (L_3) and in ten splits, available nitrogen content was found to be highest. This might be due to poor uptake of nitrogen during the later stages. This clearly explains the greater requirement of nitrogen during early phases of growth than at later part and emphasise the need for adequate supply of nutrients at time of planting and initiation of flower buds.

When the N and K nutrients are applied based on soil test values, a remarkable reduction in the available nitrogen content of the soil after harvest was noticed. The reduction was not only due to nitrogen losses through leaching, volatalisation, immobilisation but also due to uptake. But the yield level was found to be very low at this level. Hence it may be inferred that this level is insufficient to produce higher yield. In order to compensate for the above losses and to meet the requirement of banana, higher quantities of N and K seem to be essential for producing a satisfactory yield.

Fig. 13 Effect of levels of NPK on the available soil nutrient status after harvest of banana var. Nendran



L1 - 190:115:300 g NPK / plant   L2 - 380:115:600 g NPK / plant   L3 - 570:115:900 g NPK / plant

5.7.2 Available phosphorus

The available phosphorus content of the soil after harvest was higher compared to initial status in almost all treatments. Higher status of phosphorus revealed that comparatively lesser uptake of applied phosphorus has occurred in the plots.

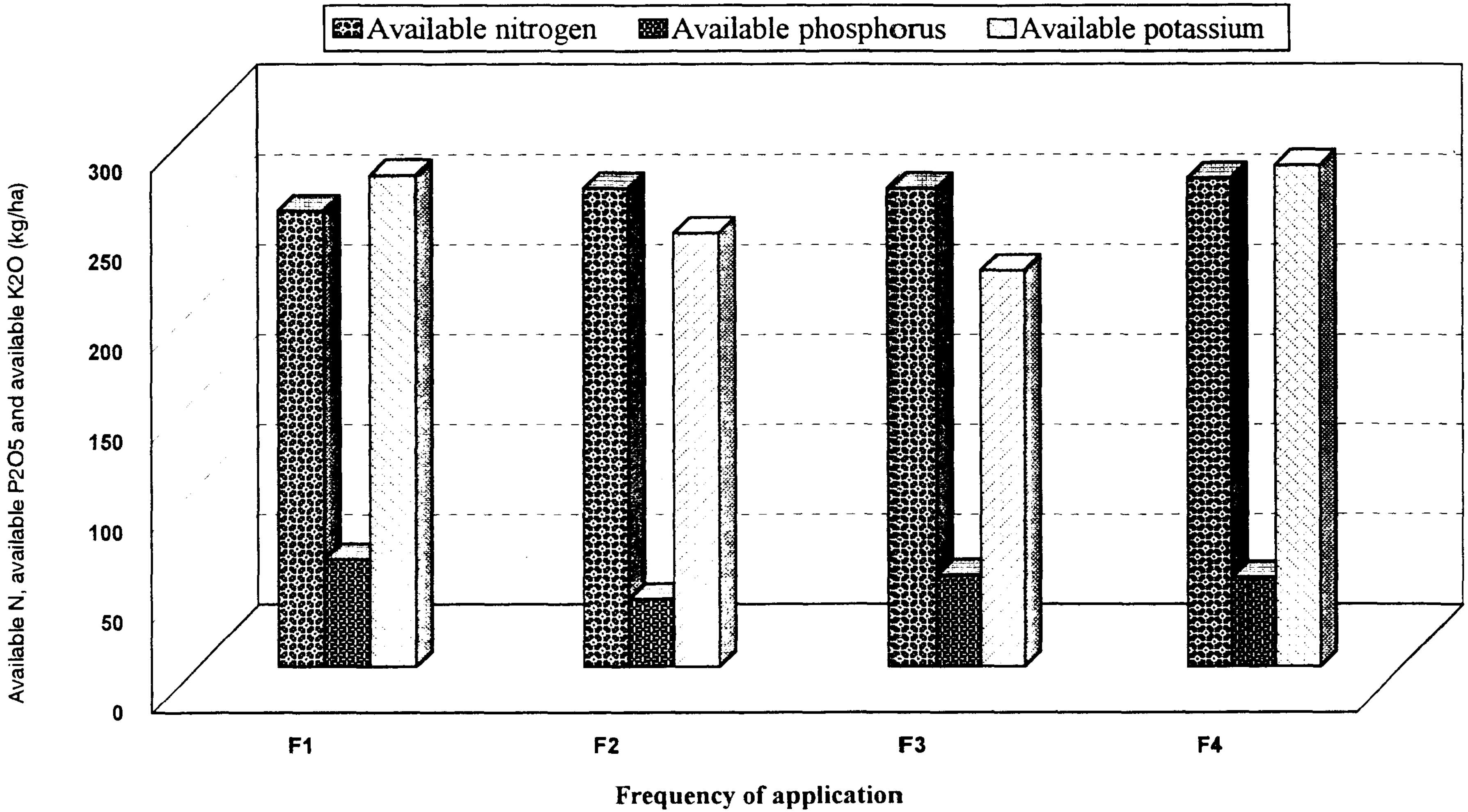
Different levels of N and K did not exert any significant differene in available phosphorus content. However frequency of application and interaction effects showed significant variation in available phosphorus content after harvest (Fig. 13 and 14). Uptake of phosphorus was found to be higher in six splits where N and K nutrients were applied in small instalments during earlier periods as well during the critical periods as evident from the comparatively lower P status in this split application compared to other splits.

