EFFECT OF SPLIT APPLICATION OF FERTILIZERS IN BANANA *cv.* 'NENDRAN'

By

B. BEENA NATESH

THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Horticulture

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Department of Horticulture
(Pomology & Floriculture and Land scaping)
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1987

DECLARATION

I hereby declare that this thesis entitled "Effect of split application of fertilizers in banana cv. Nendran" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title of any other University or Society.

Vellanikkara,
13--7--1987.

BEENA NATESH, B.

Dr.M.Aravindakshan,
Director,
Centre for Advanced Studies
in Tree Crops &
Environmental Horticulture.

College of Horticulture,
Vellanikkara,

Dated: 13-7-1987.

CERTIFICATE

Certified that this thesis entitled "Effect of split application of fertilizers in banana cv. Nendran" is a record of research work done independently by Kumari Beena Mahesh, B. 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.

M.ARAVINDAKSHAN,
Chairman,
ADVISORY COMMITTEE.

CERTIFICATE

We, the undersigned, members of the Advisory Committee of Kumari Beena Natesh, B. a candidate for the degree of Master of Science in Horticulture, majoring in Pomology and Floriculture, agree that the thesis entitled "Effect of split application of fertilizers in banana cv. Nendran" may be submitted by Kumari Beena Natesh,B. in partial fulfilment of the requirement for the degree.

Chairman:

Dr.M. ARAVINDAKSHAN

Members :

Dr.C. SREEDHARAN

Sri.V.K.G. UNNITHAN

Dr.P.K.VALSALAKUMARI

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BEENA NATESH, B.

To My Parents

C O N T E N T S

(Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

Introduction

INTRODUCTION

Banana is one of the most important remunerative tropical fruit crops occupying 20 per cent of total area under fruits in India. Kerala ranks first in acrage accounting for an area of about 51,420 hectares and a production of 331.19 thousand tonnes (Farm Guide, 1987). 'Nendran' is the most popular commercial variety of banana in the State covering nearly 30 per cent of the total area under banana.

Though Kerala ranks first in area, the production is much less compared to other States. One among many reasons is the lack of proper fertilization. Being a heavy feeder, banana requires adequate amounts of fertilizers for higher and satisfactory yields. It is estimated that an average crop removes about 300 kg N, 80 kg P_2O_5 and 800 kg K_2O from a hectare of land (Veeraraghavan, 1972).

The fertilizer application in banana is closely related to its developmental physiology. Optimum supply of nutrients throughout the different phases of growth of the plant ultimately decides crop production. The several experiments conducted in India and abroad

generally point out that the fertilisers have to be applied in full before the plant comes to reproductive phase (Summerville, 1944; Veeraraghavan, 1972; Pillai et al., 1977; Valsamma Mathew, 1980 and Sheela, 1982). Generally recommended practice is to apply the required dose of fertilizers in early and late vegetative phases. The recommendation in the State is also to apply the fertilizers in equal split doses during the second and fourth months after planting. However, there are several farmers who resort to more than two split applications especially when 'Nendran' varieties are grown on commercial scale. Advantages have been reported by such farmers especially on specific locations by splitting fertilizers more than twice.

Certain studies conducted in Kerala Agricultural University (Gopimony et al., 1979; Nambiar et al., 1979 and Rajeevan, 1985) and also in other States (Veerannah et al., 1976 and Irizarry et al., 1981) indicate that there is some justification in applying fertilizers in banana in more split doses.

The present studies were taken mainly to confirm whether more split applications are remunerative to the farmers. The studies were also aimed at to provide

possible explanations in case more split applications have favourable response.

The specific objectives of the study are listed below :-

i) to find out the effect of split application of fertilisers on flowering, yield and quality of bunches

ii) to study the nutrient status of plants at different stages of growth.

Review of Literature

REVIEW OF LITERATURE

A comprehensive review of banana nutrition has been made by Valsamma Mathew (1980), Sheela (1982) and Rajeevan (1985). The present review is therefore confined to certain relevant aspects connected with the present study.

2.1. Relative importance of nutrients

Manurial experiments in bananas conducted as early as 1921 by Fawcett had revealed that nitrogen and potassium were required in large amounts by banana, which was further confirmed by Baillon *et al.* (1933). Croutcher and Mitchell (1940) in their investigations on the nitrogen needs of 'Gros Michel' banana observed that an increase in yield could be secured only by the application of nitrogen in soils which were rich in available P_2O_5 and K_2O.

Norris and Ayyar (1942) reported that plants require large quantities of potassium, moderate quantities of nitrogen and relatively little phosphorus for optimum production. Summerville (1944) observed that for 'Dwarf Cavendish' banana grown on red basaltic soils of Queensland

there was considerable response to nitrogen and potassium when applied together than when these were applied separately. Application of phosphorus to these soils had no effect on growth.

Gandhi (1951) reported that in Poona region nitrogen was found highly beneficial whereas addition of phosphorus and potassium produced no additional yield. Simmonds (1959) stated that the time of shooting was always hastened by nitrogen. According to him there was an increase in bunch weight with increase in added dose of nitrogen.

Investigations by Bhangoo et al. (1962) in Honduras indicated significant response to the application of phosphorus and potassium in conjunction with nitrogen improving the average bunch weight of 'Giant Cavendish' banana. Little or no response was obtained from the use of nitrogen alone, while phosphorus and potassium without nitrogen had no effect on yield.

Osborne and Hewitt (1963) found no response in banana to the application of phosphatic fertilizers. They stressed the importance of potassium for higher production in banana. Twyford (1967) found that the amount of potassium was always highest of the nutrients analysed in

plants, being between 2.2 and 4.6 times as the content of nitrogen and critical manuring could be done on 4:1:14 ratio of N, P and K_2O respectively, which indicated the greater importance of potassium and much lesser requirement of phosphorus.

Turner (1969) reported that banana requires high amount of nitrogen and potassium and low amount of phosphorus. Ramaswamy and Muthukrishnan (1973) reported that for maximising the yield the quantity of nitrogen and potassium required was more compared to that of phosphorus. Pillai et al. (1977) revealed that nitrogen and potassium exerted a significant positive influence on fruit number and bunch weight. The optimum dose of N and K_2O corresponding to maximum yield of fruit was worked out as 191 and 301 g per plant respectively.

2.2. Growth parameters influenced by nutrient levels

Nitrogen as a plant food affects growth and development of plants to a marked degree and its role in the plant life has been emphasized by many workers. Croutcher and Mitchell (1940) observed that in banana an increase in yield could be secured only by the application of nitrogen in soils which were rich in available P_2O_5 and K_2O. In an experiment conducted on Musa cavendishii

by Summerville (1944) revealed that application of phosphorus did not bring about any effect on growth. In the very early stages of growth significant increase was seen associated with the presence of added potash.

In manurial investigations on banana 'Martman' variety conducted in West Bengal, Bhan and Majumdar (1956) found that the plants cropped earlier when heavy applications of nitrogen were employed. Venkatesam et al. (1965) studied the effect of nitrogen, phosphorus and potassium in 'Karpoora Chakkara Keli' banana. Nitrogen induced better growth but phosphorus and potassium had little or no influence. The effective leaf area increased with rising nutrient levels especially of nitrogen.

Martin-Prevel (1966) while working with 'Dwarf Cavendish' found an earliness of the crop due to nitrogen application. A significant positive correlation between potassium concentration in the third leaf and stem circumference and height was established by Ho (1969). Fernandez and Garcia (1972) reported a positive correlation between percentage of nitrogen in the first and third leaves at flower differentiation and flowering. Ashokkumar (1977) reported that nitrogen promoted vegetative growth. Singh et al. (1977) observed that NPK at the rate of

150, 90, 170 g/plant gave the best growth and induced earliness.

In a study conducted by Valsamma Mathew (1980) in rainfed 'Palayankodan', increased vegetative vigour of plants was indicated in terms of height and girth of pseudostem, length of petiole, number of functional leaves and leaf area with increasing levels of nitrogen. Another trial by Sheela (1982) with potassium on the same variety showed that only the plant height was increased by the supply of potassium. The highest level of potassium induced early harvest of bunches.

Anjorin and Obigbesan (1983) studied the influence of nitrogen fertilizer on the early growth and development of plantain M. paradisiaca. Nitrogen application upto 300 g/plant significantly increased plant height, pseudostem girth, pseudostem weight and leaf weight. Higher nitrogen rates (400 g/plant) depressed all these parameters.

Phosphorus requirement of banana was much less than that of nitrogen and potassium as reported by Norris and Ayyar (1942); Martin-Prevel (1964); Turner (1969); Jauhari et al. (1974) and Vadivel (1976). But phosphorus helped to produce healthy rhizome and strong root system.

2.3. Bunch and fruit characters influenced by nutrient levels

A positive relation exists between the applied nutrients and yield reported by many workers. Baillon et al. (1933) obtained increased yield with nitrogen and potash applications in banana. Croutcher and Mitchell (1940) observed increased yield due to the application of nitrogen in the variety 'Gros Michel' under Jamaican conditions. Bhan and Majumdar (1956) reported better yields due to heavy nitrogen application, but they observed no response to phosphorus and potassium. Nitrogen application significantly increased the number of hands and fingers. Simmonds (1959), Venkatesam et al. (1965) and Arunachalam et al. (1976) reported increase in all the yield attributing characters and ultimately the yield due to the application of nitrogen.

Osborne and Hewitt (1963) reported the effect of potash on finger length, bunch confirmity and weight of fruit. Jagirder and Ansari (1966) observed the effect of nitrogen, phosphorus and potassium on growth and production of 'Cavendish' banana. They observed that plants receiving N, P or K produced heavier fruit bunches than the controls (no fertilizer). Bunch weight was heaviest and number of fingers greatest for plants receiving potassium

alone. Ho (1967) obtained yields of more than 30 t/ha by maintaining potassium at 5 per cent throughout the period of growth and development. The highest yield and the largest number of fingers per hand were obtained with the above concentration of potassium. Ho (1970) reported that yield and quality response to potassium was substantial if nitrogen and phosphorus supply were adequate.

Veeraraghavan (1972) reported significant increase in number and weight of fruits in 'Nendran' banana in Kerala with 228 g N, 228 g P_2O_5 and 456 g K_2O per plant per year. Ramaswamy and Muthukrishnan (1973) studied the effect of nitrogen on fruit development in 'Robusta' banana and obtained best result with 170 g N per plant which increased the length and girth of fruit at harvest.

Kohli *et al.* (1976) reported that 180 g N, 155 g P_2O_5 and 186.75 g K_2O per plant/year was the best fertilizer dose for 'Robusta' banana, giving maximum fruit yield. Pillai *et al.* (1977) studied the response of 'Nendran' banana to different levels of nitrogen, phosphorus and potassium and the results revealed that nitrogen and potassium exerted a significant positive influence on fruit number and bunch weight. The optimum dose of N and K_2O corresponding to maximum yield was worked

out as 191 and 301 g per plant respectively. Singh et al. (1977) reported that 150 g N, 90 g P_2O_5 and 170 g K_2O/plant gave the best yield for 'Basrai' banana of Uttar Pradesh.

Singh et al. (1974) studied the effect of nitrogen and potassium on physico-chemical characters of 'Robusta' banana and reported appreciable improvement in fruit qualities with potassium combinations. According to Vadivel and Shanmughavelu (1978) increase in levels of K_2O significantly increased the reducing, non-reducing and total sugars as well as total soluble solids in the variety 'Robusta'. Acidity was decreased while sugar/acid ratio was enhanced.

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 100 g each (one week interval) during fifth month of planting resulted in an increase in the bunch weight and number of fingers per bunch. Namboar et al. (1979) found that nitrogen and potassium in equal splits at 30 and 150 days after planting recorded the maximum bunch weight. Vaisamma Mathew (1980) in her studies on the effect of nitrogen nutrition on rainfed 'Palayankodan' found that the optimum and economic

levels of nitrogen were 204.6 and 96.0 g/plant respectively.

Hernandez and Robiana (1981) studied the effect of different rates of nitrogen on the variety 'Giant Cavendish' and reported that nitrogen increased yield, hands and fruit number but did not affect fruit length, diameter and weight. Best rate of nitrogen was 100 g/plant/year. In this soil with a high phosphorus and potassium content, no significant difference was observed with or without PK application. No significant difference in variables were obtained with rates of nitrogen higher than 150 g/plant/year.

Sheela (1982) obtained increased yields with increasing levels of potassium and reported the optimum level of potassium for 'Palayankodan' as 600 g/plant. Bunch characters viz., length of bunch, number of hands, weight of hand, number of fingers, girth and weight of fingers were significantly affected by levels of potassium. Total soluble solids, total sugars, reducing sugars, sugar/acid ratio and acidity were beneficially affected with increasing levels of potassium.

Chattopadhyay et al. (1980) in 'Cavendish' banana found that nitrogen application increased the total and

reducing sugar contents of the fruits. Turner and Barkus (1982) observed that low K supply considerably reduced the bunch weight and various yield components in banana. Rajeevan (1985) studied the effect of split application of NPK fertilizer in the banana cv.'Palayankodan'. According to him, 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 sugars showed significant differences.

2.4. Split application of fertilizers

Summerville (1944) opined that the time of application of fertilizers is an important factor and for better results the fertilisers are to be applied during the early stages of growth. Later Alexandrowitz (1955) remarked that the fertilizers are to be applied in splits.

Dugain (1959) studied the effect of application of ammonium sulphate at one or two tons/ha in 2-12 instalments per year to an already acid banana soil. He reported that fractional application of nitrogen was more beneficial than frequent application in large quantities.

Many workers later recommended split application of fertilizers for obtaining higher yields in banana. Osborne and Hewitt (1963) recorded highest yield in rainfed banana when nitrogen was applied in three splits in a year. According to Ho (1967) best results were obtained in Taiwan when nitrogen was applied in five splits evenly distributed over the year and phosphorus in two splits and potassium in three splits early in the season as compared with relatively late heavy applications.

Leigh (1969) suggested application of fertilizers in three split doses at a total rates of 560 kg N, 224 kg, P_2O_5 and 672 kg K_2O/ha. Marques and Monteiro (1971) recommended at least 200 kg N, 50-150 kg P_2O_5 and 100-600 kg K_2O/ha applied in three to four applications in Mosambique as mineral fertilizers or compost. Shanmugum and Velayudham (1972) reported that K could be applied in three split doses viz., 1st, 3rd, 5th months after planting along with N in Tamil Nadu. They opined that fertilizers did not help to increase the yield if applied after the 6th month.

Veeraraghevan (1972) recommended 228 g N, 228 g P_2O_5 and 456 g K_2O for 'Nendran' banana per year during the second and fourth month after planting in two

equal split doses. For 'Palayankodan' variety, a dose of 160-200 g N, 160-200 g P_2O_5 and 320-400 K_2O/plant was recommended to be applied as above (KAU, 1986). Gopimony et al. (1979) recommended application of an additional dose of 500 g urea in five equal split doses at one week interval during 5th month of planting for obtaining higher yields. In Assam three split applications of 900 kg N, 480 kg P_2O_5 and 480 kg K_2O/ha was given for 'Dwarf Cavendish' (Sharma and Roy, 1973).

Veerannah et al. (1976) studied the nutrient uptake in 'Poovan' and 'Robusta' varieties. They reported that nitrogen and potassium were absorbed more in the pre-flowering stage in 'Robusta'. However, there was a continuous and steady uptake of nitrogen and potassium and quantities were almost equal before and after flowering in 'Poovan'. In another study application of nitrogen and potassium in equal splits 30, 60 and 150 days after planting produced maximum bunch weight (Nambiar et al., 1979).

