RESPONSE OF PAPAYA (*Carica papaya* L.) TO MAJOR MINERAL NUTRIENTS

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Dedicated

to

My Husband

DECLARATION

I hereby declare that this thesis entitled "**Response of papaya (*Carica papaya* L.) to major mineral nutrients**" 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 "**Response of papaya (*Carica papaya* L.) to major mineral nutrients**" is a record of research work done independently by Ms. Bindu, B. (2000-12-04) 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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Bindu

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CONTENTS

LIST OF TABLES

LIST OF TABLES CONTINUED

LIST OF TABLES CONTINUED

LIST OF APPENDICES

LIST OF ABBREVIATIONS

B	Boron
BCR	Benefit Cost Ratio
Ca	Calcium
cc	Cubic Centimetre
CD	Critical Difference
cm	Centimetre
Cu	Copper
et al	And others
Fe	Iron
FIB	Farm Information Bureau
Fig.	Figure
FYM	Farmyard Manure
g	Gram
ha	Hectare
ha^{-1}	Per hectare
i.e.	That is
IAA	Indole Acetic Acid
IU	International Units
K	Potassium
K_2O	Potash
kg	Kilogram
m	Metre
MAP	Months After Planting
mg	Milligram
Mg	Magnesium
mm	Millimetre
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
Na	Sodium
P	Phosphorus
P_2O_5	Phosphate
$plant^{-1}$	Per plant
ppm	Parts per million
RBD	Randomised Block Design
Rs.	Rupees
S	Sulphur
SE	Standard Error
t	tonnes
TSS	Total Soluble Solids
viz.	Namely
Vs	Versus
$year^{-1}$	Per year
Zn	Zinc

INTRODUCTION

1. INTRODUCTION

Papaya (*Carica papaya* L.) is an important fruit of the tropics. It has gained commercial importance over the years because of its varied uses; mainly for table purpose. It is a rich source of vitamin A (2020 IU and moderate source of vitamin C (40 mg 100 g^{-1}). Papaya is considered beneficial for the treatments of piles, dyspepsia, disorders of liver, spleen etc. and also for digestive disorders. Unripe fruit is used as vegetable. Papaya is an ideal fruit for processing due to year round production and availability of fruits at cheaper rates. It is used for the preparation of jam, jelly, nectar, ice cream flavour, tooty-fruity and crystallized fruits. Apart from being highly nutritious, papaya yield latex which is the source for the proteolytic enzyme papain. Papain finds extensive application in meat and leather industries, cosmetics, pharmaceuticals and production of chewing gum.

The major papaya growing states in India are Tamil Nadu, Karnataka, Maharashtra, Bihar and Kerala. Papaya suits well to our climatic conditions. In Kerala, papaya is cultivated in an area of 13,190 ha with an annual production of 59,324 tonnes and with average productivity of 4.49 t ha^{-1} (FIB, 2002). India is the largest producer of papaya in the world, accounting for an area of 70,300 ha and annual production of 16.85 lakh tonnes with average productivity of 23.9 t ha^{-1} (Manavalan and Sooriananthasundaram, 2002). Varietal evaluation trials conducted in the College of Agriculture, Vellayani have shown that CO-2 is suitable for cultivation in the state (Unnithan, 2002). Papaya is usually grown as homestead crop in Kerala. In recent years, isolated attempts have been made by some progressive farmers for commercial cultivation.

The major production constraint encountered in papaya is difficulty in maximizing yield within unit time. Balanced nutrition plays a vital role on plant growth, yield and fruit quality. Papaya is very responsive to the application of inorganic fertilizers along with organic manures. One of the reasons for low production in papaya is inadequate nourishment. Understanding the interrelationships among vegetative growth, yield and nutrient uptake will help to exploit the high yielding potential of papaya plants. As the export of papaya from India is rapidly increasing in the recent past, there is a pressing need to enhance its productivity and improve the fruit quality. However under Kerala conditions, no systematic attempts have been made on the requirement of nutrition of papaya. The present experiment was undertaken to study the response of major plant nutrients *viz.*, nitrogen, phosphorus and potassium on growth, yield and quality of papaya and also to find out the optimum dose of NPK for commercial cultivation under Kerala conditions.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

The dietary and medicinal value of papaya is well accepted. In the processing sector also papaya has got its own importance. Papaya yields the valuable proteolytic enzyme papain, used in leather and pharmaceutical industry. In Kerala papaya is grown as a homestead crop. But in the recent past, isolated attempts have been made by some progressive farmers for commercial cultivation of papaya. Balanced fertilization plays a vital role on plant growth, yield and quality. The current experiment was laid out to standardise the optimum dose of NPK for papaya under Kerala conditions. The review of literature on the effect of major plant nutrients on papaya is presented in relation to the following aspects:

biometric characters

yield characters

quality characters

nutrient uptake and

economics of cultivation.

2.1 BIOMETRIC CHARACTERS

Jauhari and Singh (1970) reported that in papaya variety Coorg Honeydew, maximum height (243.6 cm) was obtained by applying 140 g nitrogen, 70g phosphorus and 140 g potassium plant^{-1} year^{-1}. Hussain (1970) observed better vegetative growth of papaya with NPK application. Awada (1976) noted that nitrogen application increased plant growth in 'Solo' papaya. Application of 250 g N plant^{-1} year^{-1} recorded the maximum plant height and girth. Studies on nutrition of papaya variety Coorg Honeydew, Purohit (1977) revealed that plant height was significantly increased by application of nitrogen and phosphorus. While the highest level of nitrogen (500 g) resulted in significant reduction in plant height, potassium had no such effect. Muller *et al.* (1979) reported that in papaya variety Sunrise Solo, plant growth and development improved by raising proportion of farmyard manure in the soil upto 20 per cent. Higher farmyard manure levels showed no advantage.

According to Cunha and Haag (1980), uptake of nutrients by papaya tree increased with tree growth reaching a maximum at 12 months from planting. Nutrient uptake plant^{-1} in the aerial parts were N 66.7 g, K 62.8 g, Ca 24.8 g, Mg 10.3 g, S 7.3 g, P 6.3 g, Fe 229.8 mg, Mn 149.1 mg, Zn 79.7 mg, B 74.2 mg, Cu 20 mg and Mo 0.15 mg. In papaya variety Ranchi, maximum height of plant (196.5 cm) was recorded by applying 350 g N and 600 g K_2O plant^{-1} (Biswas *et al.*, 1989).

According to Reddy *et al.* (1990), plant height was not affected by different levels of nitrogen in papaya variety Coorg Honeydew. Patil *et al.* (1995) observed in papaya variety Washington that maximum plant height (208 cm) was attained with lower dose of neem cake and urea. In papaya variety Ranchi, Singh *et al.* (1998) reported that maximum plant height (186 cm) was obtained by applying 100 g N, 150 g P_2O_5 and 150 g K_2O plant^{-1}. Trindade *et al.* (2000) observed that papaya plants have higher growth at 20 per cent and 30 per cent of manure in the soil. Use of phosphorus and potassium had no additional effect on plant growth.

Cooper *et al.* (1967) observed increase in basal girth of plants under higher levels of nitrogen and potassium. Jauhari and Singh (1970) noticed that in papaya variety Coorg Honeydew, maximum girth was obtained by applying 140 g nitrogen, 70 g phosphorus and 140 g potassium plant^{-1} year^{-1}. Awada *et al.* (1975) noted that in papaya variety Solo phosphorus fertilization increased the growth rate of the tree-trunk circumference only at the early stage of growth while liming affected growth later than phosphorus. In a study on nutrition of papaya variety Solo, Awada (1977) observed that an increase in nitrogen fertilization increased the stem growth rate at the vegetative stage. Only potassium fertilization increased the stem growth rate at the bearing stage. Phosphorus increased stem growth rate at the vegetative stage only.

Purohit (1977) noted that in papaya variety Coorg Honeydew, trunk diameter was significantly influenced by nitrogen, phosphorus and potassium application. Biswas *et al.* (1989) found that in papaya variety Ranchi, maximum basal girth (38.1 cm) of plants were obtained when 350 g nitrogen and 600 g potassium were applied.

Different levels of nitrogen did not affect the plant girth in 'Coorg Honeydew' (Reddy *et al.*, 1990). According to Singh *et al.* (1998) maximum girth of plant (34.5 cm) in papaya variety Ranchi was obtained by applying N 200g, P_2O_5 450 g and K_2O 105 g plant^{-1} respectively.

According to Biswas *et al.* (1989), the highest dose of nitrogen (350 g plant^{-1}) produced more than 21 leaves plant^{-1} in papaya variety Ranchi over control. Potassium (600 g) increased leaf number by 10. The combined effect of nitrogen and potassium showed the greatest effect on leaf production, where more than 25 leaves plant^{-1} were recorded over control plants.

According to Rao and Rao (1978) nitrogen decreased the number of days to flower in papaya variety CO-1. In a similar experiment, Reddy *et al.* (1990) observed that in papaya variety Coorg Honeydew, nitrogen application induced early flowering. Patil *et al.* (1995) observed in papaya variety Washington that number of days required for emergence of first female flower from transplanting was the lowest (44 days) when 15 g N as urea, 15 g P as single super phosphate and 15 g K as muriate of potash were applied every month. In the same experiment, Patil *et al.* (1995) noted that height of the plant at which first flower appeared was maximum (120 cm) with higher level of NPK and minimum (85 cm) with higher level of FYM in papaya variety Washington. The number of days required for fruit maturity from fruit set was the lowest (160 days) by applying 15 g K as muriate of potash, 15 g N as urea and 15 g P as single super phosphate applied every month.

2.2 YIELD CHARACTERS

According to Awada and Suehisa (1970) papaya fruits removed nutrients in the descending order of K, N, Ca, Mg and P. Ratios of N, P and K removed were 1 : 0.14 : 1.48. Purohit (1977) reported that in papaya variety Coorg Honeydew application of 250 g N, 110 g P and 415 g K plant^{-1} year^{-1} resulted in the highest number of 66.6 fruits plant^{-1}.

Phosphorus fertilization increased the number of harvested fruits and yield of culls but did not affect yield of marketable fruits in papaya variety Solo (Awada and Long, 1978).

In another experiment, Awada and Long (1980) noted in papaya variety Solo that in nitrogen or potassium fertilization increased the total number and total weight of marketable fruits. Sulladmath *et al.* (1984) observed that application of 250 g phosphorus resulted in the highest number of fruits plant^{-1} in papaya variety Solo under Bangalore conditions. However in papaya variety Coorg Honeydew, Reddy *et al.* (1986) noticed that nitrogen had no effect on yield owing to more available nitrogen in soil.

Biswas *et al.* (1989) noted that in papaya variety Ranchi, treatment with nitrogen increased the fruit number from 31.1 fruits plant^{-1} under control to 42.3 fruits plant^{-1} under the highest level of nitrogen (350 g plant^{-1}). The highest number of 46 fruits were obtained when both 350 g nitrogen and 600 g potassium were applied together. Patil *et al.* (1995) observed in papaya variety Washington that maximum number of fruits plant^{-1} (98.0) was obtained by the application of 30 g nitrogen as urea, 30 g phosphorus as single super phosphate and 30 g potassium as muriate of potash month^{-1}.

Singh *et al.* (1998) reported in papaya variety Ranchi that maximum number of fruits (23.5) were obtained by applying N 200 g, P_2O_5 300 g and K_2O 500 g plant^{-1}. Auxcilia and Sathiamoorthy (1999b) observed in papaya variety CO-2 that application of 300 g nitrogen, 25 mg paclobutrazol and 0.4 per cent amino acids gave the highest fruit number (115.6 fruits tree^{-1}). Viegas *et al.* (1999) noted that application of 343 g nitrogen plant^{-1} resulted in the highest number of fruits (23) in Sunrise Solo at 360 days after transplanting.

In the studies on nutrition of papaya variety Coorg Honeydew, Purohit (1977) noticed that application of 250 g N, 110 g P and 415 g K plant^{-1} year^{-1} resulted in increased fruit weight (1.62 kg). Awada and Long (1980) reported in papaya variety Solo that nitrogen or potassium fertilization increased the weight of each marketable fruit. According to Lopez and Jurado (1983), in papaya variety P.R. 7-65, high doses of nitrogen (340 kg ha^{-1}) increased fruit weight.

Biswas *et al.* (1989) noted that in papaya variety Ranchi, maximum individual fruit weight (1125.5 g) was obtained when 350 g N and 600 g K_2O were applied plant^{-1}. Viegas *et al.* (1999) observed in papaya variety Sunrise Solo that application of 343 g nitrogen plant^{-1} resulted in the highest fruit weight of 578 g at 270 days after transplanting.

According to Awada and Long (1978) nitrogen fertilization decreased the size of fruits. On the contrary, Biswas *et al.* (1989) observed in papaya variety Ranchi that nitrogen had a great effect on increasing the size of fruits and it was more pronounced in the presence of potassium. The biggest sized fruits (15.8 cm x 12.2 cm) were obtained in plants receiving 350 g N and 600 g K plant^{-1}.

In papaya variety Coorg Honeydew Reddy *et al.* (1990) observed that average fruit size and fruit weight were not affected by different levels of nitrogen. Singh *et al.* (1998) observed in papaya variety Ranchi, that highest fruit size (57 cm length and 47.7 cm girth) was obtained by applying 200 g N, 300 g P_2O_5 and 100 g K_2O $plant^{-1}$.

In papaya variety Washington, Patil *et al.* (1995) noted that high pulp percentage (70 per cent) was obtained by applying 30 g N as neem cake. Singh *et al.* (1998) reported that maximum flesh percentage (82.5 per cent) in papaya variety Ranchi was obtained by applying 200 g N, 300 g P_2O5 and 150 g K_2O $plant^{-1}$.

In papaya variety Coorg Honeydew, Jauhari and Singh (1970) reported that nitrogen as well as potassium were effective in increasing the yield. Maximum yield (49.2 kg $plant^{-1}$) was obtained by applying 140 g N, 70 g P and 140 g K $plant^{-1}$ $year^{-1}$. Awada and Long (1971b) recorded an increase in yield of fruits in papaya variety Solo by increasing the levels of nitrogen from 57 to 113 g $plant^{-1}$. Gillard (1972) obtained the highest yield in 'Solo' papaya by treatment with 250 g each of nitrogen and potassium. According to Purohit (1977) in papaya variety Coorg Honeydew, a fertilizer dose of 250 g N, 110 g P and 415 g K $plant^{-1}$ $year^{-1}$ was the best and gave an estimated yield of 186.8 t ha^{-1} in 28 months. Rao and Rao (1978) noted that both nitrogen and phosphorus influenced yield in papaya variety CO-1.

Das *et al.* (1981) observed that nitrogen, phosphorus and potassium at the rate of 200 : 300 : 200 g $plant^{-1}$ gave high yield compared to other doses tried. Sulladmath *et al.* (1984) reported that application of 250 g phosphorus resulted in the highest yield in papaya variety Solo. Yield reduction occurred by applying potassium at rates beyond 200 g $plant^{-1}$. According to Luna and Caldas (1984) nitrogen and phosphorus increased yield in papaya. However, decrease in yield was noted with high doses of potassium (120 kg ha^{-1} and above). Biswas *et al.* (1989) reported in papaya variety Ranchi that fruit yield increased significantly by applying 350 g N and 600 K $plant^{-1}$. In papaya variety Coorg Honeydew, Reddy and Kohli (1989) noted that in the plants receiving no nitrogen, the majority of biomass accumulated in vegetative parts such as stem, leaves and roots, whereas application of nitrogen resulted in diversion of biomass towards fruits, indicating a high yield potential.

In the studies on nutrition of papaya variety Coorg Honeydew, Reddy *et al.* (1989) observed that 250 g N, 375 g P_2O_5 and 500 g K_2O plant^{-1} year^{-1} was the best fertilizer dose, which recorded an estimated fruit yield of 155.5 t ha^{-1} in a period of 12 months cropping period. Reddy *et al.* (1990) reported that in papaya variety Coorg Honeydew, nitrogen application increased fruit yield significantly. A maximum fruit yield of 18.35 kg plant^{-1} and 56.44 t ha^{-1} was obtained with 250 g nitrogen plant^{-1} year^{-1}.

Lokhande and Moghe (1991) noted in papaya variety Honeydew that soil application of 200 g N and 100 g P_2O_5 plant^{-1} in four equal splits followed by foliar spray of 1.0 per cent urea, 0.2 per cent boron and 50 ppm IAA to ring spot virus infected plants resulted in yield increase of 32.84 kg plant^{-1}. From the studies on nutrition of papaya variety Washington, Patil *et al.* (1995) inferred that higher yields (88.6 kg plant^{-1}) were obtained with the application of higher level of NPK plant^{-1} month^{-1}. Veeraraghavathatham *et al.* (1996) reported that NPK dose of 50 : 50 : 50 g plant^{-1} is recommended at each application for papaya at two months interval. This treatment increased growth as well as yield.

Singh *et al.* (1998) recorded maximum yield (26.5 kg plant^{-1}) in papaya variety Ranchi by applying 200 g N, 300 g P_2O_5 and 100 g K_2O plant^{-1}. In papaya variety CO-2, Auxcilia and Sathiamoorthy (1999b) reported that application of 300 g nitrogen, 25 mg Paclobutrazol and 0.4 per cent amino acids gave the highest fruit weight (273.63 kg tree^{-1}).

In a study on the nutrition of papaya variety Pusa Delicious, Ray *et al.* (1999) reported that best performance, with a marked reduction in papaya ring spot viral infection was observed with transplanting in October and with a heavy manurial dose consisting of 10 kg FYM, 2 kg castor cake, 1 kg cake-O-meal and 200 g each of nitrogen, phosphorus and potassium $plant^{-1}$ $year^{-1}$.

In papaya variety U.N. Cotove, the highest yield of 66 kg $plant^{-1}$ was obtained by applying 366 kg nitrogen ha^{-1} for a planting density of 1665 plants ha^{-1} (Vallejo, 1999).

There was a significantly linear response to applied nitrogen for all five phenological stages in papaya variety Solo (Allan *et al.*, 2000). Applied phosphorus showed a linear response for the first two stages and then quadratic responses. Applied potassium gave significant quadratic responses for the first three stages and then linear responses.

According to Kumar *et al.* (2000) papaya variety 9-1-D with tomato intercropping and with 25 per cent increased fertilizer level (i.e., 62.5 g each of N, P and K $plant^{-1}$ in the widest spacing of 2.1 m) recorded the highest yield of papaya (170.36 and 99.77 kg of fruit $tree^{-1}$).

Irulappan *et al.* (1984) reported that in papaya variety CO-2 application of 250 g N $plant^{-1}$ $year^{-1}$ in six split doses at bimonthly interval commencing from second month after planting was found to be optimum for good fruit and papain yield.

Auxcilia and Sathiamoorthy (1999a) observed that in papaya variety CO-2, application of 400 g N, 25 mg paclobutrazol resulted in the highest latex yield in both warm and cool seasons (17.2 and 19.3 g $fruit^{-1}$).

2.3 QUALITY CHARACTERS

Based on the studies on nutrition of papaya variety Coorg Honeydew, Jauhari and Singh (1970) reported that application of nitrogen decreased the total soluble solids (TSS) of fruits significantly, while potassium increased TSS appreciably. Purohit (1977) observed that application of potassium increased TSS of fruit and the interaction of nitrogen and potassium was significant in papaya variety Coorg Honeydew. When potassium was adequate, the TSS was not lowered by high nitrogen fertilization. Sulladmath *et al.* (1981) observed that in papaya variety Solo, application of higher levels of phosphorus and potassium significantly increased the TSS content in the fruits.

According to Biswas *et al.* (1989) TSS content of fruit was high (98.3 per cent) when 350 g N and 600 g K were applied plant^{-1} in papaya variety Ranchi. Reddy and Kohli (1989) and Reddy *et al.* (1990) observed that in papaya variety Coorg Honeydew, TSS was not affected by different levels of nitrogen. According to Lokhande and Moghe (1990) in papaya variety Honeydew, soil application of 200 g N and 100 g P_2O_5 plant^{-1} in four equal splits followed by foliar spray of 1.0 per cent urea, 0.2 per cent boron and 50 ppm IAA to ring spot virus infected plants resulted in increasing fruit quality.

Experiments conducted by Biswas *et al.* (1989) showed that in papaya variety Ranchi plants under control produced fruits with high percentage of acidity, while it declined with higher level of nitrogen and potassium.

The highest ascorbic acid content in the fruits of papaya variety Ranchi was obtained by applying 200 g N, 300 g P_2O_5 and 150 g K_2O plant^{-1} (Singh *et al.*, 1998).

In papaya variety Coorg Honeydew, nitrogen application alone significantly decreased the total sugar in fruits, while potassium increased it. Phosphorus had no visible influence on sugar percentage of fruits (Jauhari and Singh, 1970). Singh *et al.* (1998) reported in papaya variety Ranchi that maximum sugar content (9.05 per cent) in the fruit pulp was obtained by applying 200 g N, 300 g P_2O_5 and 150 g K_2O plant^{-1}.

Patil *et al.* (1995) noted that in papaya variety Washington application of lower levels of nitrogen (15 g N plant^{-1} month^{-1}) as groundnut cake helped to produce fruits with good colour on ripening.

Awada *et al.* (1979) recorded that in papaya variety Solo, flesh firmness was found to decrease with nitrogen application.

Patil *et al.* (1995) reported that in papaya variety Washington application of lower levels of nitrogen (15 g N plant^{-1} month^{-1}) in the form of groundnut cake helped in the improvement of taste of fruits.

2.4 NUTRIENT UPTAKE

According to Awada and Suehisa (1970) in papaya variety Solo, the nutrients removed from the soil by one tonne of fruits in descending order were K, N, Ca, Mg and P under Hawaii conditions. The ratio of N, P and K removed was 1 : 0.14 : 1.48.

Veerannah and Selvaraj (1984) reported that the nutrients removed by whole papaya plant at harvest were 305, 103, 524, 327 and 183 kg N, P, K, Ca and Mg ha^{-1} respectively.

In papaya variety Solo, Awada and Long (1971a) reported that recently matured petiole can be sampled as the index tissue for potassium. The critical concentration of potassium in this tissue was 3.61 per cent on dry weight basis. At the adequate level of potassium, fruit weight and TSS content were greater than at the deficiency level. In another report, Awada and Long (1971b) stated that concentrations of petiole nitrogen and fruit yield increased with nitrogen applications. Petiole nitrogen level (1.45 per cent) which gave maximum yield was used as a basis for applying nitrogen fertilizers to fruiting papaya trees. Further studies on nutrition of papaya variety Solo by Awada *et al.* (1975) revealed that liming lowered petiole concentrations of Mn, K and Mg and raised those of Ca and P. Phosphorus fertilization raised the petiole concentrations of P, N, Mn and Zn, but lowered those of K and Cu.

Awada (1977) noted that in papaya variety Solo, nitrogen fertilization increased the petiole weight at vegetative and bearing stages. Potassium fertilization did not affect petiole weight. Phosphorus fertilization increased petiole weight at vegetative stage only. Nitrogen fertilization resulted in increased petiole concentration of N and in decreased petiole concentration of moisture, K, P and Ca. Phosphorus fertilization resulted in increased petiole concentrations of P, moisture, Ca and Mg, while potassium fertilization resulted in increased petiole concentrations of K and moisture and in decreased concentrations of N, Ca and Mg. Awada and Long (1978) reported that in papaya variety Solo, nitrogen fertilization increased petiole concentrations of N, Mg, S, Fe, Mn, Zn and Cu and decreased those of Ca, S and Cu. In another study, Awada and Long (1980) found that maximum yield of marketable fruits in papaya variety Solo was associated with petiole concentrations of 1.44 per cent nitrogen and 2.52 per cent potassium. According to Lopez and Jurado (1984) in papaya variety P.R. 7-65, petiole and fruit content of calcium increased with increase in nitrogen and boron application. Except at the highest level of nitrogen applied, petiole nitrogen content decreased as boron application increased.

In papaya variety Waimanalo, Awada and Suehisa (1985) reported that increasing sodium decreased N concentration and dry weight. Potassium increased K and Ca concentrations, but decreased Na, Mg, N and P concentration and dry weight. Increase in Mg lead to increased petiole concentration of P. Reddy *et al.* (1989) observed that in papaya variety Coorg Honeydew application of nitrogen, phosphorus and potassium increased the concentration of respective elements in petioles. Different levels of nitrogen had more substantial effect than phosphorus and potassium on petiole concentration of N, P and K. In further investigations, Reddy *et al.* (1990) observed that application of nitrogen increased the petiole nutrient composition of N and reduced the concentration of P, K and Ca in Coorg Honeydew.

According to Sanyal *et al.* (1990) in papaya varieties Washington and Pusa Delicious, concentrations of all the minerals were high in leaf blade except potassium, which was higher in petiole. The leaf blade tissues for P, Ca and Mg and petiole for K at flowering may be used as index tissue to determine the nutritional status of the cultivars.

2.5 ECONOMICS OF CULTIVATION

Auxcilia and Sathiamoorthy (1999b) reported in papaya variety CO-2 that application of 300 g N, 25 mg paclobutrazol and 0.4 per cent amino acids gave the highest cost : benefit ratio (1 : 3.03).

MATERIALS AND METHODS

3. MATERIALS AND METHODS

The present investigation on "Response of papaya (*Carica papaya* L.) to major mineral nutrients" was conducted at the Department of Pomology and Floriculture, College of Agriculture, Vellayani, Thiruvananthapuram during 2000-2002. The experiment was carried out to study the response of the macronutrients *viz.*, nitrogen, phosphorus and potassium on growth, yield and quality of papaya and also to standardise the optimum dose of NPK for papaya under Kerala conditions.

The experimental site is located at 8° 5′ North latitude and 77° 1′ East longitude at an altitude of 29 meters above mean sea level. Predominant soil type is red loam belonging to Vellayani series. The soil is sandy clay loam in texture and acidic in soil reaction with a pH of 4.8.

The initial data on mechanical and chemical properties of the soil and the methods adopted for the analysis are presented in Table 1. The weather data prevailed during the cropping period is presented in Appendix III.

Papaya variety CO-2 was used for the experimental purpose. Urea (46 per cent N), Rock phosphate (28.4 per cent P) and Muriate of potash (60 per cent K) were used as sources of N, P and K respectively.

The following levels of N, P and K were applied to papaya plants in six equal splits at two months interval. Fertilizer application started thirty days after transplantation of seedlings to the main field.

(i) Levels of nitrogen

n_0 - 200 (g $plant^{-1}$ $year^{-1}$)

n_1 - 250 "

n_2 - 300 "

Table 1 Soil characteristics of experimental site

Particulars	Unit	Mean value	Method
A. Mechanical composition			
Coarse sand	Per cent	36.35	Piper (1966)
Fine sand	"	15.0	
Silt	"	17.8	
Clay	"	30.0	
B. Chemical properties			
Available N	kg ha^{-1}	215.4	Subbiah and Asija (1956)
Available P_2O_5	kg ha^{-1}	35.7	Bray and Kurtz (1945)
Available K_2O	kg ha^{-1}	114.1	Hanway and Heidal (1952)
pH		4.8	Jackson (1973)

(ii) Levels of phosphorus

p_0 - 200 (g plant^{-1} year^{-1})

p_1 - 250 "

p_2 - 300 "

(iii) Levels of potassium

k_0 - 300 (g plant^{-1} year^{-1})

k_1 - 400 "

k_2 - 500 "

(iv) Control – Zero levels of N, P and K

Treatment combinations

$T_1 - n_0p_0k_0$	$T_{11} - n_1p_0k_1$	$T_{21} - n_2p_0k_2$
$T_2 - n_0p_0k_1$	$T_{12} - n_1p_0k_2$	$T_{22} - n_2p_1k_0$
$T_3 - n_0p_0k_2$	$T_{13} - n_1p_1k_0$	$T_{23} - n_2p_1k_1$
$T_4 - n_0p_1k_0$	$T_{14} - n_1p_1k_1$	$T_{24} - n_2p_1k_2$
$T_5 - n_0p_1k_1$	$T_{15} - n_1p_1k_2$	$T_{25} - n_2p_2k_0$
$T_6 - n_0p_1k_2$	$T_{16} - n_1p_2k_0$	$T_{26} - n_2p_2k_1$
$T_7 - n_0p_2k_0$	$T_{17} - n_1p_2k_1$	$T_{27} - n_2p_2k_2$
$T_8 - n_0p_2k_1$	$T_{18} - n_1p_2k_2$	T_{28} – Control
$T_9 - n_0p_2k_2$	$T_{19} - n_2p_0k_0$	
$T_{10} - n_1p_0k_0$	$T_{20} - n_2p_0k_1$	

The experiment was conducted in 3^3 confounded factorial RBD; confounding NPK in replication-1 and NP^2K^2 in replication-2 (Fig. 1).

Number of treatments : $27 + 1 = 28$

Number of replications : 2

Number of blocks per replication : 3

Number of plots per block : $9 + 1 = 10$

Total number of plots : 60

Number of observational plants per plot : 4

Plot size : 40 m^2 per block

N

Block-1	T_6	T_{16}	T_{22}	T_{20}	T_{12}	T_{14}	T_8	T_{28}	T_{27}	T_1	Replication-1
Block-2	T_{10}	T_{23}	T_4	T_{28}	T_{17}	T_{25}	T_2	T_{15}	T_{21}	T_9	
Block-3	T_3	T_{26}	T_{11}	T_7	T_{13}	T_{28}	T_{24}	T_{19}	T_{18}	T_5	
Block-1	T_{21}	T_{11}	T_{13}	T_6	T_8	T_1	T_{28}	T_{23}	T_{25}	T_{18}	Replication-2
Block-2	T_{17}	T_5	T_{15}	T_{27}	T_7	T_{28}	T_{22}	T_3	T_{10}	T_{20}	
Block-3	T_9	T_{28}	T_{16}	T_4	T_{12}	T_{14}	T_2	T_{19}	T_{26}	T_{24}	

4m × 4m

Fig. 1 Layout of the experiment

3.1 BIOMETRIC CHARACTERS

3.1.1 Height of Plants

Height of plants were measured from soil level to the tip of growing point of all the observational plants at two months interval and expressed in centimeters and average were worked out.

3.1.2 Girth of Plants

Girth of plants were recorded at 10 centimeters above ground level in each plant and expressed in centimeters.

3.1.3 Number of Leaves

The number of fully developed leaves were recorded from all observational plants and average worked out.

3.1.4 Time of First Flowering

The number of days from sowing till the opening of first female flower was recorded and average was worked out.

3.1.5 Height at Which First Flower Appears

The height at which the first flower appears was recorded in centimeters from the ground level and average was worked out.

3.1.6 Time for Harvest

Time taken for harvest was recorded as the number of days taken from sowing to the harvest of first formed fruit in each plant.

3.1.7 Number of Flowers Cluster^{-1}

Four plants in each treatment were marked in every replication. The total number of flowers in each cluster was recorded and the average values were worked out.

3.2 YIELD CHARACTERS

3.2.1 Number of Fruits Plant^{-1}

The total number of fruits was counted from each plant and the average worked out.

3.2.2 Fruit Weight

Four fruits were taken from each observational plant and the average fruit weight was worked out and expressed in gram.

3.2.3 Fruit Length and Girth

Length of the fruit was measured from the stalk end to the floral end of the selected fruits separately and mean length was recorded in centimeters. Girth at the middle of the fruit was measured and the average was recorded in centimeters.

3.2.4 Fruit Volume

A container filled with water was taken and placed inside another container. The fruits selected were taken individually and immersed. The volume of water displaced by the fruit was measured with the help of measuring cylinder and the value was expressed in cubic centimeters.

3.2.5 Pulp Percentage

Weight of the fruit was recorded before and after peeling and removing seeds.

$$\text{Pulp percentage} = \frac{\text{Weight of pulp (g)} \times 100}{\text{Weight of fruit (g)}}$$

3.2.6 Total Yield Plant^{-1}

Weight of total number of fruits obtained from each plant was recorded and expressed in kilogram plant^{-1}.

3.2.7 Papain Yield

Amount of papain obtained from each observational plant were taken and average worked out. Papain yield was expressed as kg ha^{-1} on dry weight basis.

3.3 QUALITY CHARACTERS

3.3.1 Total Soluble Solids (TSS)

Total soluble solids of the pulp was measured using Erma hand refractometer (pocket type) and expressed in percentage.

3.3.2 Acidity

Titrable acidity of the fruit was estimated following the method proposed by Ranganna (1977) and expressed as per cent anhydrous citric acid.

3.3.3 Total Carotenoids

The estimation of total carotenoids was done as per the method described by Jensen (1978) and expressed in percentage.

3.3.4 Ascorbic Acid Content

Estimation of ascorbic acid was done as per the method described by Sadasivam and Manikam (1992) and expressed as mg per 100 gram of pulp.

3.3.5 Total Sugars

The total sugars on fresh weight basis was estimated as per the method described by Ranganna (1977) and expressed in percentage.

3.3.6 Reducing Sugars

The estimation of reducing sugars was done as per the method described by Ranganna (1977) and expressed in percentage on fresh weight basis.