Application of phosphatic fertilizer 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 applied N and K may be the reason for high phosphorus status in the soil after the experiment.

5.7.3 Available potassium

Available potassium content of the soil showed a increasing trend with increase in levels of N and K (Fig. 13) and those recorded at harvest was higher compared to initial

Fig. 14 Effect of frequency of application on the available soil nutrient status after harvest of banana var. Nendran



F1 - Three splits F2 - Six splits
F3 - Two splits F4 - Ten splits

status. According to Sindhu Prabhakar (1996) a marginal increase was noticed in available K content of the soil indicating better synergestic effect between N and available K. Sindhu (1997) also observed an increase in available K content of soil with increase in levels of K supplied from 0 to 600 g $plant^{-1}$ in 'Nendran' banana. Higher contents of available potassium in the soil supplied with highest level of N and K might be due to lesser uptake of applied potassium.

With regard to frequency of application ten splits recorded the highest content of available K_2O (Fig. 14) indicating that potassium application during the later stages of crop growth was not effectively utilised by the crop.

In the case of interaction effects, it was observed that available potassium status of the soil after harvest was relatively higher in all the split applications at L_3 level. Lesser uptake of potassium might have occured under application of excess quantities of N and K above the optimum level (L_2).

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 Incidence of pests and diseases

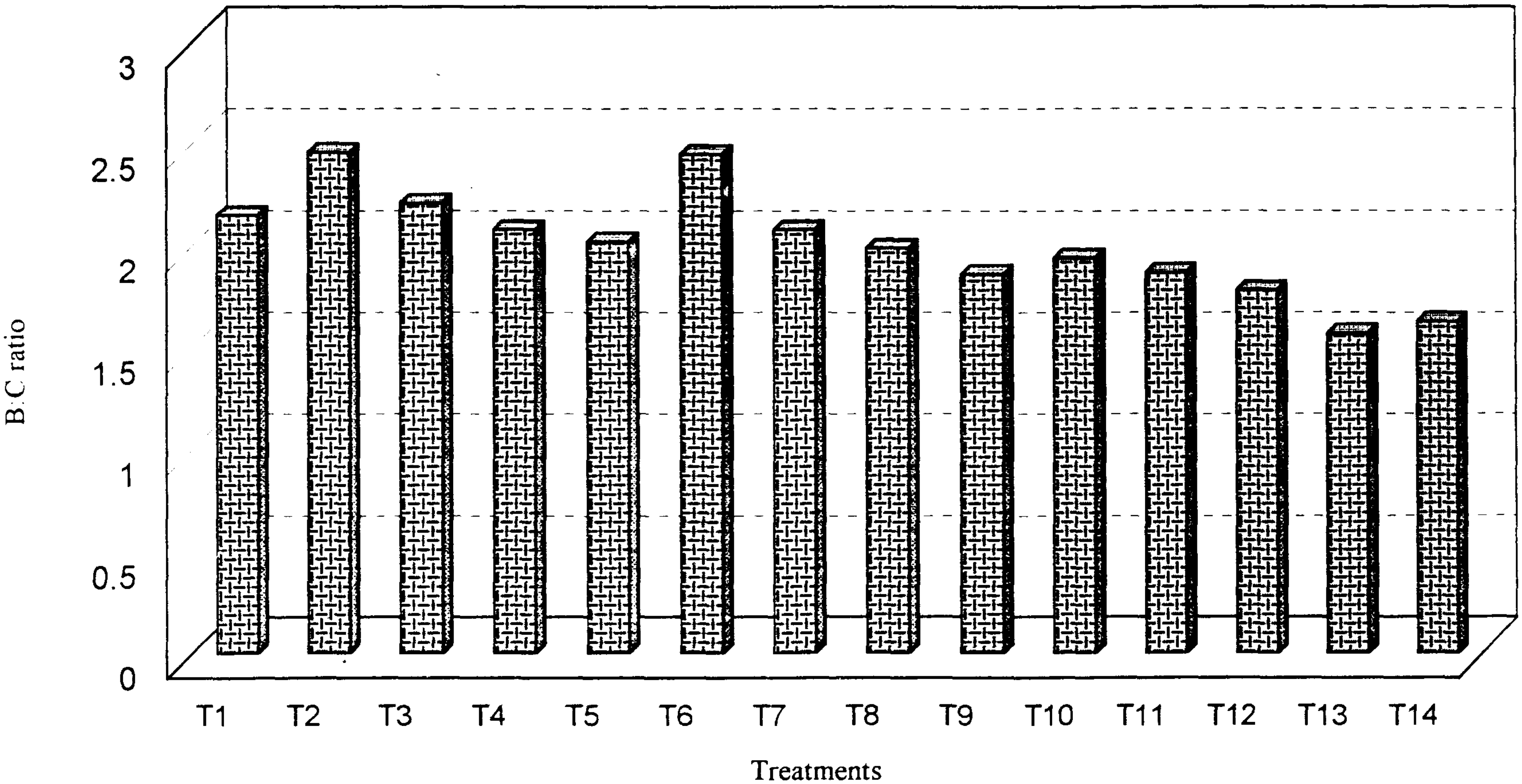
Even though occurrence of pseudostem weevil and Spodoptera infestation was noticed in the experimental field, the occurrence of sigatoka leaf spot was major.