Obiefuna (1984) studied the effect of potassium application during floral initiation stages. Six levels of K (100 to 600 g/plant) as muriate of potash (Zero K control) were applied to plantain at growth stages

ranging from 15th to the 22nd leaf appearance. All plantains given potassium produced better yields. The optimum dose was 300 g K per plant, and when applied at about 19/20 leaf stage (4 to 5 months after planting) significantly increased the bunch weight, number of marketable fingers and finger weight per plant over control. Potassium applications later than the 20th leaf stage (five months after planting) did not produce further increase with bunches developed. High yield of plantains associated with heavy potassium applications two to three months after planting could also be achieved by timely application of smaller quantities of potassium at the 19/20th leaf stages when it required most for floral initiation.

Rajeevan (1985) reported that by suitably splitting recommended dose of fertilizers alone could improve the yield by 17 per cent in 'Palayankodan' variety of banana. Based on trial conducted at Banana Research Station, Kannara, it has been suggested that for 'Nendran' applying the fertilizers in six split doses will be beneficial to improve the finger size and bunch weight (KAU, 1996).

2.5. Nutrient levels in leaf tissue

Leaf analysis technique in banana was first originated by Hewitt (1955). He adopted the third leaf as

the standard for sampling since it had the highest concentration of nutrients. The critical level of nutrients reported by him were 2.6 per cent N, 0.45 per cent P_2O_5 and 3.30 per cent K_2O. Boland (1960) found the middle lamina halves of the second leaf before shooting as the best for sampling. He reported that the optimum levels of nutrients in the leaf before shooting were the best for sampling. He found that the optimum levels of nutrients in the leaf were 2.8 to 3.0 per cent N, 0.40 to 0.55 per cent P_2O_5 and 3.8 to 4.0 per cent K_2O. Murray (1960) working in Trinidad with 'Dwarf cavendish' banana confirmed the choice of third leaf as satisfactory, particularly for nitrogen, phosphorus and potassium determinations. The critical levels reported by him were 2.60, 0.45 and 3.30 per cent N, P_2O_5 and K_2O respectively.

Twyford and Coulter (1964) found the adequacy levels of N, P_2O_5 and K_2O were 2.90, 0.29 to 0.48 and 3.90 per cent respectively. Investigations in Israel by Lahav (1972) proved that for determinating the K levels in banana the stalk of the 7th leaf is the most appropriate part of the plant to sample. Sundersingh (1972) reported that leaf nutrient content of 3.13 per cent N, 0.44 per cent P_2O_5 and 3.89 per cent K_2O in the fifth month and

3.37 per cent N, 0.51 per cent P_2O_5 and 4.36 per cent K_2O in the seventh month were the optimum for the variety 'Robusta'.

Rameswamy and Muthukrishnan (1974 b) reported that nitrogen in certain levels were effective in maximising the production in banana and a critical levels of leaf nitrogen per cent was proved to be an optimum level. Soil applications of 150 g N per plant was fixed as critical level for maximising the yield and beyond that level production was decreased. Arunachalam et al. (1976) reported the adequacy level of leaf nutrient as 3.18 to 3.43 per cent N, 0.46 to 0.54 per cent P_2O_5, 3.36 to 3.76 per cent K_2O for clones 'Dwarf Cavendish', 'Giant Cavendish', 'Robusta' and 'Lacatan'. Promotive effects were noted for plant and bunch characters to the level of 170 g per plant.

Vadivel (1976) reported that at shooting, leaf concentration of major nutrients was assessed as 1.72 to 2.30 per cent N, 0.17 to 0.22 per cent P_2O_5 and 4.00 to 4.50 per cent K_2O in 'Robusta'. Ashokkumar (1977) observed that leaf concentration of nutrients at shooting in 'Robusta' ranged from 0.98 to 2.66 per cent N, from 0.11 to 0.37 per cent P_2O_5 and from 3.60 to 5.00 per cent K_2O respectively.

Ramirez *et al.* (1978) sampled the first and third leaves of 'Dwarf Cavendish' banana plants for two years at various times from before flowering until fruit formation. All samples contained less than 2.60 per cent N. Levels of phosphorus were often lower in the third leaf than the first leaf and occasionally below 0.19 per cent. K levels tended to be higher in the first than the third leaf and were generally high ranging from 5.09 per cent in the third leaf at flower bud formation to 8.00 per cent in the first leaf before flowering.

Guijarro *et al.* (1980) compared five sampling methods in order to decrease the sample volume required for banana leaf analysis. A 10 cm transverse band from the middle of the leaf blade was recommended. It had similar N, P, K, Ca and Mg contents to the middle third of the leaf used in traditional analysis. According to Valsamma Mathew (1980) the nutrient status of the 'third leaf' at shooting ranged from 1.33 to 2.08 per cent for N, from 0.14 to 0.17 per cent for P and 2.05 to 2.76 per cent for K.

Materials and Methods

MATERIALS AND METHODS

The present investigations were carried out to study the effect of split application of fertilizers on growth, flowering, yield and quality of bunches in banana var. 'Nendran' under irrigated conditions. The experiment was conducted in the Department of Pomology & Floriculture and Landscaping, College of Horticulture, Vellanikkara, during the period 1985-'86.

Soil

The soil of the experimental area was well drained acidic and lateritic clayloam. The chemical characteristics of the soil are presented in Table 1.

Weather data

The details of the meteorological observations for the cropping season taken in the nearby Agromet Observatory are given in Appendix I. The daily maximum temperature during cropping period ranged from 29.4 to 36.2°C and minimum from 22.1 to 25.2°C. The relative humidity was from 54 to 84 per cent. During the month of planting (October, 1985) there was heavy rainfall (377.1 mm)

Table 1. Chemical characteristics of the soil

Constituents	Content in the soil (%)	Analytical method used
Total nitrogen	0.140	Microkjeldahl (Jackson, 1958)
Available phosphorus	0.002	In Bray-I extract; Chlorostannous reduced molybdophosphoric blue colour method (Jackson, 1958)
Available potassium	0.012	In 1N neutral ammonium acetate extract; flame photometric (Jackson, 1958)
pH	4.55	1: 2.5 soil water ratio; using a pH meter
E.C. (Electrical conductivity millimhos/cm)	0.07	1: 2.5 soil water ratio; using electrical conductivity bridge

which helped the early establishment of the crop. Rainfall was almost nil during the month of January and February, the pre-shooting period of the crop. The crop was irrigated twice per week from December to May. The total rainfall obtained after shooting to harvest (April-July) was heavy (1183.3 mm) and maximum rainfall was obtained during the month of June 1986 (669.9 mm).

Planting and management practices

Suckers of uniform size and age (3 months old) were selected and pseudostems were cut back retaining 15-25 cm from the corm. The rhizomes were further selected and those having 2.00 to 2.50 kg weight were selected for experimental planting. The suckers were smeared with cowdung solution and ash and dried in partial shade for a week and stored in shade upto 15 days before planting.

The field was cleared, ploughed and levelled and pits of 50 cm^3 were dug at a spacing of 2 m on either way during the end of September. Suckers were planted

on October 4th, 1985. A basal application of 10 kg green leaves was done at planting. Twenty five g of thimet granules was also applied into the pits before planting as a prophylatic measure against rhizome weevil. One month after planting 10 kg farm yard manure was also incorporated into the pits. Uniform cultural operations and crop management were adopted during the cropping period. The crop was irrigated from December to May twice per week.

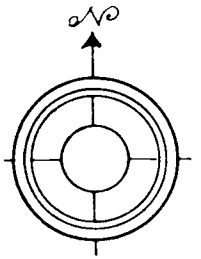
Experimental design and lay out

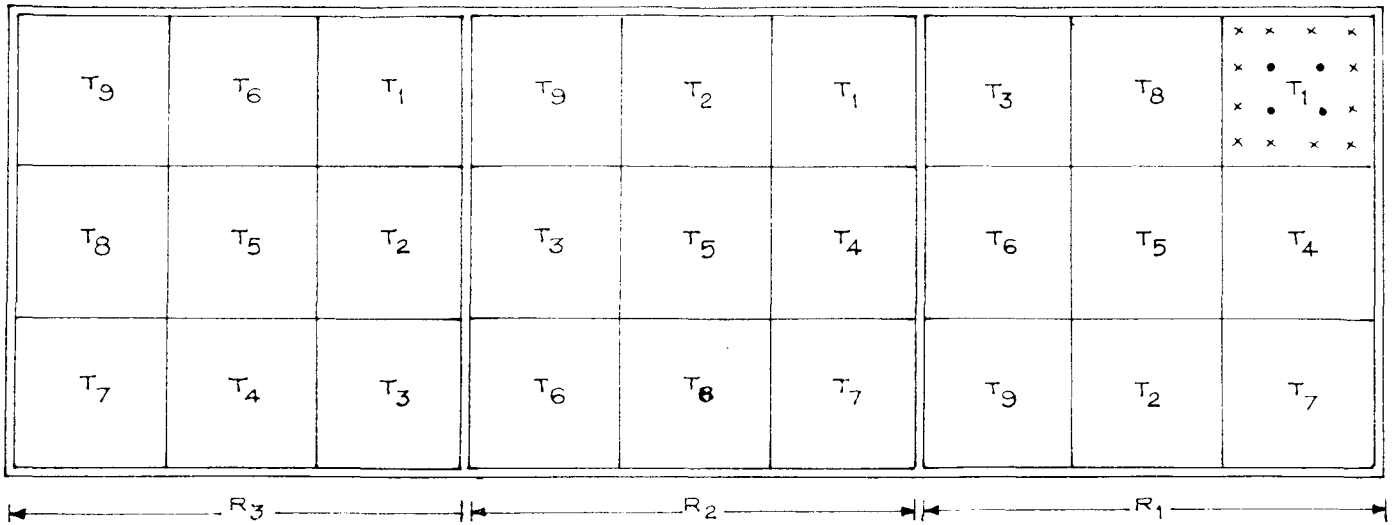
The experiment was laid out in randomised blocks with nine treatments and three replications. In each plot there were four rows and each row contained four plants. Out of total sixteen plants in a plot, the central four plants comprised the observation plants and all remaining plants were kept as border plants.

Treatments

The three different doses of fertilizers selected were furnished below.

FIG 1 LAY OUT PLAN





TREATMENTS - 9 , REPLICATIONS - 3

NO. OF SPLITS	QUANTITY OF FERTILIZER APPLIED g/PLANT/YEAR		
	190 N : 115 P_2O_5 : 300 k_2O	240 N : 140 P_2O_5 : 360 k_2O	300 N : 140 P_2O_5 : 450 k_2O
2 SPLITS	T_1	T_4	T_7
3 SPLITS	T_2	T_5	T_8
4 SPLITS	T_3	T_6	T_9

PLOT SIZE - 8 m x 8 m
SPACING - 2 m x 2 m
NUMBER PLANTS PER PLOT - 16

x x x x x - BORDER PLANTS - 12 / PLOT
• • • • OBSERVATION PLANTS - 4 / PLOT

BLOCKS
PLOTS

N	P_2O_5	K_2O	g/plant/year
190	115	300	(as per KAU Package of Practices)
240	140	360	
300	140	450	

The fertilizers were applied in three splits as given below.

2 Splits (i) 2 months after planting
(ii) 4 months after planting

3 Splits (i) 2 months after planting
(ii) 4 months after planting
(iii) 6 months after planting

4 Splits (i) 2 months after planting
(ii) 4 months after planting
(iii) 6 months after planting
(iv) 8 months after planting
(After flower emergence)

The details of the treatments are furnished hereunder.

190 N : 115 P_2O_5 : 300 K_2O g/plant/year

2 Splits - T_1

3 Splits - T_2

4 Splits - T_3

240 N : 140 P_2O_5 : 360 K_2O g/plant/year

2 Splits - T_4

3 Splits - T_5

4 Splits - T_6

300 N : 140 P_2O_5 : 450 K_2O g/plant/year

2 Splits - T_7

3 Splits - T_8

4 Splits - T_9

The nutrients nitrogen, phosphorus and potassium were supplied in the forms of urea (46.0 per cent N), superphosphate (16.0 per cent P_2O_5) and muriate of potash (60.0 per cent K_2O) respectively.

Observations

3.1 Morphological characters

Observations on various morphological characters were recorded from two months after planting to shooting at two months interval adopting the method suggested by Yang and Pao (1962).

3.1.1 Plant characters

3.1.1.1 Height of the pseudostem

The height of the pseudostem was measured from the base of the pseudostem to the axil of the youngest leaf and recorded in cm.

3.1.1.2 Girth of the pseudostem

Girth of the pseudostem was measured at 20 cm from the ground level and expressed in cm.

3.1.1.3 Number of leaves per plant

Fully opened, functional leaves present at each observation were counted.

3.1.1.4 Petiole length

Length of the petiole was measured from the point of attachment to the pseudostem to the base of the lamina.

3.1.1.5 Length of lamina

Length of lamina was measured from its base to the tip and expressed in m.

3.1.1.6 Width of lamina

Lamina width was measured at the broadest point in the middle region and expressed in m.

3.1.1.7 Leaf area per plant

The leaf area of each functional leaf was calculated as adopted by Rajeevan *et al.* (1984) (Leaf area = Length x breadth x 0.825) and expressed in m^2.

3.1.1.8 Duration of the crop

The number of days taken from planting to shooting and shooting to harvest was recorded. From these, the total duration from planting to harvest was computed.

3.1.1.9 Sucker production

The number of suckers per plant was recorded as and when they were produced. Suckers were not allowed to grow until shooting. After the emergence of the inflorescences one sucker per plant was retained.

3.1.2 Bunch characters

The bunches were harvested from experimental plants when they were fully mature as indicated by the disappearance of angles, that is "round full" (Simmonds, 1959). The following observations were made on the bunches harvested from the treatment plants.

3.1.2.1 Weight of the bunch

Weight of the bunch including the portion of the peduncle (exposed outside the plant) was recorded in kg.

3.1.2.2 Length of the bunch

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

3.1.2.3 Number of hands and fingers per bunch

The total number of hands per bunch and the total number of fingers in each bunch were recorded.

3.1.2.4 Mean weight of hand

Weight of each hand on a bunch was recorded and the mean value was calculated.

3.1.2.5 Mean weight of finger

The middle fruit in the top row of the second hand (from the base of the bunch) was selected as the representative finger (Gottreich et al., 1964) for finding out the mean weight, girth and length of finger. The weight of this representative finger was recorded as the mean

weight of finger as adopted by Valsamma Mathew (1980); Sheela (1982) and Rajeevan (1985).

3.1.2.6 Girth and length of finger

Girth of finger was measured at the mid portion and the length from the point of attachment to the tip using a fine thread and scale.

3.2 Studies on the nutrient status of plants

In order to assess the nutrient status of the plants under different treatments, the leaf analysis technique as adopted by Hewitt (1955) was followed. Leaf samples were collected at early vegetative phase (2 months after planting), late vegetative phase (4 months after planting), at shooting (7 months after planting) and at harvest (10 months after planting).

The cross sections of 2.5 cm including both lamina and midrib from the middle portion of the third leaf were taken for chemical analysis. The samples were analysed for N, P and K.

3.3 Chemical analysis

3.3.1 Plant parts

3.3.1.1 Nitrogen

Nitrogen content of the plant sample was estimated by microkjeldahl digestion - distillation method (A.O.A.C., 1960).

3.3.1.2 Phosphorus

One g of the ground sample was digested in 15 ml of a mixture of concentrated nitric acid: perchloric acid in the proportion of 2:1 and the volume made upto 100 ml with distilled water and filtered. Phosphorus in an aliquot of this extract was determined colorimetrically using vanadomolybdophosphoric yellow colour method (Jackson, 1958).

3.3.1.3 Potassium

Potassium in an aliquot of the diacid extract of the sample was determined using a flame photometer (Jackson, 1958).