3.3.7 Non-reducing Sugars

The non reducing sugar content was obtained by deducting the value for reducing sugars from the value of total sugars (Ranganna, 1977).

3.3.8 Colour of Peel and Pulp

Colour of peel was observed after the whole fruit surface changed to characteristic colour from green on ripening. Ripe fruits were cut open and the pulp colour was recorded.

3.3.9 Firmness of Pulp

Firmness of fully ripe fruit was assessed with the help of a panel of judges for organoleptic evaluation. Fully ripe fruits were utilised for the evaluation.

3.3.10 Organoleptic Qualities

The panel members for sensory analysis at the laboratory level were selected from a group of teachers and students. Ten judges were selected through triangle test as suggested by Mahony (1985). The score chart is furnished in Appendix II.

The sensory analysis of panel members were done using the scoring method and scoring was done as suggested by Swaminathan (1974). The major quality attributes included in the score were appearance, colour, texture, flavour and taste (Appendix I). Scores for overall acceptability was obtained by determining the average mean scores for each character.

3.3.11 *Shelf life of Fruits*

Days for which papaya fruit remains without decaying and retaining edible qualities at normal atmospheric conditions was recorded and average was worked out.

3.4 NUTRIENT UPTAKE

3.4.1 Soil Analysis

Soil samples were taken from the experimental area before and after the experiment. The composite sample from the experimental area before the experiment was analysed for physical and chemical properties as given in Table 1. After the experiment composite samples were collected from each plot, air dried, powdered and passed through a 2mm sieve and analysed for available N, P and K using the methods given in Table 1.

3.4.2 Nutrient Content of the Petioles

Nitrogen content in leaf petiole was estimated by modified micro-kjeldahl method (Jackson, 1973). Phosphorus content in leaf petiole was estimated colorimetrically (Jackson, 1973) and K content by flame photometric method (Piper, 1966). The tissue samples were collected from the recently matured petiole (Reddy *et al.*, 1989).

3.5 ECONOMICS OF CULTIVATION

The economics of cultivation of the crops was worked out and net income and benefit-cost ratio (BCR) were calculated as follows :

Net income (Rs. ha^{-1}) = Gross income – Cost of cultivation

$$\text{BCR} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.6 STATISTICAL ANALYSIS

The data collected on different characters were analysed by applying the technique of analysis of variance for the design 3^3 confounded factorial RBD following Panse and Sukhatme (1985). Response curves for the characters like number of fruits $plant^{-1}$, fruit weight and total yield $plant^{-1}$ was formulated as in Das and Giri (1991) and the physical optimum dose of nitrogen, phosphorus and potassium were worked out.

RESULTS

4. RESULTS

The present experiment was conducted at the Department of Pomology and Floriculture, College of Agriculture, Vellayani during 2000-2002 with an objective of studying the response of major plant nutrients *viz.*, nitrogen, phosphorus and potassium on growth, yield and quality of papaya and also to standardise the optimum dose of N, P and K for papaya under Kerala conditions. The results of the studies are presented below.

4.1 BIOMETRIC CHARACTERS

4.1.1 Height of Plants

Plant height as influenced by different levels of N, P and K as well as their interactions at different stages of growth are presented in Table 2, 3, 4 and Fig. 2.

The main effect of nitrogen was found to have significant influence on plant height at all stages of growth. At two months after planting (MAP), the highest value for plant height (49.34 cm) was recorded by n_1 which differed significantly from n_2 (45.75 cm) and n_0 (45.40 cm). The lowest value was obtained in n_0, which was statistically on par with n_2. At 4 MAP, highest value of 90.50 cm was observed with n_1 which had significant difference over n_2 (80.42 cm) and n_0 (79.16 cm). The lowest value recorded in n_0, was on par with n_2. At 6 MAP, the highest value (154.21 cm) was noticed with n_1 which differed significantly form n_2 (136.63 cm) and n_0 (127.78 cm). Lowest value was registered by n_0 which differed significantly from n_2 and n_1. At 8 MAP, n_1 recorded the highest value of 192.63 cm which differed significantly from n_2 (176.47 cm) and n_0 (175.75 cm); the latter two being statistically on par. Lowest value (175.75 cm) was noticed with n_0. At 10 MAP, n_2 recorded the highest value (226.3 cm) which differed significantly from n_1 and n_0. But n_1 (221.15 cm)

Table 2 Effect of different levels of N, P and K on plant height of papaya, cm

Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
N levels						
n_0	45.40	79.16	127.78	175.75	219.74	245.72
n_1	49.34	90.50	154.21	192.63	221.15	250.45
n_2	45.75	80.42	136.63	176.47	226.30	257.21
SE	0.82	0.83	1.06	0.68	1.29	1.17
CD (0.05)	2.41	2.13	3.13	2.01	3.80	3.45
P levels						
p_0	44.22	76.93	129.22	175.89	214.67	249.55
p_1	49.63	88.04	140.57	183.92	227.44	250.78
p_2	46.64	85.11	148.84	185.03	225.12	253.04
SE	0.82	0.83	1.06	0.68	1.29	1.17
CD (0.05)	2.41	2.13	3.13	2.01	3.80	NS
K levels						
k_0	46.24	82.17	135.68	175.25	216.08	252.63
k_1	45.77	76.68	120.40	165.74	211.59	239.86
k_2	48.48	91.23	162.55	203.85	239.55	260.88
SE	0.82	0.83	1.06	0.68	1.29	1.17
CD (0.05)	NS	2.13	3.13	2.01	3.80	3.45

MAP – Months after planting
NS – Non significant

Table 3 Interaction effect of different levels of N, P and K on plant height of papaya, cm

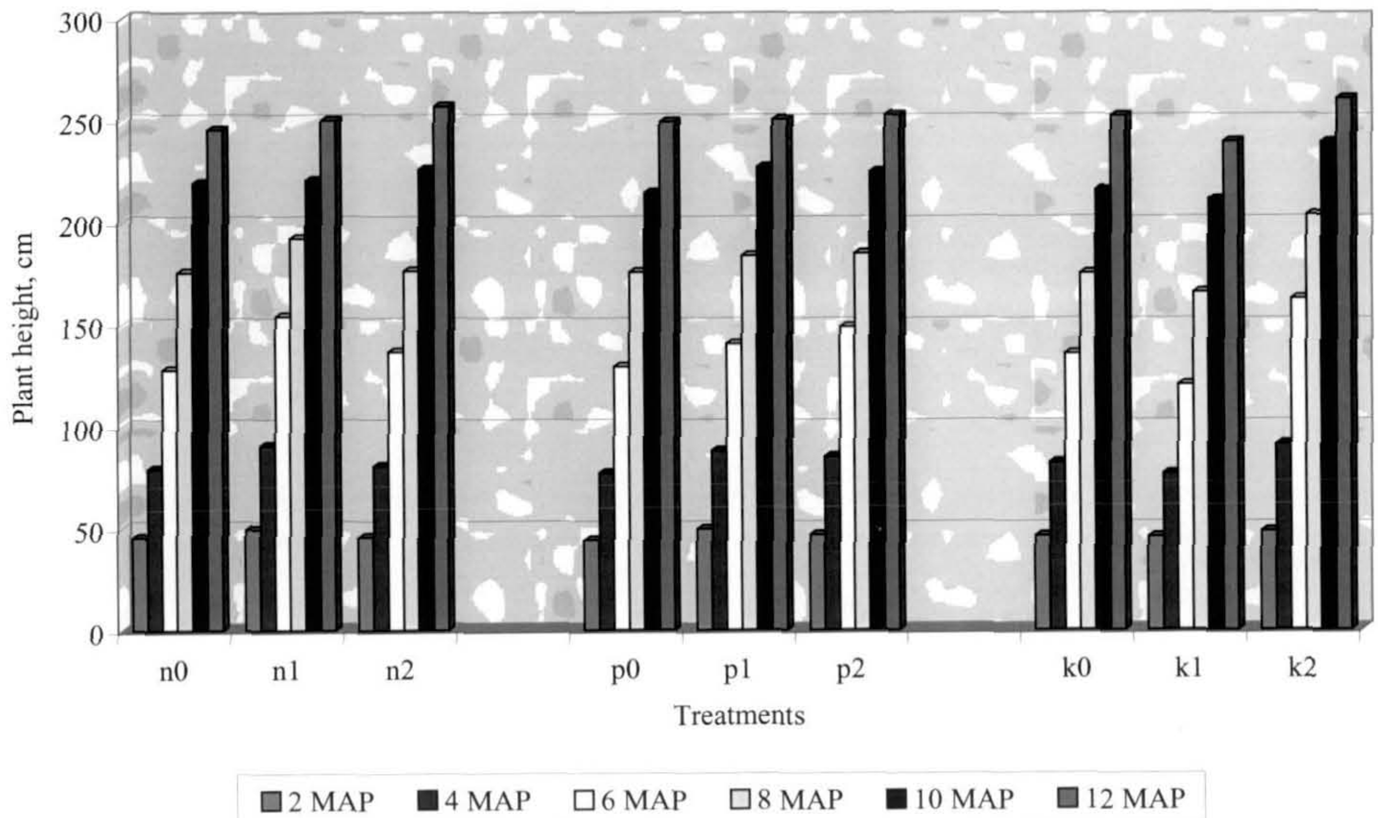
Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
n_0p_0	44.20	73.93	110.70	167.04	222.81	249.16
$n_0 p_1$	47.86	77.70	120.10	170.53	207.51	233.76
n_0p_2	44.13	85.85	152.55	189.67	228.91	254.23
$n_1 p_0$	45.85	81.83	151.83	190.09	215.70	249.00
$n_1 p_1$	54.29	101.86	157.10	205.38	237.16	260.55
$n_1 p_2$	47.89	87.80	153.71	182.41	210.60	241.80
$n_2 p_0$	42.61	75.03	125.13	170.55	205.50	250.50
$n_2 p_1$	46.75	84.56	144.51	175.86	237.65	258.05
$n_2 p_2$	47.89	81.67	140.26	183.00	235.85	261.30
SE	1.42	1.26	1.84	1.19	2.20	2.04
CD (0.05)	NS	3.69	5.42	3.49	6.59	5.98
n_0k_0	37:80	63.85	109.55	159.01	203.36	231.83
$n_0 k_1$	45.58	64.20	99.03	143.20	197.44	230.11
n_0k_2	52.82	109.43	174.76	225.03	258.43	275.21
$n_1 k_0$	54.25	90.90	152.85	186.08	215.25	259.01
$n_1 k_1$	49.45	90.55	142.03	192.82	221.71	241.83
$n_1 k_2$	44.32	90.04	167.76	198.98	226.50	250.50
$n_2 k_0$	46.66	91.75	144.65	180.67	229.65	267.06
$n_2 k_1$	42.28	75.28	120.15	161.20	215.63	247.63
$n_2 k_2$	48.30	74.23	145.11	187.54	233.71	256.95
SE	1.42	1.26	1.26	1.19	2.20	2.04
CD (0.05)	4.18	3.69	3.69	3.49	6.59	5.98
p_0k_0	45.02	76.06	119.10	153.80	204.63	250.01
$p_0 k_1$	42.95	68.46	107.30	167.56	199.06	235.85
p_0k_2	44.68	86.27	161.26	206.32	240.31	262.80
$p_1 k_0$	48.58	87.60	144.81	178.03	225.68	258.38
$p_1 k_1$	45.65	75.30	119.53	150.17	201.98	224.40
$p_1 k_2$	54.66	101.23	157.36	223.57	254.66	269.56
$p_2 k_0$	45.11	82.85	143.13	193.93	217.95	249.51
$p_2 k_1$	48.70	86.25	134.38	179.49	233.75	259.31
$p_2 k_2$	46.10	86.21	169.01	181.66	223.66	250.30
SE	1.42	1.26	1.84	1.19	2.20	2.04
CD (0.05)	4.18	3.69	5.42	3.49	6.59	5.98

MAP – Months after planting
NS – *Non significant*

Table 4 Highest order interaction of NPK on plant height of papaya, cm

No.	Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	$n_0p_0k_0$	35.75	53.55	82.15	130.30	204.00	236.85
T_2	$n_0p_0k_1$	44.00	63.90	86.00	169.53	215.84	242.80
T_3	$n_0p_0k_2$	52.85	104.35	163.95	201.30	248.60	267.85
T_4	$n_0p_1k_0$	40.15	73.20	93.15	159.73	195.15	227.10
T_5	$n_0p_1k_1$	47.10	54.50	105.60	124.54	178.25	207.45
T_6	$n_0p_1k_2$	56.35	105.40	161.55	227.31	249.15	266.75
T_7	$n_0p_2k_0$	37.50	64.80	153.35	186.99	210.95	231.55
T_8	$n_0p_2k_1$	45.65	74.20	105.50	135.53	198.25	240.10
T_9	$n_0p_2k_2$	49.26	118.55	198.80	246.48	277.55	291.05
T_{10}	$n_1p_0k_0$	52.97	91.18	145.25	186.75	213.75	262.60
T_{11}	$n_1p_0k_1$	48.32	68.15	129.75	166.02	186.60	210.55
T_{12}	$n_1p_0k_2$	36.25	86.16	180.50	217.50	246.75	273.85
T_{13}	$n_1p_1k_0$	63.75	103.60	190.95	194.47	233.10	265.65
T_{14}	$n_1p_1k_1$	44.77	94.64	132.75	182.76	214.90	235.45
T_{15}	$n_1p_1k_2$	54.35	107.35	147.60	238.91	263.50	280.55
T_{16}	$n_1p_2k_0$	46.05	77.95	122.35	177.03	198.90	248.80
T_{17}	$n_1p_2k_1$	55.25	108.87	163.60	229.68	263.65	279.50
T_{18}	$n_1p_2k_2$	42.37	76.60	175.20	140.53	169.25	197.10
T_{19}	$n_2p_0k_0$	46.35	83.45	129.90	144.36	196.15	250.60
T_{20}	$n_2p_0k_1$	36.55	73.35	106.15	167.12	194.75	254.20
T_{21}	$n_2p_0k_2$	44.95	68.30	139.35	200.17	225.60	246.70
T_{22}	$n_2p_1k_0$	41.85	86.00	150.35	179.91	248.80	282.40
T_{23}	$n_2p_1k_1$	45.10	76.80	120.25	143.21	212.80	230.35
T_{24}	$n_2p_1k_2$	53.30	90.89	162.95	204.48	251.35	261.40
T_{25}	$n_2p_2k_0$	51.80	105.82	153.70	217.76	244.00	268.20
T_{26}	$n_2p_2k_1$	45.20	75.70	134.05	173.27	239.35	258.35
T_{27}	$n_2p_2k_2$	46.67	63.50	133.05	157.97	224.20	262.75
	SE	2.46	2.18	3.20	2.06	3.89	3.53
	CD (0.05)	5.12	4.52	6.64	4.27	8.07	7.32
T_{28}	Control	33.50	45.46	69.75	110.56	139.08	163.15
	Treatments Vs control	S	S	S	S	S	S

S – Significant
MAP – Months after planting



MAP - Months after planting

Fig. 2 Effect of different levels of nitrogen, phosphorus and potassium on plant height was statistically on par with n_0 (219.74 cm), which recorded the lowest value. During 12 MAP, n_2 (257.21 cm) recorded the highest value, which had significant difference over n_1 (250.45 cm) and n_0 (245.72 cm). Lowest value was noticed with n_0 (245.72 cm) which differed significantly from n_1 and n_2.

Different levels of phosphorus was found to have significant influence on plant height at all stages except 12 MAP. AT 2 MAP, p_1 registered the highest value (49.63 cm) which differed significantly from p_2 (46.64 cm) and p_0 (44.22 cm). Lowest value was obtained from p_0, which was significantly different from p_2 and p_1. During 4 MAP, highest value (88.04 cm) was noticed with p_1 which differed significantly from p_2 (85.11 cm) and p_0 (76.93 cm). p_0 registered the lowest value, which differed significantly from p_2 and p_1. At 6 MAP, highest value was noticed with p_2 (148.84 cm) which had significant difference over p_1 and p_0. Lowest value (129.22 cm) was recorded by p_0, which differed significantly from p_1 (140.57 cm) and p_2. During 8 MAP, highest value (185.03 cm) was obtained from p_2 which was statistically on par with p_1 (183.92 cm), but significantly different from p_0 (175.89 cm) which recorded the lowest plant height. At 10 MAP, p_1 (227.44 cm) registered the highest value followed by p_2 (225.12 cm) which were statistically on par, but significantly different from p_0 (214.67 cm) which registered the lowest value. At 12 MAP, p levels had no significant influence on plant height.

Main effect of potassium was found to have significant influence on plant height at all stages except 2 MAP.

At 4 MAP, highest value for plant height (91.23 cm) was observed with k_2, which differed significantly from k_0 (82.17 cm) and k_1 ((76.68 cm). The lowest value recorded in k_1, differed significantly from k_0 and k_2. At 6 MAP, k_1 (120.40 cm) recorded the lowest value which differed significantly from k_0 (135.68 cm) and k_2 (162.55 cm). The treatment k_2

recorded the highest value, which significantly differed from k_0 and k_1. During 8 MAP, k_2 (203.85 cm) recorded the highest value, followed by k_0 (175.25 cm) and k_1 (165.74 cm), which were significantly different. At 10 MAP, k_2 (239.55 cm) registered the highest value followed by k_0 (216.08 cm) and k_1 (211.59 cm) which differed significantly from one another. At 12 MAP, highest value was noticed with k_2 (260.88 cm), which differed significantly from k_0 (252.63 cm) and k_1 (239.86 cm). Lowest value was noticed with k_1 (239.86 cm), which was significantly lesser than k_0 and k_2.

N x P interaction had significant influence on plant height at all stages of growth except at 2 MAP.

At 4 MAP, the highest value was observed in the combination n_1p_1 (101.86 cm) which was significantly different from other treatments. This was followed by the combinations n_1p_2 (87.80 cm), n_0p_2 (85.85 cm) and n_2p_1 (84.56 cm) which were statistically on par. Lowest value recorded in the combination n_0p_0 (73.93 cm), followed by n_2p_0 (75.03 cm) which were statistically on par. AT 6 MAP, highest value was noticed with the combination n_1p_1 (157.10 cm) followed by n_1p_2 (153.71 cm), n_0p_2 (152.55 cm) and n_1p_0 (151.83 cm) which were statistically on par. Lowest value recorded in the combination n_0p_0 (110.70 cm), which was significantly lesser than all other combinations. During 8 MAP, combination n_1p_1 (205.38 cm) obtained highest value, which differed significantly from all other treatments. This was followed by the combinations n_1p_0 (190.09 cm) and n_0p_2 (189.67 cm), which were statistically on par. Lowest value was noted in the combination n_0p_0 (167.04 cm) which was on par with n_0p_1 (170.53 cm). At 10 MAP, highest value was noticed with the combination n_2p_1 (237.65 cm) followed by n_1p_1 (237.16 cm) and n_2p_2 (235.85 cm), which were statistically on par. Lowest value was obtained from n_2p_0 (205.50 cm) followed by n_0p_1 (207.51 cm) and n_1p_2 (210.60 cm) which were statistically on par. At 12 MAP, highest value (261.30 cm) was recorded by the combination n_2p_2 which was on par with n_1p_1 (260.55 cm) and n_2p_1 (258.05 cm). Lowest value was obtained from n_0p_1 (233.76 cm) which differed significantly from all other treatments.

N x K interaction was found to have significant influence on plant height at all stages of growth.

At 2 MAP, highest value for plant height was obtained with combination n_1k_0 (54.25 cm) which was on par with n_0k_2 (52.82 cm). This was followed by n_1k_1 (49.45 cm), which was on par with n_0k_2. Lowest value was registered by the combination n_0k_0 (37.80 cm), which differed significantly from all other combinations. At 4 MAP, combination n_0k_2 registered the highest value (109.43 cm) which differed significantly from all other combinations. This was followed by combinations n_2k_0 (91.75 cm), n_1k_0 (90.90 cm), n_1k_1 (90.55 cm) and n_1k_2 (90.04 cm) which were on par. Lowest value was registered by n_0k_0 (63.85 cm) which was on par with n_0k_1 (64.20 cm). At 6 MAP, combination n_0k_2 (174.76 cm) recorded the highest value, which differed significantly from all other combinations. This was followed by n_1k_2 (167.76 cm) and n_1k_0 (152.85 cm) which also differed significantly from other combinations. Lowest value was registered by the combination n_0k_1 (99.03 cm), which had significant difference over other treatments. During 8 MAP, n_0k_2 produced highest value (225.03 cm) which differed significantly from all other treatments. This was followed by n_1k_2 (198.98 cm) which had significant difference over other combinations. Lowest value was obtained from n_0k_1 (143.2 cm) which had significant difference over other combinations. At 10 MAP, combination n_0k_2 (258.43 cm) registered the highest value, which differed significantly from all other combinations. This was followed by n_2k_2 (233.71 cm) and n_2k_0 (229.65 cm) which were on par. Lowest value was registered by n_0k_1 (197.44 cm) which was on par with n_0k_0 (203.36 cm). At 12 MAP, n_0k_2 registered the highest value (275.21 cm), which differed significantly from all other combinations. This was followed by n_2k_0 (267.06 cm) which also differed significantly from all other combinations. Lowest value was obtained from n_0k_1 (230.11 cm), followed by n_0k_0 (231.83 cm) which were on par.

P x K interaction had significant influence on plant height at all stages.

At 2 MAP, combinations p_1k_2 (54.66 cm) registered the highest value, which had significant difference over all other combinations. This was followed by p_2k_1 (48.70 cm), which was on par with p_1k_0 (48.58 cm), p_2k_2 (46.10 cm), p_1k_1 (45.65 cm), p_2k_0 (45.11 cm), p_0k_0 (45.02 cm) and p_0k_2 (44.68 cm). Lowest value was shown by p_0k_1 (42.95 cm) which was on par with p_0k_2 (44.68 cm), p_0k_0 (45.02 cm), p_2k_0 (45.11 cm), p_1k_1 (45.65 cm) and p_2k_2 (46.10 cm). At 4 MAP, p_1k_2 (101.21 cm) recorded the highest value. This was followed by p_1k_0 (87.60 cm), p_0k_2 (86.27 cm), p_2k_1 (86.25 cm) and p_2k_2 (86.21 cm) which were statistically on par. Lowest value was registered by p_0k_1 (68.46 cm), which was significantly different from all other combinations. At 6 MAP, p_2k_2 (169.01 cm) showed highest value, which differed significantly from all other combinations. This was followed by p_0k_2 (161.26 cm) and p_1k_2 (157.36 cm) which were on par, while p_0k_1 (107.30 cm) registered the lowest value, which differed significantly from all other combinations. During 8 MAP, combination p_1k_2 (223.57 cm) registered the highest value, which differed significantly from all other combinations. This was followed by p_0k_2 (206.32 cm). The combination of p_1k_1(150.17 cm) registered the lowest value, which was significantly different from all other combinations. At 10 MAP, highest value was noticed with the combination p_1k_2 (254.66 cm), which differed significantly from all other combinations. This was followed by p_0k_2 (240.31 cm), which also had significant difference over other combinations. Lowest value was registered by p_0k_1 (199.06 cm) which was statistically on par with p_1k_1 (201.98 cm) and p_0k_0 (204.63 cm). At 12 MAP, combination p_1k_2 (269.56 cm) registered the highest value, which differed significantly from all other combinations. This was followed by p_0k_2 (262.80 cm), p_2k_1 (259.31 cm) and p_1k_0 (258.38 cm) which were statistically on par. Combination p_1k_1 (224.40 cm) registered the lowest value which was significantly different from other combinations.

NPK interaction was found to have significant influence on plant height at all stages. At 2 MAP, $n_1p_1k_0$ (63.75 cm) showed the highest value, which differed significantly from all other treatments. This was followed by $n_0p_1k_2$ (56.35 cm), $n_1p_2k_1$ (55.25 cm), $n_1p_1k_2$ (54.35 cm), $n_2p_1k_2$ (53.30 cm), $n_1p_0k_0$ (52.97 cm), $n_0k_0p_2$ (52.85 cm) and $n_2p_2k_0$ (51.80 cm), which were on par. Lowest value among treatments was shown by $n_0p_0k_0$ (35.75 cm), which was on par with $n_1p_0k_2$ (36.25 cm), $n_2p_0k_1$ (36.55 cm), $n_0p_2k_0$ (37.50 cm) and $n_0p_1k_0$ (40.15 cm). The treatments had significant difference over control, which registered the lowest value for plant height (33.50 cm).

At 4 MAP, $n_0p_2k_2$ (118.55 cm) registered the highest value, which differed significantly from all other treatments. This was followed by $n_1p_2k_1$ (108.87 cm), $n_1p_1k_2$ (107.35 cm), $n_2p_2k_0$ (105.82 cm), $n_0p_1k_2$ (105.40 cm) and $n_0p_0k_2$ (104.35 cm), which were on par. $n_0p_0k_0$ (53.55 cm) registered the lowest value among treatments, which was on par with $n_0p_1k_1$ (54.50 cm). The treatments had significant difference over control. Control registered the lowest value (45.46 cm). During 6 MAP, $n_0p_2k_2$ (198.80 cm) recorded the highest value, which differed significantly from all other treatments. This was followed by $n_1p_1k_0$ (190.95 cm), which also differed significantly from other treatments. Among treatments, lowest value was obtained with $n_0p_0k_0$ (82.15 cm) which was on par with $n_0p_0k_1$ (86.00 cm). The treatments had significant difference over control, which registered the lowest value (69.75 cm). At 8 MAP, $n_0p_2k_2$ (246.48 cm) registered the highest value, which differed significantly from all other treatments. This was followed by $n_1p_1k_2$ (238.91 cm) which had significant difference over other treatments. Lowest value among treatments was seen with $n_0p_1k_1$ (124.54 cm) which differed significantly from other treatments. The treatments had significant difference over control. Control registered the lowest value (110.56 cm). At 10 MAP, highest value was obtained from $n_0p_2k_2$ (277.55 cm), which differed significantly from all other treatments. This was followed by $n_1p_2k_1$ (263.65 cm) and $n_1p_1k_2$ (263.50 cm) which were on par. $n_1p_2k_2$ (169.25 cm) registered the lowest value among treatments, which had significant difference over other treatments. The treatments had significant difference over control and control registered the lowest value (139.08 cm). At 12 MAP, $n_0p_2k_2$ (291.05 cm) produced the highest value, which differed significantly from other treatments. This was followed by $n_2p_1k_0$ (282.40 cm), $n_1p_1k_2$ (280.55 cm) and $n_1p_2k_1$ (279.50 cm) which were on par. n_1p_2k2 (197.10 cm) registered the lowest value, among treatment, which differed significantly from all other treatments. The treatments had significant difference over control. Control registered the lowest value (163.15 cm).

The main effects of nitrogen, phosphorus and potassium indicated that during early growth stages, nitrogen requirement was at 250 g plant^{-1} upto eight months after planting and at 300 g plant^{-1} thereafter. Phosphorus was required at 250 g plant^{-1} upto 10 MAP and thereafter there was no significant effect. During 4 MAP to 12 MAP, potassium was required at 500 g plant^{-1}.

4.1.2 Girth of Plants

Plant girth as influenced by different levels of N, P and K as well as their interactions at bimonthly intervals starting from 2 MAP are presented in Table 5, 6, 7 and Fig. 3.

Different levels of nitrogen were found to have significant influence on plant girth at 2 MAP and 6 MAP.

At 2 MAP, highest value for plant girth was observed with n_1 (4.74 cm) which differed significantly from n_0 (4.29 cm) and n_2 (3.62 cm). Lowest

Table 5 Effect of different levels of N, P and K on plant girth of papaya, cm

Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
N levels						
n_0	4.29	8.84	16.11	21.26	27.18	33.65
n_1	4.74	9.00	14.81	21.33	27.88	35.57
n_2	3.62	8.56	14.82	21.10	27.91	35.29
SE	0.144	0.16	0.13	0.15	0.65	0.61
CD (0.05)	0.42	NS	0.38	NS	NS	NS
P levels						
p_0	4.40	8.98	15.65	22.33	27.43	35.21
p_1	3.74	8.28	14.82	19.81	27.03	34.12
p_2	4.52	9.14	15.27	21.55	28.51	35.18
SE	0.144	0.16	0.13	0.15	0.65	0.61
CD (0.05)	0.42	0.47	0.38	0.46	NS	NS
K levels						
k_0	3.92	8.53	14.73	20.70	27.20	34.84
k_1	4.19	8.80	14.70	20.66	26.77	34.19
k_2	4.55	9.07	16.31	22.33	29.00	35.48
SE	0.144	0.16	0.13	0.15	0.65	0.61
CD (0.05)	0.42	NS	0.38	0.46	1.92	NS

NS – Non significant
MAP – Months after planting

Table 6 Interaction effect of different levels of N, P and K on plant girth of papaya, cm

Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
n_0p_0	4.79	9.34	17.10	21.53	26.81	34.06
$n_0 p_1$	3.95	8.00	14.86	20.03	26.90	32.31
n_0p_2	4.14	9.20	16.36	22.21	27.85	34.58
$n_1 p_0$	4.43	8.65	14.75	21.36	26.60	34.38
$n_1 p_1$	4.14	8.80	14.38	19.75	26.91	34.88
$n_1 p_2$	5.66	9.46	15.31	22.90	30.15	37.46
$n_2 p_0$	3.97	8.95	15.08	24.10	28.90	37.20
$n_2 p_1$	3.14	7.96	15.23	19.66	27.30	35.18
$n_2 p_2$	3.75	8.78	14.15	19.53	27.50	33.50
SE	0.25	0.277	0.22	0.275	1.13	1.05
CD (0.05)	0.73	NS	0.66	0.80	NS	3.10
n_0k_0	3.94	8.99	15.25	20.70	26.75	32.86
$n_0 k_1$	4.47	8.49	16.75	20.75	26.20	33.16
n_0k_2	4.46	9.04	16.35	22.33	28.61	34.93
$n_1 k_0$	4.04	7.51	13.10	19.13	22.75	34.05
$n_1 k_1$	4.96	8.76	12.68	18.96	25.71	34.00
$n_1 k_2$	5.23	10.71	18.65	25.91	32.20	38.68
$n_2 k_0$	3.78	9.08	15.83	22.28	29.10	37.61
$n_2 k_1$	3.14	9.15	14.68	22.26	28.40	35.41
$n_2 k_2$	3.95	7.46	13.95	18.76	26.20	32.85
SE	0.25	0.277	0.22	0.275	1.13	1.05
CD (0.05)	0.73	0.81	0.66	0.80	3.33	3.10
p_0k_0	4.38	8.73	14.53	21.53	25.86	35.31
$p_0 k_1$	4.01	9.17	14.93	21.66	28.06	35.61
p_0k_2	4.80	9.04	17.48	23.81	28.38	34.71
$p_1 k_0$	2.87	7.55	14.36	18.53	26.81	34.33
$p_1 k_1$	4.51	9.15	15.10	21.45	27.08	33.48
$p_1 k_2$	3.85	8.15	15.01	19.46	27.21	34.56
$p_2 k_0$	4.50	9.31	15.30	22.05	28.91	34.88
$p_2 k_1$	4.05	8.10	14.08	18.86	25.18	33.48
$p_2 k_2$	5.00	10.03	16.45	23.73	31.43	37.18
SE	0.25	0.277	0.22	0.275	1.13	1.05
CD (0.05)	0.73	0.81	0.66	0.80	3.33	NS

NS – Non significant

MAP – Months after planting

Table 7 Highest order interaction of NPK on plant girth of papaya, cm

No.	Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	$n_0p_0k_0$	5.08	9.14	15.00	19.95	25.75	32.95
T_2	$n_0p_0k_1$	4.70	8.95	17.20	21.40	28.15	35.45
T_3	$n_0p_0k_2$	4.60	9.95	19.15	23.25	26.55	33.80
T_4	$n_0p_1k_0$	2.95	7.20	14.50	18.70	25.70	31.30
T_5	$n_0p_1k_1$	4.60	9.39	14.80	20.15	26.25	30.95
T_6	$n_0p_1k_2$	4.30	7.40	15.3	21.25	28.75	34.70
T_7	$n_0p_2k_0$	3.80	10.65	16.25	23.45	28.80	34.35
T_8	$n_0p_2k_1$	4.10	7.15	18.25	20.70	24.20	33.10
T_9	$n_0p_2k_2$	4.50	9.79	14.60	22.50	30.55	36.30
T_{10}	$n_1p_0k_0$	3.90	7.85	14.40	19.00	24.10	32.20
T_{11}	$n_1p_0k_1$	4.60	9.30	14.65	21.60	28.05	35.45
T_{12}	$n_1p_0k_2$	4.80	8.80	15.20	23.50	27.65	35.50
T_{13}	$n_1p_1k_0$	3.02	7.95	13.95	19.65	27.30	38.50
T_{14}	$n_1p_1k_1$	5.45	8.85	12.70	18.65	25.50	32.35
T_{15}	$n_1p_1k_2$	3.95	9.85	16.50	20.95	27.95	33.80
T_{16}	$n_1p_2k_0$	5.20	6.75	11.00	18.75	25.85	31.45
T_{17}	$n_1p_2k_1$	4.85	8.15	10.70	16.65	23.60	34.20
T_{18}	$n_1p_2k_2$	6.95	13.50	24.25	33.30	41.00	46.75
T_{19}	$n_2p_0k_0$	4.17	9.20	14.20	25.65	27.75	40.80
T_{20}	$n_2p_0k_1$	2.75	9.27	12.95	22.00	28.00	35.95
T_{21}	$n_2p_0k_2$	5.00	8.39	18.10	24.70	30.95	34.85
T_{22}	$n_2p_1k_0$	2.65	7.50	14.65	17.25	27.45	33.20
T_{23}	$n_2p_1k_1$	3.48	9.20	17.80	25.55	29.50	37.15
T_{24}	$n_2p_1k_2$	3.30	7.20	13.25	16.20	24.95	35.20
T_{25}	$n_2p_2k_0$	4.52	10.55	18.65	23.95	32.10	38.85
T_{26}	$n_2p_2k_1$	3.20	9.00	13.30	19.25	27.75	33.15
T_{27}	$n_2p_2k_2$	3.55	6.80	10.50	15.40	22.75	28.50
	SE	0.43	0.48	0.39	0.47	1.96	1.83
	CD (0.05)	NS	0.99	0.81	0.98	4.08	3.80
T_{28}	Control	1.53	3.63	7.91	12.95	15.36	20.43
	Treatments Vs control	S	S	S	S	S	S