Sigatoka leaf spot was significantly influenced by levels of NPK and frequency of application. Interaction effects were not significant. Increase in disease infestation was observed with increase in levels of N and K, highest infestation being observed at the highest level (L_3). The higher infestation might be solely due to nitrogen since potassium imparts resistance to diseases. According to Stover (1971) increase in nitrogen level results in more succulencey of cells as such susceptibility to leaf spot disease increases Sindhu Prabhakar (1996) also observed significant increase in incidence of leaf spot with increasing doses of nitrogen.

5.9 Economics of production

The maximum net profit and benefit cost ratio was observed by T_6 (L_2F_2) (Fig. 15). This was due to comparatively higher bunch yield recorded at this level. At highest level of NPK net profit and benefit cost ratio were found to be lower. Lower yields recorded at this level might have reduced the net profit and B:C ratio. Also the two additional treatments (T_{13} and T_{14}) were also not profitable from the point of view of benefit cost analysis.

Fig. 15 Economics of production (B:C ratio)



T1 - L1F1 T2 - L1F2 T3 - L1F3 T4 - L1F4 T5 - L2F1 T6 - L2F2 T7 - L2F3
T8 - L2F4 T9 - L3F1 T10 - L3F2 T11 - L3F3 T12 - L3F4 T13 - A1 T14 - A2

SUMMARY

SUMMARY

The present investigation on "Maximisation of productivity by rescheduling the nutrient application in banana (*Musa* AAB group 'Nendran') was carried out at the Instructional farm attached to College of Agriculture, Vellayani during December 1995 to September 1996. The objectives of the study were to find out the optimum dose of major nutrients and frequency of their application to maximise the productivity of banana.