3.3.2 Qualitative analysis of fruits

The fruits collected from well ripe bunches were used for quality analysis. The middle fruit in the top row of the second hand was selected as the representative sample. Samples were taken from each fruit from three portion viz., top, middle and bottom and these samples were then pooled and macerated in wering blender. Triplicate samples from these were used for analysis of different constituents as detailed below.

3.3.2.1 Total soluble solids

Total soluble solids were found out by a pocket refractometer and were expressed as percentage.

3.3.2.2 Acidity

Ten g of the macerated sample was mixed with distilled water and made upto a known volume. An aliquot of the filtered solution was titrated against 0.1 N sodium hydroxide using phenolphthalein as indicator. The acidity was expressed as percentage of citric acid (A.O.A.C., 1960).

3.3.2.3 Reducing sugars

The reducing sugars of the sample were determined as per the method described by A.O.A.C. (1960) and as adopted by Valsamma Mathew (1980), Sheela (1982) and Rajeevan (1985).

To a known quantity of macerated pulp, a small quantity of distilled water was added. The solution after thorough mixing was clarified with neutral lead acetate and deleaded with sodium oxalate and made upto a known volume. The solution was titrated against a mixture of Fehling's A and B solutions using methylene blue as

indicator. The content of reducing sugars was expressed as percentage.

3.3.2.4 Total sugars

Total sugars were determined as per the method described by A.O.A.C. (1960). Five ml of concentrated hydrochloric acid was added to a known volume of clarified solution and the content was kept overnight. The solution was then neutralised by adding sodium hydroxide and titrated against a mixture of Fehling's A and B solutions.

3.3.2.5 Non-reducing sugars

This was computed by working out the difference between the total and reducing sugars.

3.3.2.6 Sugar/acid ratio

This was arrived by dividing the total sugars with titratable acidity and this was reckoned as a measure of fruit quality.

3.4 Statistical analysis

The data obtained in the study were subjected to statistical analysis by applying the technique of analysis of variance for randomised block design (Panse and Sukhatme, 1985).

Results

RESULTS

The results of the present investigation on the effect of split application of fertilizers on growth parameters, bunch characters, fruit quality and nutrient concentration in leaf tissue of 'Nendran' banana are presented below.

4.1 Growth parameters

4.1.1 Height of the pseudostem

Data on mean height of plants at the three phases of growth viz., early vegetative phase, late vegetative phase and at shooting are presented in Table 2.

In all the three stages, the treatments did not show any significant difference on the mean height of plants.

4.1.2 Girth of the pseudostem

The results (Table 3) showed that there was no significant difference between treatments in the girth of pseudostem at different stages of growth.

Table 2. Effect of split application of NPK on plant height at different stages of growth

Treatment	Plant height (cm)		
	Early vegetative phase	Late vegetative phase	At shooting
T_1	48.42	143.75	299.58
T_2	50.14	147.42	301.67
T_3	51.45	153.50	310.42
T_4	50.50	143.17	295.25
T_5	50.58	145.25	303.75
T_6	51.33	148.92	307.92
T_7	48.44	135.67	285.53
T_8	49.42	143.08	294.58
T_9	48.17	144.22	305.58
CD (0.05)	NS	NS	NS
SEm ±	2.36	4.62	6.64

Table 3. Effect of split application of NPK on girth of pseudostem at different stages of growth

Treatment	Plant girth (cm)		
	Early vegetative phase	Late vegetative phase	At shooting
T_1	18.37	40.21	63.00
T_2	17.92	39.54	62.75
T_3	18.42	38.54	61.42
T_4	18.33	36.54	64.42
T_5	18.33	36.75	63.33
T_6	18.50	37.08	62.16
T_7	16.92	33.87	64.38
T_8	17.92	36.16	64.17
T_9	18.00	37.50	62.44
CD (0.05)	NS	NS	NS
SEm ±	0.88	1.70	0.93

4.1.3 Number of functional leaves

Data on the mean number of functional leaves per plant in the different treatments at various stages of growth are presented in Table 4. Plants under different treatments did not show any significant difference at various stages of growth.

4.1.4 Length of petiole

Data on petiole length under different treatments also did not show any significant difference on the length of petiole at any stage of growth studied (Table 5).

4.1.5 Total leaf area

Data on total leaf area at various stages of growth under different treatments are given in Table 6. Treatments did not show any significant difference in total leaf area at various stages of growth. However, the result showed that plants receiving T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year) recorded the maximum leaf area during late vegetative phase and harvesting time.

4.1.6 Duration of the crop

The duration of the crop from planting to shooting, from shooting to harvest and from planting to harvest were

Table 4. Effect of split application of NPK on number of functional leaves at different stages of growth

Treatment	Number of functional leaves			
	Early vegetative phase	Late vegetative phase	At shooting	At harvest
T_1	8.17	12.58	14.42	8.50
T_2	7.92	12.16	13.83	8.16
T_3	7.92	12.67	13.75	8.58
T_4	8.33	12.42	13.67	8.33
T_5	8.00	11.75	13.58	8.92
T_6	8.25	12.33	13.83	8.58
T_7	8.08	11.83	14.08	8.38
T_8	8.33	12.25	13.00	8.58
T_9	8.08	12.47	14.42	8.64
CD (0.05)	NS	NS	NS	NS
SEm ±	0.19	0.37	0.36	0.27

Table 5. Effect of split application of NPK on petiole length at different stages of growth

Treatment	Petiole length (cm)		
	Early vegetative phase	Late vegetative phase	At shooting
T_1	15.82	23.58	47.33
T_2	15.87	23.12	47.08
T_3	15.70	23.02	50.42
T_4	15.90	22.37	48.08
T_5	15.83	21.79	49.50
T_6	15.62	23.00	48.92
T_7	15.90	20.58	46.19
T_8	15.86	21.58	47.42
T_9	15.45	22.20	52.30
CD (0.05)	NS	NS	NS
SEm ±	0.36	1.01	1.79

Table 6. Effect of split application of NPK on total leaf area at different stages of growth

Treatment	Total leaf area (m^2)			
	At early vegatative phase	At late vegetative phase	At shooting	At harvest
T_1	1.26	6.98	14.50	8.50
T_2	1.16	6.78	13.43	8.89
T_3	1.25	7.24	14.95	9.06
T_4	1.30	6.99	14.25	8.67
T_5	1.15	6.61	14.60	8.82
T_6	1.24	7.11	14.05	8.49
T_7	1.05	5.95	14.34	8.29
T_8	1.17	6.24	13.41	8.49
T_9	1.12	6.23	15.40	8.97
CD (0.05)	NS	NS	NS	NS
SEm ±	0.12	0.46	0.65	0.54

also not differed significantly among the treatments (Table 7). Earliest shooting was recorded in T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits) of 191.83 days. The minimum days for harvest was noticed in T_1 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in two splits) of 291.66 days and maximum duration of 301.74 days in T_9 (300 N: 140 P_2O_5: 450 K_2O g/plant/year in four splits).

4.1.7 Sucker production

Data on the sucker production at shooting and at harvest under different treatments are furnished in Table 8. The results showed that there was no significant difference in number of suckers produced at shooting or at harvest under different treatments.

4.2 Bunch characters

Data pertaining to the various bunch and finger characters under different treatments are presented in Tables 9 and 10.

4.2.1 Weight of bunch

Significant differences were noticed between treatments with respect to bunch weight (Fig.2). Maximum bunch weight of 11.13 kg was recorded in T_4 (240 N:

Table 7. Effect of split application of NPK on the duration of crop

Treatment	Duration (days)		
	Planting to shooting	Shooting to harvest	Planting to harvest
T_1	195.16	96.50	291.66
T_2	196.42	96.00	292.42
T_3	191.83	101.42	293.25
T_4	202.75	95.58	298.33
T_5	204.67	91.16	295.83
T_6	193.75	100.33	294.08
T_7	208.08	92.83	300.91
T_8	201.33	98.25	299.58
T_9	201.36	100.38	301.74
CD (0.05)	NS	NS	NS
SEm ±	4.46	3.00	2.98

Table 8. Effect of split application of NPK on sucker production

Treatment	Number of suckers produced	
	At shooting	At harvest
T_1	7.92	9.17
T_2	7.67	8.08
T_3	8.08	8.50
T_4	7.58	8.25
T_5	8.50	8.83
T_6	7.08	7.50
T_7	6.17	7.42
T_8	7.08	7.83
T_9	8.08	8.75
CD (0.05)	NS	NS
SEm ±	0.66	0.72

140 P_2O_5 : 360 K_2O g/plant/year in two splits) which was on par with T_6 (240 N: 140 P_2O_5 : 360 K_2O g/plant/year in four splits) and T_3 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in four splits). These treatments were significantly superior to T_1 (190 N: 115 P_2O_5 : 300 K_2O g/plant in two splits), the recommendation in K.A.U. Package of Practices. This treatment had recorded a bunch weight of 9.59 kg. The minimum bunch weight was recorded in plants receiving T_7 (300 N: 140 P_2O_5 : 450 K_2O g/plant/year in two splits) of weight 9.41 kg.

4.2.2 Length of bunch

With respect to length of bunch, the differences among treatments were not found significant.

4.2.3 Number of hands per bunch

Data on mean number of hands per bunch showed that effects due to treatments were not significant.

4.2.4 Weight of hand

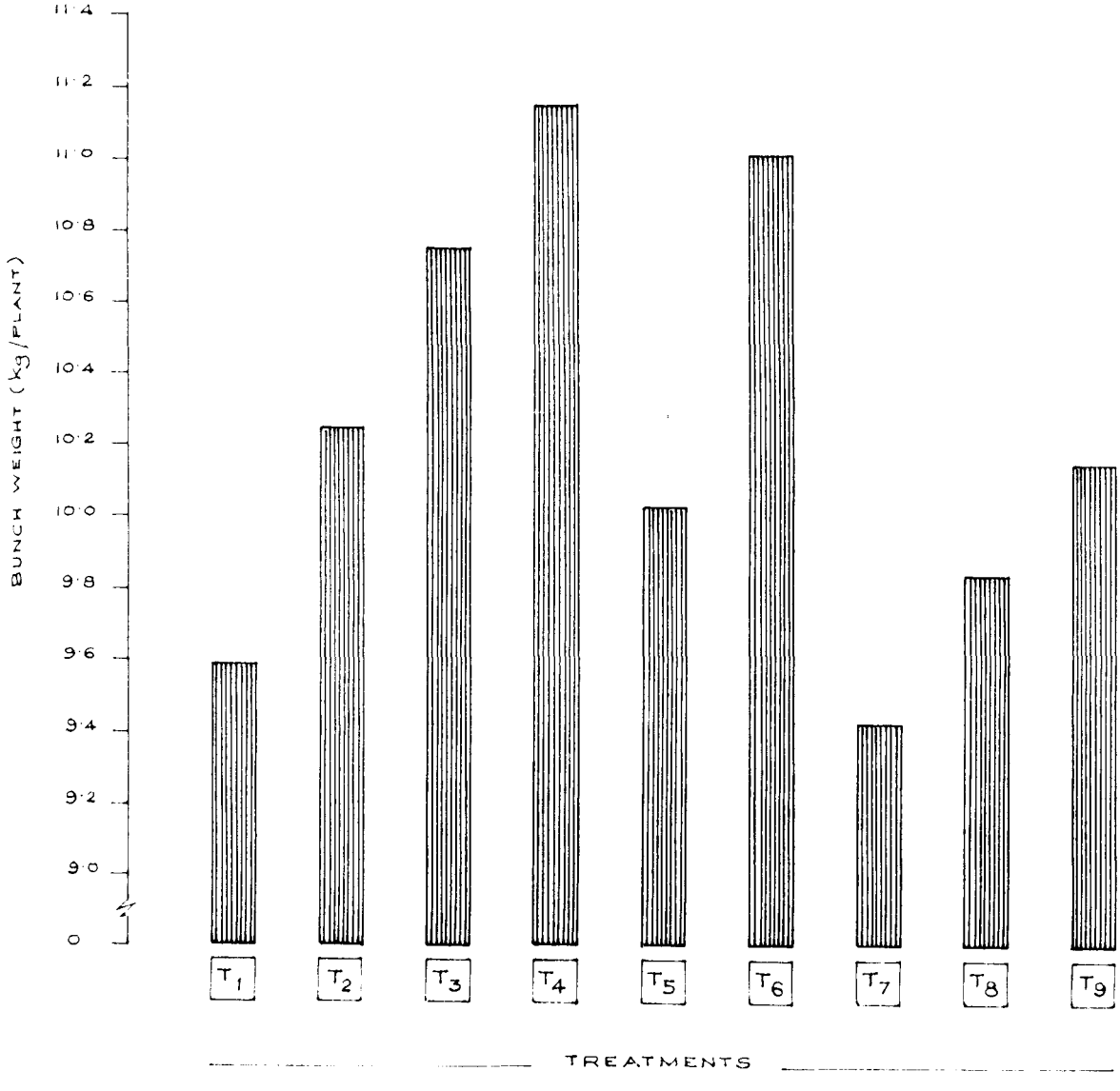
The mean weight of hand differed significantly among treatments. T_6 recorded the maximum weight of 1.96 kg which was significantly superior to T_7 and T_8. All other treatments were on par.

Table 9. Effect of split application of NPK on bunch characters

Treatment	Weight of bunch (kg)	Length of bunch (cm)	Number of hands/bunch	Mean weight of hand (kg)
T_1	9.59	35.42	5.08	1.84
T_2	10.25	35.00	4.83	1.83
T_3	10.75	38.00	4.83	1.95
T_4	11.13	36.75	5.00	1.91
T_5	10.08	36.00	5.00	1.81
T_6	11.00	38.75	5.08	1.96
T_7	9.41	34.08	5.00	1.69
T_8	9.83	39.17	5.33	1.70
T_9	10.14	35.19	5.03	1.91
CD (0.05)	0.64	NS	NS	0.16
SEm ±	0.21	1.59	0.13	0.05

No.of splits	Quantity of fertilizer applied g/plant/year		
	190 N: 115 P_2O_5: 300 K_2O	240 N: 140 P_2O_5: 360 K_2O	300 N: 140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG. 2 EFFECT OF SPLIT APPLICATION OF NPK ON BUNCH WEIGHT



4.2.5 Number of fingers/bunch

The number of fingers/bunch showed no significant difference among treatments. However, maximum number of fingers (51.75) were recorded in plants receiving T_4.

4.2.6 Number of fingers/hand

The number of fingers/hand also did not show any significant difference among different treatments.

4.2.7 Length of finger

The length of finger was also not varied significantly under different treatments. The length was maximum in T_9 (25.44 cm) followed by T_3 (25.42 cm).

4.2.8 Girth of finger

Data on girth of finger showed that effects due to different treatments were not varied significantly. Maximum girth of finger was recorded in T_6 (12.58 cm) followed by T_3 (12.25 cm).