NS – Non significant, S – Significant, MAP – Months after planting

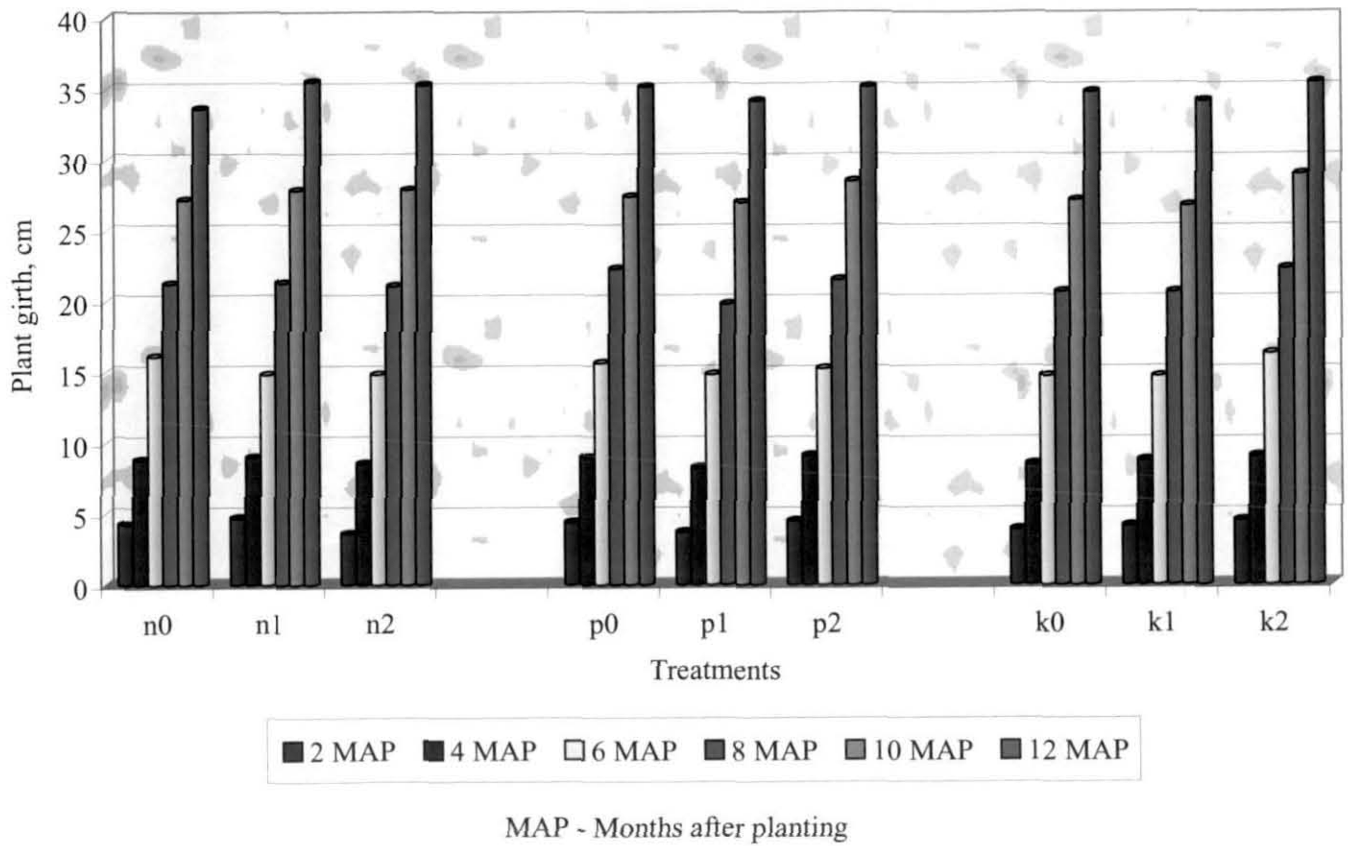


Fig. 3 Effect of different levels of nitrogen, phosphorus and potassium on plant girth

value was noted with n_2 (3.62 cm). At 6 MAP, n_0 (16.11 cm) showed the highest value, which differed significantly from n_2 (14.82 cm) and n_1 (14.81 cm). Lowest value was shown by n_1 (14.81 cm), which was on par with n_2.

Main effect of phosphorus was found to have significant influence on plant girth at all stages except 10 MAP and 12 MAP. At 2 MAP and 4 MAP highest value was recorded by p_2 which was on par with p_0. Lowest value was registered by p_1, which differed significantly from p_0 and p_2. At 6 MAP, highest value was noticed with p_0 (15.65 cm) which was on par with p_2 (15.27 cm). Lowest value was shown by p_1 (14.82 cm) which differed significantly from p_2 (15.27 cm) and p_0 (15.65 cm). At 8 MAP, p_0 (22.33 cm) registered the highest value, which differed significantly from other treatments. p_1 (19.81 cm) recorded the lowest value, which had significant difference over other treatments.

Different levels of potassium were found to have significant influence on plant girth at all stages except 4 MAP and 12 MAP. At 2 MAP, highest value was obtained from k_2 (4.55 cm) which was on par with k_1 (4.19 cm). k_0 (3.92 cm) recorded the lowest value. At 6 MAP and 8 MAP, k_2 recorded the highest value which differed significantly from k_0 and k_1. Lowest value was shown by k_1, which was on par with k_0. During 10 MAP, k_2 (29.00 cm) reported the highest value, which was on par with k_0 (27.20 cm). Lowest value was reported by k_1 (26.77 cm) which was on par with k_0 (27.20 cm).

N x P interaction was found to have significant influence on plant girth at all stages except 4 MAP and 10 MAP. At 2 MAP, highest value was noticed with the combination n_1p_1 (5.66 cm), which differed significantly from all other combinations. This was followed by n_0p_0 (4.79 cm), n_1p_0 (4.43 cm), n_0p_2 (4.14 cm) and n_1p_1 (4.14 cm) which were on par. Lowest value was shown by n_2p_1 (3.14 cm) which was on par with n_2p_2 (3.75 cm). During 6 MAP, combination n_0p_0 (17.10 cm) showed the highest value, which was significantly different from all other combinations. This was followed by n_0p_2 (16.36 cm). Lowest value was noticed with combination n_2p_2 (14.15 cm), which was statistically on par with n_1p_1 (14.38 cm) and n_1p_0 (14.75 cm). During 8 MAP, combination n_2p_0 (24.10 cm) recorded the highest value, which differed significantly from all other combinations. This was followed by n_1p_2 (22.90 cm) and n_0p_2 (22.21 cm), which were on par. The combination n_2p_2 (19.53 cm) recorded lowest value, which was statistically on par with n_2p_1 (19.66 cm), n_1p_1 (19.75 cm) and n_0p_1 (20.03 cm). At 12 MAP, combination n_1p_2 (37.46 cm) showed the highest value which was on par with n_2p_0 (37.20 cm), n_2p_1 (35.18 cm), n_1p_1 (34.88 cm), n_0p_2 (34.58 cm) and n_1p_0 (34.38 cm). Lowest value was recorded by combination n_0p_1 (32.31 cm) which was on par with all other treatments except n_2p_0 (37.20 cm) and n_1p_2 (37.46 cm).

N x K interaction was found to have significant influence on plant girth at all stages. At 2 MAP, highest value was shown by the combination n_1k_2 (5.23 cm), which was on par with n_1k_1 (4.96 cm). This was followed by n_0k_1 (4.47 cm) and n_0k_2 (4.46 cm) which were on par. Lowest value was observed with combination n_2k_1 (3.14 cm) which was on par with n_2k_0 (3.78 cm). During 4 MAP, combination n_1k_2 (10.71 cm) showed the highest value, which differed significantly from all other combinations. This was followed by n_2k_1 (9.15 cm), n_2k_0 (9.08 cm), n_0k_2 (9.04 cm), n_0k_0 (8.99 cm), n_1k_1 (8.76 cm) and n_0k_1 (8.49 cm) which were on par. Lowest value was noticed with combination n_2k_2 (7.46 cm) which was on par with n_1k_0 (7.51 cm). During 6 MAP, highest value was noticed with combination n_1k_2 (18.65 cm) which had significant difference over all other combinations. This was followed by n_0k_1 (16.75 cm), which was statistically on par with n_0k_2 (16.35 cm). Lowest value was noted with n_1k_1 (12.68 cm) which differed significantly from all other combinations. At 8 MAP, combination n_1k_2 (25.91 cm) showed the highest value, which had significant difference overall other combinations. This was followed by n_0k_2 (22.33 cm) which was on par with n_2k_0 (22.28 cm) and n_2k_1 (22.26 cm). Lowest value was noted with n_2k_2 (18.76 cm) which was on par with n_1k_1 (18.96 cm) and n_1k_0 (19.13 cm). During 10 MAP, highest value was noticed with combination n_1k_2 (32.20 cm) which was on par with n_2k_0 (29.10 cm), but significantly different from all other combination. This was followed by n_0k_2 (28.61 cm), n_2k_1 (28.40 cm), n_0k_0 (26.75 cm), n_0k_1 (26.20 cm) and n_2k_2 (26.20 cm) which were on par. Lowest value was recorded by n_1k_0 (22.75 cm) which was on par with n_1k_1 (25.71 cm). During 12 MAP, combination n_1k_2 (38.68 cm) reported the highest value, which was on par with n_2k_0 (37.61 cm). Combination n_2k_2 (32.85 cm) reported the lowest value which was on par with n_0k_0 (32.86 cm), n_1k_1 (34.03 cm), n_1k_0 (34.05 cm), n_0k_2 (34.93 cm) and n_2k_1 (35.41 cm).

P x K interaction was found to have significant influence on plant girth at all stages except 12 MAP.

At 2 MAP, highest value was noted with combination p_2k_2 (5.00 cm) which was on par with p_0k_2 (4.80 cm), p_1k_1 (4.51 cm), p_2k_0 (4.50 cm) and p_0k_0 (4.38 cm). Lowest value was shown by combination p_1k_0 (2.87 cm) which had significant difference over other combinations. During 4 MAP, combination p_2k_2 (10.03 cm) showed highest value, which was significantly different from all other combinations except p_2k_0 (9.31 cm). Combination p_2k_0 was on par with p_0k_1 (9.17 cm), p_1k_1 (9.15 cm), p_0k_2 (9,04 cm) and p_0k_0 (8.73 cm). Lowest value was recorded by combination p_1k_0 (7.55 cm) which was on par with p_2k_1 (8.10 cm) and p_1k_2 (8.15 cm). At 6 MAP, p_0k_2 (17.48 cm) reported highest value, which differed significantly from all other combinations. This was followed by p_2k_2 (16.45 cm) which also differed significantly from other combinations. Lowest value was noted with p_2k_1 (14.08 cm), which differed significantly from all other combinations, but statistically on par with p_1k_0 (14.36 cm) an p_0k_0 (14.53 cm). During 8 MAP, combination p_0k_2 (23.81 cm) showed highest value, which differed significantly from all other combinations, but statistically on par with p_2k_2 (23.73 cm). Lowest value was noticed with p_1k_0 (18.53 cm) which was on par with p_2k_1 (18.86 cm). At 10 MAP, combination p_2k_2 (31.34 cm) reported the highest value, which was on par with p_2k_0 (28.91 cm) and p_0k_2 (28.38 cm) and differed significantly from all other combinations. Lowest value was shown by combination p_2k_1 (25.18 cm) which was on par with p_0k_0 (25.86 cm), p_1k_0 (26.81 cm), p_1k_1 (27.08 cm), p_1k_2 (27.21 cm), p_0k_1 (28.06 cm) and p_0k_2 (28.38 cm).

NPK interaction was found to have significant influence on par plant girth at all stages except 2 MAP. At 4 MAP, highest value was shown by $n_1p_2k_2$ (13.50 cm) which differed significantly from all other treatments. This was followed by $n_0p_2k_0$ (10.65 cm) which was on par with $n_2p_2k_0$ (10.55 cm), $n_0p_0k_2$ (9.95 cm), $n_1p_1k_2$ (9.85 cm) and $n_0p_2k_2$ (9.79 cm). Lowest value among treatments were shown by $n_1p_2k_0$ (6.75 cm) which was on par with $n_2p_2k_2$ (6.80 cm), $n_0p_2k_1$ (7.15 cm), $n_2p_1k_2$ (7.20 cm), $n_0p_1k_0$ (7.20 cm), $n_0p_1k_2$ (7.40 cm) and $n_2p_1k_0$ (7.50 cm). The treatments had significant difference over control. Control reported the lowest value (3.63 cm). At 6 MAP, $n_1p_2k_2$ reported the highest value (24.25 cm) which had significant difference over other treatments. This was followed by $n_0p_0k_2$ (19.15 cm) which was on par with $n_2p_2k_0$ (18.65 cm). Lowest value among treatments were shown by $n_2p_2k_2$ (10.50 cm) which was on par with $n_1p_2k_1$ (10.70 cm) and $n_1p_2k_0$ (11.00 cm) but significantly different from other treatments. Treatments had significant difference over control, which reported the lowest value (7.91 cm). During 8 MAP, $n_1p_2k_2$ (33.30 cm) reported the highest value for plant girth, which differed significantly from all other treatments. This was followed by $n_2p_0k_0$ (25.65 cm), $n_2p_1k_1$ (25.55 cm) and $n_2p_0k_2$ (24.70 cm) which were on par. Lowest value among the treatment was shown by $n_2p_2k_2$ (15.40 cm). This was followed by $n_2p_1k_2$ (16.20 cm), which were on par. The treatments had significant difference over control. Control reported least value (12.95 cm). During 10 MAP, highest value for plant girth was noted with $n_1p_2k_2$ (41.00 cm) which had significant difference over other treatments. This was followed by $n_2p_2k_0$ (32.10 cm), $n_2p_0k_2$ (30.95 cm), $n_0p_2k_2$ (30.55 cm), $n_2p_1k_1$ (29.50 cm), $n_0p_2k_0$ (28.80 cm), $n_0p_1k_2$ (28.75 cm), $n_0p_0k_1$ (28.15 cm) and $n_1p_0k_1$ (28.05 cm) which were on par. Lowest value among treatments was noted with $n_2p_2k_2$ (22.75 cm). This was followed by $n_1p_2k_1$ (23.60 cm), $n_1p_0k_0$ (24.10 cm), $n_0p_2k_1$ (24.20 cm), $n_2p_1k_2$ (24.95 cm), $n_1p_1k_1$ (25.50 cm), $n_0p_1k_0$ (25.70 cm), $n_0p_0k_0$ (25.75 cm), $n_1p_2k_0$ (25.85), $n_0p_1k_1$ (26.25 cm) and $n_0p_0k_2$ (26.55 cm), which were on par. The treatments had significant difference over control. Control reported the lowest value (15.36 cm). At 12 MAP, $n_1p_2k_2$ (46.75 cm) reported the highest value for plant girth, which differed significantly from all other treatments. This was followed by $n_2p_0k_0$ (40.80 cm), $n_2p_2k_0$ (38.85 cm), $n_1p_1k_0$ (38.50 cm), $n_2p_1k_1$ (37.15 cm) which were on par. Lowest value among treatments was observed with $n_2p_2k_2$ (28.50 cm), which was on par with $n_0p_1k_1$ (30.95 cm), $n_0p_1k_0$ (31.30 cm), $n_1p_2k_0$ (31.45 cm) and $n_1p_0k_0$ (32.20 cm) which were on par. Treatments had significant difference over control, which reported lowest value for plant girth (20.43 cm).

In general, nitrogen at 250 g plant^{-1}influenced plant girth at early stages of growth. Thereafter there was no significant effect. Effect of phosphorus at 200 g level was notable upto 8 MAP and thereafter there was no significant effect. Potassium at 500 g plant^{-1} had influence on plant girth.

4.1.3 Number of Leaves

Leaf number as influenced by different levels of N, P and K as well as their interactions at bimonthly intervals starting from 2 MAP are presented in Table 8, 9 and 10.

Different levels of nitrogen were found to have significant influence on leaf number at all stages. At 2 MAP, 4 MAP, 6 MAP and 8 MAP, n_2 showed the highest value for leaf number which differed significantly from other treatments. Lowest value was observed with n_0, which differed significantly from other treatments. This was followed by n_1. At 10

Table 8 Effect of different levels of N, P and K on leaf number of papaya

Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
N levels						
n_0	9.58	12.91	16.95	22.15	26.29	29.71
n_1	10.38	13.56	17.75	23.11	25.31	29.86
n_2	11.14	14.87	18.71	23.98	26.87	33.02
SE	0.15	0.112	0.116	0.09	0.16	0.20
CD (0.05)	0.44	0.32	0.34	0.26	0.48	0.59
P levels						
p_0	10.16	13.96	18.36	23.79	26.62	31.73
p_1	10.13	13.00	16.90	22.15	25.10	29.65
p_2	10.81	14.38	18.16	23.30	26.75	31.20
SE	0.15	0.112	0.116	0.09	0.16	0.20
CD (0.05)	0.44	0.32	0.34	0.26	0.48	0.59
K levels						
k_0	9.31	12.19	16.11	21.04	24.02	28.55
k_1	9.07	12.36	16.31	22.19	25.16	28.84
k_2	12.72	16.78	21.00	26.01	29.29	35.20
SE	0.15	0.112	0.116	0.09	0.16	0.20
CD (0.05)	0.44	0.32	0.34	0.26	0.48	0.59

MAP – Months after planting

Table 9 Interaction effect of different levels of N, P and K on leaf number of papaya

Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
n_0p_0	9.88	13.38	18.28	23.58	27.25	31.26
$n_0 p_1$	9.51	12.83	16.60	22.03	25.71	28.13
n_0p_2	9.34	12.51	15.98	20.85	25.91	29.75
$n_1 p_0$	9.86	13.65	17.70	23.03	25.55	28.93
$n_1 p_1$	9.63	12.05	16.06	21.46	23.40	29.76
$n_1 p_2$	11.65	15.00	19.48	24.85	26.98	30.88
$n_2 p_0$	10.73	14.85	19.10	24.76	27.06	35.01
$n_2 p_1$	11.25	14.13	18.03	22.96	26.20	31.06
$n_2 p_2$	11.45	15.63	19.01	24.21	27.36	32.98
SE	0.26	0.19	0.20	0.15	0.28	0.35
CD (0.05)	0.76	0.57	0.59	0.46	0.84	1.03
n_0k_0	7.95	11.15	14.08	19.20	22.70	26.60
$n_0 k_1$	8.96	11.31	15.91	20.76	24.73	28.05
n_0k_2	11.83	16.26	20.86	26.50	31.45	34.50
$n_1 k_0$	10.05	12.08	16.91	21.78	24.40	27.51
$n_1 k_1$	9.28	12.80	17.35	22.73	25.20	29.48
$n_1 k_2$	11.81	15.81	18.98	24.83	26.33	32.58
$n_2 k_0$	9.95	13.35	17.33	22.15	24.96	31.53
$n_2 k_1$	8.96	12.98	15.66	23.08	25.56	29.00
$n_2 k_2$	14.51	18.28	23.15	26.71	30.10	38.53
SE	0.26	0.19	0.20	0.15	0.28	0.35
CD (0.05)	0.76	0.57	0.59	0.46	0.84	1.03
p_0k_0	7.68	10.63	15.38	20.46	24.20	31.63
$p_0 k_1$	9.58	13.56	16.83	23.41	25.73	29.35
p_0k_2	13.21	17.68	22.86	27.50	29.93	34.23
$p_1 k_0$	9.48	11.21	14.70	20.10	22.35	25.11
$p_1 k_1$	9.59	11.73	16.08	20.28	23.20	28.05
$p_1 k_2$	11.31	16.06	19.91	26.08	29.76	35.80
$p_2 k_0$	10.78	14.73	18.25	22.56	25.51	28.90
$p_2 k_1$	8.03	11.80	16.01	22.88	26.56	29.13
$p_2 k_2$	13.63	16.61	20.21	24.46	28.18	35.58
SE	0.26	0.19	0.20	0.15	0.28	0.35
CD (0.05)	0.76	0.57	0.59	0.46	0.84	1.03

MAP – Months after planting

Table 10 Highest order interaction of NPK on leaf number of papaya

No.	Treatments	2 MAP	4 MAP	6 MAP	8 MAP	10 MAP	12 MAP
T_1	$n_0p_0k_0$	9.05	13.20	17.40	21.15	24.95	30.30
T_2	$n_0p_0k_1$	6.70	9.64	14.00	19.25	22.35	25.95
T_3	$n_0p_0k_2$	13.90	17.30	23.45	30.35	34.45	37.55
T_4	$n_0p_1k_0$	8.35	10.00	12.60	18.30	20.45	22.10
T_5	$n_0p_1k_1$	10.40	12.50	17.85	22.35	26.45	28.95
T_6	$n_0p_1k_2$	9.79	16.00	19.35	25.45	30.25	33.35
T_7	$n_0p_2k_0$	6.45	10.25	12.25	18.15	22.70	27.40
T_8	$n_0p_2k_1$	9.80	11.80	15.90	20.70	25.40	29.25
T_9	$n_0p_2k_2$	11.80	15.50	19.80	23.70	29.65	32.60
T_{10}	$n_1p_0k_0$	6.80	8.20	13.20	18.75	23.90	27.15
T_{11}	$n_1p_0k_1$	10.50	15.25	19.15	26.65	28.70	31.60
T_{12}	$n_1p_0k_2$	12.30	17.50	20.75	23.70	24.05	28.05
T_{13}	$n_1p_1k_0$	9.64	11.25	15.40	19.30	21.15	24.75
T_{14}	$n_1p_1k_1$	11.50	13.45	17.95	20.45	22.55	30.50
T_{15}	$n_1p_1k_2$	7.75	11.45	14.85	24.65	26.50	34.05
T_{16}	$n_1p_2k_0$	13.70	16.80	22.15	27.30	28.15	30.65
T_{17}	$n_1p_2k_1$	5.85	9.70	14.95	21.10	24.35	26.35
T_{18}	$n_1p_2k_2$	15.40	18.50	21.35	26.15	28.45	35.65
T_{19}	$n_2p_0k_0$	7.20	10.50	15.55	21.50	23.75	37.45
T_{20}	$n_2p_0k_1$	11.55	15.80	17.35	24.35	26.15	30.50
T_{21}	$n_2p_0k_2$	13.45	18.25	24.40	28.45	31.30	37.10
T_{22}	$n_2p_1k_0$	10.45	12.40	16.10	22.70	25.45	28.50
T_{23}	$n_2p_1k_1$	6.90	9.25	12.45	18.05	20.60	24.70
T_{24}	$n_2p_1k_2$	16.40	20.75	25.55	28.15	32.55	40.00
T_{25}	$n_2p_2k_0$	12.20	17.15	20.35	22.25	25.70	28.65
T_{26}	$n_2p_2k_1$	8.45	13.90	17.20	26.85	29.95	31.80
T_{27}	$n_2p_2k_2$	13.70	15.85	19.50	23.55	26.45	38.50
	SE	0.45	0.33	0.34	0.27	0.49	0.61
	CD (0.05)	0.93	0.69	0.72	0.56	1.03	1.26
T_{28}	Control	4.70	6.65	11.15	15.05	18.95	21.70
	Treatments Vs control	S	S	S	S	S	S

S – Significant, MAP – Months after planting

MAP, n_2 (26.87) showed highest value, which differed significantly from other treatments. n_1 (25.31) showed lowest value. This was followed by n_0 (26.29). At 12 MAP, n_2 (33.02) showed highest value, which differed significantly from other treatments. Lowest value (29.70) was noted with n_0, which was statistically on par with n_1 (29.86).

Main effect of P was found to have significant influence on leaf number at all stages. At 2 MAP, highest value was given by p_2 (10.81), which differed significantly from other treatments. Lowest value was observed with p_1 (10.13), which was statistically on par with p_0 (10.16). During 4 MAP, highest value was noted with p_2 (14.38), which had significant difference over other treatments. Lowest value was given by p_1 (13.00). This was followed by p_0 (13.96). During 6 MAP and 12 MAP, highest value for leaf number was noted with p_0, which was statistically on par with p_2, but significantly different from p_1. Lowest value was recorded by p_1. At 8 MAP, p_0 (23.79) showed the highest value which differed significantly from other treatments. Lowest value (22.15) was noted with p_1, which differed significantly from p_2 (23.3) and p_0 (23.79). During 10 MAP, p_2 (26.75) showed the highest value which was on par with p_0 (26.62). Lowest value was recorded by p_1 (25.10), which differed significantly from other treatments.

Main effect of K was found to have significant effect on leaf number at all stages. At 2 MAP, highest value was noted with k_2 (12.72), which differed significantly from other treatments. Lowest value was noted with k_1 (9.07), which was on par with k_0 (9.31). During 4 MAP, 6 MAP and 12 MAP, highest value for leaf number was recorded by k_2, which differed significantly from other treatments. Lowest value was noticed with k_0, which was statistically on par with k_1. At 8 MAP and 10 MAP, highest value for leaf number was observed with k_2 which differed significantly from other treatments. Lowest value was recorded by k_0, which differed significantly from k_1 and k_2.

N x P interaction was found to have significant influence on leaf number at all stages. At 2 MAP, highest value was recorded with the combination n_1p_2 (11.65), which was on par with n_2p_2 (11.45) and n_2p_1 (11.25), but significantly different from other combinations. Lowest value as shown by the combination n_0p_2 (9.34) followed by n_0p_1 (9.51), n_1p_1 (9.63), n_1p_0 (9.86) and n_0p_0 (9.88) which were on par. At 4 MAP, highest value was obtained from the combination n_2p_2 (15.63), which differed significantly from other combinations. This was followed by n_1p_2 (15.00) and n_2p_0 (14.85) which were on par. Lowest value was noted with n_1p_1 (12.05) which was on par with n_0p_2 (12.51). During 6 MAP, highest value was recorded by combination n_1p_2 (19.48) which was on par with n_2p_0 (19.10) and n_2p_2 (19.01). Lowest value was obtained from the combination n_0p_2 (15.98), which was on par with n_1p_1 (16.06). During 8 MAP, highest value for leaf number was noticed with n_1p_2 (24.85), which was on par with n_2p_0 (24.76). Lowest value was noticed with n_0p_2 (20.85), which differed significantly from all other combinations. During 10 MAP, highest value for leaf number was noted from n_2p_2 (27.36), which was on par with n_0p_0 (27.25), n_2p_0 (27.06) and n_1p_2 (26.98). Lowest value was obtained from n_1p_1 (23.40), which differed significantly from all other combinations. At 12 MAP, highest value (35.01) was obtained from combination n_2p_0, which differed significantly from all other combinations. This was followed by n_0p_0 (31.26) which also differed significantly from other combinations. Lowest value was noticed with combination n_0p_1 (28.13), which was on par with n_1p_0 (28.93).

N x K interaction was found to have significant influence on leaf number at all stages. During 2 MAP, highest value was given by the combination n_2k_2 (14.51), which differed significantly from other combination. This was followed by the combination n_0k_2 (11.83), which was on par with n_1k_2 (11.81). Lowest value was observed with combination n_0k_0 (7.95), which differed significantly from other combinations. During 4 MAP, highest value (18.28) was obtained from combination n_2k_2, which differed significantly from all other combinations. This was followed by n_0k_2 (16.26) and n_1k_2 (15.81) which were on par. Lowest value was noted with combination n_0k_0 (11.15), which was on par with n_0k_1 (11.31). During 6 MAP, highest value for leaf number was obtained from combination n_2k_2 (23.15), which differed significantly from other combinations. This was followed by the combination n_0k_2 (20.86) which also differed significantly from other combinations. Lowest value was recorded by the combination n_0k_0 (14.08), which differed significantly from other combinations. During 8 MAP, highest value was obtained from combination n_2k_2 (26.71), which was on par with n_0k_2 (26.50). Lowest value was obtained from the combination n_0k_0 (19.20) which differed significantly from other combinations. At 10 MAP, highest value was seen with the combination n_0k_2 (31.45), which differed significantly from other combinations. This was followed by the combination n_2k_2 (30.10) which differed significantly from other combinations. Lowest value was obtained from combination n_0k_0 (22.70), which differed significantly from other combination. During 12 MAP, highest value for leaf number was obtained from combination n_2k_2 (38.53) which differed significantly from other combinations. This was followed by combination n_0k_2 (34.50), which also differed significantly from other combinations. Lowest value was reported by combination n_0k_0 (26.60) which was on par with n_1k_0 (27.51).

Interaction P x K had significant influence on leaf number at all stages. At 2 MAP, highest value was obtained from combination p_2k_2 (13.63) which was on par with p_0k_2 (13.21). Lowest value was obtained from p_0k_0 (7.68) which was on par with p_2k_1 (8.03). During 4 MAP, highest value was obtained from combination p_0k_2 (17.68), which differed significantly from other combinations. This was followed by p_2k_2 (16.61) which was on par with p_1k_2 (16.06). Lowest value was obtained from p_0k_0 (10.63) which differed significantly from other combinations. During 6 MAP, highest value was noted with combination p_0k_2 (22.86), which differed significantly from other combinations. This was followed by p_2k_2 (20.21) and p_1k_2 (19.91), which were on par. Lowest value was noted with combination p_1k_0 (14.70), which differed significantly from other combinations. During 8 MAP, highest value was obtained from combination p_0k_2 (27.50) which differed significantly from other combinations. This was followed by p_1k_2 (26.08) which also differed significantly from other combinations. Lowest value was obtained from combination p_1k_0 (20.10), which was on par with p_1k_1 (20.28) and p_0k_0 (20.46). During 10 MAP, highest value was obtained from combination p_0k_2 (29.93), which was on par with p_1k_2 (29.76). Lowest value was obtained from combination p_1k_0 (22.35) which differed significantly from other combinations. At 12 MAP, highest value for leaf number was obtained from combination p_1k_2 (35.80) which was on par with p_2k_2 (35.58). Lowest value was obtained from combination p_1k_0 (25.11), which also differed significantly from other combinations. This was followed by p_1k_1 (28.05) and p_2k_0 (28.90) which were on par.

NPK interaction had significant influence on leaf number at all stages. At 2 MAP, highest value for leaf number was obtained from $n_2p_1k_2$ (16.40) which differed significantly from other treatments. This was followed by $n_1p_2k_2$ (15.40), which also differed significantly from other treatments. Lowest value among treatments was noted with $n_1p_2k_1$ (5.85) which was on par with $n_0p_2k_0$ (6.45) and $n_0p_0k_1$ (6.70). The treatments showed significantly higher number of leaves over control which recorded the lowest value (4.70).