The soil of the experimental site belongs to the taxonomic class 'Kaolinitic Isohyperthermic Rhodic Haplustox' with a textural class of sandy clay loam. The experiment was laid out in Factorial Randomised Block Design (3x4+2) with three levels of NPK and four frequencies of application along with two additional treatments in two replications. The salient results of the experiment are briefly summarised below.

1. Height and girth of the plant increased with increase in levels of N and K upto L2 level (380:115:600 g NPK $plant^{-1}$), thereafter showed a gradual decline and the effects were found to be statistically significant at all the three stages of growth (fifth month, flowering and harvest). Fertilizer application in six splits (at planting, one, two, four and five

months after planting and at bunch emergence stages) has recorded the maximum height and girth at all the three stages. No marked improvement in height and girth was observed when number of splits was increased to ten. Application of 380:115:600 g NPK plant^{-1} applied in six splits have recorded the highest height of the plant which was significantly different from other treatments. Although not significant comparatively higher girth were also recorded by this treatment.

2. Maximum number of leaves and highest LAI was recorded by application of 380:115:600 g NPK plant^{-1}. Also fertilizer application in six splits was found to be the best with regard to number of leaves and LAI. The nutrient level 380:115:600 g NPK plant^{-1} applied in six splits was observed to be very effective in producing the maximum number of leaves and LAI.

3. Increasing the levels of N and K to L_2 (double the present recommended dose of N and K) has induced early shooting and thereby resulted in the reduction of total crop duration. Fertilizer application in six splits have also significantly advanced the shooting, bunch maturation and has significantly reduced the total crop duration.

4. Among the bunch characters studied only the number of fingers bunch^{-1}, bunch length and bunch weight were positively influenced by levels of NPK. Application of 380:115:600 g NPK

plant^{-1} recorded the maximum number of fingers bunch^{-1}, bunch length and bunch weight. Apart from the bunch characters number of hands was also positively influenced by frequency of application. Fertilizer application in six splits found to record the highest number of hands and fingers bunch^{-1}, bunch length and bunch weight.

5. All the fruit characters at maturity stage viz. weight, volume, length and girth of finger, pulp dry weight, peel dry weight and total dry weight of finger were significantly influenced by levels of NPK. Application of double the recommended dose of N and K (380:115:600g NPK plant^{-1}) has recorded the highest value with regard to the above characters and was significantly different from the other levels. But in the case of frequency of application all the above characters except girth of finger has exhibited a positive effect. Significant improvement in fruit characters was observed at six splits compared to other splits.

6. Levels of NPK, frequency of application and their interaction effects exerted in profound influence on the ripe fruit characters. Highest pulp weight, peel weight and finger weight were recorded at L_2 level (380:115:600g NPK plant^{-1}). However pulp/peel ratio was highest at the lowest level of N and K (190:115:300g NPK plant^{-1}). Six splits application of fertilizer has recorded significantly higher finger weight

(ripe), pulp weight, peel weight and pulp/peel ratio. Application of 380:115:600 g NPK plant^{-1} in six splits was found to record significantly higher finger weight and pulp weight compared to all other treatment combinations including the two additional treatments (A_1 and A_2).

7. All the quality attributes studied except ascorbic acid content were significantly influenced by levels of NPK. Better quality attributes such as high total soluble solid, low acidity, comparatively higher total sugars, highest non reducing sugars, highest sugar/acid ratio and longer shelf life were recorded at the lowest level of NPK (L_1). Increasing the levels of NPK caused a gradual decline in quality attributes. Frequency of application and interaction effects showed positive influence only on the starch content and non-reducing sugar content of fruits.

8. Evaluation of the sensory attributes like taste, texture and lump formation also exhibited a similar trend to that of other quality attributes. Poor quality fruits were produced at the highest level of N and K applied in two splits.

9. No significant difference in the NPK content of the third leaf at harvest was observed by different levels of NPK, frequency of application and their interaction effects.