4.2.9 Weight of finger

The weight of finger showed significant difference among various treatments. Plants under T_3 recorded the

Table 10. Effect of split application of NPK on finger characters

Treatment	Number of fingers/ bunch	Number of fingers/ hand	Length of finger (cm)	Girth of finger (cm)	Weight of finger (g)
T_1	48.92	9.92	24.08	11.92	178.33
T_2	47.92	9.92	23.92	11.75	193.75
T_3	45.83	9.50	25.42	12.25	196.66
T_4	51.75	10.08	24.00	11.45	182.50
T_5	46.83	9.83	24.67	11.37	173.33
T_6	49.50	10.00	24.58	12.58	184.16
T_7	48.67	9.75	23.58	11.67	163.33
T_8	48.75	9.83	22.75	11.67	181.66
T_9	49.58	10.00	25.44	11.80	191.38
CD (0.05)	NS	NS	NS	NS	13.92
SEm ±	1.57	0.16	0.64	0.39	4.64

Plate I A second hand from T_1 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in two splits) Scale 1cm = 5cm

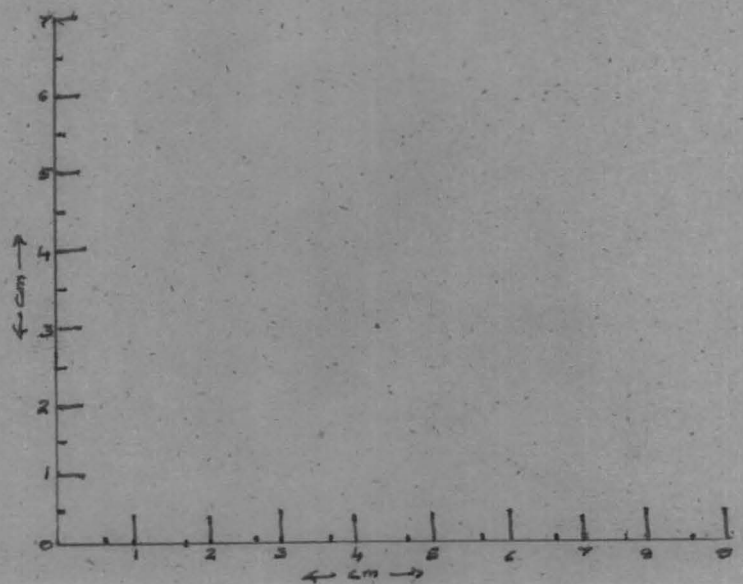
Plate II A second hand from T_2 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in three splits) scale 1cm = 5cm

Plate - I

Plate - II

Plate III A second hand from T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits) Scale 1cm = 5cm

Plate IV A second hand from T_4 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in two splits) Scale 1cm = 5cm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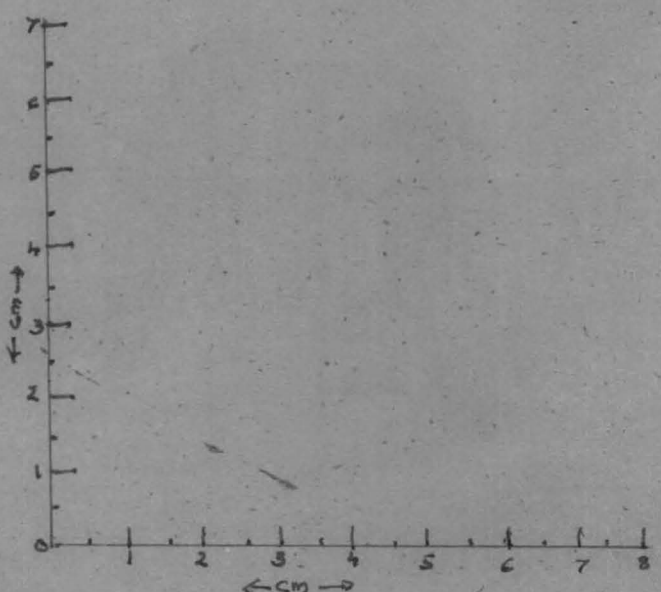
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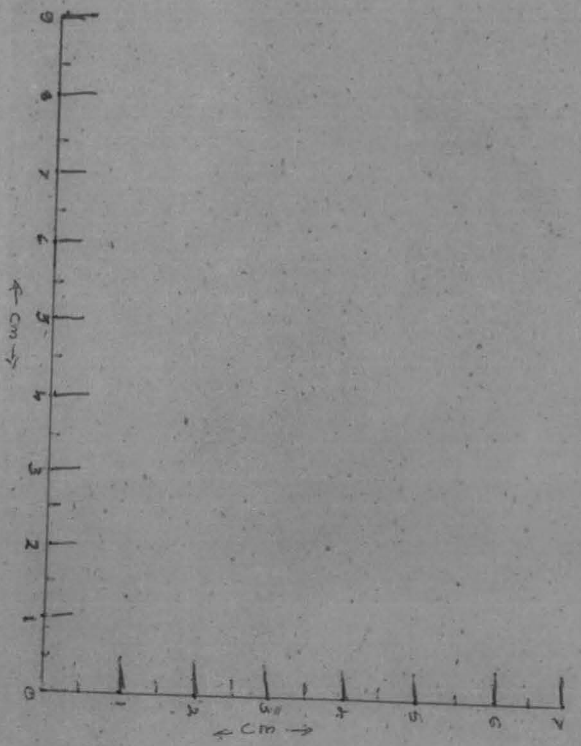
Plate - III

Plate - IV

Plate V A second hand from T_5 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in three splits) Scale 1cm = 5cm

Plate VI A second hand from T_6 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in four splits) Scale 1cm = 5cm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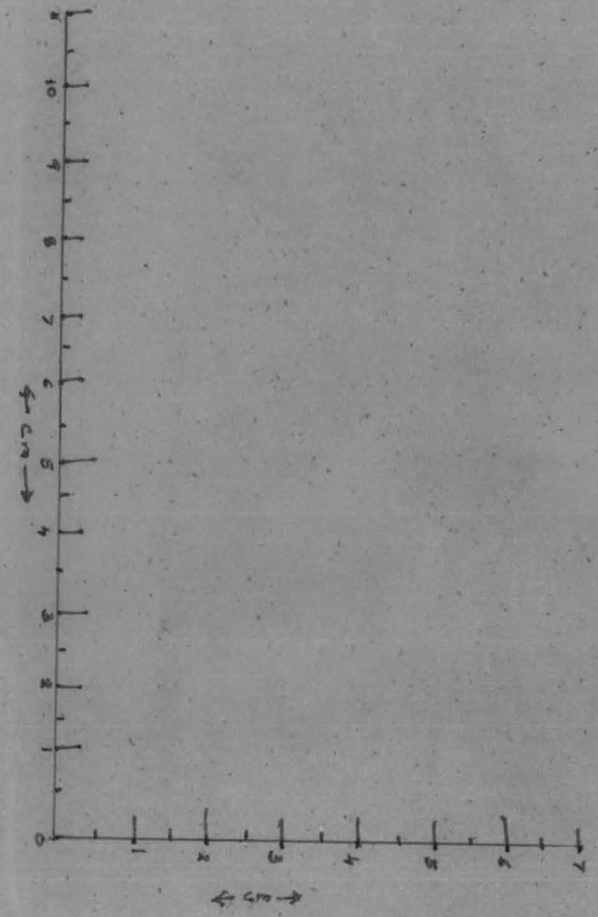
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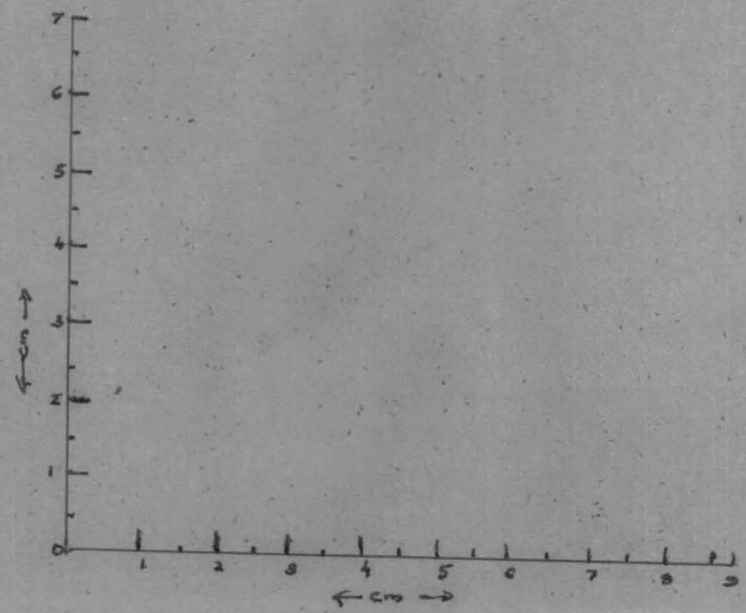
Plate - V

Plate - VI

Plate VII A second hand from T_7 (300 N: 140 P_2O_5: 450 K_2O g/plant/year in two splits) scale 1cm = 5cm

Plate VIII A second hand from T_8 (300 N: 140 P_2O_5: 450 K_2O g/plant/year in three splits) scale 1cm = 5cm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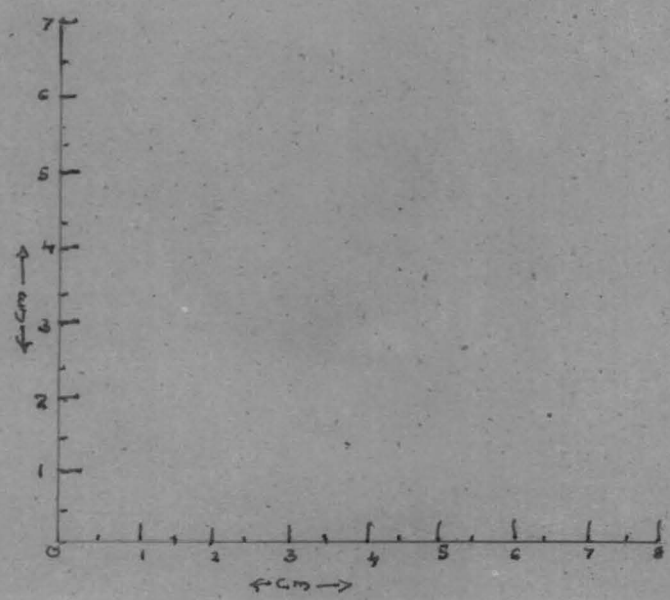
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Plate - VII

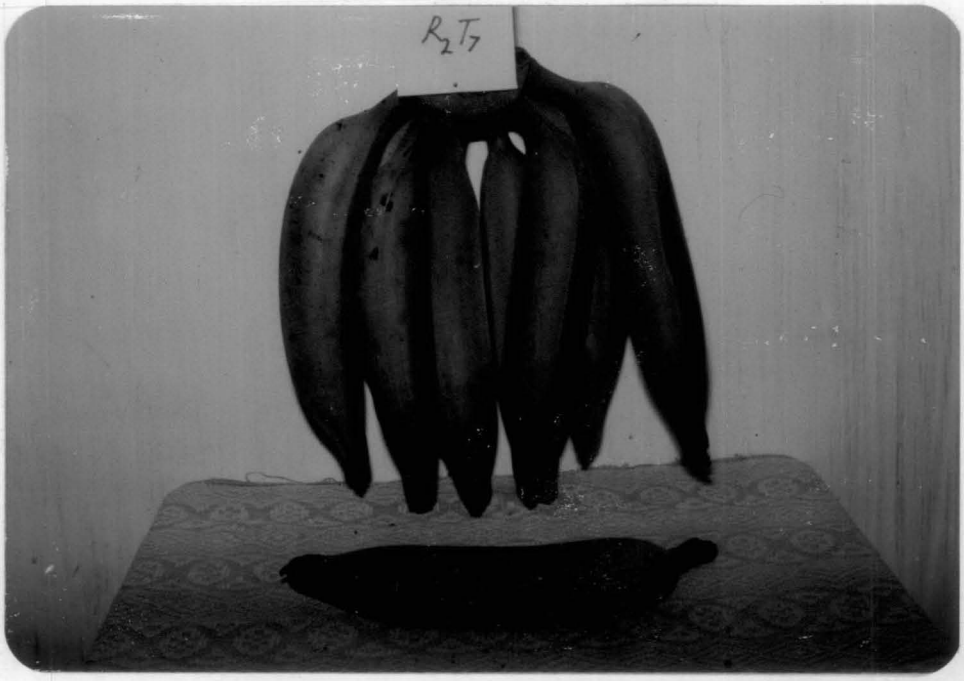

Plate - VIII

Plate IX A second hand from T_9 (300 N: 140 P_2O_5: 450 K_2O g/plant/year in four splits) Scale 1cm = 5cm

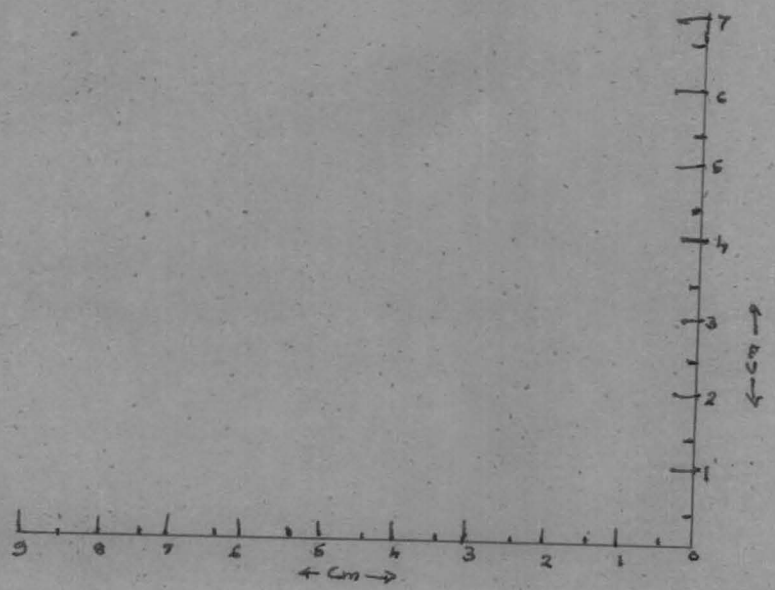
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Plate - IX

maximum weight for finger (196.66 g). T_2, T_6 and T_9 were on par with T_3. The minimum finger weight of 163.33 g was found in T_7.

4.3 Fruit characters

Data on physical characters of the fruit as influenced by the different treatments are presented in Table 11 and Fig.3.

4.3.1 Weight of fruit

The weight of fruit varied significantly among different treatments. The highest fruit weight was recorded in T_3 (183.33 g) which was significantly superior to T_1. Treatments T_2, T_4 and T_6 were on par with T_3.

4.3.2 Weight of pulp

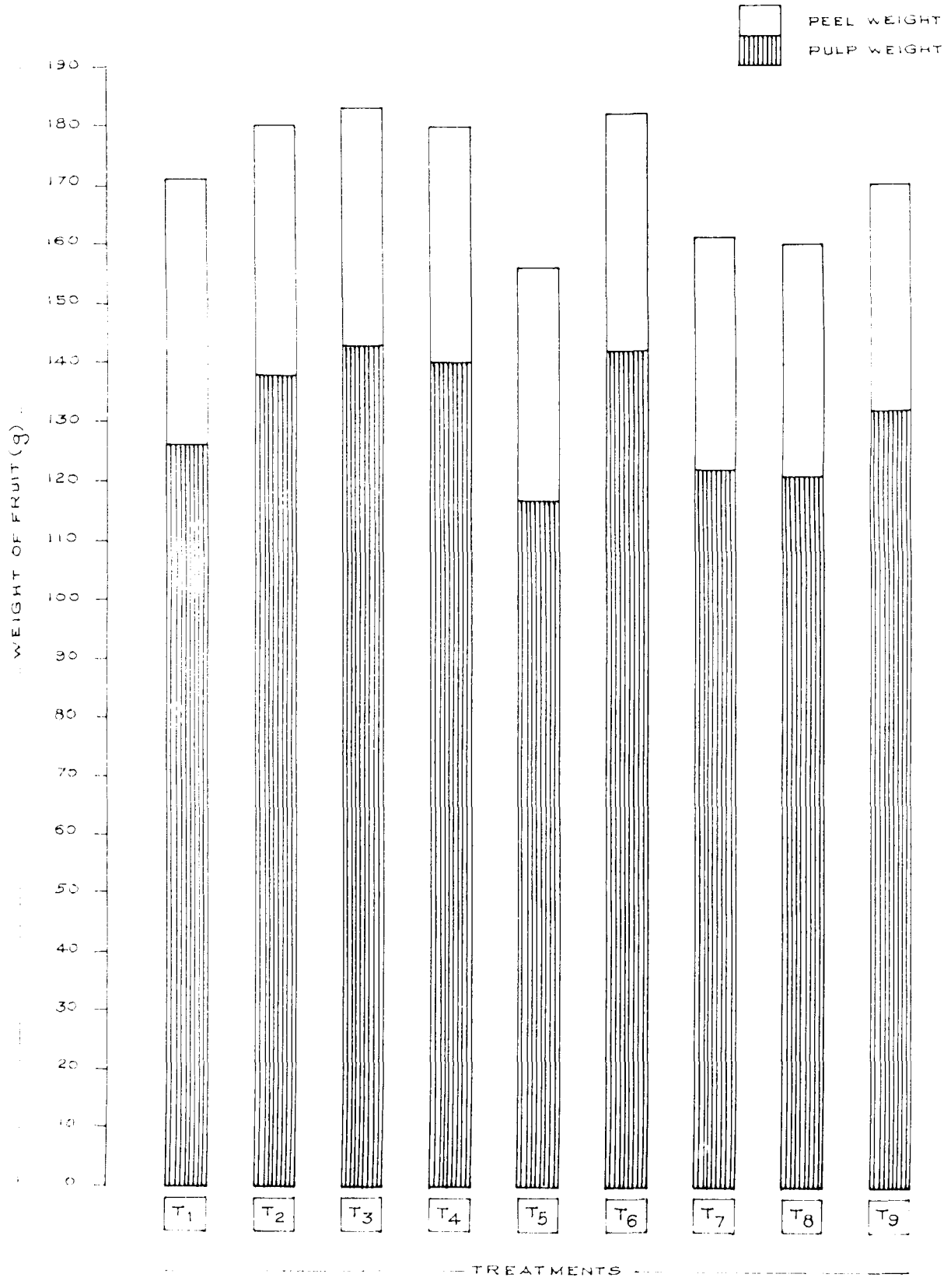
The weight of pulp varied significantly among different treatments. The maximum pulp was recorded in plants receiving T_3 with a pulp weight of 143.33 g. Treatments T_2, T_4 and T_6 were on par with T_3. Also T_3 is significantly superior to T_1.