During 4 MAP, highest value was observed with $n_2p_1k_2$ (20.75) which differed significantly from other treatments. This was followed by $n_1p_2k_2$ (18.5) which was on par with $n_2p_0k_2$ (18.25). Lowest value among the treatments was noted with $n_1p_0k_0$ (8.20), which differed significantly from other treatments. The treatments, had significant difference over control. Control reported lowest value (6.65). During 6 MAP, highest value was recorded by $n_2p_1k_2$ (25.55), which differed significantly from other treatments. This was followed by $n_2p_0k_2$ (24.40) which also differed significantly from other treatments. Lowest value among the treatment was recorded by $n_0p_2k_0$ (12.25) which was on par with $n_2p_1k_1$ (12.45) and $n_0p_1k_0$ (12.60). These treatments had significant difference over control, which reported the least value for leaf number (11.15). During 8 MAP, the highest value was reported by $n_0p_0k_2$ (30.35) which differed significantly from other treatments. This was followed by $n_2p_0k_2$ (28.45) and $n_2p_1k_2$ (28.15) which were on par. Lowest value among treatments was reported by $n_2p_1k_1$ (18.05) followed by $n_0p_2k_0$ (18.15) and $n_0p_1k_0$ (18.30) which were on par. Treatments had significant difference over control, which reported the lowest value for leaf number (15.05). During 10 MAP, $n_0p_0k_2$ registered the highest value (34.45), which differed significantly from other treatments. This was followed by $n_2p_1k_2$ (32.55), which also differed significantly from other treatments. Lowest value among treatment was registered by $n_0p_1k_0$ (20.45), which was on par with $n_2p_1k_1$ (20.60) and $n_1p_1k_0$ (21.15). Treatments had significant difference over control, which reported least value (18.95). 12 MAP, highest value for leaf number was registered by $n_2p_1k_2$ (40.00) which differed significantly from other treatments. This was followed by $n_2p_2k_2$ (38.50), $n_0p_0k_2$ (37.55) and $n_2p_0k_0$ (37.45) which were on par. Lowest value among treatments was noticed with $n_0p_1k_0$ (22.10) which differed significantly from other treatments. This was followed by $n_2p_1k_1$ (24.70), $n_1p_1k_0$ (24.75) and $n_0p_0k_1$ (25.95) which were on par and had significant difference over control, which registered lowest value for leaf number (21.7).

It was observed that nitrogen at 300 g plant^{-1} influenced leaf production positively. Phosphorus at 300 g plant^{-1}and potassium at 500 g plant^{-1}influenced the number of leaves plant^{-1}.

4.1.4 Time of First Flowering

The data on time for first flowering as influenced by different levels of N, P and K as well as their interactions are presented in Table 11, 12, 13 and Fig. 4.

Main effect of nitrogen was found to have significant influence on time for first flowering. Highest value was given by n_0 (177.65 days), which differed significantly from other treatments. Lowest value was given by n_1 (152.05 days) which differed significantly from other treatments.

Different levels of phosphorus was found to have significant influence on time for first flowering. Highest value (174.53 days) was reported by p_0, which differed significantly from other treatments. Lowest value (163.36 days) was seen with p_2, which differed significantly from other treatments.

Different levels of potassium had significant influence on time for first flowering. Highest value (178.74 days) was reported by k_0, which differed significantly from other treatments. Lowest value (153.81 days) was recorded by k_2, which differed significantly from k_1 (171.48 days) and k_0 (178.74 days).

N x P interaction was found to have significant influence on time of first flowering. Highest value (195.46 days) was observed with combination n_0p_0, which differed significantly from other treatments. This was followed by n_2p_1 (178.28 days) and n_2p_0 (174.68 days) which were on par. Lowest value was noticed with combination n_1p_2 (148.25 days), which differed significantly from other treatments. This was followed by n_1p_0 (153.5 days) and n_1p_1 (154.41 days), which were on par.

N x K interaction had significant influence on time for first flowering. Highest value was recorded by combination n_2k_0 (190.68 days), which was on par with n_0k_2 (190.26 days). Lowest value was

Table 11 Effect of different levels of N, P and K on time taken for first flowering, height at first flowering, number of flowers cluster^{-1} and time for harvest

Treatments	Time for first flowering (days)	Height of first flowering (cm)	Number of flowers cluster^{-1}	Time for harvest (days)
N levels				
n_0	177.65	102.98	1.88	245.13
n_1	152.05	113.39	1.83	239.48
n_2	174.33	106.10	1.88	243.10
SE	0.91	3.23	0.15	0.60
CD (0.05)	2.66	NS	NS	1.76
P levels				
p_0	174.55	103.65	2.00	243.16
p_1	166.12	113.54	1.83	244.21
p_2	163.36	105.28	1.77	240.34
SE	0.91	3.23	0.15	0.60
CD (0.05)	2.66	NS	NS	1.76
K levels				
k_0	178.74	107.48	1.83	248.25
k_1	171.48	103.41	1.77	239.66
k_2	153.81	111.58	2.00	239.80
SE	0.91	3.23	0.15	0.60
CD (0.05)	2.66	NS	NS	1.76

NS – Non significant

Table 12 Interaction effect of different levels of N, P and K on time taken for first flowering, height at first flowering, number of flowers cluster^{-1} and time for harvest

Treatments	Time for first flowering (days)	Height of first flowering (cm)	Number of flowers cluster^{-1}	Time for harvest (days)
n_0p_0	195.46	101.96	2.00	239.24
$n_0 p_1$	165.68	104.38	1.83	248.86
n_0p_2	171.81	102.61	1.83	247.11
$n_1 p_0$	153.50	108.93	2.33	247.21
$n_1 p_1$	154.41	122.33	1.51	235.41
$n_1 p_2$	148.25	108.91	1.66	235.81
$n_2 p_0$	174.68	100.06	1.66	242.85
$n_2 p_1$	178.28	113.91	2.16	248.35
$n_2 p_2$	170.03	104.31	1.83	238.10
SE	1.57	5.59	0.26	1.03
CD (0.05)	4.62	NS	NS	3.05
n_0k_0	174.43	101.78	1.83	249.25
n_0k_1	168.26	100.00	1.66	233.23
n_0k_2	190.26	107.18	2.16	252.93
$n_1 k_0$	171.11	115.03	2.00	254.08
$n_1 k_1$	162.05	108.95	1.50	241.93
$n_1 k_2$	123.00	116.20	2.00	222.43
$n_2 k_0$	190.68	105.63	1.66	241.41
$n_2 k_1$	184.13	101.30	2.16	243.83
$n_2 k_2$	148.18	111.36	1.83	244.05
SE	1.57	5.59	0.26	1.03
CD (0.05)	4.62	NS	NS	3.05
p_0k_0	191.90	103.51	2.00	248.40
$p_0 k_1$	173.91	104.65	1.50	239.28
p_0k_2	157.83	102.80	2.50	241.81
$p_1 k_0$	187.01	111.83	2.00	254.36
$p_1 k_1$	152:23	100.38	1.66	241.11
$p_1 k_2$	159.13	128.41	1.83	237.15
$p_2 k_0$	157.31	107.10	1.50	241.98
$p_2 k_1$	188.30	105.21	2.16	238.60
$p_2 k_2$	144.48	103.53	1.66	240.45
SE	1.57	5.59	0.26	1.03
CD (0.05)	4.62	NS	NS	3.05

NS – Non significant

Table 13 Highest order interaction of NPK on time taken for first flowering, height at first flowering, number of flowers cluster^{-1} and time for harvest

No.	Treatments	Time for first flowering (days)	Height of first flowering (cm)	Number of flowers cluster^{-1}	Time for harvest (days)
T_1	$n_0p_0k_0$	208.90	99.95	2.00	239.5
T_2	$n_0p_0k_1$	172.90	105.05	1.50	226.65
T_3	$n_0p_0k_2$	204.60	100.90	2.50	252.10
T_4	$n_0p_1k_0$	151.15	96.65	2.00	254.55
T_5	$n_0p_1k_1$	137.50	88.55	1.50	231.75
T_6	$n_0p_1k_2$	208.40	127.95	2.00	260.30
T_7	$n_0p_2k_0$	163.25	108.75	1.50	253.65
T_8	$n_0p_2k_1$	194.40	106.40	2.00	241.30
T_9	$n_0p_2k_2$	157.80	92.70	2.00	246.40
T_{10}	$n_1p_0k_0$	147.25	109.65	2.50	252.60
T_{11}	$n_1p_0k_1$	185.65	107.30	1.50	257.55
T_{12}	$n_1p_0k_2$	127.60	109.85	3.00	231.50
T_{13}	$n_1p_1k_0$	197.10	125.90	2.00	259.55
T_{14}	$n_1p_1k_1$	146.65	106.70	1.00	234.90
T_{15}	$n_1p_1k_2$	119.50	134.40	1.50	211.80
T_{16}	$n_1p_2k_0$	169.00	109.55	1.50	250.10
T_{17}	$n_1p_2k_1$	153.85	112.85	2.00	233.33
T_{18}	$n_1p_2k_2$	121.90	104.35	1.50	224.00
T_{19}	$n_2p_0k_0$	219.55	100.95	1.50	253.05
T_{20}	$n_2p_0k_1$	163.20	101.60	1.50	233.65
T_{21}	$n_2p_0k_2$	141.30	97.65	2.00	241.85
T_{22}	$n_2p_1k_0$	212.80	112.95	2.00	249.00
T_{23}	$n_2p_1k_1$	172.55	105.90	2.50	256.70
T_{24}	$n_2p_1k_2$	149.50	122.90	2.00	239.35
T_{25}	$n_2p_2k_0$	139.70	103.00	1.50	222.20
T_{26}	$n_2p_2k_1$	216.65	96.39	2.50	241.15
T_{27}	$n_2p_2k_2$	153.75	113.55	1.50	250.95
	SE	2.73	9.70	0.45	1.80
	CD (0.05)	5.66	NS	NS	3.73
T_{28}	Control	224.30	95.18	1.16	266.50
	Treatments Vs control	S	S	S	S

NS – Non significant, S – Significant

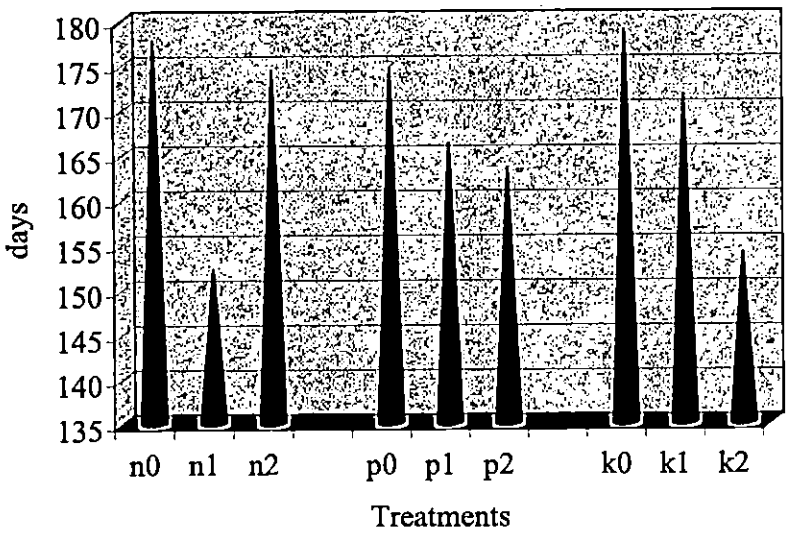


Fig. 4 Effect of different levels of nitrogen, phosphorus and potassium on time for first flowering

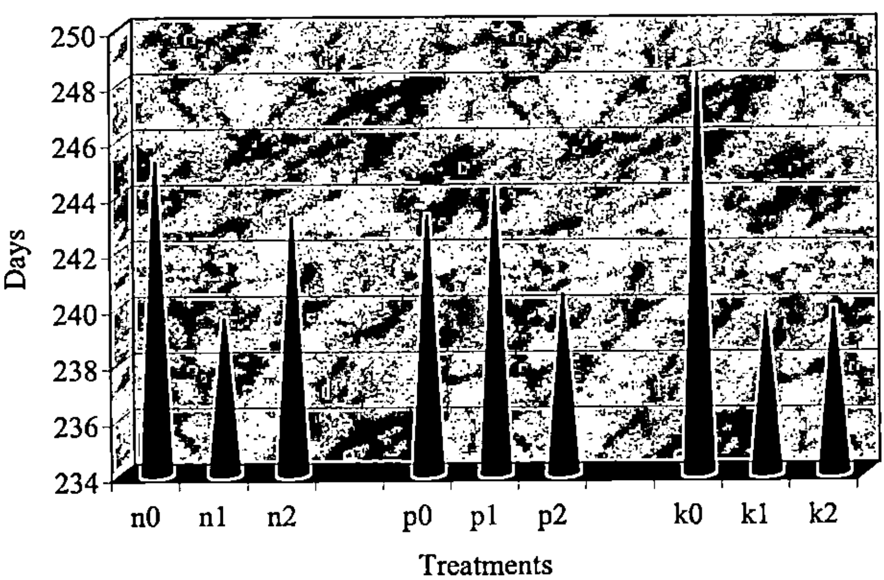


Fig. 5 Effect of different levels of nitrogen, phosphorus and potassium on time for harvest

reported by combination n_1k_2 (123.0 days), which differed significantly from other combinations.

P x K interaction was found to have significant influence on time for first flowering. Highest value was reported by combination p_0k_1 (191.9 days), which was on par with p_2k_1 (188.3 days). Lowest value was noticed with combination p_2k_2 (144.48 days), which differed significantly from other treatments. This was followed by combination p_1k_1 (152.23 days), which also differed significantly from other combinations.

NPK interaction had significant influence on time for first flowering. Highest value was reported by $n_2p_0k_0$ (219.55 days), which was on par with $n_2p_2k_1$ (216.65 days). Lower duration for flowering among treatments was recorded by $n_1p_1k_2$ (119.5 days) which was on par with $n_1p_2k_2$ (121.9 days). Treatments had significant difference over control, which reported highest value (224.3 days) for time of first flowering.

Plants receiving nitrogen at 250 g plant^{-1}, phosphorus at 300 g plant^{-1} and potassium at 500 g plant^{-1}took the shortest time for appearance of first flower.

4.1.5 Height at First Flowering

Data on height at first flowering as influenced by different levels of N, P and K as well as their interactions are presented in Table 11, 12 and 13.

Main effect of nitrogen, phosphorus and potassium were not find to have significant influence on height of first flowering.

N x P, N x K and P x K interactions as well as NPK interaction were not found to have significant influence on height of first flowering.

The treatments had significant difference over control, which reported a value of 95.18 cm, which was comparatively lesser than all treatments.

The different levels of nitrogen, phosphorus and potassium did not significantly influenced the height of first flowering.

4.1.6 Time for Harvest

Time for harvest as influenced by different levels of N, P and K as well as their interactions are presented in the Table 11, 12, 13 and Fig. 5.

Different levels of nitrogen had significant influence on time for harvest. The highest value was reported by n_0 (245.13 days), which differed significantly from other treatments. Lowest value was observed with n_1 (239.48 days), which differed significantly from other treatments.

Main effect of phosphorus had significant influence on time for harvest. Highest value (244.21 days) was observed with p_1, which was on par with p_0 (243.16 days). Lowest value was obtained from p_2 (240.34 days) which differed significantly from other treatments.

Different levels of potassium had significant influence on time for harvest. Highest value was recorded by k_0 (248.25 days) which differed significantly from other treatments. Lowest value was observed from k_1 (239.66 days) which was on par with k_2 (239.8 days).

N x P interaction had significant influence on time for harvest. Highest value was seen with combination n_0p_1 (248.86 days) followed by n_2p_1 (248.35 days), n_1p_0 (247.21 days) and n_0p_2 (247.11 days) which were on par. Lowest value was noticed from n_1p_1 (235.41 days) which was on par with n_1p_2 (235.81 days) and n_2p_2 (238.1 days).

N x K interaction was found have significant influence on time for harvest. Highest value was observed with combination n_1k_0 (254.08 days), which was on par with n_0k_2 (252.93 days). Lowest value was noted with n_1k_2 (222.43 days) which differed significantly from other combinations. This was followed by n_0k_1 (233.23 days), which also differed significantly from other combinations.

P x K interaction was significant. Highest value was noted with combination p_1k_0 (254.36 days), which differed significantly from other combinations. Lowest value was noticed with combination p_1k_2 (237.15 days) followed by p_2k_1 (238.6 days) and p_0k_1 (239.28 days), which were on par.

NPK interaction had significant influence on time for harvest. Highest value was noted with $n_0p_1k_2$ (260.3 days) followed by $n_1p_0k_0$ (259.55 days), $n_1p_0k_1$ (257.55 days) and $n_2p_1k_1$ (254.55 days) which were on par. Lowest value, among treatments was reported by $n_1p_1k_2$ (211.8 days) which differed significantly from other treatments. This was followed by $n_2p_2k_0$ (222.2 days) and $n_1p_2k_2$ (224.0 days). Treatments had significant difference over control, which reported highest value (266.5 days) for harvest.

Nitrogen at 250 g $plant^{-1}$, phosphorus at 300 g $plant^{-1}$and potassium at 500 g $plant^{-1}$, shortened the time for harvesting the first fruit.

4.1.7 Number of Flowers $Cluster^{-1}$

Number of flowers $cluster^{-1}$ as influenced by different levels of N, P and K as well as their interactions are presented in Table 11, 12 and 13.

Main effect of nitrogen, phosphorus and potassium and N x P, N x K, P x K and NPK interactions were not find to have significant influence on number of flowers $cluster^{-1}$. However, the treatments had significant difference over control. Control reported a value of 1.16.

The different levels of nitrogen, phosphorus and potassium did not significantly influenced the number of flowers $cluster^{-1}$.

4.2 YIELD CHARACTERS

4.2.1 Number of Fruits $Plant^{-1}$

Data on the effect of different levels of N, P and K as well as their interactions on number of fruits $plant^{-1}$ are presented in Table 14, 15, 16 and Fig. 6.

Table 14 Effect of different levels of N, P and K on yield characters of papaya

Treatments	Number of fruits plant^{-1}	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)
N levels				
n_0	23.54	946.23	24.88	37.55
n_1	28.60	1015.08	24.65	33.11
n_2	26.06	938.15	23.78	34.15
SE	0.47	7.69	0.77	0.90
CD (0.05)	1.39	22.56	NS	2.65
P levels				
p_0	22.93	1048.29	23.45	36.78
p_1	27.30	978.28	25.37	36.04
p_2	27.96	872.89	24.49	31.98
SE	0.47	7.69	0.77	0.90
CD (0.05)	1.39	22.56	NS	2.65
K levels				
k_0	26.97	930.01	24.11	32.35
k_1	23.28	965.87	23.54	34.01
k_2	27.94	1003.58	25.66	38.45
SE	0.47	7.69	0.77	0.90
CD (0.05)	1.39	22.56	NS	2.65

NS – Non significant

Table 14 Continued

Treatments	Fruit volume (cc)	Pulp percentage	Total yield / plant (kg)	Papain yield (kg ha^{-1})
N levels				
n_0	767.65	77.74	24.88	329.98
n_1	903.65	81.21	30.63	460.65
n_2	824.64	82.02	30.04	322.53
SE	4.89	0.63	0.55	7.24
CD (0.05)	14.35	1.85	1.61	21.23
P levels				
p_0	903.89	79.82	27.27	369.62
p_1	847.31	81.81	31.49	360.47
p_2	744.75	79.35	26.70	383.07
SE	4.89	0.63	0.55	7.24
CD (0.05)	14.35	1.85	1.61	NS
K levels				
k_0	786.27	81.62	27.70	359.10
k_1	817.80	77.77	27.50	325.03
k_2	891.87	81.59	30.36	429.02
SE	4.89	0.63	0.55	7.24
CD (0.05)	14.35	1.85	1.61	21.23

NS – Non significant

Table 15 Interaction effect of different levels of N, P and K on yield characters of papaya

Treatments	Number of fruits $plant^{-1}$	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)
n_0p_0	22.41	1110.02	24.82	40.50
$n_0 p_1$	25.86	896.74	25.36	37.96
n_0p_2	22.35	831.92	24.46	34.18
$n_1 p_0$	24.98	1013.99	23.51	34.18
$n_1 p_1$	29.91	1158.12	26.81	37.50
$n_1 p_2$	30.90	873.11	23.61	27.66
$n_2 p_0$	21.40	1020.85	22.03	35.66
$n_2 p_1$	26.13	879.97	23.93	32.66
$n_2 p_2$	30.65	9130.65	25.39	34.11
SE	0.82	13.32	1.35	1.56
CD (0.05)	2.42	39.08	NS	4.60
n_0k_0	27.03	955.15	25.38	34.65
$n_0 k_1$	23.38	841.22	22.62	35.51
n_0k_2	20.21	1042.32	26.65	42.48
$n_1 k_0$	28.90	822.13	22.20	28.55
$n_1 k_1$	19.96	1167.92	25.10	34.63
$n_1 k_2$	36.93	1055.19	26.65	36.16
$n_2 k_0$	24.98	1012.76	24.75	33.85
$n_2 k_1$	26.51	888.47	22.91	31.88
$n_2 k_2$	26.68	913.23	23.69	36.71
SE	0.82	13.32	1.35	1.56
CD (0.05)	2.42	39.08	NS	NS
p_0k_0	24.43	1083.32	23.43	33.36
$p_0 k_1$	17.56	1119.47	23.18	39.46
p_0k_2	26.80	942.07	23.75	37.51
$p_1 k_0$	27.13	962.71	23.83	35.38
$p_1 k_1$	23.28	909.83	25.01	32.73
$p_1 k_2$	31.50	1062.31	27.26	40.01
$p_2 k_0$	29.35	744.00	25.06	28.30
$p_2 k_1$	29.01	868.31	22.43	29.83
$p_2 k_2$	25.53	1006.37	25.97	37.83
SE	0.82	13.32	1.35	1.56
CD (0.05)	2.42	39.08	NS	4.60

NS – Non significant

Table 15 Continued

Treatments	Fruit volume (cc)	Pulp percentage	Total yield / plant (kg)	Papain yield (kg ha^{-1})
n_0p_0	901.51	78.52	24.85	390.08
$n_0 p_1$	713.90	80.57	27.05	303.11
n_0p_2	687.55	74.14	22.76	296.75
$n_1 p_0$	915.70	82.14	29.73	412.90
$n_1 p_1$	1035.61	82.81	35.10	458.61
$n_1 p_2$	759.65	78.70	27.07	510.45
$n_2 p_0$	894.46	78.79	27.55	305.68
$n_2 p_1$	792.41	82.06	32.33	319.68
$n_2 p_2$	787.05	85.21	30.26	342.03
SE	8.47	1.09	0.95	12.54
CD (0.05)	24.86	3.21	2.80	36.78
n_0k_0	766.58	79.28	31.61	303.08
$n_0 k_1$	648.57	74.11	18.31	334.78
n_0k_2	887.81	79.85	24.73	352.08
$n_1 k_0$	681.90	79.22	24.12	394.66
$n_1 k_1$	1047.08	79.32	31.77	370.91
$n_1 k_2$	981.98	85.11	36.00	616.38
$n_2 k_0$	910.35	86.36	27.36	379.56
$n_2 k_1$	757.76	79.88	32.41	269.41
$n_2 k_2$	805.81	79.82	30.36	318.61
SE	8.47	1.09	0.95	12.50
CD (0.05)	24.86	3.21	2.80	36.78
p_0k_0	939.43	82.83	29.77	355.26
$p_0 k_1$	959.50	82.09	26.54	329.65
p_0k_2	812.75	74.54	25.81	423.95
$p_1 k_0$	807.95	81.11	25.50	307.18
$p_1 k_1$	797.37	75.62	27.61	305.23
$p_1 k_2$	936.61	88.71	41.36	469.00
$p_2 k_0$	611.45	80.92	27.83	414.86
$p_2 k_1$	696.55	75.60	28.34	340.23
$p_2 k_2$	926.25	81.53	23.91	394.16
SE	8.47	1.09	0.95	12.54
CD (0.05)	24.86	3.21	2.80	36.78

Table 16 Highest order interaction of NPK on yield characters of papaya

No.	Treatments	Number of fruits plant^{-1}	Fruit weight (g)	Fruit length (cm)	Fruit girth (cm)
T_1	$n_0p_0k_0$	29.25	1163.65	25.95	40.55
T_2	$n_0p_0k_1$	21.25	959.16	21.86	38.05
T_3	$n_0p_0k_2$	16.75	1207.27	26.65	42.90
T_4	$n_0p_1k_0$	30.55	835.05	24.90	37.00
T_5	$n_0p_1k_1$	20.85	855.97	25.85	34.40
T_6	$n_0p_1k_2$	26.20	999.21	25.35	42.50
T_7	$n_0p_2k_0$	21.30	866.75	25.30	26.40
T_8	$n_0p_2k_1$	28.05	708.53	20.15	34.10
T_9	$n_0p_2k_2$	17.70	920.50	27.95	42.05
T_{10}	$n_1p_0k_0$	24.05	895.76	21.60	24.25
T_{11}	$n_1p_0k_1$	15.90	1246.70	25.30	41.45
T_{12}	$n_1p_0k_2$	35.00	899.45	23.65	36.85
T_{13}	$n_1p_1k_0$	26.05	1116.92	22.65	33.80
T_{14}	$n_1p_1k_1$	19.50	1018.80	24.90	36.40
T_{15}	$n_1p_1k_2$	43.60	1338.65	32.90	42.30
T_{16}	$n_1p_2k_0$	36.00	453.70	22.35	27.60
T_{17}	$n_1p_2k_1$	24.50	1238.18	25.10	26.05
T_{18}	$n_1p_2k_2$	32.20	927.47	23.40	29.35
T_{19}	$n_2p_0k_0$	20.00	1190.57	22.75	35.30
T_{20}	$n_2p_0k_1$	15.55	1152.48	22.40	38.90
T_{21}	$n_2p_0k_2$	28.65	719.50	20.95	32.80
T_{22}	$n_2p_1k_0$	24.20	936.15	23.95	35.35
T_{23}	$n_2p_1k_1$	29.50	854.70	24.30	27.40
T_{24}	$n_2p_1k_2$	24.70	849.06	23.55	35.25
T_{25}	$n_2p_2k_0$	30.75	911.57	27.55	30.90
T_{26}	$n_2p_2k_1$	34.50	658.24	22.05	29.35
T_{27}	$n_2p_2k_2$	26.70	1171.40	26.57	42.10
	SE	1.42	23.07	2.33	2.71
	CD (0.05)	2.96	47.86	NS	5.63
T_{28}	Control	11.15	395.60	16.13	23.45
	Treatments Vs control	S	S	S	S

NS – Non significant, S – Significant

Table 16 Continued

No.	Treatments	Fruit volume (cc)	Pulp percentage	Total yield / plant (kg)	Papain yield (kg ha^{-1})
T_1	$n_0p_0k_0$	975.69	80.19	32.25	356.80
T_2	$n_0p_0k_1$	758.75	76.74	19.80	415.85
T_3	$n_0p_0k_2$	970.10	78.64	22.50	397.60
T_4	$n_0p_1k_0$	669.10	82.07	35.55	251.90
T_5	$n_0p_1k_1$	676.82	72.73	17.40	264.95
T_6	$n_0p_1k_2$	795.80	86.93	28.20	392.50
T_7	$n_0p_2k_0$	654.90	75.58	27.05	300.55
T_8	$n_0p_2k_1$	510.15	72.87	17.75	323.55
T_9	$n_0p_2k_2$	897.55	73.98	23.50	266.15
T_{10}	$n_1p_0k_0$	758.61	81.48	24.47	318.90
T_{11}	$n_1p_0k_1$	1170.20	86.94	37.08	314.25
T_{12}	$n_1p_0k_2$	818.30	77.99	27.65	605.55
T_{13}	$n_1p_1k_0$	899.44	75.16	19.15	323.45
T_{14}	$n_1p_1k_1$	951.85	82.37	26.40	377.80
T_{15}	$n_1p_1k_2$	1255.55	90.91	59.75	674.60
T_{16}	$n_1p_2k_0$	387.65	81.02	28.76	541.65
T_{17}	$n_1p_2k_1$	1019.20	68.64	31.85	420.70
T_{18}	$n_1p_2k_2$	872.10	86.43	20.60	569.00
T_{19}	$n_2p_0k_0$	1084.00	86.83	32.60	390.10
T_{20}	$n_2p_0k_1$	949.55	82.58	22.75	258.85
T_{21}	$n_2p_0k_2$	649.85	66.98	27.30	268.70
T_{22}	$n_2p_1k_0$	855.30	86.11	21.80	346.20
T_{23}	$n_2p_1k_1$	763.45	71.77	39.05	272.95
T_{24}	$n_2p_1k_2$	758.50	88.30	36.15	339.90
T_{25}	$n_2p_2k_0$	791.75	86.15	27.70	402.40
T_{26}	$n_2p_2k_1$	560.30	85.30	35.44	276.45
T_{27}	$n_2p_2k_2$	1009.10	84.11	27.65	347.25
	SE	14.68	1.89	1.71	21.72
	CD (0.05)	30.45	3.93	3.43	45.05
T_{28}	Control	312.90	57.49	5.93	58.65
	Treatments Vs control	S	S	S	S

S – Significant

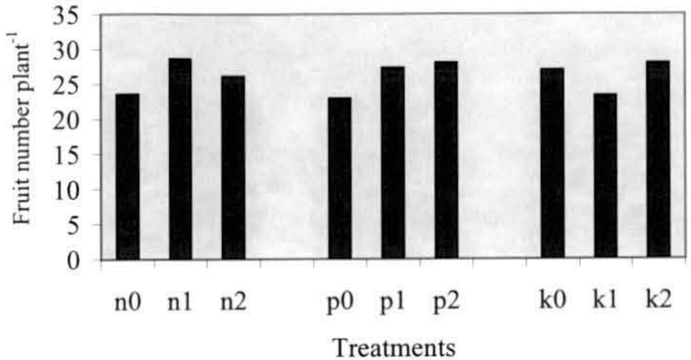


Fig. 6 Effect of different levels of nitrogen, phosphorus and potassium on number of fruits plant^{-1}

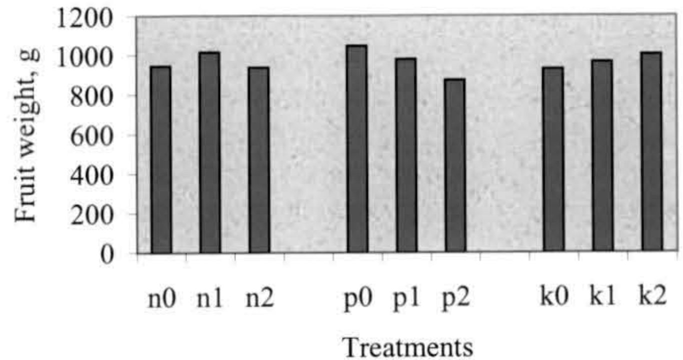


Fig. 7 Effect of different levels of nitrogen, phosphorus and potassium on fruit weight

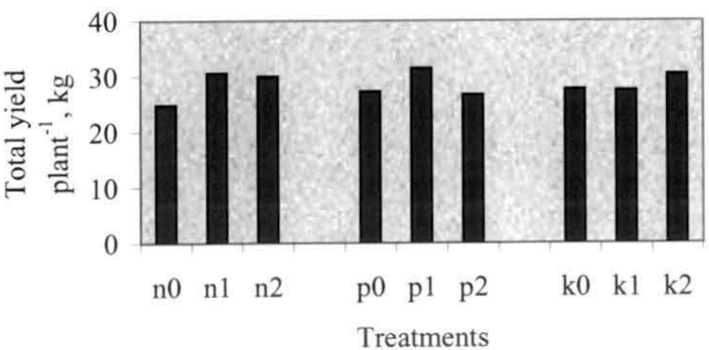


Fig. 8 Effect of different levels of nitrogen, phosphorus and potassium on total yield plant^{-1}

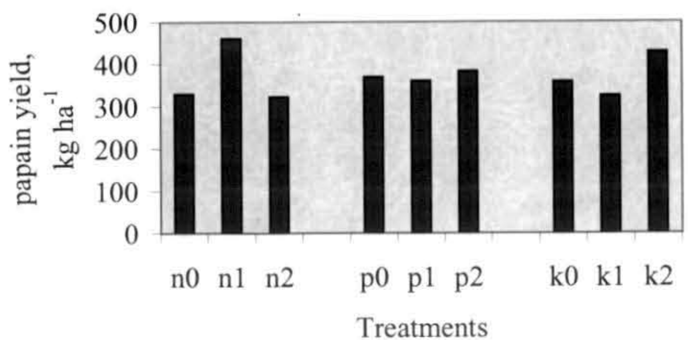


Fig. 9 Effect of different levels of nitrogen, phosphorus and potassium on papain yield

Main effect of nitrogen was found to have significant influence on number of fruits plant^{-1}. Highest value was noted with n_1 (28.6), which differed significantly from other treatments. Lowest value was observed with n_0 (23.54), which differed significantly from n_2 (26.06) and n_1.

Main effect of phosphorus had significant influence on number of fruits plant^{-1}. Highest value (27.96) was observed with p_2, which was on par with p_1 (27.3). Lowest value was noted with p_0 (22.93), which differed significantly from other treatments.

Different levels of potassium had significant influence on number of fruits plant^{-1}. Highest value (27.94) was noticed with k_2, which was on par with k_0 (26.97). Lowest value was obtained from k_1 (23.28) which differed significantly from other treatments.

N x P interaction had significant influence on number of fruits plant^{-1}. Highest value was recorded by the combination. n_1p_2 (30.90), which was on par with n_2p_2 (30.65) and n_1p_1 (29.91). Lowest value was obtained from n_2p_0 (21.4) followed by n_0p_2 (22.35), n_0p_0 (22.41), which were on par.