10. Available NPK content of soil after harvest was higher compared to initial status for all treatments except T14 (NPK based on soil test value). Available K_2O content showed an increasing trend with increase in levels of N and K. Available nitrogen content was highest at the highest level of N and K and lowest at the level which produced the highest bunch yield (ie. 380:115:600 g NPK $plant^{-1}$).

11. Though there were minor occurrences of pseudostem weevil and spodoptera in the field, occurrence of Sigatoka leaf spot turned out to be the major disease. Per cent infection index showed an increasing trend with increase in levels of N and K. Leaf spot infestation was comparatively lower at two split application of fertilizers.

12. Maximum benefit cost ratio was recorded by the lowest level of N and K applied in six splits (T_2) followed by double the recommended dose of N and K applied in six splits (T_6). Lowest B:C ratio was recorded by T_{13}. The highest net profit was realised ha^{-1} in T_6 and lowest in T_{13}.

From the findings of the present investigation it may be given as an adhoc recommendation to the farmers to apply 380:115:600 g NPK $plant^{-1}$ in six splits to obtain the maximum yield in 'Nendran' banana to cater to the demands of the market. Further confirmatory trials have to be conducted with this treatment combination in farmers field in a number of locations along with farmers practice with a view to give a realistic recommendation.

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* Originals not seen

APPENDICES

APPENDIX - I

Weather parameters during the cropping period

	Temperature °C		Mean relative humidity (%)	Total rainfall (cm)
	Maximum	Minimum		
December 1995	33.1	20.0	71.1	-
January 1996	32.3	20.1	72.8	0.8
February 1996	32.7	20.7	71.3	2.10
March 1996	33.7	21.4	70.2	-
April 1996	32.8	23.2	79.7	5.1
May 1996	33.2	23.9	74.9	5.1
June 1996	29.8	22.0	81.2	25.8
July 1996	28.6	21.5	83.2	17.3
August 1996	29.3	21.8	83.1	10.7
September 1996	30.1	23.2	82.5	16.2

APPENDIX II

Details of split application of fertilizers

Levels of NPK - Three

L_1 - 190:115:300 g NPK plant^{-1}

L_2 - 380:115:600 g NPK plant^{-1}

L_3 - 570:115:900 g NPK plant^{-1}

Frequency of application	Quantity applied					
	L_1		L_2		L_3	
	N	K	N	K	N	K
	g plant^{-1}		g plant^{-1}		g plant^{-1}	
1) Three splits (F_1)						
Two months after planting	63.3	100	126.6	200	190	300
Four months after planting	63.3	100	126.6	200	190	300
Six months after planting	63.3	100	126.6	200	190	300
2) Six splits (F_2)						
At planting	40	60	80	120	120	180
One month after planting	30	60	60	120	90	180
Two months after planting	30	60	60	120	90	180
Four months after planting	30	60	60	120	90	180
Five months after planting	30	60	60	120	90	180
Just after complete emergence of bunch	30		60		90	

Frequency of application	Quantity applied					
	L_1		L_2		L_3	
	N	K	N	K	N	K
	g plant^{-1}		g plant^{-1}		g plant^{-1}	
3) Two splits (F_3)						
Two months after planting	95	150	190	300	285	450
Four months after planting	95	150	190	300	285	450
4) Ten splits (F_4)						
22 days after planting	19	30	38	60	57	90
44 days after planting	19	30	38	60	57	90
66 days after planting	19	30	38	60	57	90
88 days after planting	19	30	38	60	57	90
110 days after planting	19	30	38	60	57	90
132 days after planting	19	30	38	60	57	90
154 days after planting	19	30	38	60	57	90
176 days after planting	19	30	38	60	57	90
198 days after planting	19	30	38	60	57	90
220 days after planting	19	30	38	60	57	90

Note: P_2O_5 was applied in two splits first as basal (65 g plant^{-1} and second, one month after planting (50 g plant^{-1}) as per POP for all treatments except T_{13} and T_{14}