Table 11. Effect of split application of NPK on fruit characters

Treatment	Weight of fruit (g)	Weight of pulp (g)	Weight of peel (g)	Pulp/peel ratio
T_1	170.00	126.67	43.33	3.03
T_2	180.30	138.64	41.66	3.33
T_3	183.33	143.33	40.00	3.58
T_4	180.00	140.00	40.00	3.50
T_5	156.66	116.66	40.00	3.25
T_6	182.38	142.38	40.00	3.56
T_7	161.16	122.41	38.75	3.16
T_8	160.00	121.66	38.34	3.17
T_9	170.12	132.62	37.50	3.54
CD (0.05)	10.67	8.42	NS	0.30
SEm ±	3.56	2.80	1.54	0.10

No. of splits	Quantity of fertilizer applied g/plant/year		
	190N:115 P_2O_5: 300 K_2O	240 N:140 P_2O_5: 360 K_2O	300 N:140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG. 3 EFFECT OF SPLIT APPLICATION OF N P K ON FRUIT CHARACTERS



4.3.3 Weight of peel

The data showed that the weight of peel was not varied significantly under different treatments. Maximum peel weight was found in T_1 (43.33 g) and minimum in T_9 (37.50 g).

4.3.4 Pulp/peel ratio

The pulp/peel ratio by weight varied significantly under different treatments. The maximum value was recorded in T_3 (3.58) followed by T_6 and T_9 (3.56 and 3.54) respectively.

4.4 Fruit quality

The data on the various qualitative characters of fruits as affected by different treatments are presented in Table 12.

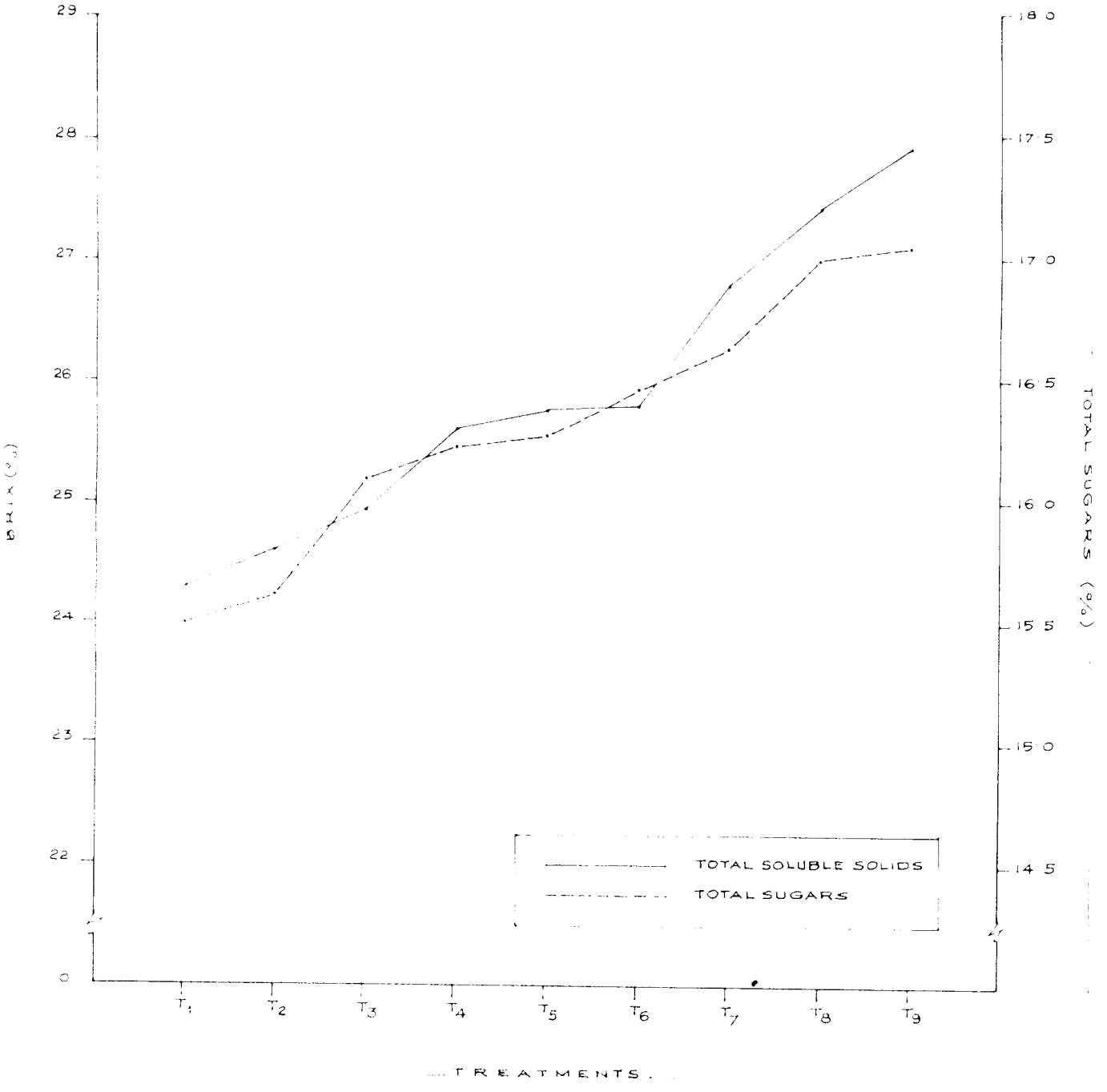
4.4.1 Total soluble solids

The treatment T_9 recorded the highest T.S.S. of 27.93 per cent (Fig.4) which is significantly superior to treatments T_1 to T_6.

Table 12. Effect of split application of NPK on fruit quality

Treatments	Total soluble solids (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Sugar/acid ratio	Acidity (%)
T_1	24.32	6.67	8.84	15.52	33.26	0.47
T_2	24.66	6.70	9.02	15.72	33.49	0.47
T_3	24.95	7.19	9.02	16.21	37.70	0.43
T_4	25.66	7.41	8.86	16.28	36.74	0.44
T_5	25.76	6.78	9.07	16.36	36.37	0.44
T_6	25.86	7.22	9.18	16.40	34.89	0.47
T_7	26.86	7.23	9.63	16.86	40.14	0.42
T_8	27.40	7.33	9.69	17.03	40.54	0.42
T_9	27.93	7.52	9.57	17.09	40.69	0.42
CD (0.05)	1.10	NS	NS	0.57	2.73	0.02
SEm ±	0.31	0.23	0.41	0.29	0.91	0.00

FIG. 4 EFFECT OF SPLIT APPLICATION OF NPK ON TOTAL SOLUBLE SOLIDS AND TOTAL SUGARS.



4.4.2 Reducing sugars

There was no significant difference among different treatments with regard to reducing sugars.

4.4.3 Non-reducing sugars

Data showed that non-reducing sugar content was not differed significantly due to various treatments.

4.4.4 Total sugars

T_9 recorded the maximum value 17.09 per cent (Fig.4) which is significantly superior to T_1, T_2 and T_3. Treatments T_9, T_8, T_6, T_4 were on par.

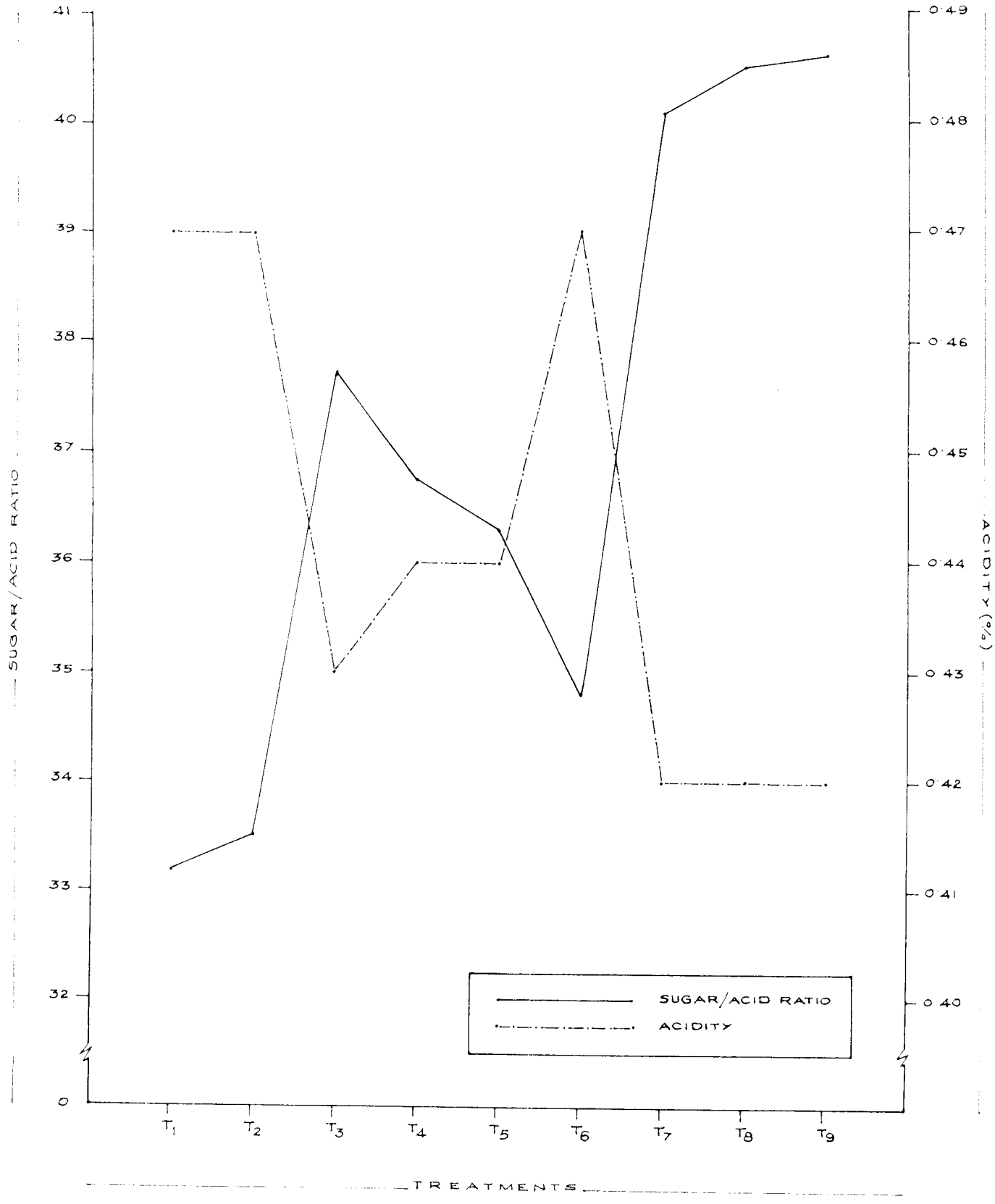
4.4.5 Sugar/acid ratio

Significant differences were observed in sugar/acid ratio due to treatments (Fig.5). The highest value of sugar/acid ratio was recorded in T_9 (40.69 per cent) which is on par with T_8 and T_7. But it is significantly superior to T_1, T_2 and T_3.

4.4.6 Acidity

The acidity was significantly superior in T_1, T_2 and T_6 (0.47 per cent). Minimum values for acidity was recorded in T_7, T_8 and T_9 (0.42 per cent).

FIG. 5 EFFECT OF SPLIT APPLICATION OF N P K ON SUGAR/ACID RATIO AND ACIDITY.



4.5 Nutrient concentration in leaf tissue

4.5.1 Nitrogen

Data relating to nutrient concentrations revealed that the nitrogen concentration varied significantly among treatments at shooting and at harvest although no significant difference was noticed during the early and late vegetative phases. Highest concentration at shooting was found in T_3 (3.82 per cent) and at harvest (2.58 per cent) in T_9 (Table 13, Fig.6).

4.5.2 Phosphorus

With respect to phosphorus concentration, there was no significant difference among the treatments at various stages of growth (Table 14, Fig.7).