N x K interaction had significant influence on number of fruits plant^{-1}. Highest value (36.93) was obtained from combination n_1k_2 which differed significantly from other treatments. This was followed by n_1k_0 (28.9), n_0k_0 (27.03), n_2k_2 (26.68) and n_2k_1 (26.51), which were on par. Lowest value was noticed with n_1k_1 (19.96) which was on par with n_0k_2 (20.21).

P x K interaction had significant influence on number of fruits plant^{-1}. Highest value was noticed with p_1k_2 (31.50) followed by p_2k_0 (29.35), which were on par. Lowest value was recorded by p_0k_1 (17.56) which differed significantly from other combinations. This was followed by p_1k_1 (23.28), p_0k_0 (24.43) and p_2k_2 (25.53) which were on par.

NPK interaction was significant. Highest value was obtained from $n_1p_1k_2$ (43.6) which differed significantly from other treatments. This was followed by $n_1p_2k_0$ (36.00), $n_0p_0k_1$ (35.00) and $n_2p_2k_1$ (34.50), which were on par. Lowest value (15.55) among treatment was noticed with $n_2p_0k_1$ followed by $n_1p_0k_1$ (15.90), $n_0p_0k_2$ (16.75) and $n_0p_2k_2$ (17.70) which were on par.

Treatments had significant influence over control, which registered the least value (11.15) for number of fruits plant^{-1}.

Nitrogen at 250 g plant^{-1}, phosphorus at 250 g plant^{-1}and potassium at 500 g plant^{-1} had increased the number of fruits plant^{-1} by way of mean effect as well as interaction effects of the nutrients.

4.2.2 Fruit Weight

Data on fruit weight, as influenced by different levels of N, P and K as well as their interactions are presented in Table 14, 15, 16 and Fig. 7.

Different levels of nitrogen had significant influence on fruit weight. Highest value was reported from n_1 (1015.08 g), which differed significantly from other treatments. n_2 reported the lowest value (938.15 g) which was on par with n_0 (946.23 g).

Main effect of phosphorus was found to have significant influence on fruit weight. p_0 reported the highest value (1048.29 g), which differed significantly from other treatments. p_2 (872.89 g) recorded the lowest value, which differed significantly from p_1 (978.28 g) and p_0.

Main effect of potassium had significant influence on fruit weight. Highest value was obtained from k_2 (1003.50 g) which differed significantly from other treatments. k_0 (930.01 g) reported the lowest value, which also differed significantly from other treatments.

N x P interaction was significant. Highest value was reported from combination n_1p_1 (1158.12 g), which differed significantly from other treatments. Lowest value was obtained from combination n_0p_2 (831.92 g) which differed significantly from other combinations. This was followed by n_1p_2 (873.118 g), n_2p_1 (879.97 g) and n_0p_1 (896.74 g) which were on par.

N x K interaction was significant. Highest value was obtained from combination n_1k_1 (1167.92 g), which differed significantly from other treatments. This was followed by n_1k_2 (1055.19 g) and n_0k_2 (1042.32 g), which were on par. Lowest value was obtained from n_1k_0 (822.13 g), followed by n_0k_1 (841.22 g), which were on par.

P x K interaction had significant influence on fruit weight, combination p_0k_1 (1119.47 g) reported highest value, which was on par with p_0k_0 (1083.32 g). Lowest value was noticed with p_2k_0 (744.00 g), which differed significantly from other combinations.

NPK interaction was found to have significant influence on fruit weight. Highest value was obtained from $n_1p_1k_2$ (1338.65 g), which differed significantly from other treatments. This was followed by $n_1p_0k_1$ (1246.77 g), $n_1p_2k_1$ (1238.18 g) and $n_0p_0k_2$ (1207.27 g) which were on par. Lowest value among treatments was shown by $n_1p_2k_0$ (453.70 g) which differed significantly from other treatments. This was followed by $n_2p_2k_1$ (658.24 g), which also differed significantly from other treatments. Treatments had significant difference over control, which reported lowest value for fruit weight (395.60 g).

Fruit weight was found to increase with nitrogen at 250 g $plant^{-1}$, phosphorus at 250 g $plant^{-1}$ and potassium at 500 g $plant^{-1}$.

4.2.3 Fruit Length

Fruit length as influenced by different levels of N, P and K as well as their interactions are presented in Table 14, 15 and 16.

Main effect of N, P, K. and N x P, N x K, P x K and NPK interactions were not significant.

Fruit length was not significantly affected by various treatments.

4.2.4 Fruit Girth

Data on effect of different levels of N, P and K as well as their interactions on fruit girth are presented in Table 14, 15 and 16.

Main effect of nitrogen was significant. Highest value was registered with n_0 (37.55 cm) which differed significantly from other treatments. Lowest value was registered with n_1 (33.11 cm) which was on par with n_2 (34.15 cm).

Different levels of phosphorus was found to have significant influence on fruit girth. p_0 (36.78 cm) registered the highest value, which was on par with p_1 (36.04 cm). Lowest value was registered by p_2 (31.98 cm).

Main effect of potassium was significant. k_2 (38.45 cm) registered the highest value, which differed significantly from other treatments. k_0 (32.35 cm) registered the lowest value, which was on par with k_1 (34.01 cm).

N x P interaction had significant influence on fruit girth. Highest value was obtained from n_0p_0 (40.50 cm), which was on par with n_0p_1 (37.96 cm) and n_1p_1 (37.50 cm). Lowest value (27.66 cm) was obtained from n_1p_2, which differed significantly from other combinations.

N x K interaction was not significant. P x K interaction was found to have significant influence on plant girth. p_1k_2 (40.01 cm) registered the highest value, followed by p_0k_1 (39.46 cm) and p_2k_2 (37.83 cm), which were on par. p_2k_0 (28.30 cm) registered the lowest value, which was on par with p_2k_1 (29.83 cm) and p_1k_1 (32.73 cm).

NPK interaction was significant. Highest value was obtained from $n_0p_0k_2$ (42.90 cm), which was on par with $n_0p_1k_2$ (42.50 cm), $n_1p_1k_2$ (42.30 cm), $n_2p_2k_2$ (42.70 cm), $n_0p_2k_2$ (42.05 cm), $n_1p_0k_1$ (41.45 cm), $n_0p_0k_0$ (40.55 cm), $n_2p_0k_1$ (38.90 cm) and $n_0p_0k_1$ (38.05 cm). Lowest value among treatments was registered by $n_1p_0k_0$ (24.25 cm), which was on par with $n_1p_2k_1$ (26.05 cm), $n_0p_2k_0$ (26.40 cm), $n_2p_1k_1$ (27.40 cm), $n_1p_2k_0$ (27.60 cm), $n_1p_2k_2$ (29.35 cm) and $n_2p_2k_1$ (29.35 cm).

The treatment had significant difference over control, which reported lowest value for fruit girth (23.45 cm).

Fruit girth was found to increase at nitrogen 200 g plant^{-1}, phosphorus at 200 g plant^{-1} and potassium at 500 g plant^{-1} under single effect as well as combined effect.

4.2.5 Volume of Fruit

Fruit volume as influenced by different levels of N, P and K as well as their interactions are presented in Table 14, 15 and 16.

Different levels of nitrogen had significant influence on fruit volume. Highest value (903.65 cc) was reported by n_1, which differed significantly from other treatments. Lowest value was registered by n_0 (767.65 cc), which differed significantly from other treatments.

Main effect of phosphorus had significant influence on fruit volume. Highest value was reported by p_0 (903.89 cc), which differed significantly from other treatments. Lowest value was registered by p_2 (744.75 cc).

Main effect of potassium was significant. Highest value was reported by k_2 (891.87 cc), which differed significantly from other treatments. k_0 (786.27 cc) reported the lowest value, which differed significantly from other treatments.

N x P interaction was significant. Highest value (1035.61 cc) was obtained from n_1p_1, which differed significantly from other treatments. This was followed by n_1p_0 (915.7 cc), n_0p_0 (901.57 cc) and n_2p_0 (894.46 cc). Lowest value was obtained from n_0p_2 (687.55 cc), which differed significantly from other treatments.

N x K interaction was found to have significant influence on fruit volume. Highest value was obtained from combination n_1k_1 (1047.08 cc), which differed significantly from other treatments. Lowest value was registered by n_0k_1 (648.57 cc), which differed significantly from other treatments.

P x K interaction had significant influence on fruit volume. Highest value was reported by p_0k_1 (959.5 cc), which was on par with p_0k_0 (939.43 cc) and p_1k_2 (936.61 cc). Lowest value (611.45 cc) was reported from p_2k_0, which differed significantly from other treatments.

NPK interaction was found to have significant influence on fruit volume. Highest value was obtained from $n_1p_1k_2$ (1255.55 cc) which differed significantly from other treatments. This was followed by $n_1p_0k_1$ (1170.2 cc), which also differed significantly from other treatments. Lowest value among treatments was obtained from $n_1p_2k_0$ (387.65 cc) which differed significantly from other treatments. The treatments had significant difference over control, which recorded the lowest value for fruit volume (312.9 cc).

Nitrogen at 250 g plant^{-1}, phosphorus at 250 g plant^{-1} and potassium at 500 g plant^{-1} was found to increase fruit volume.

4.2.6 Pulp Percentage

Effect of different levels of N, P and K as well as their interactions on pulp percentage are presented in Table 14, 15 and 16.

Main effect of nitrogen was significant. Highest value was reported by n_2 (82.02 per cent), which was on par with n_1 (81.21 per cent). Lowest value was reported by n_0 (77.74 per cent).

Different levels of phosphorus had significant influence on pulp percentage. p_1 (81.81 per cent) reported the highest value, which differed significantly from other treatments. Lowest value was reported by p_2 (79.35 per cent), which was on par with p_0 (79.82 per cent).

Main effect of potassium had significant influence on pulp percentage. k_0 (81.62 per cent) reported the highest value, which was on par with k_2 (81.59 per cent). Lowest value was reported by k_1 (77.77 per cent).

N x P interaction was significant. Highest value was recorded by combination n_2p_2 (85.21 per cent), which was on par with n_1p_1 (82.81 per cent), n_1p_0 (82.14 per cent) and n_2p_1 (82.06 per cent). Lowest value was obtained from n_0p_2 (74.14 per cent), which differed significantly from other treatments.

N x K interaction had significant influence on pulp percentage. n_2k_0 (86.36 per cent) registered the highest value, which was on par with n_1k_2 (85.11 per cent). Lowest value was registered with n_0k_1 (74.11 per cent), which differed significantly from other treatments.

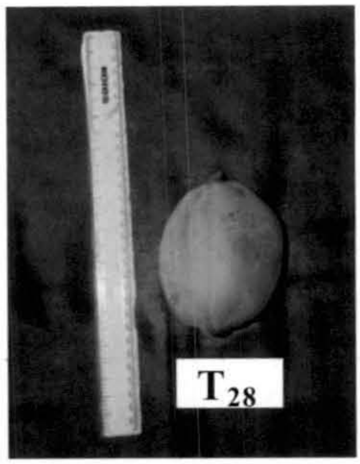
P x K interaction was significant. Highest value (88.71 per cent) was registered by p_1k_2, which differed significantly from other treatments. Lowest value was obtained from p_0k_2 (74.54 per cent), which was on par with p_2k_1 (76.60 per cent) and p_1k_1 (75.62 per cent).

NPK interaction had significant influence on pulp percentage. Highest value was recorded from $n_1p_1k_2$ (90.91 per cent), which was on par with $n_2p_1k_2$ (88.30 per cent). Lowest values among treatments was obtained from $n_2p_0k_2$ (66.98 per cent), followed by $n_2p_1k_1$ (68.64 per cent), which were on par. The treatments had significant difference over control, which reported lowest value (57.49 per cent).

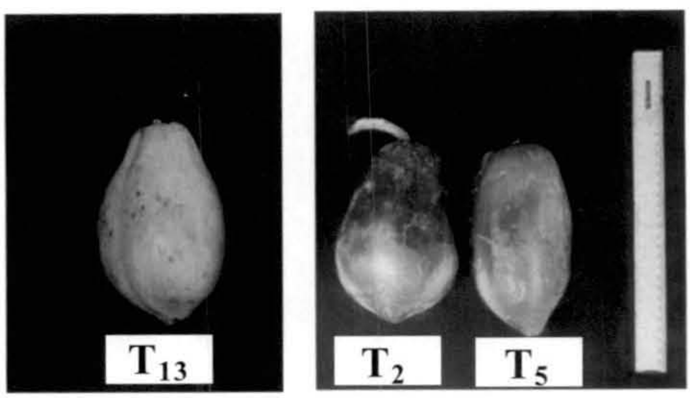
The pulp percentage was found to increase with nitrogen at 250 g plant^{-1}, phosphorus at 250 g plant^{-1}and potassium 500 g plant^{-1}under single as well as combined effect.

4.2.7 Total Yield Plant^{-1}

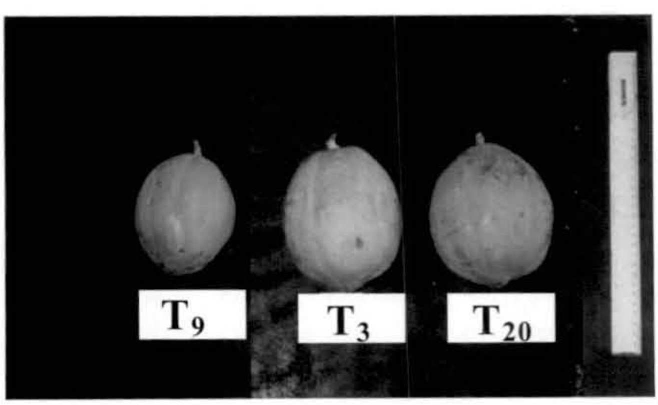
The data on fruit yield plant^{-1}, as influenced by different levels of N, P and K as well as their interactions are presented in Table 14, 15, 16, Fig. 8 and Plate 1.



A. Yield up to 5 kg plant^{-1}

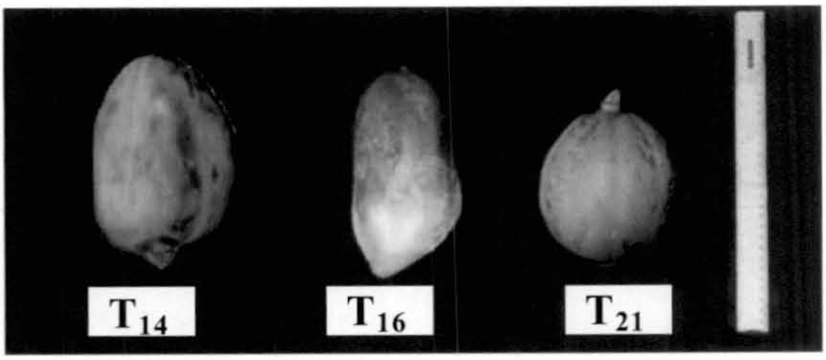


B. Yield up to 15 to 20 kg plant^{-1}

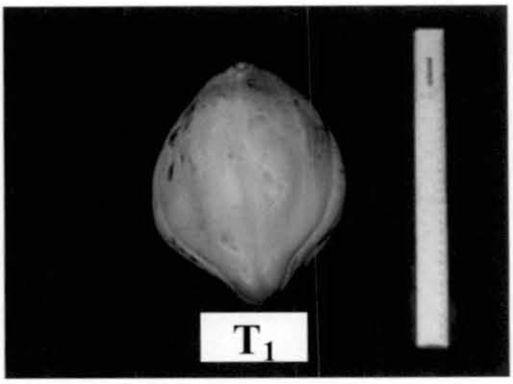


C. Yield upto 21 to 25 kg plant^{-1}

Plate 1. Fruit samples from different treatments



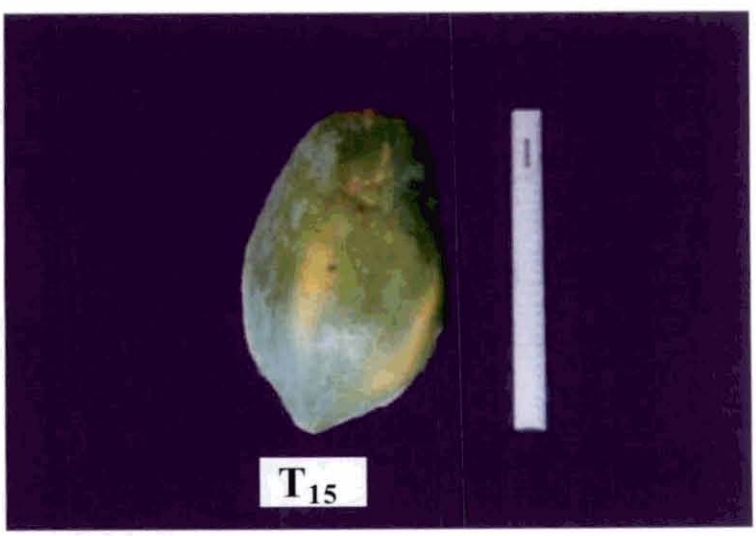
D. Yield upto 26 to 30 kg plant^{-1}



E. Yield upto 31 to 35 kg plant^{-1}

Plate 1. Continued

F. Yield upto 35 to 40 kg $plant^{-1}$



G. Yielding 40 kg and above $plant^{-1}$

Plate 1. Continued

Different levels of nitrogen had significant influence on total fruit yield plant^{-1}. Highest value was noticed with n_1 (30.63 kg), which was on par with n_2 (30.04 kg). Lowest value was reported by n_0 (24.88 kg).

Main effect of phosphorus was significant. p_1 (31.49 kg) produced highest fruit yield plant^{-1}, which differed significantly from other treatments. Lowest value was obtained from p_2 (26.70 kg), which was on par with p_0 (27.37 kg).

Different levels of potassium had significant influence on total yield plant^{-1}. Highest value was recorded by k_2 (30.36 kg), which differed significantly from other treatments. Lowest value was registered by k_1 (27.50 kg), which was on par with k_0 (27.70 kg).

N x P interaction had significant influence on total yield plant^{-1}. n_1p_1 (35.10 kg) registered the highest value, which was on par with n_2p_1 (32.33 kg). Lowest value was recorded with n_0p_2 (22.76 kg), which was on par with n_0p_0 (24.85 kg).

N x K interaction was significant. Highest value was obtained from combination n_1k_2 (36.00 kg), which differed significantly from other treatments. This was followed by n_2k_1 (32.41 kg), n_1k_1 (31.77 kg), n_0k_0 (31.61 kg) and n_2k_2 (30.36 kg), which were on par. Lowest value (18.31 kg) was obtained from n_0k_1, which differed significantly from other treatments.

NPK interaction was significant. Highest value was reported by $n_1p_1k_2$ (59.75 kg) which differed significantly from other treatments. This was followed by $n_2p_1k_1$ (39.05 kg), $n_1p_0k_1$ (37.08 kg) and $n_2p_1k_2$ (36.15 kg), which were on par. Lowest value among treatments was obtained from $n_0p_1k_1$ (17.41 kg), which was on par with $n_0p_2k_1$ (17.75 kg), $n_1p_1k_0$ (19.15 kg), $n_0p_0k_1$ (19.80 kg) and $n_1p_2k_2$ (20.60 kg). The treatments had significant difference over control, which reported the lowest value (5.93 kg).

Nitrogen at 250 g plant^{-1}, phosphorus at 250 g plant^{-1} and potassium 500 g plant^{-1} increased the yield plant^{-1} under main effect as well as interaction effects of nutrients.

4.2.8 Papain Yield

Data on papain yield as influenced by different levels of N, P and K as well as their interactions are presented in Table 14, 15, 16 and Fig. 9.

Main effect of nitrogen had significant influence on papain yield. Highest value was noted with n_1 (460.68 kg ha^{-1}), which differed significantly from other treatments. Lowest value was reported by n_2 (322.53 kg ha^{-1}), which was on par with n_0 (329.98 kg ha^{-1}).

Main effect of phosphorus was not significant.

Main effect of potassium had significant influence on papain yield. Highest value was registered by k_2 (429.02 kg ha^{-1}), which differed significantly from other treatments. Lowest value was obtained from k_1 (325.03 kg ha^{-1}).

N x P intraction had significant influence in papain yield. Highest value was noted with combination n_1p_2 (510.45 kg ha^{-1}), which differed significantly from other treatments. Lowest value was obtained from combination n_0p_2 (296.75 kg ha^{-1}), followed by n_0p_1 (303.11 kg ha^{-1}), n_2p_0 (305.88 kg ha^{-1}) and n_2p_1 (319.68 kg ha^{-1}), which were on par.

N x K interaction had significant influence on papain yield. Highest value was noted with n_1k_2 (616.38 kg ha^{-1}), which differed significantly from other treatments. This followed by n_1k_0 (394.66 kg ha^{-1}), n_2k_0 (379.56 kg ha^{-1}) and n_1k_1 (370.91 kg ha^{-1}), which were on par. Lowest value was noticed with n_2k_1 (269.41 kg ha^{-1}), which was on par with n_0k_0 (303.08 kg ha^{-1}).

P x K interaction was significant. Highest value was noted with combination p_1k_2 (469.00 kg ha^{-1}), which differed significantly from other treatments. Lowest value was recorded by p_1k_1 (305.23 kg ha^{-1}), which was on par with p_1k_0 (307.18 kg ha^{-1}), p_0k_1 (329.65 kg ha^{-1}) and p_2k_1 (340.23 kg ha^{-1}).

NPK interaction had significant influence on papain yield. Highest value was obtained from $n_1p_1k_2$ (674.60 kg ha^{-1}), which differed significantly from other treatments. This was followed by $n_1p_0k_2$ (605.55 kg ha^{-1}) and $n_1p_2k_2$ (569.00 kg ha^{-1}) which were on par. Lowest value among treatments was registered by $n_0p_1k_0$ (251.90 kg ha^{-1}), which was on par with $n_2p_0k_1$ (258.85 kg ha^{-1}), $n_0p_1k_1$ (264.95 kg ha^{-1}), $n_0p_2k_2$ (266.15 kg ha^{-1}), $n_2p_0k_2$ (268.70 kg ha^{-1}), $n_2p_1k_1$ (272.95 kg ha^{-1}) and $n_2p_2k_1$ (276.45 kg ha^{-1}). The treatments had significant difference over control, which reported the least value for papain yield (58.65 kg ha^{-1}).

Nitrogen 250 g $plant^{-1}$, phosphorus at 250 g $plant^{-1}$and potassium 500 g $plant^{-1}$increased papain yield $plant^{-1}$.

4.3 QUALITY CHARACTERS

4.3.1 Total Soluble Solid (TSS)

Data on TSS as influenced by different levels of N, P and K as well as their interactions are presented in Table 17, 18 and 19

Main effect of nitrogen and phosphorus was not significant.

Main effect of potassium had significant influence on TSS. Highest value was reported by k_2 (13.52 per cent), which was on par with k_0 (12.49 per cent), but significantly different from k_1 (11.24 per cent).

N x P interaction had significant influence on TSS. Highest TSS value was recorded by the combination n_0p_2 (14.33 per cent), which was on par with n_1p_1 (12.84 per cent) and n_1p_0 (12.83 per cent). Lowest value was obtained from combination n_2p_2 (11.74 per cent), which was on par with all other combination except n_0p_2.

N x K interaction was significant highest value was obtained from combination n_0k_2 (14.98 per cent), which was on par with n_1k_0 (13.38 per

Table 17 Effect of different levels of N, P and K on TSS, acidity, total carotenoids and ascorbic acid content of papaya

Treatments	TSS (per cent)	Acidity (per cent)	Total carotenoids (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})
N levels				
n_0	12.78	0.19	2.28	42.38
n_1	12.46	0.27	2.11	43.34
n_2	12.05	0.20	2.18	43.31
SE	0.34	0.012	0.11	0.82
CD (0.05)	NS	0.038	NS	NS
P levels				
p_0	12.45	0.25	2.15	42.77
p_1	12.22	0.20	2.22	41.79
p_2	12.59	0.21	2.21	44.47
SE	0.34	0.012	0.11	0.82
CD (0.05)	NS	0.038	NS	NS
K levels				
k_0	12.49	0.21	1.93	42.67
k_1	11.24	0.23	2.31	41.62
k_2	13.52	0.22	2.33	44.74
SE	0.34	0.012	0.11	0.82
CD (0.05)	1.02	NS	0.33	2.41

NS – Non significant

Table 18 Interaction effect of different levels of N, P and K on TSS, acidity, total carotenoids and ascorbic acid content of papaya

Treatments	TSS (per cent)	Acidity (per cent)	Total carotenoids (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})
n_0p_0	12.02	0.20	2.08	41.15
$n_0 p_1$	11.99	0.20	2.33	41.07
n_0p_2	14.33	0.15	2.44	44.93
$n_1 p_0$	12.83	0.30	2.12	44.65
$n_1 p_1$	12.84	0.23	2.19	41.01
$n_1 p_2$	11.70	0.29	2.02	44.37
$n_2 p_0$	12.49	0.26	2.25	42.52
$n_2 p_1$	11.83	0.17	2.13	43.28
$n_2 p_2$	11.74	0.18	2.17	44.12
SE	0.60	0.02	0.19	1.42
CD (0.05)	1.77	NS	NS	NS
n_0k_0	12.10	0.20	1.86	42.01
$n_0 k_1$	11.26	0.20	2.40	39.58
n_0k_2	14.98	0.16	2.60	45.56
$n_1 k_0$	13.38	0.24	1.75	43.07
$n_1 k_1$	11.66	0.24	2.19	41.51
$n_1 k_2$	12.33	0.34	2.39	45.45
$n_2 k_0$	12.00	0.19	2.18	42.92
$n_2 k_1$	10.81	0.25	2.34	43.78
$n_2 k_2$	13.26	0.16	2.02	43.21
SE	0.60	0.02	0.19	1.42
CD (0.05)	1.77	0.06	NS	NS
p_0k_0	12.88	0.23	1.92	43.69
$p_0 k_1$	10.78	0.26	2.61	41.78
p_0k_2	13.68	0.27	1.91	42.85
$p_1 k_0$	11.64	0.16	2.07	39.43
$p_1 k_1$	11.36	0.24	2.17	43.81
$p_1 k_2$	13.66	0.21	2.42	42.12
$p_2 k_0$	12.96	0.24	1.81	44.88
$p_2 k_1$	11.59	0.20	2.15	39.28
$p_2 k_2$	13.23	0.19	2.67	49.25
SE	0.60	0.02	0.19	1.42
CD (0.05)	NS	NS	0.58	4.18

NS – Non significant

Table 19 Highest order interaction of NPK on TSS, acidity, total carotenoids and ascorbic acid content of papaya

No.	Treatments	TSS (per cent)	Acidity (per cent)	Total carotenoids (mg 100 g^{-1})	Ascorbic acid (mg 100 g^{-1})
T_1	$n_0p_0k_0$	11.60	0.13	2.17	41.85
T_2	$n_0p_0k_1$	10.63	0.26	2.56	38.85
T_3	$n_0p_0k_2$	13.84	0.23	1.52	42.75
T_4	$n_0p_1k_0$	10.80	0.20	2.13	40.40
T_5	$n_0p_1k_1$	10.76	0.22	2.33	40.55
T_6	$n_0p_1k_2$	14.43	0.19	2.54	42.28
T_7	$n_0p_2k_0$	13.92	0.26	1.28	43.80
T_8	$n_0p_2k_1$	12.41	0.13	2.31	39.35
T_9	$n_0p_2k_2$	16.67	0.07	3.73	51.65
T_{10}	$n_1p_0k_0$	14.80	0.24	1.80	47.56
T_{11}	$n_1p_0k_1$	11.70	0.29	2.93	41.85
T_{12}	$n_1p_0k_2$	12.00	0.36	1.62	44.55
T_{13}	$n_1p_1k_0$	12.70	0.18	1.85	36.70
T_{14}	$n_1p_1k_1$	10.82	0.20	1.62	43.45
T_{15}	$n_1p_1k_2$	14.98	0.33	3.10	42.90
T_{16}	$n_1p_2k_0$	12.65	0.31	1.61	44.95
T_{17}	$n_1p_2k_1$	12.46	0.23	2.02	39.25
T_{18}	$n_1p_2k_2$	10.02	0.34	2.44	48.92
T_{19}	$n_2p_0k_0$	12.25	0.34	1.79	41.67
T_{20}	$n_2p_0k_1$	10.02	0.22	2.35	44.65
T_{21}	$n_2p_0k_2$	15.21	0.21	2.60	41.25
T_{22}	$n_2p_1k_0$	11.43	0.10	2.20	41.20
T_{23}	$n_2p_1k_1$	12.50	0.29	2.57	47.45
T_{24}	$n_2p_1k_2$	11.57	0.11	1.61	41.20
T_{25}	$n_2p_2k_0$	12.32	0.15	2.53	45.91
T_{26}	$n_2p_2k_1$	9.91	0.24	2.11	39.25
T_{27}	$n_2p_2k_2$	13.00	0.15	1.86	47.20
	SE	1.04	0.03	0.34	2.46
	CD (0.05)	NS	0.08	0.71	NS
T_{28}	Control	7.48	0.43	0.76	31.75
	Treatments Vs control	S	S	S	S

NS – Non significant, S – Significant

cent) and n_2k_2 (13.26 per cent). Lowest value was given by the combination n_2k_1 (10.81 per cent), followed by n_0k_1 (11.26 per cent), n_1k_1 (11.66 per cent), n_2k_0 (12.00 per cent), n_0k_0 (12.10 per cent) and n_1k_2 (12.33 per cent), which were on par.

Interaction P x K and NPK were not significant. The treatments had significant difference over control, which reported lowest value for TSS (7.48 per cent).

Among the major nutrients potassium at 500 g $plant^{-1}$ had a positive effect on TSS of fruits.

4.3.2 Acidity

Acidity as influenced by different levels of N, P and K as well as their interactions are presented in Table 17, 18, 19 and Fig. 10.

Effect of different levels of nitrogen had significant influence on acidity. Highest value was produced by n_1 (0.27 per cent), which differed significantly from other treatments. Lowest value was noticed with n_0 (0.19 per cent), which was on par with n_2 (0.20 per cent).

Different levels of phosphorus had significant influence on acidity. Highest value was obtained from p_0 (0.25 per cent), which differed significantly from other treatments. Lowest value was reported by p_1 (0.20 per cent) which was on par with p_2 (0.21 per cent).

Main effect of potassium was not significant.

Interactions N x P and P x K were also not significant.

Interaction N x K influenced the acidity. Highest value was recorded by the combination n_1k_2 (0.34 per cent), which differed significantly from other combinations. Lowest value was obtained from the combination n_2k_2 (0.16 per cent) and n_0k_2 (0.16 per cent) followed by n_2k_0 (0.19 per cent), n_0k_0 (0.20 per cent), n_0k_1(0.20 per cent) which were on par.

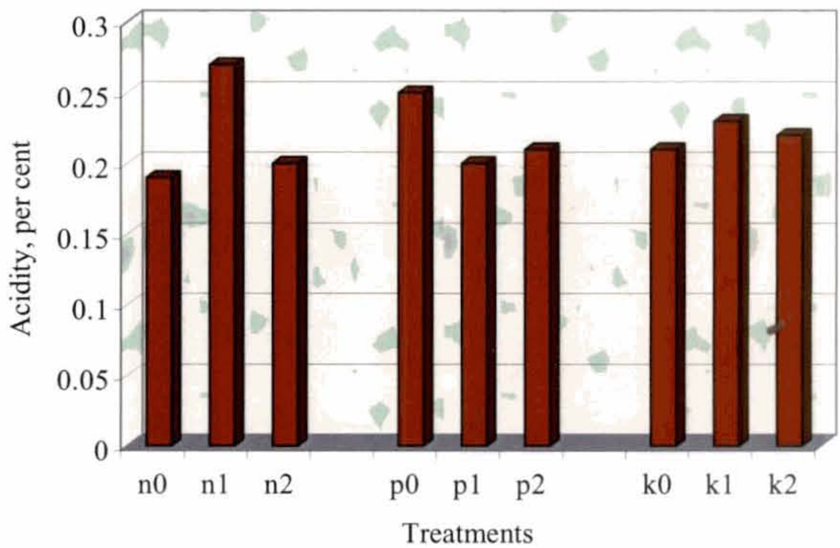


Fig.10 Effect of different levels of nitrogen, phosphorus and potassium on acidity of fruits

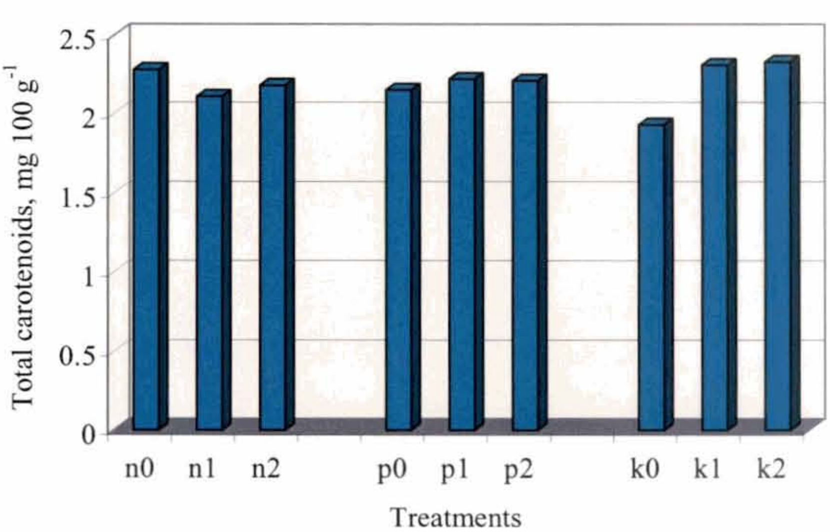


Fig. 11 Effect of different levels of nitrogen, phosphorus and potassium on total carotenoids content of fruits

NPK interaction had significant influence on acidity. Lowest value among treatments was noticed with $n_0p_2k_2$ (0.07 per cent), which was statistically on par with $n_2p_1k_0$ (0.10 per cent), $n_2p_1k_2$ (0.11 per cent), $n_0p_0k_0$ (0.13 per cent), $n_0p_2k_1$ (0.13 per cent) and $n_2p_2k_0$ (0.25 per cent). Highest value was reported by $n_1p_0k_2$ (0.36 per cent), which was followed by $n_1p_2k_2$ (0.34 per cent), $n_2p_0k_0$ (0.34 per cent), $n_1p_1k_2$ (0.33 per cent), $n_1p_2k_0$ (0.31 per cent) , $n_1p_0k_1$ (0.29 per cent) and $n_2p_1k_1$ (0.29 per cent), which were statistically on par. The treatments had significant difference over control, which reported highest value for acidity (0.437 per cent).