APPENDIX - III

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	A	B	C	D	E	F	G	H	I	J
1) Taste										
Excellent (5)										
Very good (4)										
Good (3)										
Fair (2)										
Poor (1)										
2) Texture										
Soft (5)										
Neither hard nor soft (4)										
Hard (3)										
Very hard (2)										
Brittle (1)										
3) Lump formation										
No lump (5)										
Slight lump (4)										
Medium lump (3)										
High lump (2)										
Very high lump (1)										

APPENDIX IV

Sigatoka leaf spot disease index

Disease index	Leaf area infected (%)
0	0 - 5
1	6 - 10
2	11 - 25
3	26 - 40
4	41 - 60
5	61 - 75
6	76 and above

(Suharban, 1977)

MAXIMISATION OF PRODUCTIVITY BY RESCHEDULING THE NUTRIENT APPLICATION IN BANANA

(*Musa AAB group 'Nendran'*)

By

DOVELYN PETERS C.

ABSTRACT OF THE THESIS

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE DEGREE

MASTER OF SCIENCE IN AGRICULTURE

FACULTY OF AGRICULTURE
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DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, THIRUVANANTHAPURAM

1997

ABSTRACT

An experiment was conducted at the Instructional Farm attached to College of Agriculture, Vellayani during December 1995 to September 1996 with the objectives of finding out the optimum dose of fertilizer and frequency of their application to maximise the productivity of banana. Three levels of NPK and four frequencies of application and two additional treatments (Farmer's practice and NPK based on soil test value) were tested for their efficacy in 3x4+2 factorial RBD with two replications.

The results of the study revealed that application of 380:115:600 g NPK plant^{-1} (L_2) significantly improved the vegetative characters viz. height and girth of pseudostem, number of leaves and LAI and induced early shooting (184.06 days) and reduced the total crop duration (268.59 days). Fertilizer application in six splits have also significantly improved the vegetative characters. However application of 380:115:600 g NPK plant^{-1} in six splits could impart significant improvement only on the height of the plant.

Bunch yield was observed to be the highest (10.42 kg) at L2 level. Significant improvement in the bunch characters and finger characters (mature) observed at this level resulted in higher bunch yield. Among the bunch characters, number of

fingers bunch^{-1} (46.49) and bunch length (54.35 cm) were highest at L_2 level. Significantly higher values for all the finger characters studied were recorded at this level. In the case of frequency of application, six splits recorded the highest bunch weight (11.20 kg) compared to other splits. Here also as in the case with NPK levels, six splits recorded significantly higher values for all the finger characters studied and the bunch characters viz., number of fingers bunch^{-1} and bunch length which in turn contributed to higher bunch weight.

Among the ripe fruit characters, highest pulp/peel ratio was recorded at the lowest level of NPK (190:115:300 g NPK plant^{-1}) even though higher finger weight, pulp weight and peel weight were recorded at L_2 level. Six splits recorded significantly higher finger weight and pulp weight compared to other splits. However highest pulp/peel ratio recorded at six splits was on par with ten splits. Application of 380:115:600 g NPK plant^{-1} in six splits recorded significantly higher finger weight and pulp weight compared to other treatments.

Among the quality attributes, significantly higher values for TSS, total and nonreducing sugars, sugar/acid ratio were recorded at lowest level of NPK (L_1) and these values showed a decreasing trend with increase in levels of NPK. However acidity and reducing sugar content values were lowest at L_1 level and these values increased with increase in levels of N and K. However starch content was highest at L_2 level. Frequency of application and interaction effects were significant only with respect to starch content and non reducing sugar content. Sensory evaluation of ripe fruits revealed that lowest level of NPK (190:115:300 g NPK plant^{-1}) produced better quality fruits.

NPK content of index leaf at harvest did not show any significant variation among treatments. Available NPK content of the soil after harvest recorded higher values compared to initial status. Available phosphorus and K_2O contents recorded highest values at L_3 level indicating lesser uptake by the plant.

When the economics of production was worked out, it was observed that T_2 recorded the highest B:C ratio (2.46) followed by T_6 (2.45) while highest net profit (Rs.18460) was obtained in T_6.

The present study revealed that application of 380:115:600 g NPK plant^{-1} in six splits was beneficial for better growth, yield and quality of fruits in 'Nendran' banana.