4.5.3 Potassium

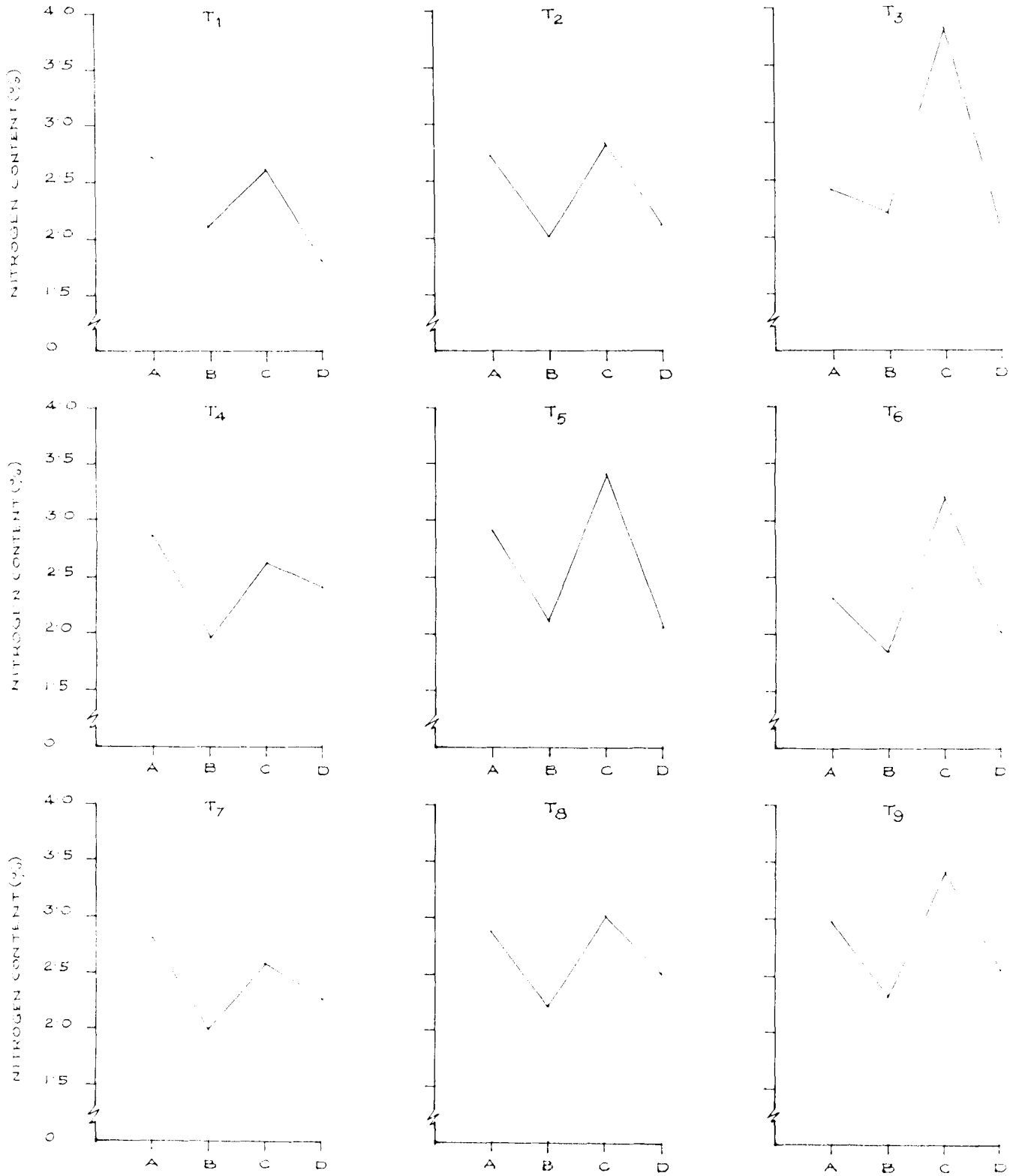
Concentration of potassium also showed significant variation among the treatments at shooting and at harvest (Table 15, Fig.8). At shooting, maximum concentration was observed in T_7 (3.57 per cent) and minimum in T_2 (2.75 per cent). At harvest, maximum concentration was found in T_3 (2.53 per cent) and minimum in T_2 (2.02 per cent).

Table 13. Effect of split application of NPK on nitrogen content (%) of the index leaf at different stages of growth

Treatment	Early vegetative phase	Late vegetative phase	At shooting	At harvest
T_1	2.72	2.22	2.62	1.82
T_2	2.70	2.02	2.83	2.16
T_3	2.38	2.16	3.82	2.13
T_4	2.70	1.96	2.58	2.40
T_5	2.94	2.12	3.46	2.06
T_6	2.30	1.84	3.21	2.02
T_7	2.70	2.06	2.55	2.28
T_8	2.80	2.22	2.99	2.54
T_9	2.98	2.32	3.41	2.58
CD (0.05)	NS	NS	0.43	0.36
SEm ±	0.17	0.14	0.14	0.12

No.of splits	Quantity of fertilizer applied g/plant/year		
	190 N: 115 P_2O_5: 300 K_2O	240 N: 140 P_2O_5: 360 K_2O	300 N: 140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG 6. EFFECT OF SPLIT APPLICATION OF NPK ON NITROGEN CONTENT OF THE INDEX LEAF AT VARIOUS STAGES OF GROWTH.



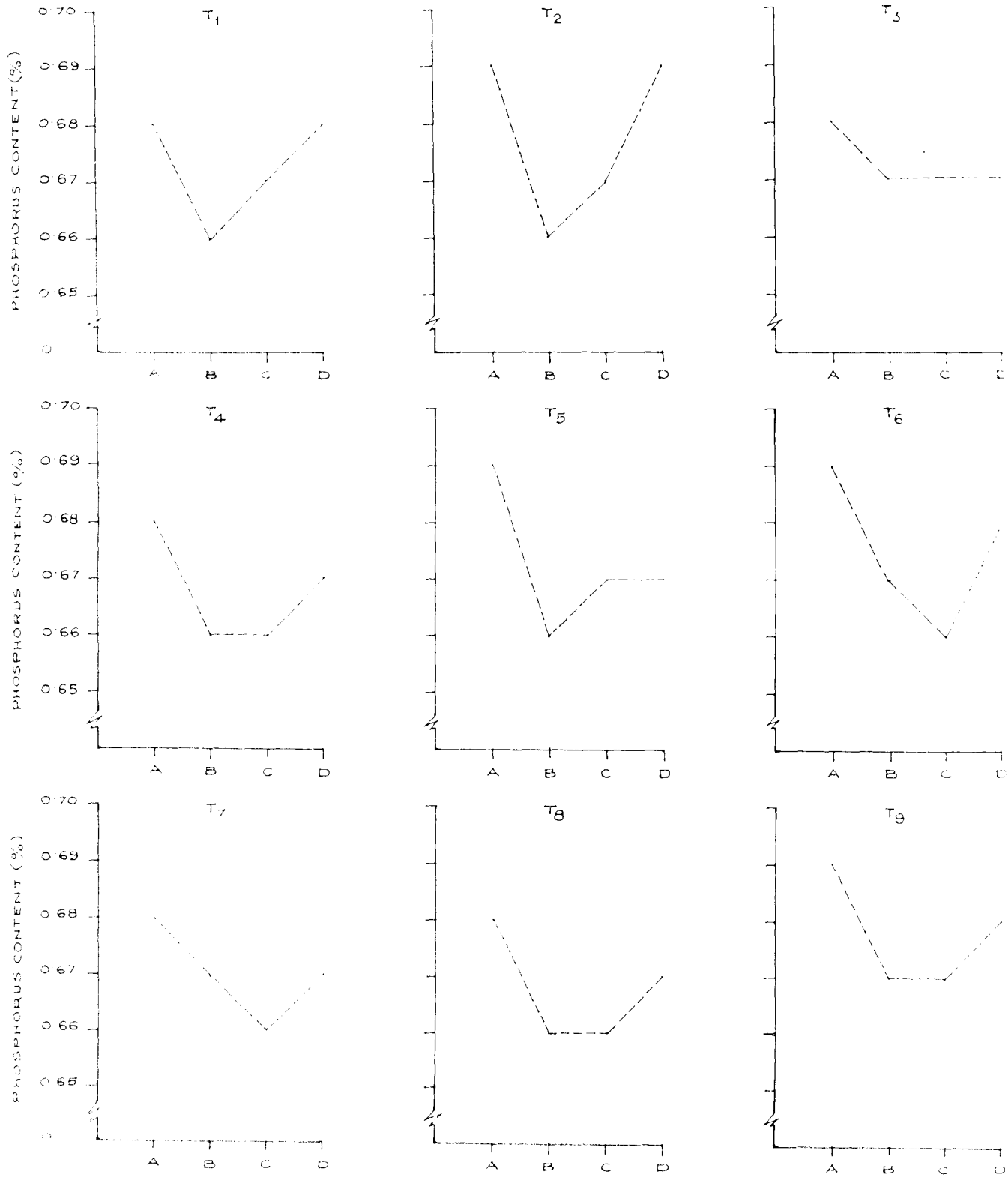
A - EARLY VEGETATIVE PHASE , B - LATE VEGTATIVE PHASE , C - SHOOTING , D - HARVEST

Table 14. Effect of split application of NPK on phosphorus content (%) of the index leaf at different stages of growth

Treatment	Early vegetative phase	Late vegetative phase	At shooting	At harvest
T_1	0.68	0.66	0.67	0.68
T_2	0.69	0.66	0.67	0.69
T_3	0.68	0.67	0.67	0.67
T_4	0.68	0.66	0.66	0.67
T_5	0.69	0.66	0.67	0.67
T_6	0.69	0.67	0.66	0.68
T_7	0.68	0.67	0.66	0.67
T_8	0.68	0.66	0.66	0.67
T_9	0.69	0.67	0.67	0.68
CD (0.05)	NS	NS	NS	NS
SEm ±	0.00	0.00	0.00	0.00

No. of splits	Quantity of fertilizer applied g/plant/year		
	190N:115 P_2O_5: 300 K_2O	240 N:140 P_2O_5: 360 K_2O	300 N:140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG. 7. EFFECT OF SPLIT APPLICATION OF NPK ON PHOSPHORUS CONTENT OF INDEX LEAF AT VARIOUS STAGES OF GROWTH.



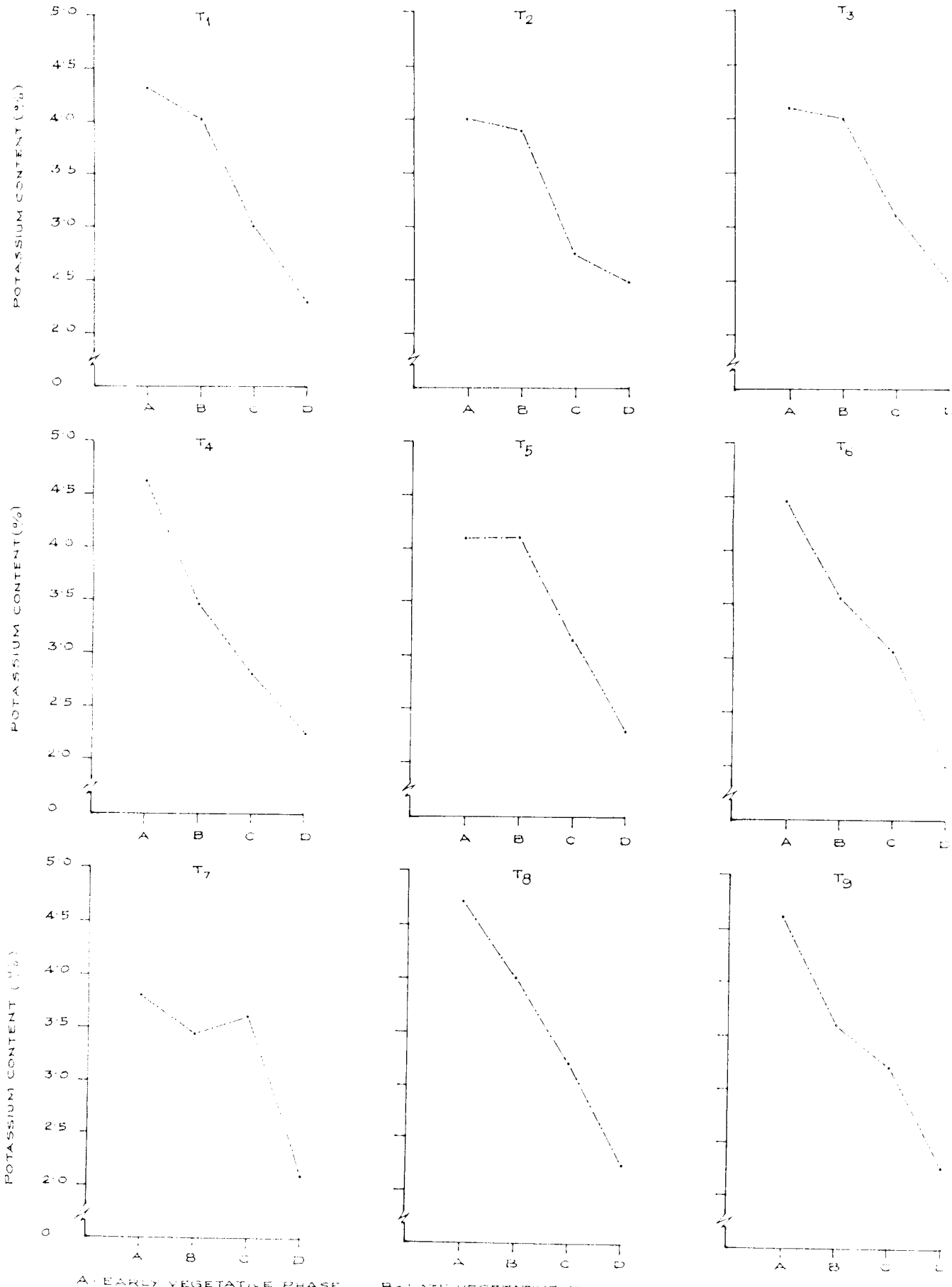
A - EARLY VEGETATIVE PHASE , B - LATE VEGETATIVE PHASE , C - SHOOTING , D - HARVEST

Table 15. Effect of split application of NPK on potassium content (%) of the index leaf at different stages of growth

Treatment	Early vegetative phase	Late vegetative phase	At shooting	At harvest
T_1	4.30	4.07	3.00	2.26
T_2	4.03	3.93	2.75	2.02
T_3	4.15	3.98	3.18	2.53
T_4	4.58	3.48	2.80	2.25
T_5	4.15	4.17	3.18	2.32
T_6	4.47	3.58	3.07	2.05
T_7	3.80	3.48	3.57	2.15
T_8	4.71	4.00	3.20	2.27
T_9	4.60	3.58	3.20	2.28
CD (0.05)	NS	NS	0.44	0.24
SEm ±	0.31	0.24	0.15	0.09

No. of splits	Quantity of fertilizer applied g/plant/year		
	190N:115 P_2O_5: 300 K_2O	240 N:140 P_2O_5: 360 K_2O	300 N:140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG. 8 EFFECT OF SPLIT APPLICATION OF NPK ON POTASSIUM CONTENT OF INDEX LEAF AT VARIOUS STAGES OF GROWTH



4.6 Economics of split application of fertilizers

In the present investigation, three different doses of fertilizers were adopted for banana var. Nendran one is recommended dose and other two are higher doses. Those were applied in three different splits. In the experiment, maximum profit was obtained in T_4 where 240 N: 140 P_2O_5: 360 K_2O g/plant/year was applied in two splits. From this treatment about 14.80 per cent higher income was obtained compared to control (190 N: 115 P_2O_5: 300 K_2O g/plant/year in two splits). Negative percentage of profit was obtained in T_7 (-4.32) and T_8 (-5.22) and almost nil percentage in T_9 (+1.06). In these three treatments, highest dose of fertilizer (300 N: 140 P_2O_5: 450 K_2O g/plant/year) was applied in different splits (two, three and four splits respectively). The treatment T_6 had $^{+}$11.92 per cent profit and T_3 had $^{+}$9.87 per cent profit which were on par with T_4 (Table 16, Fig.9).

Table 16. Effect of split application of NPK on the economics of cultivation (per hectare)

Treatment	Mean yield bunch weight (kg)	Income from bunches Rs.4.00/kg	Extra cost on additional fertilizers and splits			Income (deducting extra cost)	Amount over control	% increase over control
			Fertilizers Rs.	Labour charge Rs.	Total cost Rs.			
T_1	23975	95900	-	-	-	95900.00	-	-
T_2	25625	102500	-	1066.50	1066.50	101433.50	5533.50	+ 5.77
T_3	26875	107500	-	2133.00	2133.00	105367.00	9467.00	+ 9.87
T_4	27825	111300	1205.58	-	1205.58	110094.42	14194.42	+14.80
T_5	25200	100800	1205.58	1066.50	2272.08	98527.92	2627.92	+ 2.74
T_6	27500	110000	1205.58	2133.50	3338.58	106661.42	10761.42	+11.92
T_7	23525	94100	2343.14	-	2343.14	91756.86	-4143.14	- 4.32
T_8	23575	94300	2343.14	1066.50	3409.64	98890.36	-5009.64	- 5.22
T_9	25350	101400	2343.14	2133.00	4476.14	96923.86	1023.86	+ 1.06

This is on the account of the additional cost of cultivation. For additional split the charges will be as given below. (Man @ Rs.26/- and woman @ Rs.24.50 per day).

a) Taking basins for application of fertilizers (100 basins/man)
b) Mixing and application charges (150 basins/woman)

Cost of fertilizers/kg

Urea	Rs.2.12
Super phosphate	Rs.0.85
Muriate of potash	Rs.1.19

Source - Norms fixed by Kerala Agricultural University

Discussion

DISCUSSION

Banana being a gross feeder, requires heavy manuring for its growth and fruiting. It is estimated that an average crop removes 300 kg N, 80 kg P_2O_5 and 800 kg K_2O from a hectare of land (Veeraraghavan, 1972). Judicious and regular manuring is imperative for efficient banana production.