Nitrogen at 200 g plant^{-1}, phosphorus at 250 g plant^{-1}had produced fruits of low acidity, while potassium did not significantly influenced.

4.3.3 Total Carotenoids

Total carotenoids as affected by different levels of N, P and K as well as their interactions are presented in Table 17, 18, 19 and Fig. 11.

Main effect of nitrogen and phosphorus were not significant.

Main effect of potassium had profound influence on carotenoid content of fruits. Highest value for carotenoids was obtained from k_2 (2.33 mg 100 g^{-1}), which was on par with k_1 (2.31 mg 100 g^{-1}). These were significantly different from k_0 (1.93 per cent), which showed the lowest value.

Interactions N x P and N x K were not significant.

For carotenoids the interaction P x K was significant. Highest value was noted with the combination p_2k_2 (2.67 mg 100 g^{-1}), followed by p_0k_1 (2.61 mg 100 g^{-1}), p_1k_2 (2.42 mg 100 g^{-1}), p_1k_1 (2.17 mg 100 g^{-1}) and p_2k_1 (2.15 mg 100 g^{-1}), which were statistically on par.

NPK interaction had significant influence on carotenoid content. Highest value for carotenoid was obtained from $n_0p_2k_2$ (3.73 mg 100 g^{-1}), which was on par with $n_1p_1k_2$ (3.10 mg 100 g^{-1}). This was followed by $n_1p_0k_1$ (2.93 mg 100 g^{-1}), $n_2p_0k_2$ (2.60 mg 100 g^{-1}), $n_2p_1k_1$ (2.57 mg 100 g^{-1}),

$n_0p_0k_1$ (2.56 mg 100 g^{-1}), $n_0p_1k_2$ (2.54 mg 100 g^{-1}), $n_2p_2k_0$ (2.53 mg 100 g^{-1}) and $n_1p_2k_2$ (2.44 mg 100 g^{-1}). Lowest value of carotenoids among treatments was obtained from $n_0p_2k_0$ (1.28 mg 100 g^{-1}) which was on par with $n_0p_0k_2$ (1.52 mg 100 g^{-1}), $n_1p_2k_0$ (1.61 mg 100 g^{-1}), $n_2p_1k_2$ (1.61 mg 100 g^{-1}), $n_1p_1k_1$ (1.62 mg 100 g^{-1}), $n_1p_0k_2$ (1.62 mg 100 g^{-1}), $n_2p_0k_0$ (1.79 mg 100 g^{-1}), $n_1p_0k_0$ (1.80 mg 100 g^{-1}), $n_1p_1k_0$ (1.85 mg 100 g^{-1}) and $n_2p_2k_2$ (1.86 mg 100 g^{-1}).

The treatments had significant difference over control which reported lowest carotenoid content (0.766 mg 100 g^{-1}).

The combination of 200 g $plant^{-1}$nitrogen, 300 g $plant^{-1}$ phosphorus and 500 g $plant^{-1}$potassium was found to increase the carotenoid content.

4.3.4 Ascorbic Acid Content

The data on ascorbic acid content of fruits as influenced by different levels of N, P and K as well as their interactions are presented in the Table 17, 18 and 19.

Main effect of nitrogen and phosphorus were not significant.

Main effect of potassium had significant influence on ascorbic acid content of fruits. Higher ascorbic content was seen in the treatment k_2 (44.74 mg 100 g^{-1}), which was on par with k_0 (42.67 mg 100 g^{-1}). k_0 was statistically on par with k_1 (41.62 mg 100 g^{-1}), which showed the lowest value.

Interaction N x P and N x K were not significant.

Interaction P x K had significant influence on ascorbic acid content. Highest value was obtained from combination p_2k_2 (49.25 mg 100 g^{-1}), which differed significantly from other combinations. Lowest value was obtained from combination p_2k_1 (39.28 mg 100 g^{-1}) followed by p_1k_0 (39.43 mg 100 g^{-1}), p_0k_1 (41.78 mg 100 g^{-1}), p_1k_2 (42.12 mg 100 g^{-1}) and p_0k_2 (42.85 mg 100 g^{-1}), which were on par.

NPK interaction was not significant. The treatments had significant difference over control, which reported lowest ascorbic acid content (31.75 mg 100 g^{-1}).

Different levels of nitrogen, phosphorus and potassium did not markedly influence the ascorbic acid content.

4.3.5 Total Sugars

Total sugar content as influenced by different levels of N, P and K as well as their interactions are presented in Table 20, 21, 22 and Fig. 12..

Main effect of nitrogen had significant influence on total sugar content. Highest value was noticed with n_0 (11.98 per cent), which differed significantly from other treatments. Lowest value was observed with n_2 (10.85 per cent), which was on par with n_1 (10.93 per cent).

Different levels of phosphorus had significant influence on total sugar content. Highest value was obtained from p_0 (11.59 per cent), which differed significantly from other treatments. Lowest value was obtained form p_1 (10.81 per cent), which differed significantly from other treatment.

Different levels of potassium was found to have significant influence on total sugar content. Highest value was noticed with k_2 (13.47 per cent), which differed significantly from other treatments. Lowest value was obtained from k_1 (9.88 per cent), which differed significantly from k_0 (10.41 per cent) and k_2.

N x P interaction had significant influence on total sugar content. Highest value was obtained from combination n_0p_2 (12.57 per cent), which was on par with n_0p_0 (12.46 per cent). Lowest value was noted with combination n_1p_1 (10.29 per cent), which was on par with n_2p_2 (10.55 per cent).

N x K interaction was found to have significant effect on total sugar content. Highest value was obtained from combination n_0k_2 (14.73 per cent),

Table 20 Effect of different levels of N, P and K on sugar content of papaya

Treatments	Total sugars (per cent)	Reducing sugars (per cent)	Non reducing sugars (per cent)
N levels			
n_0	11.98	10.01	1.97
n_1	10.93	8.82	2.11
n_2	10.85	8.96	1.89
SE	0.07	0.03	0.12
CD (0.05)	0.22	0.11	NS
P levels			
p_0	11.59	9.31	2.28
p_1	10.81	9.07	1.74
p_2	11.36	9.41	1.95
SE	0.07	0.03	0.12
CD (0.05)	0.22	0.11	0.37
K levels			
k_0	10.41	8.59	1.82
k_1	9.88	7.70	2.18
k_2	13.47	11.49	1.98
SE	0.07	0.03	0.12
CD (0.05)	0.22	0.11	NS

NS – Non significant

Table 21 Interaction effect of different levels of N, P and K on sugar content of papaya

Treatments	Total sugars (per cent)	Reducing sugars (per cent)	Non reducing sugars (per cent)
n_0p_0	12.46	10.23	2.23
$n_0\ p_1$	10.90	9.07	1.83
n_0p_2	12.57	10.72	1.85
$n_1\ p_0$	11.55	8.95	2.60
$n_1\ p_1$	10.29	8.81	1.48
$n_1\ p_2$	10.95	8.71	2.24
$n_2\ p_0$	10.76	8.75	2.01
$n_2\ p_1$	11.24	9.33	1.91
$n_2\ p_2$	10.55	8.80	1.75
SE	0.13	0.06	0.22
CD (0.05)	0.39	0.19	NS
n_0k_0	10.62	8.83	1.79
$n_0\ k_1$	10.59	8.45	2.14
n_0k_2	14.73	12.74	1.99
$n_1\ k_0$	11.14	9.03	2.11
$n_1\ k_1$	9.13	7.01	2.12
$n_1\ k_2$	12.52	10.43	2.09
$n_2\ k_0$	9.46	7.91	1.55
$n_2\ k_1$	9.93	7.65	2.28
$n_2\ k_2$	13.15	11.31	1.84
SE	0.13	0.06	0.22
CD (0.05)	0.39	0.19	NS
p_0k_0	11.08	9.03	2.05
$p_0\ k_1$	10.05	7.58	2.47
p_0k_2	13.65	11.32	2.33
$p_1\ k_0$	10.46	8.83	1.63
$p_1\ k_1$	9.11	7.08	2.03
$p_1\ k_2$	12.86	11.30	1.56
$p_2\ k_0$	9.67	7.92	1.75
$p_2\ k_1$	10.49	8.45	2.04
$p_2\ k_2$	13.90	11.86	2.04
SE	0.13	0.06	0.22
CD (0.05)	0.39	0.19	NS

NS – Non significant

Table 22 Highest order interaction of NPK on sugar content of papaya

No.	Treatments	Total sugars (per cent)	Reducing sugars (per cent)	Non reducing sugars (per cent)
T_1	$n_0p_0k_0$	12.25	10.38	1.87
T_2	$n_0p_0k_1$	10.60	8.60	2.00
T_3	$n_0p_0k_2$	14.55	11.72	2.83
T_4	$n_0p_1k_0$	8.73	7.24	1.49
T_5	$n_0p_1k_1$	9.73	7.31	2.42
T_6	$n_0p_1k_2$	14.25	12.66	1.59
T_7	$n_0p_2k_0$	10.88	8.87	2.01
T_8	$n_0p_2k_1$	11.43	9.45	1.98
T_9	$n_0p_2k_2$	15.41	13.85	1.56
T_{10}	$n_1p_0k_0$	12.68	9.71	2.97
T_{11}	$n_1p_0k_1$	8.29	5.09	3.20
T_{12}	$n_1p_0k_2$	13.70	12.05	1.65
T_{13}	$n_1p_1k_0$	12.15	10.85	1.30
T_{14}	$n_1p_1k_1$	7.70	6.40	1.30
T_{15}	$n_1p_1k_2$	11.03	9.20	1.83
T_{16}	$n_1p_2k_0$	8.59	6.55	2.04
T_{17}	$n_1p_2k_1$	11.42	9.55	1.87
T_{18}	$n_1p_2k_2$	12.85	10.05	2.80
T_{19}	$n_2p_0k_0$	8.33	7.00	1.33
T_{20}	$n_2p_0k_1$	11.26	9.05	2.21
T_{21}	$n_2p_0k_2$	12.70	10.20	2.50
T_{22}	$n_2p_1k_0$	10.50	8.39	2.11
T_{23}	$n_2p_1k_1$	9.92	7.55	2.30
T_{24}	$n_2p_1k_2$	13.30	12.05	1.25
T_{25}	$n_2p_2k_0$	9.56	8.35	1.21
T_{26}	$n_2p_2k_1$	8.63	6.35	2.28
T_{27}	$n_2p_2k_2$	13.45	11.70	1.75
	SE	0.23	0.35	0.38
	CD (0.05)	0.47	0.23	NS
T_{28}	Control	5.65	4.35	1.30
	Treatments Vs control	S	S	S

NS – Non significant, S – Significant

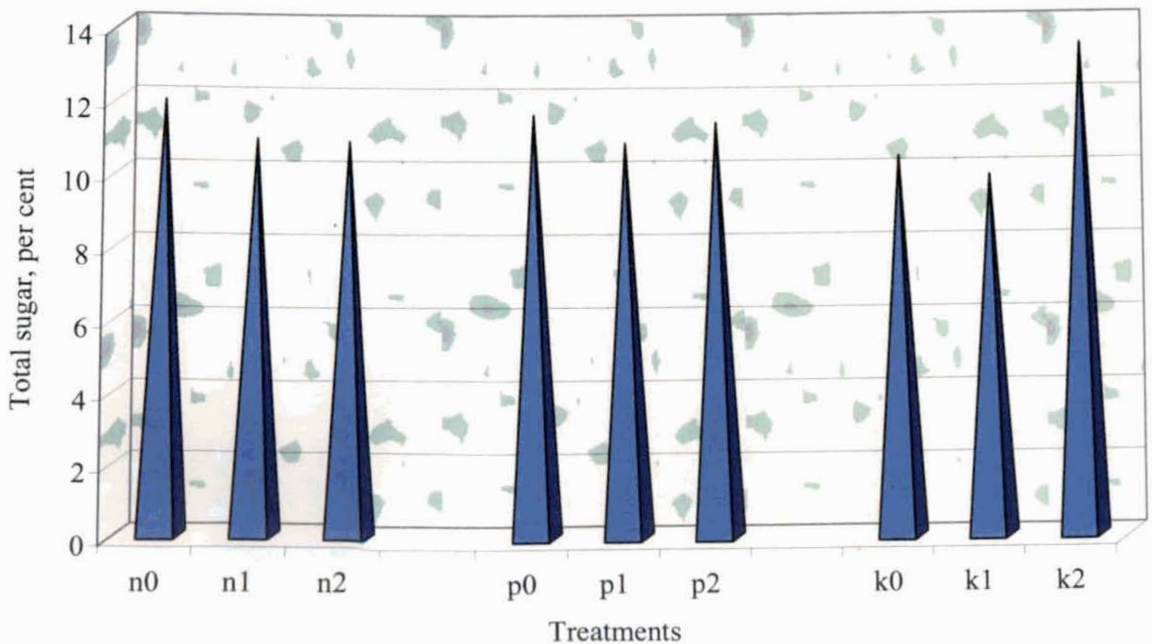


Fig. 12 Effect of different levels of nitrogen, phosphorus and potassium on total sugar contents of fruits

which differed significantly from other treatments. Lowest value was obtained from n_1k_1 (9.13 per cent), which was on par with n_2k_0 (9.46 per cent).

P x K interaction had significant influence on total sugar content. Highest value was noticed with combination p_2k_2 (13.9 per cent), which was on par with p_0k_2 (13.65 per cent). Lowest value was noted with combination p_1k_1 (9.11 per cent), which differed significantly from other combinations. This was followed by p_2k_0 (9.67 per cent), which was on par with p_0k_1 (10.05 per cent).

NPK interaction was found to have significant influence on total sugar content. Highest value (15.41 per cent) was noticed with $n_0p_2k_2$, which differed significantly from other treatments. This was followed by $n_0p_0k_2$ (14.55 per cent) and $n_0p_1k_2$ (14.25 per cent), which were on par. Lowest value, among treatments was obtained from $n_1p_1k_1$ (7.7 per cent), which differed significantly from other treatments. This was followed by $n_1p_0k_1$ (8.29 per cent), which was on par with $n_2p_0k_0$ (8.33 per cent), $n_1p_2k_0$ (8.59 per cent), $n_2p_2k_1$ (8.63 per cent) and $n_0p_1k_0$ (8.73 per cent). The treatment had significant difference over control, which reported least value for total sugar content (5.65 per cent).

Nitrogen at 200 g plant^{-1}, phosphorus at 200 g plant^{-1}and potassium at 500 g plant^{-1} was found to increase total sugar content of fruits.

4.3.6 Reducing Sugars

Data on reducing sugar content as affected by different levels of N, P and K as well as their interactions are presented in Table 20, 21 and 22.

Different levels of nitrogen was found to have significant influence on reducing sugar content. Highest value was recorded by n_0 (10.01 per cent), which differed significantly from other treatments. Lowest value was reported by n_1 (8.82 per cent), which differed significantly from other treatments.

Main effect of phosphorus had significant influence on reducing sugar content. Highest value was observed with p_2 (9.41 per cent), which was on par with p_0 (9.31 per cent). Lowest value was reported by p_1 (9.07 per cent), which differed significantly from other treatments.

Different levels of potassium had significant influence on reducing sugar content. Highest value was seen with k_2 (11.49 per cent), which differed significantly from other treatments. Lowest value was observed with k_1 (7.7 per cent), which differed significantly from k_0 (8.59 per cent) and k_2.

N x P interaction had significant influence on reducing sugar content. Combination n_0p_2 (10.72 per cent) reported highest value, which differed significantly from other combinations. This was followed by combination n_0p_0 (10.23 per cent), which also differed significantly from other combinations. Lowest value was reported by combination n_1p_2 (8.71 per cent), followed by n_2p_0 (8.75 per cent), n_2p_2 (8.8 per cent) and n_1p_1 (8.81 per cent) which were on par.

N x K interaction had significant influence on reducing sugar content. Combination n_0k_2 (12.74 per cent) reported highest value, which differed significantly from other treatments. Lowest value was reported by combination n_1k_1 (7.01 per cent) which also differed significantly from other treatments.

P x K interaction was found to have significant influence on reducing sugar content. Highest value was noticed with p_2k_2 (11.86 per cent) which differed significantly from other treatments. Lowest value was reported by p_1k_1 (7.08 per cent), which also differed significantly from other treatments.

NPK interaction had significant influence on reducing sugar content. Highest value was noticed with $n_0p_2k_2$ (13.85 per cent), which differed significantly from other treatments. Lowest value among treatments was noted with $n_1p_0k_1$ (5.09 per cent), which was on par with $n_2p_2k_1$ (6.35 per cent), $n_1p_1k_1$ (6.4 per cent) and $n_1p_2k_0$ (6.55 per cent). The treatments had significant difference over control, which reported lowest reducing sugar content (4.35 per cent).

Main effect of 200 g plant^{-1} of nitrogen, 300 g plant^{-1} phosphorus and 500 g plant^{-1} potassium and their interaction increased reducing sugars in the fruits.

4.3.7 Non Reducing Sugars

Non reducing sugar content as influenced by different levels of N, P and K as well, as their interactions are presented in Table 20, 21 and 22.

Main effects of nitrogen and potassium were not significant. Different levels of phosphorus had significant influence on non reducing sugar content. Highest value was obtained from p_0 (2.28 per cent), which was on par with p_2 (1.95 per cent). Lowest value was recorded by p_1 (1.74 per cent), which differed significantly from p_2 and p_0.

N x P, N x K, P x K and NPK interactions were not significant.

In general, the treatments did not increase the non reducing sugar content.

4.3.8 Colour of Peel

Peel colour of fruit at edible ripe stage are presented in Table 23.

Treatments $n_0p_0k_2$, $n_0p_1k_1$, $n_0p_2k_0$, $n_0p_2k_1$, $n_1p_1k_1$, $n_1p_2k_0$, $n_1p_2k_1$, $n_2p_0k_1$ and $n_2p_2k_0$ had yellowish green peel colour. Rest all the treatments had light yellow peel colour.

4.3.9 Colour of Pulp

Colour of pulp at edible ripe stage are presented in Table 23.

Treatments $n_0p_0k_1$, $n_0p_0k_2$, $n_0p_1k_0$, $n_1p_0k_1$, $n_1p_1k_0$, $n_1p_1k_1$, $n_1p_2k_2$ and $n_2p_2k_2$ had yellowish orange pulp colour. Rest of the treatment had orange pulp colour.

Table 23 Effect of N, P and K on peel and quality of papaya

Treatments	Colour of peel	Colour of pulp	Firmness of pulp
T_1	Light yellow	Orange	Firm
T_2	Light yellow	Yellowish orange	Firm
T_3	Yellowish green	Yellowish orange	Fairly firm
T_4	Light yellow	Yellowish orange	Fairly firm
T_5	Yellowish green	Orange	Firm
T_6	Light yellow	Orange	Fairly firm
T_7	Yellowish green	Orange	Firm
T_8	Yellowish green	Orange	Fairly firm
T_9	Light yellow	Orange	Firm
T_{10}	Light yellow	Orange	Fairly firm
T_{11}	Light yellow	Yellowish orange	Firm
T_{12}	Light yellow	Orange	Fairly firm
T_{13}	Light yellow	Yellowish orange	Fairly firm
T_{14}	Yellowish green	Yellowish orange	Firm
T_{15}	Light yellow	Orange	Firm
T_{16}	Yellowish green	Orange	Firm
T_{17}	Yellowish green	Orange	Firm
T_{18}	Light yellow	Yellowish orange	Fairly firm
T_{19}	Light yellow	Orange	Firm
T_{20}	Yellowish green	Orange	Fairly firm
T_{21}	Light yellow	Orange	Firm
T_{22}	Light yellow	Orange	Firm
T_{23}	Light yellow	Orange	Firm
T_{24}	Light yellow	Orange	Fairly firm
T_{25}	Yellowish green	Orange	Firm
T_{26}	Light yellow	Orange	Firm
T_{27}	Light yellow	Yellowish orange	Firm
T_{28}	Light yellow	Orange	Firm

4.3.10 Firmness of Pulp

Data on firmness of pulp are presented in Table 23.

Treatments $n_0p_0k_2$, $n_0p_1k_0$, $n_0p_1k_2$, $n_0p_2k_1$, $n_1p_0k_0$, $n_1p_0k_2$, $n_1p_1k_0$, $n_1p_2k_2$, $n_2p_0k_1$ and $n_2p_1k_2$ had fairly firm flesh. Rest all treatments had firm flesh.

4.3.11 Organoleptic Qualities

Data on organoleptic qualities of papaya are presented in Table 24.

The mean score obtained for appearance ranged between 1.34 to 3.72. $n_0p_2k_2$ obtained highest score followed by $n_1p_1k_1$ and $n_0p_1k_0$. Lowest score was obtained for T_{28} (control).

The evaluation of colour revealed that $n_0p_2k_2$ obtained highest score followed by $n_0p_0k_2$ and $n_0p_0k_0$. Lowest score was seen for control. Scores obtained for colour ranged from 2.12 to 3.84.

While considering the flavour, it was noted that highest score was obtained for $n_1p_1k_1$, followed by $n_0p_2k_2$. The lowest score was recorded for $n_1p_0k_1$ followed by $n_2p_2k_0$. Scores obtained for flavour ranged from 2.51 to 3.53.

Mean scores obtained for taste ranged between 1.76 to 3.73. $n_0p_2k_2$ recorded highest score followed by $n_2p_2k_0$ and $n_1p_1k_2$. Lowest score was recorded by $n_2p_1k_0$ followed by $n_0p_2k_1$ and $n_2p_2k_2$.

With regard to texture of pulp, it was seen that $n_1p_1k_2$ recorded the highest score followed by $n_0p_2k_2$ and $n_0p_0k_2$. Lowest score was observed with $n_2p_2k_2$ followed by $n_0p_0k_2$. Scores obtained for texture ranged between 2.14 to 3.53.

Freedom from papain odour is our important quality attribute with regard to papaya. Highest score was secured by $n_0p_2k_2$ followed by $n_1p_2k_0$ and $n_1p_0k_1$. Lowest score was recorded by $n_2p_1k_0$. followed by $n_2p_2k_2$ and $n_2p_0k_0$. The scores ranged between 1.5 to 3.54.

Table 24 Organoleptic qualities of papaya (mean score)

Treatments	Appearance	Colour	Flavour	Taste	Texture	Papain odour	Overall acceptability
T_1	2.51	3.61	2.68	2.13	2.89	2.04	15.86
T_2	1.81	2.56	2.79	2.51	3.05	1.99	14.71
T_3	3.33	3.66	3.17	3.20	3.42	3.20	19.98
T_4	3.50	2.50	3.33	2.82	2.54	2.56	17.25
T_5	2.25	2.31	2.65	2.34	2.66	2.81	15.02
T_6	2.80	2.25	2.73	2.02	3.00	2.20	15.00
T_7	3.12	3.40	3.00	2.51	2.91	3.14	16.08
T_8	2.46	2.80	2.51	1.81	2.78	1.93	14.29
T_9	3.72	3.84	3.51	3.73	3.52	3.54	21.85
T_{10}	2.83	3.03	2.90	3.00	2.81	2.85	17.42
T_{11}	3.00	3.23	2.51	2.81	3.18	3.26	17.99
T_{12}	2.55	2.61	2.94	3.16	2.69	3.19	17.14
T_{13}	3.43	3.00	2.89	2.93	2.93	2.73	17.91
T_{14}	3.52	2.52	3.53	2.89	3.01	2.24	17.71
T_{15}	3.20	3.46	3.28	3.26	3.53	3.03	19.76
T_{16}	2.52	3.24	3.01	3.21	2.24	3.34	17.56
T_{17}	2.67	2.56	2.63	1.93	3.08	1.71	14.58
T_{18}	3.14	3.53	2.85	2.10	2.98	2.91	17.51
T_{19}	3.00	2.93	3.11	1.93	3.40	1.65	16.02
T_{20}	3.21	3.41	3.42	3.20	3.30	3.20	19.74
T_{21}	2.56	3.28	2.95	2.32	2.18	2.85	16.14
T_{22}	2.91	2.64	3.28	1.76	2.53	1.50	14.62
T_{23}	3.02	3.19	2.81	1.98	2.46	1.68	15.14
T_{24}	2.73	3.22	2.62	2.61	3.14	2.67	16.57
T_{25}	3.10	3.00	2.52	3.36	2.98	2.83	17.79
T_{26}	2.83	2.93	3.08	3.21	3.00	2.54	15.59
T_{27}	3.22	3.23	3.40	1.86	2.14	1.55	15.40
T_{28}	1.34	2.12	2.53	2.61	2.90	2.24	13.74

A detailed assessment of the organoleptic quality of papaya, it was seen that $n_0p_2k_2$ was most acceptable with a score of 21.85 followed by $n_0p_0k_2$ and $n_1p_1k_2$. Least mean score was observed with control (13.74), followed by $n_0p_2k_1$.

In general the combination of 200 g plant^{-1} nitrogen, 300 g plant^{-1} phosphorus and 500 g plant^{-1} potassium was found to improve the organoleptic qualities of the fruits.

4.3.12 Shelf Life

Data on shelf life of papaya at ambient conditions as influenced by different levels of N, P and K as well their interactions are presented in Table 25, 26, 27 and Fig. 13.

Main effect of nitrogen had significant influence on shelf life of papaya. Highest value was obtained from n_0 (5.60 days), which differed significantly from other treatments. Lowest value was obtained from n_1 (5.07 days), which differed significantly from n_2 (5.35 days) and n_0.

Different levels of phosphorus had significant influence on shelf life of papaya. Highest shelf life was obtained from p_1 (5.46 days), which was on par with p_0 (5.45 days). Lowest value was obtained from p_2 (5.12 days), which differed significantly from other treatments.

Different levels of potassium had significant influence on shelf life of papaya. Highest shelf life was noted with k_2 (5.55 days), which differed significantly from other treatments. Lowest shelf life was reported by k_0 (5.02 days), which differed significantly from k_1 (5.45 days) and k_2.

N x P interaction had significant influence on shelf life of papaya. Highest value was noticed with combination n_0p_1 (5.91 days), which differed significantly from other combinations. This was followed by n_0p_2 (5.51 days) which was on par with n_2p_0 (5.5 days), n_1p_0 (5.46 days), n_2p_1

Table 25 Effect of different levels of N, P and K on shelf life of papaya

Treatments	Shelf life (days)
N levels	
n_0	5.60
n_1	5.07
n_2	5.35
SE	0.03
CD (0.05)	0.09
P levels	
p_0	5.45
p_1	5.46
p_2	5.12
SE	0.03
CD (0.05)	0.09
K levels	
k_0	5.02
k_1	5.45
k_2	5.55
SE	0.03
CD (0.05)	0.09

Table 26 Interaction effect of different levels of N, P and K on shelf life of papaya

Treatments	Shelf life (days)
n_0p_0	5.38
$n_0 p_1$	5.91
n_0p_2	5.51
$n_1 p_0$	5.46
$n_1 p_1$	5.01
$n_1 p_2$	4.75
$n_2 p_0$	5.50
$n_2 p_1$	5.43
$n_2 p_2$	5.11
SE	0.05
CD (0.05)	0.16
n_0k_0	4.88
$n_0 k_1$	6.10
n_0k_2	5.83
$n_1 k_0$	4.11
$n_1 k_1$	5.56
$n_1 k_2$	5.55
$n_2 k_0$	6.06
$n_2 k_1$	4.70
$n_2 k_2$	5.28
SE	0.05
CD (0.05)	0.16
p_0k_0	5.48
$p_0 k_1$	5.91
p_0k_2	4.95
$p_1 k_0$	5.61
$p_1 k_1$	4.41
$p_1 k_2$	6.33
$p_2 k_0$	3.96
$p_2 k_1$	6.03
$p_2 k_2$	5.38
SE	0.05
CD (0.05)	0.16

Table 27 Highest order interaction of NPK on shelf life of papaya

No.	Treatments	Shelf life (days)
T_1	$n_0p_0k_0$	5.15
T_2	$n_0p_0k_1$	6.95
T_3	$n_0p_0k_2$	4.05
T_4	$n_0p_1k_0$	5.40
T_5	$n_0p_1k_1$	6.05
T_6	$n_0p_1k_2$	6.30
T_7	$n_0p_2k_0$	4.10
T_8	$n_0p_2k_1$	5.30
T_9	$n_0p_2k_2$	7.15
T_{10}	$n_1p_0k_0$	4.00
T_{11}	$n_1p_0k_1$	6.80
T_{12}	$n_1p_0k_2$	5.60
T_{13}	$n_1p_1k_0$	4.70
T_{14}	$n_1p_1k_1$	3.35
T_{15}	$n_1p_1k_2$	7.00
T_{16}	$n_1p_2k_0$	3.65
T_{17}	$n_1p_2k_1$	6.55
T_{18}	$n_1p_2k_2$	4.05
T_{19}	$n_2p_0k_0$	7.30
T_{20}	$n_2p_0k_1$	4.00
T_{21}	$n_2p_0k_2$	5.20
T_{22}	$n_2p_1k_0$	6.75
T_{23}	$n_2p_1k_1$	3.85
T_{24}	$n_2p_1k_2$	5.70
T_{25}	$n_2p_2k_0$	4.15
T_{26}	$n_2p_2k_1$	6.25
T_{27}	$n_2p_2k_2$	4.95
	SE	0.10
	CD (0.05)	0.20
T_{28}	Control	3.16
	Treatments Vs control	S

S – Significant

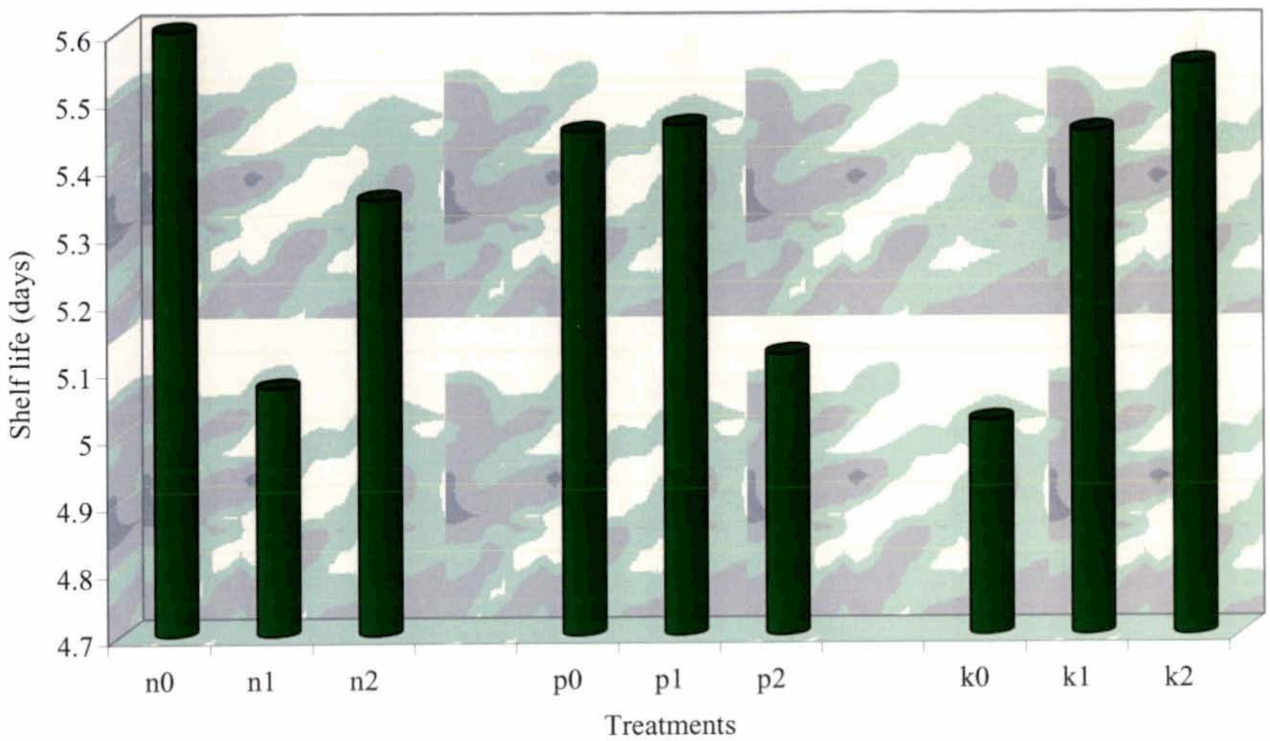


Fig. 13 Effect of different levels of nitrogen, phosphorus and potassium on shelf life of fruits

(5.43 days) and n_0p_0 (5.38 days). Lowest value was reported by n_1p_2 (4.75 days), which differed significantly from other combinations.

N x K interaction had significant influence on shelf life of papaya. Highest shelf life was obtained from combination n_0k_1 (6.1 days), which was on par with n_2k_0 (6.06 days). Lowest shelf life was noticed with n_1k_0 (4.11 days), which differed significantly from other combinations.

P x K interaction was found to have significant influence on shelf life of papaya. Combination p_1k_2 (6.33 days) reported highest shelf life, which differed significantly from other combinations. This was followed by p_2k_1 (6.03 days) and p_0k_1 (5.91 days), which were on par. Lowest value was noticed with combination p_2k_0 (3.96 days), which differed significantly from other combinations.

NPK interaction had significant influence on shelf life of papaya. Highest shelf life was obtained from $n_2p_0k_0$ (7.3 days), which was on par with $n_0p_2k_2$ (7.15 days). This was followed by $n_1p_1k_2$ (7.0 days) and $n_0p_0k_1$ (6.95 days) which were on par. Lowest value, among treatment was recorded from $n_1p_1k_1$ (3.35 days) which differed significantly from other treatments. The treatments had significant difference over control, which reported lowest shelf life (3.16 days).

In general, it was observed that nitrogen at 200 g plant^{-1}, phosphorus at 250 g plant^{-1}and potassium at 500 g plant^{-1}was found to increase the shelf life of fruits.

4.4 NUTRIENT UPTAKE

4.4.1 Soil Nitrogen

Data on soil nitrogen content as influenced by different levels of N, P and K and their interactions are presented in Table 28, 29 and 30.

Main effect of nitrogen had significant influence on soil nitrogen content. Highest value was reported by n_1 (351.82 kg ha^{-1}), which differed significantly from other treatments. Lowest value was obtained

Table 28 Effect of different levels of N, P and K on soil nitrogen, phosphorus and potassium content

Treatments	Soil Nitrogen (kg ha^{-1})	Soil Phosphorus (kg ha^{-1})	Soil Potassium (kg ha^{-1})
N levels			
n_0	327.52	95.71	275.78
n_1	351.82	96.95	299.43
n_2	298.09	93.56	300.95
SE	6.41	0.54	1.59
CD (0.05)	18.81	1.59	4.66
P levels			
p_0	302.18	83.65	287.87
p_1	315.92	94.49	291.90
p_2	359.34	108.07	296.40
SE	6.41	0.54	1.59
CD (0.05)	18.81	1.59	4.66
K levels			
k_0	320.93	87.40	274.21
k_1	302.43	98.97	268.58
k_2	354.07	99.83	333.37
SE	6.41	0.54	1.59
CD (0.05)	18.81	1.59	4.66

Table 29 Interaction effect of different levels of N, P and K on soil nitrogen, phosphorus and potassium content

Treatments	Soil Nitrogen (kg ha^{-1})	Soil Phosphorus (kg ha^{-1})	Soil Potassium (kg ha^{-1})
n_0p_0	299.38	86.53	265.85
$n_0 p_1$	340.51	92.69	282.33
n_0p_2	342.68	107.91	279.18
$n_1 p_0$	343.50	81.55	293.98
$n_1 p_1$	342.50	94.79	308.18
$n_1 p_2$	369.48	114.50	296.13
$n_2 p_0$	263.66	82.80	303.80
$n_2 p_1$	264.75	96.00	285.18
$n_2 p_2$	365.86	101.80	313.88
SE	11.11	0.94	2.75
CD (0.05)	32.59	2.76	8.08
n_0k_0	316.23	79.49	227.81
$n_0 k_1$	278.18	106.23	261.98
n_0k_2	388.16	101.41	337.56
$n_1 k_0$	347.15	91.61	294.08
$n_1 k_1$	331.50	91.06	258.55
$n_1 k_2$	376.83	108.16	345.66
$n_2 k_0$	299.43	91.11	300.73
$n_2 k_1$	297.63	99.63	285.23
$n_2 k_2$	297.21	89.93	316.90
SE	11.11	0.94	2.75
CD (0.05)	32.59	2.76	8.08
p_0k_0	267.50	78.03	266.75
$p_0 k_1$	340.28	92.66	278.31
p_0k_2	298.76	80.26	318.56
$p_1 k_0$	277.25	87.69	282.71
$p_1 k_1$	252.78	94.91	256.70
$p_1 k_2$	417.73	100.88	336.28
$p_2 k_0$	418.06	96.50	273.16
$p_2 k_1$	314.25	109.35	270.75
$p_2 k_2$	345.71	118.36	345.28
SE	11.11	0.94	2.75
CD (0.05)	32.59	2.76	8.08

Table 30 Highest order interaction of NPK on soil nitrogen, phosphorus and potassium content

No.	Treatments	Soil Nitrogen (kg ha^{-1})	Soil Phosphorus (kg ha^{-1})	Soil potassium (kg ha^{-1})
T_1	$n_0p_0k_0$	271.90	93.35	214.30
T_2	$n_0p_0k_1$	283.10	91.20	273.00
T_3	$n_0p_0k_2$	343.15	75.05	310.25
T_4	$n_0p_1k_0$	269.40	63.63	279.55
T_5	$n_0p_1k_1$	244.15	107.80	246.25
T_6	$n_0p_1k_2$	508.00	106.65	321.20
T_7	$n_0p_2k_0$	407.40	81.50	189.60
T_8	$n_0p_2k_1$	307.30	119.70	266.70
T_9	$n_0p_2k_2$	313.35	122.55	381.25
T_{10}	$n_1p_0k_0$	293.75	70.95	302.70
T_{11}	$n_1p_0k_1$	425.60	91.85	255.25
T_{12}	$n_1p_0k_2$	311.15	81.85	324.00
T_{13}	$n_1p_1k_0$	308.35	92.55	292.85
T_{14}	$n_1p_1k_1$	242.10	63.95	267.35
T_{15}	$n_1p_1k_2$	477.05	127.90	364.35
T_{16}	$n_1p_2k_0$	439.55	111.35	286.70
T_{17}	$n_1p_2k_1$	326.80	117.40	253.05
T_{18}	$n_1p_2k_2$	342.30	114.75	348.65
T_{19}	$n_2p_0k_0$	236.85	69.80	283.25
T_{20}	$n_2p_0k_1$	312.15	94.95	306.70
T_{21}	$n_2p_0k_2$	242.00	83.90	321.45
T_{22}	$n_2p_1k_0$	254.00	106.90	275.75
T_{23}	$n_2p_1k_1$	272.10	113.00	256.50
T_{24}	$n_2p_1k_2$	268.15	68.10	323.30
T_{25}	$n_2p_2k_0$	407.45	96.40	343.20
T_{26}	$n_2p_2k_1$	308.65	90.95	292.50
T_{27}	$n_2p_2k_2$	381.50	117.80	305.95
	SE	19.24	1.62	4.77
	CD (0.05)	39.91	3.38	9.90
T_{28}	Control	210.60	33.00	111.96
	Treatments Vs control	S	S	S

S – Significant

from n_2 (298.09 kg ha^{-1}), which differed significantly from n_0 (327.52 kg ha^{-1}) and n_1.

Different levels of phosphorus had significant influence on soil nitrogen content. Highest value was obtained from p_2 (359.34 kg ha^{-1}), which differed significantly from other treatments. Lowest value was noticed from p_0 (302.18 kg ha^{-1}), which was on par with p_1 (315.92 kg ha^{-1}).

Main effect of potassium was significant. Highest value was noticed from k_2 (354.07 kg ha^{-1}) which differed significantly from other treatments. Lowest value was noted from k_1 (302.43 kg ha^{-1}), which was on par with k_0 (320.93 kg ha^{-1}).

N x P interaction had significant influence on soil nitrogen content. Highest value was obtained from combination n_1p_2 (369.48 kg ha^{-1}) followed by n_2p_2 (365.86 kg ha^{-1}), n_1p_0 (343.50 kg ha^{-1}), n_0p_2 (342.68 kg ha^{-1}), n_1p_1 (342.50 kg ha^{-1}) and n_0p_1 (340.51 kg ha^{-1}), which were on par. Lowest value was noticed with combination n_2p_0 (263.66 kg ha^{-1}) which was on par with n_1p_1 (264.75 kg ha^{-1}).

N x K interaction was significant. n_0k_2 (388.16 kg ha^{-1}) recorded the highest value which was on par with n_1k_2 (376.83 kg ha^{-1}). Lowest value was noticed from n_0k_1 (278.18 kg ha^{-1}), which was on par with n_0k_2 (297.21 kg ha^{-1}), n_2k_1 (297.63 kg ha^{-1}) and n_2k_0 (299.43 kg ha^{-1}).

P x K interaction had significant influence on soil nitrogen content. Highest value was produced by combination p_2k_0 (418.06 kg ha^{-1}), which was on par with p_1k_2 (417.73 kg ha^{-1}). Lowest value was produced by p_1k_1 (252.78 kg ha^{-1}), which was on par with p_0k_0 (267.50 kg ha^{-1}) and p_1k_0 (277.25 kg ha^{-1}).

NPK interaction had significant influence on soil nitrogen content. Highest value was obtained from $n_0p_1k_2$ (508.00 kg ha^{-1}), which was on par with $n_1p_1k_2$ (477.05 kg ha^{-1}). Lowest value was produced by $n_2p_0k_0$ (236.85 kg ha^{-1}), followed by $n_2p_0k_2$ (242.00 kg ha^{-1}), $n_1p_1k_1$ (242.10 kg

ha^{-1}), $n_0p_1k_1$ (244.15 kg ha^{-1}), $n_2p_1k_0$ (254.00 kg ha^{-1}), $n_2p_1k_2$ (268.15 kg ha^{-1}), $n_0p_1k_0$ (269.40 kg ha^{-1}), $n_0p_0k_0$ (271.90 kg ha^{-1}) and $n_2p_1k_1$ (272.10 kg ha^{-1}) which were on par. Treatments had significant difference over control. Control reported lowest value for soil nitrogen content (210.60 kg ha^{-1}).

4.4.2 Soil Phosphorus

Data on soil phosphorus content as influenced by different levels of N, P and K as well as their interactions are presented in Table 28, 29 and 30.

Main effect of nitrogen had significant influence on soil phosphorus content. Highest value was noted with n_1 (96.95 kg ha^{-1}), which was on par with n_0 (95.71 kg ha^{-1}). Lowest value was noted with n_2 (93.56 kg ha^{-1}), which differed significantly from other treatments.

Main effect of phosphorus was found to have significant influence on soil phosphorus content. Highest value was produced by p_2 (108.07 kg ha^{-1}), which differed significantly from other treatments. Lowest value was noticed with p_0 (83.65 kg ha^{-1}) which differed significantly from other treatments.

Main effect of potassium was significant. k_2 (99.83 kg ha^{-1}) produced the highest value, which was on par with k_1 (98.77 kg ha^{-1}). Lowest value was noticed with k_0 (87.40 kg ha^{-1}), which differed significantly from other treatments.

N x P interaction had significant influence on soil phosphorus content. Combination n_1p_2 produced highest value (114.50 kg ha^{-1}) which differed significantly from other treatments. Lowest value was noted with n_1p_0 (81.55 kg ha^{-1}) which was on par with n_2p_0 (82.80 kg ha^{-1}).

N x K interaction had significant influence on soil phosphorus content. Highest value was noted with combination n_1k_2 (108.16 kg ha^{-1}) which was on par with n_0k_1 (106.23 kg ha^{-1}). Lowest value was noticed with n_0k_0 (79.49 kg ha^{-1}), which differed significantly from other treatments. This was followed by n_2k_2 (89.93 kg ha^{-1}), n_1k_1 (91.06 kg ha^{-1}), n_2k_0 (91.11 kg ha^{-1}) and n_1k_0 (91.61 kg h^{-1}) which were on par.

P x K interaction was significant. Highest value was noted from combination p_2k_2 (118.36 kg ha^{-1}), which differed significantly from other treatments. Lowest value was noted with p_0k_0 (78.03 kg ha^{-1}), which was on par with p_0k_2 (80.26 kg ha^{-1}).

NPK interaction had significant influence on soil phosphorus content. $n_1p_1k_2$ (127.9 kg ha^{-1}) registered highest value, which differed significantly from other treatments. This was followed by $n_0p_2k_2$ (122.55 kg ha^{-1}) and $n_0p_2k_1$ (119.70 kg ha^{-1}), which were on par. Lowest value was noticed with $n_0p_1k_0$ (63.63 kg ha^{-1}) which was on par with $n_1p_1k_1$ (63.95 kg ha^{-1}). Treatments had significant difference over control. Control registered lowest value for soil phosphorus content (33 kg ha^{-1}).

4.4.3 Soil Potassium

Soil potassium content as influenced by different levels of N, P and K as well as their interactions are presented in Table 28, 29 and 30.

Main effect of nitrogen was significant. Highest value was recorded by n_2 (300.95 kg ha^{-1}), which was on par with n_1 (229.43 kg ha^{-1}). Lowest value was registered by n_0 (275.78 kg ha^{-1}), which differed significantly from other treatments.

Main effect of phosphorus was significant. Highest value was noticed with p_2 (296.40 kg ha^{-1}), which was on par with p_1 (291.90 kg ha^{-1}). Lowest value was registered by p_0 (287.70 kg ha^{-1}), which was on par with p_1.

Different levels of potassium had significant influence on soil potassium content. Highest value was noticed from k_2 (333.37 kg ha^{-1}), which differed significantly from other treatments. k_1 (268.58 kg ha^{-1}) registered the lowest value, which differed significantly from other treatments.

N x P interaction had significant influence on soil potassium content. Combination n_2p_2 (313.88 kg ha^{-1}) registered the highest value, which was on par with n_1p_1 (308.18 kg ha^{-1}). Lowest value was noticed with n_0p_0 (265.85 kg ha^{-1}), which differed significantly from other treatments. This was followed by n_0p_2 (279.18 kg ha^{-1}), n_0p_1 (282.33 kg ha^{-1}) and n_2p_1 (285.15 kg ha^{-1}), which were on par.

N x K interaction was significant. Highest value was noted with combination n_1k_2 (345.66 kg ha^{-1}), which differed significantly from other treatments. Lowest value was obtained from n_0k_0 (227.81 kg ha^{-1}), which differed significantly from other treatments. This was followed by n_1k_1 (258.55 kg ha^{-1}) and n_0k_1 (261.98 kg ha^{-1}), which was on par.

P x K interaction was significant. Highest value was noticed with p_2k_2 (345.28 kg ha^{-1}), which differed significantly from other treatments. Lowest value was noticed from p_1k_1 (256.70 kg ha^{-1}), which differed significantly from other treatments.

NPK interaction was significant. Highest value was produced by $n_0p_2k_2$ (381.25 kg ha^{-1}), which differed significantly from other treatments. This was followed by $n_1p_1k_2$ (364.35 kg ha^{-1}), which also differed significantly from other treatments. Lowest value was noted with $n_0p_2k_0$ (189.60 kg ha^{-1}), which differed significantly from other treatments. Treatments had significant difference over control. Control reported least value for soil potassium (111.90 kg ha^{-1}).

4.4.4 Leaf Petiole Nitrogen

Data on leaf petiole nitrogen content as influenced by different levels of N, P and K as well as their interactions are presented in Table 31, 32 and 33.

Different levels of nitrogen had significant influence on leaf petiole nitrogen content. Highest value was produced by n_1 (1.94 per cent), which

Table.31 Effect of different levels of N, P and K on leaf petiole content of nitrogen, phosphorus and potassium

Treatments	Leaf petiole nitrogen (per cent)	Leaf petiole phosphorus (per cent)	Leaf petiole potassium (per cent)
N levels			
n_0	1.57	0.27	3.15
n_1	1.94	0.29	3.32
n_2	1.71	0.32	3.34
SE	0.01	0.005	0.01
CD (0.05)	0.03	0.01	0.03
P levels			
p_0	1.51	0.28	3.02
p_1	1.94	0.31	3.37
p_2	1.77	0.29	3.43
SE	0.01	0.005	0.01
CD (0.05)	0.03	0.017	0.03
K levels			
k_0	1.40	0.22	2.68
k_1	1.67	0.27	3.05
k_2	2.16	0.40	4.08
SE	0.01	0.005	0.01
CD (0.05)	0.03	0.017	0.03

Table 32 Interaction effect of different levels of N, P and K on leaf petiole content of nitrogen, phosphorus and potassium

Treatments	Leaf petiole nitrogen (per cent)	Leaf petiole phosphorus (per cent)	Leaf petiole potassium (per cent)
n_0p_0	1.50	0.27	2.92
$n_0 p_1$	1.60	0.275	2.80
n_0p_2	1.62	0.29	3.73
$n_1 p_0$	1.48	0.26	2.80
$n_1 p_1$	2.50	0.30	3.76
$n_1 p_2$	1.84	0.31	3.40
$n_2 p_0$	1.55	0.32	3.34
$n_2 p_1$	1.73	0.38	3.54
$n_2 p_2$	1.86	0.28	3.15
SE	0.02	0.01	0.02
CD (0.05)	0.06	0.02	0.06
n_0k_0	1.41	0.24	2.70
$n_0 k_1$	1:61	0.20	2.66
n_0k_2	1.70	0.38	4.10
$n_1 k_0$	1.37	0.19	2.58
$n_1 k_1$	1.79	0.30	3.09
$n_1 k_2$	2.65	0.38	4.29
$n_2 k_0$	1.41	0.22	2.76
$n_2 k_1$	1.61	0.30	3.41
$n_2 k_2$	2.12	0.45	3.86
SE	0.02	0.01	0.02
CD (0.05)	0.06	0.02	0.06
p_0k_0	1.30	0.21	3.13
$p_0 k_1$	1.41	0.27	2.59
p_0k_2	1.82	0.36	3.33
$p_1 k_0$	1.33	0.19	2.32
$p_1 k_1$	1.80	0.28	2.94
$p_1 k_2$	2.71	0.48	4.84
$p_2 k_0$	1.55	0.25	2.58
$p_2 k_1$	1.82	0.25	3.62
$p_2 k_2$	1.95	0.37	4.08
SE	0.02	0.01	0.02
CD (0.05)	0.06	0.02	0.06

Table 33 Highest order interaction of NPK on leaf petiole content of nitrogen, phosphorus and potassium

No.	Treatments	Leaf petiole nitrogen (per cent)	Leaf petiole phosphorus (per cent)	Leaf petiole potassium (per cent)
T_1	$n_0p_0k_0$	1.44	0.27	3.53
T_2	$n_0p_0k_1$	1.23	0.21	2.41
T_3	$n_0p_0k_2$	1.83	0.32	2.84
T_4	$n_0p_1k_0$	1.49	0.20	2.22
T_5	$n_0p_1k_1$	1.58	0.22	2.47
T_6	$n_0p_1k_2$	1.74	0.40	3.71
T_7	$n_0p_2k_0$	1.31	0.26	2.35
T_8	$n_0p_2k_1$	2.03	0.18	3.10
T_9	$n_0p_2k_2$	1.53	0.42	5.74
T_{10}	$n_1p_0k_0$	1.07	0.17	2.75
T_{11}	$n_1p_0k_1$	1.52	0.28	2.13
T_{12}	$n_1p_0k_2$	1.85	0.34	3.52
T_{13}	$n_1p_1k_0$	1.44	0.16	2.54
T_{14}	$n_1p_1k_1$	2.31	0.28	3.40
T_{15}	$n_1p_1k_2$	3.76	0.45	5.34
T_{16}	$n_1p_2k_0$	1.62	0.24	2.45
T_{17}	$n_1p_2k_1$	1.56	0.34	3.75
T_{18}	$n_1p_2k_2$	2.34	0.35	4.01
T_{19}	$n_2p_0k_0$	1.41	0.19	3.13
T_{20}	$n_2p_0k_1$	1.47	0.32	3.25
T_{21}	$n_2p_0k_2$	1.78	0.44	3.65
T_{22}	$n_2p_1k_0$	1.08	0.22	2.21
T_{23}	$n_2p_1k_1$	1.50	0.33	2.96
T_{24}	$n_2p_1k_2$	2.62	0.58	5.47
T_{25}	$n_2p_2k_0$	1.74	0.26	2.94
T_{26}	$n_2p_2k_1$	1.87	0.25	4.02
T_{27}	$n_2p_2k_2$	1.98	0.35	2.48
	SE	0.03	0.01	0.03
	CD (0.05)	0.07	3.6	8.49
T_{28}	Control	0.56	0.04	0.81
	Treatments Vs control	S	S	S

S – Significant

differed significantly from other treatments. Lowest value was noted with n_0 (1.57 per cent), while differed significantly from other treatments.

Main effect of phosphorus was significant. p_1 (1.94 per cent) reported the highest value, which differed significantly from other treatments. Lowest value was registered by p_0 (1.51 per cent) which differed significantly from other treatments.

Main effect of potassium was significant k_2 (2.16 per cent) reported highest value, which differed significantly from other treatments. k_0 (1.40 per cent) reported lowest value, which differed significantly from other treatments.

N x P interaction had significant influence on leaf petiole nitrogen content. Combination n_1p_1 produced highest value (2.50 per cent), which differed significantly from other treatments. This was followed by n_2p_1 (1.86 per cent) and n_1p_2 (1.84 per cent) which were on par. Combination n_1p_0 (1.48 per cent) registered lowest value, which was on par with n_0p_0 (1.50 per cent).

N x K interaction was significant. Highest value was noticed with combination n_1k_2 (2.65 per cent), which differed significantly from other treatments. Lowest value was noticed with combination n_1k_0 (1.37 per cent), which were on par with n_2k_0 (1.41 per cent) and n_0k_0 (1.41 per cent).

P x K interaction had significant influence on leaf petiole nitrogen content. Highest value was obtained from combination p_1k_2 (2.71 per cent). Lowest value was obtained from combination p_0k_0 (1.30 per cent), which was on par with p_1k_0 (1.33 per cent).

NPK interaction had significant influence on leaf petiole nitrogen content. Highest value was recorded by $n_1p_1k_2$ (3.76 per cent), which differed significantly from other treatments. Lowest value was obtained from $n_1p_0k_0$ (1.07 per cent) followed by $n_2p_1k_0$ (1.08 per cent), which were on par.

Treatment had significant difference over control. Control reported least value (0.561 per cent).

4.4.5 Leaf Petiole Phosphorus

Leaf petiole phosphorus content as influenced by different levels of N, P and K and their interactions are presented in Table 31, 32 and 33.

Main effect of nitrogen had significant influence on leaf petiole phosphorus content. Highest value was noted with n_2 (0.32 per cent) which differed significantly from other treatments. Lowest value was obtained from n_0 (0.27 per cent), which was on par with n_1 (0.29 per cent).

Main effect of phosphorus was significant. p_1 registered highest value (0.31 per cent), which differed significantly from other treatments. Lowest value was noticed with p_0 (0.28 per cent), which was on par with p_2 (0.29 per cent).

Different levels of potassium had significant influence on leaf petiole phosphorus content. k_2 (0.40 per cent) produced highest value, which differed significantly from other treatments. Lower value was noticed with k_0 (0.22 per cent), which was on par with k_1 (0.27 per cent).

N x P interaction was significant. Combination n_2p_1 (0.38 per cent) registered the highest value, which differed significantly from other treatments. This was followed by n_2p_0 (0.32 per cent), n_1p_2 (0.31 per cent) and n_1p_1 (0.30 per cent), which were on par. Lowest value was noticed with n_1p_0 (0.26 per cent), which was on par with n_0p_0 (0.27 per cent) and n_0p_1 (0.27 per cent).

N x K interaction was significant. Highest value was obtained from combination n_2k_2 (0.45 per cent), which differed significantly from other combinations. Lowest value was obtained from n_1k_0 (0.19 per cent), which was on par with n_0k_1 (0.20 per cent).

P x K interaction was significant. Combination p_1k_2 (0.48 per cent) reported highest value, which differed significantly from other treatments. Lowest value was obtained from combination p_1k_0 (0.19 per cent), which was on par with p_0k_0 (0.21 per cent).

NPK interaction had significant influence on leaf petiole phosphorus content. Highest value was obtained from $n_2p_1k_2$ (0.58 per cent), which differed significantly from other treatments. This was followed by $n_1p_1k_2$ (0.45 per cent), $n_2p_0k_2$ (0.44 per cent) and $n_0p_2k_2$ (0.42 per cent), which were on par. Lowest value was noticed with $n_1p_1k_0$ (0.16 per cent), which was on par with $n_1p_0k_0$ (0.17 per cent), $n_0p_2k_1$ (0.18 per cent) and $n_1p_2k_2$ (0.195 per cent). Treatments had significant difference over control. Control reported lowest value of leaf petiole phosphorus content (0.043 per cent).

4.4.6 Leaf Petiole Potassium

Data on leaf petiole potassium as influenced by different levels of N, P and K as well as their interactions are presented in Table 31, 32 and 33.

Main effect of nitrogen was significant. Highest value was obtained from n_2 (3.34 per cent) which was on par with n_1 (3.32 per cent). Lowest value was obtained from n_0 (3.15 per cent) which differed significantly from other treatments.

Different levels of phosphorus had significant influence on leaf petiole potassium content. Highest value was obtained from p_2 (3.43 per cent), which differed significantly from other treatments. Lowest value was recorded by p_0 (3.02 per cent), which differed significantly from p_1 (3.37 per cent) and p_2.

Main effect of potassium was significant. Highest value was registered by k_2 (4.08 per cent), which differed significantly from other treatments. Lowest value was registered by k_0 (2.68 per cent), which differed significantly from other treatments.

N x P interaction was significant. Combination n_1p_1 (3.76 per cent) produced highest value, which was on par with n_0p_2 (3.73 per cent). Lowest value (2.80 per cent) was reported by n_1p_0, which was on par with n_0p_1 (2.803 per cent).

N x K interaction had significant influence on leaf petiole potassium content. Combination n_1k_2 (4.29 per cent) produced highest value, which differed significantly from other treatments. Lowest value was registered by n_1k_0 (2.58 per cent), which differed significantly from other treatments. This was followed by n_0k_1 (2.66 per cent) and n_0k_0 (2.70 per cent) which were on par.

P x K interaction was significant. Combination p_1k_2 (4.84 per cent) registered the highest value, which differed significantly from other treatments. Lowest value was registered by p_1k_0 (2.32 per cent) which differed significantly from other treatments.

NPK interaction had significant influence on leaf petiole potassium content. Highest value was obtained from $n_0p_2k_2$ (5.74 per cent), which differed significantly from other treatments. This was followed by $n_2p_1k_2$ (5.47 per cent) and $n_1p_1k_2$ (5.34 per cent), which also differed significantly from other treatments. Lowest value was obtained from $n_1p_0k_1$ (2.13 per cent) which was on par with $n_2p_1k_0$ (2.21 per cent). Treatments had significant difference over control. Control reported lowest value for leaf petiole potassium content (0.81 per cent).

In general it was seen that nitrogen at 250 g plant^{-1}, phosphorus at 250 g plant^{-1}and potassium at 500 g plant^{-1}increased petiole content of these nutrients.

4.5 ECONOMICS OF CULTIVATION

4.5.1 Benefit : Cost Ratio (BCR)

Data on benefit : cost ratio as affected by different levels of N, P and K as well as their interactions are presented in Table 34, 35 and 36.

Table 34 Effect of different levels of N, P and K on benefit : cost ratio

Treatments	Benefit : Cost ratio
N levels	
n_0	1.65
n_1	1.85
n_2	1.81
SE	0.04
CD (0.05)	0.14
P levels	
p_0	1.78
p_1	1.94
p_2	1.59
SE	0.04
CD (0.05)	0.14
K levels	
k_0	1.73
k_1	1.75
k_2	1.82
SE	0.04
CD (0.05)	NS

NS – Non significant

Table 35 Interaction effect of different levels of N, P and K on benefit : cost ratio

Treatments	Benefit : cost ratio	No.	Treatments	Benefit : cost ratio
n_0p_0	1.76	T_1	$n_0p_0k_0$	2.14
$n_0 p_1$	1.79	T_2	$n_0p_0k_1$	1.77
n_0p_2	1.40	T_3	$n_0p_0k_2$	1.36
$n_1 p_0$	1.87	T_4	$n_0p_1k_0$	2.35
$n_1 p_1$	2.10	T_5	$n_0p_1k_1$	1.28
$n_1 p_2$	1.59	T_6	$n_0p_1k_2$	1.75
$n_2 p_0$	1.70	T_7	$n_0p_2k_0$	1.68
$n_2 p_1$	1.94	T_8	$n_0p_2k_1$	1.08
$n_2 p_2$	1.77	T_9	$n_0p_2k_2$	1.44
SE	0.083	T_{10}	$n_1p_0k_0$	1.55
CD (0.05)	NS	T_{11}	$n_1p_0k_1$	2.31
		T_{12}	$n_1p_0k_2$	1.76
n_0k_0	2.06	T_{13}	$n_1p_1k_0$	1.15
$n_0 k_1$	1.38	T_{14}	$n_1p_1k_1$	1.59
n_0k_2	1.51	T_{15}	$n_1p_1k_2$	3.55
$n_1 k_0$	1.47	T_{16}	$n_1p_2k_0$	1.73
$n_1 k_1$	1.92	T_{17}	$n_1p_2k_1$	1.88
$n_1 k_2$	2.16	T_{18}	$n_1p_2k_2$	1.17
$n_2 k_0$	1.67	T_{19}	$n_2p_0k_0$	2.04
$n_2 k_1$	1.95	T_{20}	$n_2p_0k_1$	1.43
$n_2 k_2$	1.80	T_{21}	$n_2p_0k_2$	1.64
SE	0.08	T_{22}	$n_2p_1k_0$	1.33
CD (0.05)	0.24	T_{23}	$n_2p_1k_1$	2.34
		T_{24}	$n_2p_1k_2$	2.18
p_0k_0	1.91	T_{25}	$n_2p_2k_0$	1.65
$p_0 k_1$	1.83	T_{26}	$n_2p_2k_1$	2.09
p_0k_2	1.59	T_{27}	$n_2p_2k_2$	1.58
$p_1 k_0$	1.61		SE	0.14
$p_1 k_1$	1.73		CD (0.05)	0.30
$p_1 k_2$	2.49	T_{28}	Control	0.48
$p_2 k_0$	1.686		Treatment Vs control	S
$p_2 k_1$	1.685			
$p_2 k_2$	1.40			
SE	0.08			
CD (0.05)	0.24			

NS – Non significant

Table 36 Cost of cultivation of papaya under different combinations of N, P and K

No.	Treatments	Total cost (Rs. ha^{-1})	Total returns (Rs. ha^{-1})	Net profit (Rs. ha^{-1})	Benefit cost Ratio
T_1	$n_0p_0k_0$	113025.30	241875.00	128849.70	2.14
T_2	$n_0p_0k_1$	83898.30	148500.00	64601.70	1.77
T_3	$n_0p_0k_2$	124080.30	168750.00	44669.70	1.36
T_4	$n_0p_1k_0$	113457.30	266625.00	153167.70	2.35
T_5	$n_0p_1k_1$	101952.30	130500.00	28547.70	1.28
T_6	$n_0p_1k_2$	120856.30	211500.00	90643.70	1.75
T_7	$n_0p_2k_0$	120758.30	202875.00	82116.70	1.68
T_8	$n_0p_2k_1$	123263.30	133125.00	9861.70	1.08
T_9	$n_0p_2k_2$	122395.80	176250.00	53854.20	1.44
T_{10}	$n_1p_0k_0$	117972.30	183525.00	65552.70	1.55
T_{11}	$n_1p_0k_1$	120347.30	278100.00	157752.70	2.31
T_{12}	$n_1p_0k_2$	117826.30	207375.00	89548.70	1.76
T_{13}	$n_1p_1k_0$	124891.30	143625.00	18733.70	1.15
T_{14}	$n_1p_1k_1$	124528.30	198000.00	73471.70	1.59
T_{15}	$n_1p_1k_2$	125972.30	448125.00	322152.70	3.55
T_{16}	$n_1p_2k_0$	124472.30	215700.00	91227.70	1.73
T_{17}	$n_1p_2k_1$	126847.30	238875.00	112027.70	1.88
T_{18}	$n_1p_2k_2$	132051.30	154500.00	22448.70	1.17
T_{19}	$n_2p_0k_0$	119347.30	244500.00	125152.70	2.04
T_{20}	$n_2p_0k_1$	118972.30	170625.00	51652.70	1.43
T_{21}	$n_2p_0k_2$	124097.30	204750.00	80652.70	1.64
T_{22}	$n_2p_1k_0$	123863.30	163500.00	39636.70	1.33
T_{23}	$n_2p_1k_1$	124972.30	292875.00	167902.70	2.34
T_{24}	$n_2p_1k_2$	124097.30	271125.00	147027.70	2.18
T_{25}	$n_2p_2k_0$	125847.30	207750.00	81902.70	1.65
T_{26}	$n_2p_2k_1$	126873.30	265800.00	138926.70	2.09
T_{27}	$n_2p_2k_2$	130597.30	207375.00	76777.70	1.58
T_{28}	Control	90972.30	44475.00	-46497.30	0.48

Input cost

Cost of nitrogen Rs. 11.00 kg^{-1}
Cost of phosphorus Rs. 26.00 kg^{-1}
Cost of potassium Rs. 9.50 kg^{-1}
Cost of seed Rs. 600.00 for 300 g

Out put cost

Papaya Rs. 3.00 kg^{-1}

Main effect of nitrogen was significant. Highest value (1.85) was obtained from n_1, which was on par with n_2 (1.81). Lowest value was registered by n_0 (1.65).