Summerville (1944) opined that the time of application of fertilizers is an important factor and for better results the fertilizers are to be applied during the early stages of growth. Later Alexandrowitz (1955) emphasised that fertilizers are to be applied in splits. However, the number of splits has been at variance especially among the cultivators. Reports in general indicate the beneficial effects of applying fertilizers in two splits for bananas (Veeraraghavan, 1972; Pillai et al., 1977; Valsamma Mathew, 1980 and Sheela, 1982). There are however instances where later splits have been found to be useful (Gopimony et al., 1979; Nambiar et al., 1979; Irizarry et al., 1981 and Rajeevan, 1985).

According to package of practices of the Kerala Agricultural University 1982, it is recommended to apply the prescribed dose in two splits, the first at two months after planting and second at four months after planting. The major problem of banana cultivation under Kerala condition is the low bunch weight which is mainly caused due to reduced finger size.

The present investigation was conducted to find out the effect of fertilizers, when applied in more splits than that is generally recommended i.e. two split applications. The results of the studies are discussed hereunder.

5.1 Growth parameters

The effect of split application of fertilizers on various morphological characters viz., height and girth of pseudostem, number of functional leaves, petiole length and total leaf area were observed at three different stages of growth viz., early vegetative phase (2 months after planting), late vegetative phase (4 months after planting) and at shooting (7 months after planting). It was found that none of the morphological characters varied significantly among the treatments. Controversial to this,

Rajeevan (1985) based on the studies on the effect of split application of recommended dose of NPK fertilisers on 'Palayankodan' reported that the growth parameters such as plant height, girth of pseudostem and number of functional leaves were significantly influenced by various treatments during the later stages of growth. A similar pattern of increase in vegetative characters due to an increment in the supply of fertilisers was reported by various workers (Jambulingum *et al.*, 1975; Arunachalam *et al.*, 1976 and Singh *et al.*, 1977).

In the fertiliser experiments conducted in India and elsewhere it has been brought out that the functional leaf is a major parameter which contributes to the ultimate yield of banana. Crontcher and Mitchell (1940); Katyal and Chadha (1961); Battikhah and Khalidy (1962) and Venkatesam *et al.* (1965) observed that increase in nitrogen levels increased the number of leaves. Lacoevilhe (1973) indicated that potassium application influenced the number of leaves. The functional leaves at all stages were not affected by the doses and splits tried in the present study.

The total leaf area did not show significant difference under various treatments at various stages of growth. Valsamma Mathew (1980) while working with rainfed

'Palayankodan' reported that the leaf are significantly increased during the 7th month. The increased uptake of nutrients during this stage might have contributed to the larger leaf area.

The crop duration also did not differ significantly among the different treatments. Earliest shooting was recorded in T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits). The minimum duration was noticed in T_1 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in two splits). Venkatesam *et al.* (1965) after conducting a trial employing different levels of nitrogen opined that though the duration from planting to shooting was markedly influenced, the maturity period of bunch was not influenced by the treatments. More vigorous plants took comparatively lesser time to shooting. The works of Singh *et al.* (1977), Valsamma Mathew (1980) and Sheela (1982) were also on similar lines. Rajeevan (1985) reported that split application of the recommended dose influence only in the duration between planting to shooting.

In the present investigation, maximum duration was observed in T_9 (300 N: 140 P_2O_5: 450 K_2O g/plant/year/four splits). The conclusion for the delay in harvest due to highest level of nitrogen fertilizers may be accounted for the

supra optimal level of nitrogen diverting carbohydrate into vegetative growth and lowering the levels of other nutrients in the vegetative tissue (Black, 1965). A combination of N and K in correct proportion is necessary for manupulating the crop growth reported by several workers (Croutcher and Mitchell, 1940; Summerville, 1944; Bhangoo et al., 1962 and Melin, 1970).

Number of suckers produced at shooting and at harvest did not show any significant difference among the treatments.

5.2 Yield and yield attributes

In banana, yield is a function of number of hands, number of fingers in a hand, weight of hand, girth and weight of individual fingers (Simmonds, 1959; Venkatesan et al., 1965 and Arunachalam et al., 1976). Any of these parameters may play a prominent role depending upon environmental conditions. In the present investigation, effect of different doses of fertilizers and its split application showed significant differences among the treatments with respect to bunch weight. Maximum bunch weight (11.13 kg) was noticed in T_4 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in two splits) which was on par with T_6

(240 N: 140 P_2O_5 : 360 K_2O g/plant/year in four splits) and T_3 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in four splits). These treatments were significantly superior to T_1 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in two splits). Rajeevan (1985) reported maximum bunch weight when applied major amount of fertilizers in the early stages of growth.

The minimum bunch weight of 9.41 kg was recorded in plants receiving T_7 (300 N: 140 P_2O_5 : 450 K_2O g/plant/year in two splits). The result came in confirmity with the finding of Rao (1978) who reported that banana responds to nitrogen, but beyond a certain level the benefits are not proportional. Excess nitrogen fertilizers beyond optimum limit will be used for entire vegetative growth. Veeraraghavan (1972) reported significant increase in yield in 'Nendran' banana in Kerala with 228 g N, 228 g P_2O_5 and 456 g K_2O/plant/year.

In the present study, T_4 recorded maximum bunch weight mainly due to more number of fingers per bunch and per hand compared to all other treatments, though differences were not significant. Pillai *et al.* (1977) revealed that nitrogen and potassium exerted a significant positive influence on fruit number and bunch weight.

Vijayaraghavakumar *et al.* (1984) based on their statistical studies in the influence of biometric characters on yield in banana reported that number of fingers is having the maximum direct effect. It is also probable that the number of fingers is influenced more by the quantity of fertilizer upto a certain level than time of application.

The bunch weight of T_6 and T_3 were on par with T_4. The reason behind this increased weight is the higher finger weight and hand weight compared to other treatments. Murray (1960) and Shanmugum and Velayudham (1972) were of opinion that fertilizers did not help in increasing the yield if applied after six months. But Rajeevan (1985) reported a higher yield in 'Palayankodan' by split application of recommended dose of fertilizers upto eight months. In the above study, significant difference in weight of bunch was mainly contributed by number of hands and number of fingers rather than weight of individual finger.

Though length and girth of finger did not vary significantly, it was clear from the present trial that there was some improvement in the size of finger in terms of length and girth when the same dose of fertilizer was given in more splits. This might be due to the continuous

uptake of nutrients throughout the growth period where fertilizers were applied even in later stages.

5.3 Fruit characters

The fruit and pulp weight varied significantly among the treatments. The highest fruit weight of 183.33 g was recorded in T_3 which was significantly superior to T_1. Treatments T_2, T_4 and T_6 were on par with T_3. These treatments were superior to T_7, T_8 and T_9 in which the highest dose of fertilizers was given which clearly indicated that fruit weight could not be increased by fertilizers beyond a certain level.

Pulp weight also showed the same trend. The weight of peel was not varied significantly due to various treatments. Maximum peel weight was found in T_1 (43.33 g) and minimum in T_9 (37.50 g). The pulp/peel ratio by weight also varied significantly among the treatments. There was an increase in pulp/peel ratio when the same dose of fertilizer was given in more splits. Rajeevan (1985) reported that among the physical characters of the fruits, only the pulp/peel ratio differed significantly as influenced by splits.

5.4 Fruit quality

In the present study, an improvement of fruit quality was noticed when higher doses of fertilizers were given. Total soluble solids, total sugars, sugar/acid ratio and acidity varied significantly while reducing sugars and non-reducing sugars were not showed significant variation. In this experiment an increase in total soluble solids, total sugars and sugar/acid ratio was noticed with increase in fertilizer dose. Splitting of same dose of fertilizers did not show much variation. Here too, the quantity of fertilizers rather than splits might influence the quality. But Rajeevan (1985) reported significant differences among treatments for total sugars and reducing sugars by split application.

According to Vadivel (1976), application of potassium exerted marked effect on nearly every feature of fruit quality. With increase in potassium, total soluble solids, reducing sugars, non-reducing sugars and total sugars were increased whereas the acidity was reduced. In the present study also, similar results were obtained. These findings also confirmed the results of Sundersingh (1972) and Jambulingam *et al.* (1975). Tisdale and Nelson (1971)

attributed these effects of potassium due to its involvement in carbohydrate synthesis, breakdown and translocation of starch and synthesis of protein and neutralisation of physiologically important organic acids.

Valsamma Mathew (1980) reported that nitrogen markedly improved the quality of fruits in respect of total soluble solids, total sugars, reducing sugars and non-reducing sugars. According to Singh (1975), the qualitative improvement with nitrogen application might be attributed to the promotive effect in the process of photosynthesis and stimulated function of several enzymes in the physiological process of fruit development.

Sheela (1982) reported significant beneficial effects due to potassium application on quality attributes like total soluble solids, total sugars, reducing sugars, sugar/acid ratio and acidity.

5.5 Nutrient concentration in leaf tissues

Leaf tissue analysis for nitrogen, phosphorus and potassium at various stages of growth revealed that nitrogen concentration varied significantly at shooting and at harvest. The nitrogen concentration in leaf tissue

was more when the same dose was applied in more splits than two splits. At the time of harvest, there was sharp decrease in nitrogen concentration.

There was no significant difference among the treatments in phosphorus concentration at various stages of growth. Compared to nitrogen and potassium, phosphorus concentration was very little (0.66 - 0.69 per cent). Little or no response to phosphorus was pointed out by several earlier workers (Fawcett, 1921; Baillon et al., 1933; Norris and Ayyar, 1942; Osborne and Hewitt, 1963; Turner, 1965 and Pillai et al., 1977).

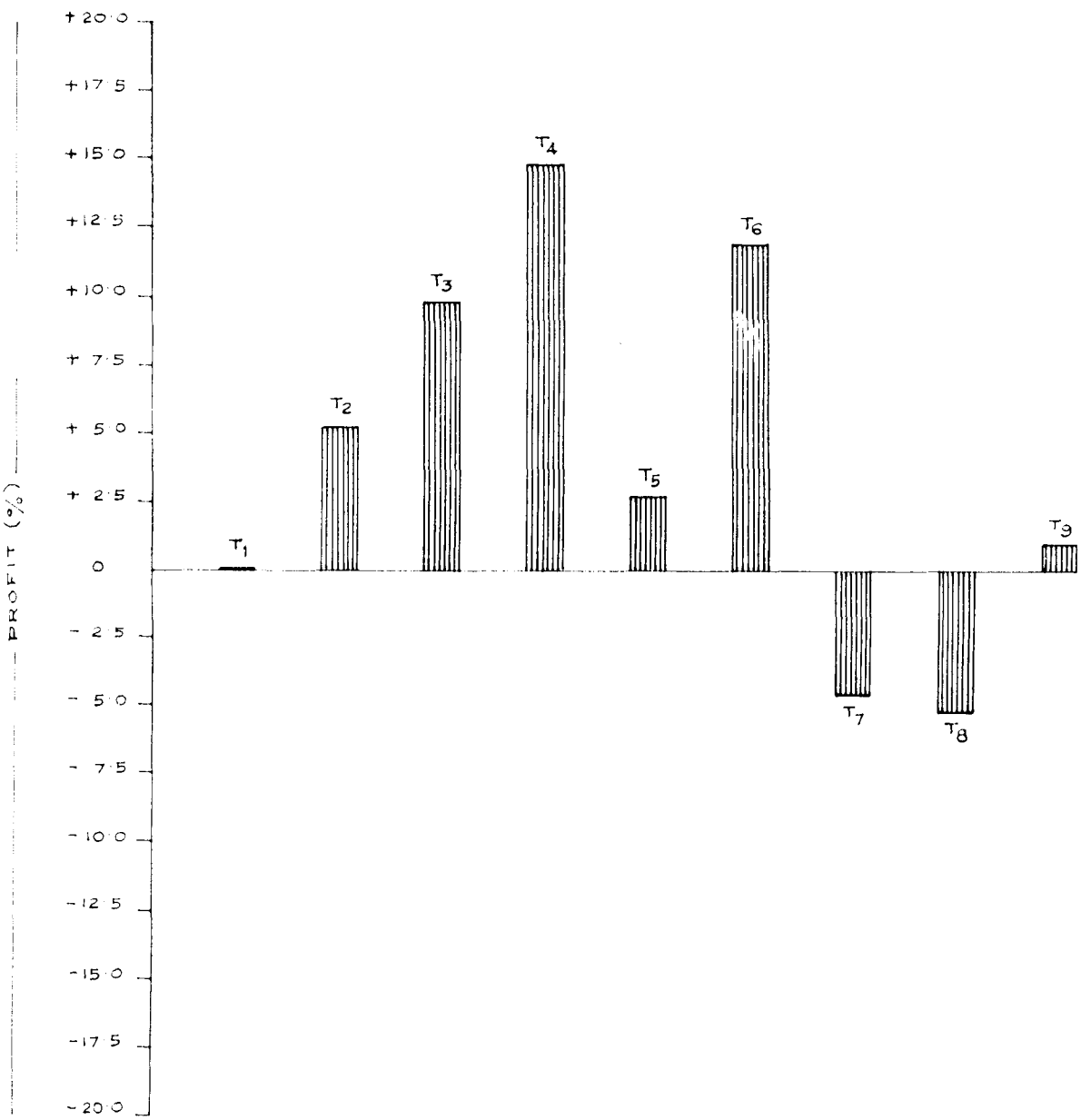
The differences due to treatments were significant with regard to potassium concentration at shooting and at harvest. At shooting, maximum concentration was observed in T_7 (3.57 per cent) and minimum in T_2 (2.75 per cent). At harvest, maximum concentration was found in T_3 (2.53 per cent) and minimum in T_2 (2.02 per cent).

5.6 Economics of cultivation

Economics of cultivation of 'Nendran' with three different doses of fertilizers in three different splits showed that percentage of profit as compared to control

No. of splits	Quantity of fertilizer applied g/plant/year		
	190N:115 P_2O_5: 300 K_2O	240 N:140 P_2O_5: 360 K_2O	300 N:140 P_2O_5: 450 K_2O
2 Splits	T_1	T_4	T_7
3 Splits	T_2	T_5	T_8
4 Splits	T_3	T_6	T_9

FIG. 9. EFFECT OF SPLIT APPLICATION OF NPK ON THE ECONOMICS OF CULTIVATION.



varied from -5.22 to 14.80 (Table 16 and Fig.9). Maximum profit of +14.80 per cent was obtained in T_4 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in 2 splits) closely followed by T_6 (same dose in four splits) about +11.92 per cent. When recommended dose was applied in four splits (T_3) a profit of +9.87 per cent was obtained over control (190 N: 115 P_2O_5: 300 K_2O g/plant/year in two splits). When the highest dose of 300 N: 140 P_2O_5: 450 K_2O g/plant/year was applied (T_7, T_8 and T_9) in whatever splits, the cost of production increased resulting in net loss.

The present studies clearly indicate that the recommended dose of fertilizers viz., 190 N: 115 P_2O_5: 300 K_2O g/plant/year when applied in four splits had favoured yield than the same dose was applied in two splits. Probably under the high rainfall conditions of Kerala, where the soil is lateritic the fertilizer dose if applied in more than two stages is more effective due to their availability during the growth phases of the plant. When higher doses of fertilizers are applied in two splits it equalled four splits of recommended dose, perhaps indicating the residual availability of applied nutrients in the soil for a longer period.

In a crop like banana where the development physiology is closely related to the production, a uniform growth could be assured if fertilizers are made available in optimum quantities during the entire growth phases of the plant. The split application of nutrients appears to be a useful method; the effect of course being specific and depends upon factors like soil, climate etc.

Summary

SUMMARY

The salient results of the present investigation on the effect of split application of NPK fertilizers on flowering, yield and quality of bunches and on nutrient status of plants in leaf tissue at different stages of growth for banana var. Nendran under irrigated conditions are summarised below.

1. None of the morphological characters like height and girth of pseudostem, number of functional leaves, length of petiole, total leaf area, crop duration and sucker production were significantly influenced by different treatments at various stages of growth.

2. Significant differences were noticed among the treatments with respect to bunch weight. Maximum bunch weight of 11.13 kg was recorded in T_4 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in two splits). This treatment was on par with T_6 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in four splits) and T_3 (recommended dose of Kerala Agricultural University 190 N: 115 P_2O_5: 300 K_2O g/plant/year in 4 splits) and is significantly superior to T_1 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in two splits).

3. Among the bunch characters, length of bunch and number of hands per bunch remained unaffected by different treatments, while weight of hand showed significant difference. Maximum hand weight of 1.96 kg was recorded in T_6 which was significantly superior to T_7 (300 N: 140 P_2O_5: 450 K_2O g/plant/year in two splits) and T_8 (300 N: 140 P_2O_5: 450 K_2O g/plant in three splits). All other treatments were on par.

4. Among the finger characters, only the weight of finger showed significant variation among the different treatments whereas length and girth of finger remained unaffected. Plants under T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits) recorded the maximum weight for finger (196.67 g). T_2, T_6 and T_9 were on par with T_3. The minimum finger weight of 163.33 g was found in T_7.

5. Fruit weight, pulp weight and pulp/peel ratio varied significantly in different treatments whereas peel weight remained unaffected. Maximum fruit weight and pulp weight were recorded in plants which received T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits) and minimum in T_5 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in three splits).

6. Among the various qualitative attributes studied, significant differences were observed with regard to total soluble solids, total sugars, acidity and sugar/acid ratio. However, reducing sugars and non-reducing sugars were not influenced significantly by various treatments. An increase in total soluble solids, total sugars and sugar/acid ratio was noticed with increase in fertilizer dose. But acidity was in a decreasing rate.

7. Data relating to nutrient status had revealed that the nitrogen concentration varied significantly among the treatments at shooting and at harvest although no significant variation was noticed during early and late vegetative phases. At shooting, highest concentration of 3.82 per cent was found in T_3 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in four splits) and minimum in T_7 (2.55 per cent). At harvest, T_9 (300 N: 140 P_2O_5 : 450 K_2O g/plant/year in four splits) recorded the maximum nitrogen percentage of 2.58 and minimum in T_1 (1.82 per cent).

8. Phosphorus concentration showed no significant difference among the treatments at various stages of growth.

9. Concentration of potassium also showed significant variation among the treatments at shooting and

at harvest. At shooting, maximum concentration of 3.57 per cent was observed in T_7 and minimum of 2.75 per cent in T_2 (190 N: 115 P_2O_5 : 300 K_2O g/plant/year in three splits). At harvest, maximum concentration was found in T_3 (2.53 per cent) and minimum in T_2 (2.02 per cent).

10. The percentage of profit over control varied from -5.22 to +14.80. Maximum profit was obtained in T_4 when a dose of 240 N: 140 P_2O_5 : 360 K_2O g/plant/year was applied in two splits (+14.80). Also applying the same dose in four splits (T_6) and recommended dose in four splits (T_3) gave good results (+11.92 per cent and +9.87 per cent respectively) compared to other treatments. Minimum profits were obtained in treatments T_7, T_8 and T_9 where a dose of 300 N: 140 P_2O_5 : 450 K_2O g/plant/year was applied in 2 splits, 3 splits and 4 splits respectively. In these cases, cost of production increased resulting in net loss.

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Appendices

Appendix I. Meteorological parameters of the experimental site at College of Horticulture, Vellanikkara, for the period from September 1985 to August 1986.

Month	Temperature (°C)		Rainfall (mm)	Number of rainy days per month	Mean relative humidity (%)
	Maximum	Minimum			
1985					
September	30.5	23.0	59.3	6	80
October	31.1	22.5	377.1	16	77
November	31.8	22.3	14.4	2	70
December	32.2	22.9	58.8	2	62
1986					
January	32.5	22.4	1.2	-	58
February	34.2	22.1	1.9	-	58
March	36.2	24.3	8.4	1	60
April	36.0	25.2	23.2	3	67
May	34.2	24.7	108.8	7	72
June	30.0	23.1	669.9	20	84
July	29.5	23.2	381.4	16	84
August	29.4	22.7	358.7	12	83

Source - Agromet Observatory, Vellanikkara

Appendix XI. Analysis of variance for effect of split application of NPK on plant height at different stages of growth

Source	Degrees of freedom	Mean squares		
		Early vegetative phase	Late vegetative phase	At shooting
Block	2	14.20	9.84	672.75
Treatment	8	21.65	71.18	179.50
Error	16	16.80	64.25	132.36
Total	26			

Appendix III. Analysis of variance for effect of split application of NPK on plant girth at different stages of growth

Source	Degrees of freedom	Mean squares		
		Early vegetative phase	Late vegetative phase	At shooting
Block	2	0.50	5.45	1.07
Treatment	8	0.72	10.88	3.32
Error	16	2.30	6.76	2.58
Total	26			

Appendix IV. Analysis of variance for effect of split application of NPK on functional leaves at different stages of growth

Source	Degrees of freedom	Mean squares			
		Early vegetative phase	Late vegetative	At shooting	At harvest
Block	2	0.12	1.10	3.82	0.23
Treatment	8	0.08	0.30	0.58	0.14
Error	16	0.11	0.42	0.39	0.23
Total	26				

Appendix V. Analysis of variance for effect of split application of MSK on petiole length at different stages of growth

Source	Degrees of freedom	Mean squares		
		Early vegetative phase	Late vegetative phase	At shooting
Block	2	0.55	10.36	187.16
Treatment	8	0.07	3.35	10.98
Error	16	0.41	3.09	9.62
Total	26			

Appendix VI. Analysis of variance for effect of split application of NPK on total leaf area at different stages of growth

Source	Degrees of freedom	Mean squares			
		Early vegetative phase	Late vegetative phase	At shoot-ing	At harvest
Block	2	0.02	0.83	30.85	1.26
Treatment	8	0.01	0.61	1.26	1.70
Error	16	0.04	0.65	1.29	0.92
Total	26				

Appendix VII. Analysis of variance for effect of split application of NPK on sucker production and duration of crop

Source	Degrees of freedom	Mean squares				
		Number of suckers		Days to shoot from planting	Days to harvest from shooting	Days to harvest from planting
		At shooting	At harvest			
Block	2	3.61	7.70	0.44	33.27	27.38
Treatment	8	1.49	1.11	89.22	36.85	38.81
Error	16	1.31	1.58	59.94	27.15	26.67
Total	26					

Appendix VIII. Analysis of variance for effect of split application of NPK on bunch characters

Source	Degrees of freedom	Mean squares			
		Weight of bunch	Length of bunch	Number of hands/bunch	Mean weight of hand
Block	2	0.01	7.68	0.04	0.05
Treatment	8	1.09**	9.64	0.07	0.03*
Error	16	0.14	7.63	0.05	0.01
Total	26				

* Significant at 5% level

** Significant at 1% level

T_6 T_3 T_4 T_9 T_1 T_2 T_5 T_8 T_7

T_4 T_6 T_3 T_2 T_9 T_5 T_8 T_1 T_7

Appendix IX. Analysis of variance for effect of split application of NPK on finger characters

Source	Degrees of freedom	Mean squares				
		Number of fingers/ bunch	Number of fingers/ hand	Length of finger	Girth of finger	Weight of finger
Block	2	15.53	0.21	1.03	0.50	157.59
Treatment	8	8.65	0.09	2.24	0.43	289.15**
Error	16	7.43	0.08	1.24	0.45	64.68
Total	26					

** Significant at 1% level

T_3 T_2 T_9 T_6 T_4 T_8 T_1 T_5 T_7

Appendix X. Analysis of variance for effect of split application of NPK on fruit charecters

Source	Degrees of freedom	Mean squares			
		Fruit weight	Pulp weight	Peel weight	Pulp/peel ratio
Block	2	1.66	4.47	3.53	0.03
Treatment	8	324.97**	269.43**	9.17	0.17**
Error	16	38.06	23.68	7.18	0.03
Total	26				

** Significant at 1% level

T_3 T_6 T_2 T_4 T_9 T_1 T_7 T_8 T_5

T_3 T_6 T_4 T_2 T_9 T_1 T_7 T_8 T_5

T_3 T_6 T_9 T_4 T_2 T_5 T_8 T_7 T_1

Appendix XI. Analysis of variance for effect of split application of NPK on fruit quality

Source	Degrees of freedom	Mean squares					
		Total soluble solids	Reducing sugars	Non-reducing sugars	Total sugars	Sugar/acid ratio	Acidity
Block	2	0.25	0.05	0.02	0.12	0.19	0.000
Treatment	8	4.58**	0.31	0.33	0.99**	25.38**	0.001**
Error	16	0.28	0.16	0.50	0.25	2.49	0.000
Total	26						

** Significant at 1% level

$T_9\ T_8\ T_7 \quad T_6\ T_5\ T_4 \quad T_3\ T_2\ T_1$

$T_9\ T_8\ T_7 \quad T_6\ T_5\ T_4 \quad T_3 \quad T_2 \quad T_1$

$T_9\ T_8\ T_7 \quad T_3 \quad T_4\ T_5\ T_6 \quad T_2 \quad T_1$

$T_1\ T_2\ T_6 \quad T_4\ T_5\ T_3 \quad T_7 \quad T_8 \quad T_9$

Appendix XII. Analysis of variance for effect of split application of NPK on nitrogen content of the index leaf at different stages of growth

Source	Degrees of freedom	Mean squares			
		Early vegetative phase	Late vegetative phase	At shooting	At harvest
Block	2	0.12	0.07	0.24	0.07
Treatment	8	0.16	0.07	0.61**	0.26**
Error	16	0.08	0.06	0.06	0.04
Total	26				

**Significant at 1% level

T_3 T_5 T_9 T_6 T_8 T_2 T_1 T_4 T_7

T_9 T_8 T_4 T_7 T_2 T_3 T_5 T_6 T_1

Appendix XIII. Analysis of variance for effect of split application of NPK on phosphorus content of index leaf at different stages of growth

Source	Degrees of freedom	Mean squares			
		Early vegetative phase	Late vegetative phase	At shooting	At harvest
Block	2	0.00	0.00	0.00	0.00
Treatment	8	0.00	0.00	0.00	0.00
Error	16	0.00	0.00	0.00	0.00
Total	26				

Appendix XIV. Analysis of variance for effect of split application of NPK on potassium content of index leaf at different stages of growth

Source	Degrees of freedom	Mean squares			
		Early vegetative phase	Late vegetative phase	At shooting	At harvest
Block	2	0.13	0.02	0.50	0.01
Treatment	8	0.28	0.22	0.18**	0.08**
Error	16	0.28	0.17	0.07	0.02
Total	26				

** Significant at 1% level

T_7 T_8 T_9 T_5 T_3 T_6 T_1 T_4 T_2

T_3 T_5 T_9 T_8 T_1 T_4 T_7 T_6 T_2

EFFECT OF SPLIT APPLICATION OF FERTILIZERS IN BANANA *cv.* 'NENDRAN'

By

B. BEENA NATESH

ABSTRACT OF THE THESIS

submitted in partial fulfilment of
the requirement for the degree

Master of Science in Horticulture

Faculty of Agriculture
Kerala Agricultural University

Department of Horticulture
(Pomology & Floriculture and Land scaping)
COLLEGE OF HORTICULTURE
Vellanikkara - Trichur
KERALA - INDIA

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ABSTRACT

The present investigation was carried out in the Department of Pomology & Floriculture and Landscaping, College of Horticulture, Vellanikkara from 1985 to 1986. The object of the study was to find out the effect of split application of fertilizers on flowering, yield and quality of bunches and also to study the nutrient status of plants at different stages of growth for banana var. 'Nendran' under irrigated conditions. The treatments comprised of three different doses of NPK. Those were i) 190 N: 115 P_2O_5: 300 K_2O g/plant/year (as per Kerala Agricultural University Package of Practices) ii) 240 N: 140 P_2O_5: 360 K_2O g/plant/year iii) 300 N: 140 P_2O_5: 450 K_2O g/plant/year. The fertilizers were applied in three different splits. i) as two splits (two months and four months after planting), ii) as three splits (two, four and six months after planting), iii) as four splits (two, four, six and eight months after planting). The experiment was laid out in a randomised block design.

Morphological characters such as height and girth of pseudostem, number of functional leaves, length of

petiole, total leaf area were studied. The results revealed that the morphological characters were not significantly influenced by various treatments. The crop duration and sucker production also remained unaffected by various treatments.

Significant differences were noticed among treatments with respect to bunch weight. Maximum bunch weight of 11.13 kg was recorded in T_4 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in two splits). This treatment was on par with T_6 (same dose in four splits) and T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits).

Among the bunch charecters, length of bunch and number of hands per bunch remained unaffected while weight of hand showed significant difference. Maximum hand weight of 1.96 kg was recorded in T_6 (240 N: 140 P_2O_5: 360 K_2O g/plant/year in four splits).

Among the finger characters, only the weight of finger showed significant variation whereas length and girth of finger remained unaffected. Plants under T_3 recorded the maximum finger weight (196.67 g).

Fruit weight, pulp weight and pulp/peel ratio veried significantly in different treatments whereas pulp

weight remained unaffected. Maximum fruit weight and pulp weight were recorded in plants receiving T_3 (190 N: 115 P_2O_5: 300 K_2O g/plant/year in four splits).

Among the qualitative characters, reducing and non-reducing sugars did not vary significantly. However, a significant increase in total soluble solids, total sugars and sugar/acid ratio was noticed with increase in fertilizer dose. But acidity was in a decreasing rate with higher doses.

Studies on nutrient concentration in the index leaf revealed that nitrogen concentration varied significantly at shooting and at harvest. At shooting, higher concentration of 3.82 per cent was found when a fertilizer dose of 190 N: 115 P_2O_5: 300 K_2O g/plant/year was applied in four splits (T_3) and minimum in T_4 (2.55 per cent). At harvest, the maximum nitrogen percentage of 2.58 per cent was recorded when a fertilizer dose of 300 N: 140 P_2O_5: 450 K_2O g/plant/year was applied in four splits (T_9) and minimum in T_1 (1.82 per cent). Phosphorus concentration showed no significant difference at various stages of growth. Concentration of potassium showed significant variation at shooting and at harvest. At shooting, maximum

concentration of 3.57 per cent was observed when a fertilizer dose of 300 N: 140 P_2O_5: 450 K_2O g/plant/year was applied in two splits (T_7) and minimum of 2.75 per cent in T_2. At harvest, maximum concentration was found in T_3 (2.53 per cent) and minimum in T_2 (2.02 per cent).

When the economics was worked out it was found that profit upto 14.80 per cent over control could be obtained when a fertilizer dose of 240 N: 140 P_2O_5: 360 K_2O g/plant/year was applied in two splits. When the same dose in four splits (T_6) and the recommended dose as per Kerala Agricultural University Package of Practices in four splits (T_3) also gave good results (+11.92 per cent and +9.87 per cent respectively). Profits were minimum when a fertilizer dose of 300 N: 140 P_2O_5: 450 K_2O g/plant/year was given as two splits, three splits and four splits.