Main effect of phosphorus had significant influence on benefit : cost ratio. Highest value was obtained from p_1 (1.94), which differed significantly from other treatments. Lowest value (1.59) was obtained from p_2 differed significantly from other treatments.

Main effect of K and N x P interactions were not significant.

N x K interaction had significant influence on benefit : cost ratio. Highest benefit : cost ratio was recorded by combination n_1k_2 (2.16), which differed significantly from other combinations. Lowest value was registered by combination n_0k_1 (1.38), which differed significantly from other treatments. This was followed by combination n_1k_0 (1.47) and n_0k_2 (1.51), which were on par.

P x K interaction had significant influence on benefit : cost ratio. Highest benefit : cost ratio was reported by the combination p_1k_2 (2.49), which differed significantly from other combinations. Lowest benefit : cost ratio was recorded by p_2k_2 (1.40), which differed significantly from other treatments. This was followed by p_0k_2 (1.59) and p_1k_0 (1.61), which were on par.

NPK interaction was found to have significant influence on benefit : cost ratio. Highest benefit : cost ratio was obtained from $n_1p_1k_2$ (3.55) which differed significantly from other treatments. This was followed by $n_0p_1k_0$ (2.35), $n_2p_1k_1$ (2.33), $n_1p_0k_1$ (2.30), $n_2p_1k_2$ (2.18), $n_0p_0k_0$ (2.14) and $n_2p_2k_1$ (2.09), which were on par. Lowest benefit : cost ratio was registered by $n_0p_2k_1$ (1.08) followed by $n_1p_1k_0$ (1.15), $n_1p_2k_2$ (1.17), $n_0p_1k_1$ (1.28), $n_2p_1k_0$ (1.32) and $n_0p_0k_2$ (1.36), which were on par. Treatments had significant difference over control. Control registered the lowest benefit : cost ratio (0.48).

The combination of 250 g plant^{-1} nitrogen, 250 g plant^{-1} phosphorus and potassium at 500 g plant^{-1} found to result in highest benefit : cost ratio.

4.6 STANDARDISATION OF RESPONSE TO APPLIED NUTRIENTS

4.6.1 Number of Fruits Plant^{-1}

Data on physical dose of nitrogen, phosphorus and potassium on number of fruits plant^{-1}are presented in Table 37.

Physical optimum dose of nitrogen, phosphorus and potassium on number of fruits plant^{-1} were 275 g nitrogen, 300 g phosphorus and 400 g potassium plant^{-1} year^{-1}.

4.6.2 Fruit Weight

Data on physical dose of nitrogen, phosphorus and potassium for fruit weight are presented in Table 37.

Physical optimum dose of nitrogen, phosphorus and potassium on fruit weight were 260 g nitrogen, 250 g phosphorus and 400 g potassium plant^{-1} year^{1}.

4.6.3 Total Yield Plant^{-1}

Data on physical dose of nitrogen, phosphorus and potassium for total yield plant^{-1}are presented in Table 37.

Physical optimum dose of nitrogen, phosphorus and potassium on total yield plant^{-1}were 260 g nitrogen, 250 g phosphorus and 340 g potassium plant^{-1} year^{-1}.

The results of the present studies indicated that application of N, P and K at a dose of 250 : 250 : 500 g plant^{-1} year^{-1} in six split doses at two months interval, resulted in better growth, yield as well as quality of fruits.

Table 37 Physical optimum dose of N, P and K for papaya

Character	Physical optimum dose			Expected optimum value
	N (g $plant^{-1}$ $year^{-1}$)	P (g $plant^{-1}$ $year^{-1}$)	K (g $plant^{-1}$ $year^{-1}$)	
Number of fruits $plant^{-1}$	275	300	400	28.56
Fruit weight (g)	260	250	400	1024.34
Total yield (kg $plant^{-1}$)	260	250	340	30.38

DISCUSSION

5. DISCUSSION

Papaya is one of the major tropical fruits suited for both nutrition gardens and commercial orcharding. Due to year round availability of fruits, high nutritive value, reasonably high returns per unit area, easiness in management and scope for processing, this fruit has attained a place of prominence in tropical fruit orchards. Balanced nutrition plays a vital role on plant growth, yield and fruit quality. Hence the present experiment was conducted with an objective of studying the response of major plant nutrients *viz.*, nitrogen, phosphorus and potassium on growth, yield and quality of papaya. Standardisation of optimum dose of N, P and K for papaya for Kerala conditions is also aimed at. The results of the experiment with the above objectives are discussed here under:

5.1 BIOMETRIC CHARACTERS

5.1.1 Height of Plants

The present study revealed that plant height increased by applying nitrogen fertilizers. During early stages of growth (*i.e.*, during 2 MAP, 4 MAP, 6 MAP and 8 MAP) there was a slight increase in plant height with the application of upto 250 g nitrogen plant^{-1} year^{-1}, but with the highest dose (300 g nitrogen plant^{-1} year^{-1}), there was a slight decrease in plant height. During later stages of growth (i.e., during 10 MAP and 12 MAP) plant height increased by increasing the level of nitrogen.

Wadleigh (1957) reported the beneficial effect of nitrogen in promoting growth; mainly due to enhanced synthesis of protein and amino acids. Jauhari and Singh (1970) noted in papaya variety Coorg Honeydew that nitrogen increased the height of plants. According to Awada (1976) nitrogen application increased plant growth in 'Solo' papaya. Purohit (1977) observed in papaya variety Coorg Honeydew that plant height was significantly increased by application of nitrogen, while the highest level of nitrogen (500 g plant^{-1}) resulted in significant reduction in plant height. Similar results were obtained from the present experiment upto 300 g nitrogen plant^{-1} year^{-1}. Biswas *et al.* (1989) also noted in papaya variety Ranchi that height of plants increased with increasing level of nitrogen applied.

Results of the present experiment revealed that phosphorus application had significant influence on plant height at all stages except 12 MAP. During 2 MAP, 4 MAP and 10 MAP, highest values for plant height was obtained with medium dose of phosphorus (250 g plant^{-1} year^{-1}). During 6 MAP and 8 MAP, plant height increased by increasing the level of phosphorus and the highest values were recorded with the highest dose of phosphorus (300 g plant^{-1} year^{-1}).

Awada (1977) noticed in papaya variety 'Solo' that phosphorus application resulted in faster stem growth during flowering. In a similar experiment, Purohit (1977) also observed in papaya variety Coorg Honeydew that plant height was significantly increased by application of phosphorus, as observed in the current experiment.

Potassium application had significant influence on plant height at all stages of growth, except 2 MAP. Plant height increased by applying different levels of potassium. Highest plant height was obtained with highest dose of potassium (500 g plant^{-1} year^{-1}).

In similar experiments, Awada (1977) reported that in papaya variety 'Solo', potassium application resulted in plants with greater stem growth rate during bearing. Biswas *et al.* (1989) also noted in papaya variety Ranchi that application of potassium caused significant increase in plant height.

NP, NK and PK interactions had significant influence on plant height.

NPK interaction had significant influence on plant height at all stages of growth. At 2 MAP, treatment $n_1p_1k_0$ gave maximum plant height. At all stages except 2 MAP, treatment $n_0p_2k_2$ gave highest plant height. This may be due to better combination of NPK. Lower dose of nitrogen (200 g plant^{-1} year^{-1}) combined with highest dose of phosphorus (300 g plant^{-1} year^{-1}) and potassium (500 g plant^{-1} year^{-1}) gave maximum plant height.

Hussain (1970) observed better vegetative growth of papaya with NPK application. The result of the present study is in confirmity with the observations of Singh *et al.* (1998) who observed that in papaya variety Ranchi, lower dose of nitrogen combined with higher dose of phosphorus and potassium showed synergistic effect, thus resulting in increased height of the plant.

5.1.2 Girth of Plants

The present study revealed that nitrogen had significant influence on plant girth only at 2 MAP and 6 MAP. During these periods plant girth increased by applying different levels of nitrogenous fertilizers. But when highest level of nitrogen was used, there was a reduction in plant girth. This finding is in confirmity with the observations of Purohit (1977) and Purohit *et al.* (1979), who observed that in papaya variety Washington, nitrogen at lower levels increased plant girth, but at higher levels it had depressing effect on growth.

Jauhari and Singh (1970) reported in papaya variety Coorg Honeydew that maximum plant girth was obtained by applying 140 g nitrogen plant^{-1} year^{-1}. Awada (1976) noted in papaya variety Solo that nitrogen application (250 g nitrogen plant^{-1} year^{-1}) recorded maximum plant girth. Continuing the studies, Awada (1977) observed in papaya variety Solo that nitrogen fertilization increased the stem growth rate at vegetative stage.

Phosphorus had significant influence on plant girth at all stages except 10 MAP and 12 MAP. At 2 MAP and 4 MAP *i.e.*, during early stages of growth, highest dose of phosphorus (300 g plant^{-1} year^{-1}) resulted in maximum plant girth. But during 6 MAP and 8 MAP *i.e.*, during later stages of growth, application of highest dose of phosphorus resulted in slight reduction in plant girth. This results are in line with the findings of Awada *et al.* (1975), who noted in papaya variety Solo that phosphorus fertilization increased the growth rate of tree-trunk circumference only at the early stage of growth. Purohit (1977) noted in papaya variety Coorg Honeydew that trunk diameter was significantly influenced by phosphorus application.

Present study revealed that potassium application had significant influence on plant girth at all stages of growth except 4 MAP and 12 MAP. Highest level of potassium (500 g plant^{-1} year^{-1}) resulted in maximum girth of plants at all stages of growth.

The increase in basal girth under higher level of potassium was considered to be due to more uptake and accumulation of potash in leaf tissues, which in turn improved the photosynthetic efficiency (Cooper *et al.*, 1967) causing greater synthesis, translocation and accumulation of carbohydrates. Result of present study is in confirmity with the findings of Awada and Suehisa (1970), who reported that effect of potassium on trunk diameter was non-significant at twelve month age, probably because at this stage, plants were heavily laden with developing fruits of first crop and developing fruit became a stronger sink for potassium than for other nutrients. Jauhari and Singh (1970) observed in papaya variety Coorg Honeydew that potash application increased the thickness of plants.

NP interaction had significant influence on plant girth at all stages of growth except 4 MAP and 10 MAP. NK interaction also had significant influence on plant girth, at all stages of growth. Jauhari and Singh (1970) observed in papaya variety Coorg Honeydew that NK interaction increased girth of plants.

PK interaction had significant influence on plant girth at all stages of growth except 12 MAP.

Present study revealed that NPK interaction had significant influence on plant girth at all stages except 2 MAP. At all stages treatment $n_1p_2k_2$ produced maximum plant girth. Probable reasons for better girth of papaya plant in these treatments may be higher requirement of nitrogen, phosphorus and potassium and synergistic effect between nitrogen and phosphorus as observed by Yawalkar *et al.* (1981) also. Potassium probably stimulated the efficiency of nitrogen utilization in respect of growth.

5.1.3 Number of Leaves

Result of the present study revealed that nitrogen application had significant influence on number of leaves at all stages of growth. Application of highest dose of nitrogen (300 g plant^{-1} year^{-1}) resulted in maximum number of leaves. By increasing the level of nitrogen, number of leaves produced also increased.

Biswas *et al.* (1989) noted in papaya variety Ranchi that treatment with nitrogen markedly influenced leaf production. The highest dose of nitrogen (350 g plant^{-1}) produced more than 21 leaves plant^{-1} over control.

Phosphorus application increased number of leaves at all stages of growth. During 2 MAP, 4 MAP and 10 MAP, highest dose of phosphorus (300 g plant^{-1} year^{-1}) resulted in maximum number of leaves. During 6 MAP, 8 MAP and 12 MAP, lowest level of phosphorus (200 g plant^{-1} year^{-1}) resulted in largest number of leaves.

Potassium had significant influence on leaf number at all stages of growth. Increasing the dose of potassium increased the leaf number. At all stages of growth, highest level of potassium (500 g plant^{-1} year^{-1})

resulted in the maximum number of leaves. This result was in confirmity with the findings of Biswas *et al.* (1989), who reported that in papaya variety Ranchi potassium application had pronounced effect on leaf production, which increased the leaf number by 10, at highest level of potassium.

NP and NK interaction had significant influence on leaf production. Biswas *et al.* (1989) noted that in papaya variety Ranchi, combined effect of nitrogen and potassium showed the greatest effect on leaf production, where more than 25 leaves plant^{-1} were recorded over control.

NPK interaction had significant influence on leaf number at all stages of growth. At all stages except 8 MAP and 10 MAP treatment $n_2p_1k_2$ showed highest number of leaves *i.e.*, highest level of nitrogen and potassium combined with medium dose of phosphorus resulted in the maximum production of leaves. During 8 MAP and 10 MAP treatment $n_0p_0k_2$ produced maximum number of leaves.

5.1.4 Time Taken for First Flowering

Nitrogen application had significant influence on time taken for first flowering. Application of medium dose of nitrogen (250 g plant^{-1} year^{-1}) reduces days taken for flowering.

From similar experiments, Rao and Rao (1978) also reported in papaya variety CO-1 that, nitrogen decreased the number of days to flower. Reddy *et al.* (1990) observed in papaya variety Coorg Honeydew that nitrogen application induced early flowering.

Increasing the dose of phosphorus and potassium decreased the number of days taken for flowering, when compared to the application of lowest level of phosphorus and potassium.

NP, NK and PK interactions had significant influence on time for first flowering. NPK interaction had significant influence on time for first flowering. Treatment $n_1p_1k_2$ reported lowest number of days (199.5 days) for flowering. Medium dose of nitrogen (250 g plant^{-1} year^{-1}), medium dose of phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) resulted in lowest duration for flowering.

5.1.5 Height of First Flowering

The present study revealed that none of the treatments differed significantly with respect to height of first flowering.

5.1.6 Time for Harvest

Application of nitrogen had significant influence on time for harvest. Application of highest dose of nitrogen (300 g plant^{-1} year^{-1}) resulted in slight increase in the time taken for harvest, while medium dose of nitrogen (250 g plant^{-1} year^{-1}) reduced it. Application of phosphorus (300 g plant^{-1} year^{-1}) and potassium (500 g plant^{-1} year^{-1}) had significant influence on time for harvest.

NP, NK, PK and NPK interactions had significant influence on time for harvest. Combined application of 250 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1} resulted in the lowest number of days for harvest. While control plants registered maximum number of days for harvest.

Patil *et al.* (1995) observed in papaya variety Washington that number of days required for fruit maturity from fruit set was lowest by applying 15 g K as muriate of potash, 158 N as urea and 15 g P as single super phosphate, applied every month.

5.1.7 Number of Flowers Cluster^{-1}

The present study revealed that none of the treatments differed significantly with respect to number of flowers cluster^{-1}. In general, application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1} in six split doses at two months interval had a promoting effect on growth characters of papaya variety CO-2 under Kerala conditions.

5.2 YIELD CHARACTERS

5.2.1 Number of Fruits Plant^{-1}

Nitrogen application had significant influence on number of fruits plant^{-1}. Application of medium dose of nitrogen (250 g plant^{-1} year^{-1}) resulted in maximum number of fruits plant^{-1}.

Awada and Long (1980) noted in papaya variety Solo that nitrogen application increased the total number of marketable fruits. In papaya variety Ranchi, Biswas *et al.* (1989) noticed that treatment with nitrogen (350 g plant^{-1}) increased the number of fruits plant^{-1}. Purohit (1993) reported that in papaya variety Coorg Honeydew, application of 250 g nitrogen gave significantly more number of fruits. Viegas *et al.* (1999) observed that application of 343 g nitrogen resulted in highest number of fruits in Sunrise Solo at 360 days after transplanting.

Phosphorus application had significant influence on number of fruits plant^{-1}. Application of highest dose of phosphorus (300 g plant^{-1} year^{-1}) registered in the maximum number of fruits plant^{-1}.

Awada and Long (1978) reported that in papaya variety Solo, phosphorus fertilization increased the number of harvested fruits. Purohit *et al.* (1979) noted in papaya variety Coorg Honeydew that application of 250 g phosphorus recorded the highest number of fruits plant^{-1}.

Use of potassium had significant influence on number of fruits plant^{-1}. Application of highest dose of potassium (500 g plant^{-1} year^{-1}) resulted in highest number of fruits plant^{-1}. This result was in confirmity with the findings of Purohit (1977), who observed that in papaya variety Coorg Honeydew application of 500 g K_2O gave significantly more number of fruits plant^{-1}. Awada and Long (1980) noticed that in papaya variety Solo, potassium fertilization increased the total number of marketable fruits. Biswas *et al.* (1989) reported in papaya variety Ranchi that potassium application at different levels increased the number of fruits plant^{-1}.

NP interaction had significant influence on number of fruits plant^{-1}, as observed by Purohit *et al.* (1979) in papaya variety Coorg Honeydew where NP interaction was significant in increasing the number of fruits plant^{-1}.

NK interaction had significant influence on number of fruits plant^{-1}. Purohit (1977) also noted in papaya variety Coorg Honeydew that NK interaction had significant influence on number of fruits plant^{-1}.

PK interaction also had significant influence on number of fruits plant^{-1}.

NPK interaction had significant influence on number of fruits plant^{-1}. Highest number of fruits was obtained from treatment $n_1p_1k_2$ i.e., medium dose of nitrogen (250 g plant^{-1} year^{-1}) and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum number of fruits plant^{-1}.

Purohit (1977) reported that in papaya variety Coorg Honeydew application of 250 g nitrogen, 110 g phosphorus and 415 g potassium plant^{-1} year^{-1} resulted in the highest number of fruits plant^{-1}. Patil *et al.* (1995) observed that in papaya variety Washington, maximum number of fruits plant^{-1} was obtained by the application of 30 g N as urea, 30 g P a single super phosphate and 30 g K as muriate of potash month^{-1}. Singh *et al.* (1998) reported in papaya variety Ranchi that maximum number of fruits were obtained by applying N 200 g, p_2O_5 300 g and K_2O 500 g plant^{-1}.

5.2.2 Fruit weight

The present studies revealed that nitrogen application had significant influence on fruit weight. Application of medium dose of nitrogen (250 g plant^{-1} year^{-1}) resulted in the highest fruit weight.

Awada and Long (1980) reported in papaya variety Solo that nitrogen application increased the weight of each marketable fruit. According to Lopez and Jurado (1983) in papaya variety P.R. 7-65, high doses of nitrogen increased fruit weight. Biswas *et al.* (1989) noted that in papaya variety Ranchi, weight of individual fruit significantly increased with the increased dose of nitrogen. Viegas *et al.* (1999) observed in papaya variety Sunrise Solo that application of 343 g N plant^{-1} resulted in the highest fruit weight of 578 g at 270 days after transplanting.

Phosphorus application had significant influence on fruit weight. Application of lowest dose of phosphorus (200 g plant^{-1} year^{-1}) resulted in highest fruit weight.

Fruit weight increased by increasing the level of potassium. Highest fruit weight was obtained with highest dose of potassium (500 g plant^{-1}/ year).

Awada and Long (1980) observed that in papaya variety Solo, potassium fertilization increased the weight of each marketable fruit.

NP, NK and PK interactions had significant influence on fruit weight.

NPK interaction had significant influence on fruit weight. Highest fruit weight was obtained from the treatment $n_1p_1k_2$. Medium dose of nitrogen and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum fruit weight. This may be due to better combinations of N, P and K.

Purohit (1977) noticed that application of 250 g N, 110 g P and 415 K plant^{-1} year^{-1} resulted in increased fruit weight.

5.2.3 Fruit Length

The present studies revealed that none of the treatments differed significantly with respect to fruit weight.

5.2.4 Fruit Girth

Nitrogen application increased fruit girth. Application of 200 g of nitrogen plant^{-1} year^{-1}) resulted in the maximum fruit girth.

Biswas *et al.* (1989) noted in papaya variety Ranchi that, nitrogen had a great effect on increasing the size of fruits.

Application of phosphorus had significant influence on fruit girth. Lowest dose of phosphorus (200 g plant^{-1} year^{-1}) resulted in the maximum fruit girth. Increasing the level of phosphorus had a decreasing effect.

Potassium application also had significant influence on fruit girth. Increasing the dose of potassium increased fruit girth. Maximum fruit girth was seen with highest dose of potassium (500 g plant^{-1} year^{-1}).

Biswas *et al.* (1989) observed that in papaya variety Ranchi, application of potassium increased breadth of fruit.

NP and PK interaction had significant influence on fruit girth. NK interaction was not significant with respect to fruit girth.

NPK interaction had significant influence on fruit girth. Highest fruit girth was obtained with treatment $n_0p_0k_2$. Lowest dose of nitrogen and phosphorus (200 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum fruit girth. Singh *et al.* (1998) reported that in papaya variety Ranchi, highest fruit size was obtained by applying 200 g N, 300 g P_2O_5 and 100 g K_2O plant^{-1}.

5.2.5 Fruit Volume

Nitrogen had significant influence on fruit volume. Medium dose of nitrogen (250 g plant^{-1} year^{-1}) gave maximum fruit volume, while highest dose of nitrogen (300 g plant^{-1} year^{-1}) showed a reduction in volume.

Phosphorus application also had significant influence on fruit volume. Lowest level of phosphorus (200 g plant^{-1} year^{-1}) gave maximum fruit volume, but increasing the level of phosphorus resulted in a decrease in volume.

As in the case of nitrogen and phosphorus, potassium also had significant influence on fruit volume. Increasing the level of potassium increases fruit volume. Maximum fruit volume was reported by highest level of potassium (500 g plant^{-1} year^{-1}).

NP, NK and PK interactions had significant influence on fruit volume. Highest fruit volume was obtained from treatment $n_1p_1k_2$. Medium dose of nitrogen and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum fruit volume.

No earlier reports on the effect of N, P, K application on fruit volume in papaya could be traced.

5.2.6 Pulp Percentage

Nitrogen had significant influence on pulp percentage of papaya fruits. Increasing the level of nitrogen increased pulp percentage. Highest pulp percentage was seen with highest dose of nitrogen (300 g plant^{-1} year^{-1}).

Patil *et al.* (1995) noted that in papaya variety Washington, high pulp percentage (70 per cent) was obtained by applying 30 g nitrogen as neem cake, applied every month.

Phosphorus had significant influence on pulp percentage. Medium dose of phosphorus (250 g plant^{-1} year^{-1}) gave maximum pulp percentage.

Potassium also had significant influence on pulp percentage. Lowest dose of potassium (300 g plant^{-1} year^{-1}) gave highest pulp percentage.

NP, NK, PK and NPK interactions had significant influence on pulp percentage. Highest pulp percentage was reported by treatment $n_1p_1k_2$. Medium dose of nitrogen and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum pulp percentage. Singh *et al.* (1998) reported that maximum flesh percentage (82.50 per cent) in papaya variety Ranchi, was obtained by applying 200 g N, 300 g P_2O_5 and 150 g K_2O plant^{-1}. The flesh thickness and percentage seems to be associated with the size and weight of the fruits.

5.2.7 Total Yield Plant^{-1}

Nitrogen application had significant influence on total yield plant^{-1}. Application of medium dose of nitrogen (250 g plant^{-1} year^{-1}) resulted in highest yield.

In papaya variety Coorg Honeydew, Jauhari and Singh (1970) reported that nitrogen was effective in increasing the yield. Awada and Long (1971b) recorded an increase in yield of fruits in papaya variety Solo by nitrogen application. Gillard (1972) obtained the highest yield in Solo papaya by treatment with 250 g each of nitrogen and potassium plant^{-1}. According to Luna and Caldas (1984), nitrogen increased yield in papaya. Biswas *et al.* (1989) reported in papaya variety Ranchi that fruit yield increased significantly by applying 350 g nitrogen and 600 g potassium plant^{-1}. Reddy and Kohli (1989) noted that in papaya variety Coorg Honeydew application of nitrogen, resulted in diversion of biomass towards fruits, indicating a high yield potential. Reddy *et al.* (1990) reported that in papaya variety Coorg Honeydew, nitrogen application increased fruit yield significantly.

Phosphorus application had significant influence on total yield plant^{-1}. Application of medium dose of phosphorus (250 g plant^{-1} year^{-1}) resulted in highest yield plant^{-1}.

Reddy *et al.* (1989) reported that in papaya variety Coorg Honeydew, effect of phosphorus application on fruit yield was more pronounced as compared to nitrogen or potassium application. Purohit (1977) also observed similar result. Rao and Rao (1978) noted that both nitrogen and phosphorus influenced, yield in papaya variety CO-1. According to Luna and Caldas (1984), phosphorus application increased yield in papaya. Sulladmeth *et al.* (1984) reported that application of 250 g phosphorus resulted in the highest yield in papaya variety Solo.

Potassium application had significant influence on total yield plant^{-1}. Application of highest dose of potassium (500 g plant^{-1} year^{-1}) resulted in the highest yield plant^{-1}.

Jauhari and Singh (1970) noted in papaya variety Coorg Honeydew that application of potash increased yield significantly. Potassium is an essential element in certain enzymatically catalyzed transphosphorylation reactions, which may be regarded as role of potassium in carbohydrate metabolism. Purohit (1993) reported that in papaya variety Coorg Honeydew application of potassium at 500 g K_2O gave significantly more yield.

NP, NK and PK interactions had significant influence on total yield plant^{-1}.

NPK interaction had significant influence on total yield plant^{-1}. Highest fruit yield was obtained from treatment $n_1p_1k_2$. Medium dose of nitrogen and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum yield plant^{-1}. The possible explanation for higher yield in treatment $n_1p_1k_2$ could be a favourable combination of NPK, which provided better vigour to the plants. There is a close relationship between vigour of plant and yield (Singh *et al.*, 1998). Very unsatisfactory and uneconomical yield was found in plants under control.

Jauhari and Singh (1970) noted in papaya variety Coorg Honeydew that maximum yield plant^{-1} was obtained by applying 140 g N, 70 g P and 140 g K plant^{-1} year^{-1}. According to Purohit (1977) in papaya variety Coorg Honeydew, a fertilizer dose of 250 g N, 110 g P and 415 g K plant^{-1} year^{-1} gave maximum yield plant^{-1}. In the studies on nutrition of papaya variety Coorg Honeydew, Reddy *et al.* (1989) observed that 250 g N, 375 g P_2O_5 and 500 g K_2O plant^{-1} year^{-1} gave maximum yield plant^{-1}. Patil *et al.* (1995) revealed that in papaya variety Washington, higher yields were obtained with the application of higher level of NPK plant^{-1} month^{-1}.

Veeraraghavathatham *et al.* (1996) reported that NPK dose of 50 : 50 : 50 g $plant^{-1}$ is recommended at each application for papaya at two month interval. This treatment increased yield $plant^{-1}$. Singh *et al.* (1998) recorded maximum yield in papaya variety Ranchi by applying 200 g N, 300 g P_2O_5 and 100 g K_2O $plant^{-1}$.

5.2.8 Papain Yield

Nitrogen application influenced papain yield significantly. Application of medium dose of nitrogen (250 g $plant^{-1}$ $year^{-1}$) resulted in highest papain yield.

Irulappan *et al.* (1984) reported that in papaya variety C0-2, application of 250 g nitrogen $plant^{-1}$ $year^{-1}$ in six split doses at bimonthly interval, commencing from second month after planting was found to be optimum for papain yield. Auxcilia and Sathiamoorthy (1999a) observed that in papaya variety CO-2, application of 400 g nitrogen, 25 mg paclobutrazol resulted in the highest latex yield in both warm and cool seasons.

Phosphorus application also had significant influence on papain yield. Highest papain yield was obtained by using highest level of phosphorus (300 g $plant^{-1}$ $year^{-1}$).

As in the case of nitrogen and phosphorus, potassium had significant influence on papain yield. Application of highest level of potassium (500 g $plant^{-1}$ $year^{-1}$) resulted in maximum papain yield.

NP, NK and PK interactions had significant influence on papain yield.

NPK interaction also had significant influence on papain yield. Highest papain yield was obtained from treatment $n_1p_1k_2$ *i.e.*, Medium dose of nitrogen and phosphorus (250 g $plant^{-1}$ $year^{-1}$) combined with highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$) gave maximum papain yield. In general, as in the case of vegetative characters, the yield characters of papaya variety CO-2 was positively influenced by application of NPK at 250 : 250 : 500 g plant^{-1} year^{-1} at six equal split doses.

5.3 QUALITY CHARACTERS

5.3.1 TSS (Total Soluble Solids)

Nitrogen and phosphorus application had no significant influence on TSS content of fruits. This finding is in confirmity with the observations of Reddy and Kohli (1989) and Reddy *et al.* (1990) who observed that in papaya variety Coorg Honeydew, TSS was not affected by different levels of nitrogen.

Potassium application had significant influence on TSS content of plants. Highest dose of potassium (500 g plant^{-1} year^{-1}) gave highest TSS content of fruits.

Purohit (1977) reported in papaya variety Coorg Honeydew that application of potassium increased TSS content of fruit. Jauhari and Singh (1970) recorded in papaya variety Coorg Honeydew that application of potassium increased TSS appreciably.

NP and NK interactions had significant influence on TSS content of fruits. Purohit (1977) reported that NK interaction had significant influence on TSS content in papaya variety Coorg Honeydew.

PK and NPK interaction had no significant influence on TSS content of fruits.

5.3.2 Acidity

Nitrogen application had significant influence on acidity of fruits. Acidity of fruits declined with highest dose of nitrogen (300 g plant^{-1} year^{-1}).

Biswas *et al.* (1989) showed that in papaya variety Ranchi, plants under control produced fruits with high percentage of acidity, while it declined with higher levels of nitrogen and potassium.

Phosphorus application had significant influence on acidity of fruits. Highest acidity was obtained with lowest dose of phosphorus (200 g $plant^{-1}$ $year^{-1}$) and lowest acidity with medium dose of phosphorus (250 g $plant^{-1}$ $year^{-1}$).

In the present experiment application of different levels of potassium had no influence on acidity of fruits.

Interactions NP and PK were not significant, while interaction NK influenced acidity. Lowest acidity was obtained from combination of 300 g nitrogen and 500 g potassium $plant^{-1}$ $year^{-1}$. Highest dose of nitrogen combined with highest dose of potassium gave lowest acidity.

NPK interaction had significant influence on acidity. Lowest acidity was noticed with the combined application of 200 g nitrogen, 300 g phosphorus and 500 g potassium $plant^{-1}$ $year^{-1}$. Control reported highest acidity of fruits.

5.3.3 Total Carotenoids

Nitrogen and phosphorus application had no effect on total caroteinoids.

Potassium application had significant influence on total carotenoids content of fruits. Highest carotenoid content was obtained from highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$). Carotenoid content increased with increasing the level of potassium.

Interaction NP and NK had no significant influence on carotenoid content, while PK interaction was significant.

NPK interaction had significant influence on carotenoid content. Highest carotenoid content was reported by treatment $n_0p_2k_2$. Lowest dose of nitrogen (200 g $plant^{-1}$ $year^{-1}$) combined with highest dose of phosphorus (300 g $plant^{-1}$ $year^{-1}$) and highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$) gave highest carotenoid content.

No earlier reports on effect of N, P and K application on carotenoid content of papaya could be traced.

5.3.4 Ascorbic acid

Nitrogen and phosphorus application had no significant influence on ascorbic acid content of fruits.

Potassium application had significant influence on ascorbic acid content. Highest ascorbic acid content was obtained with highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$).

Interactions NP, NK and NPK had no significant influence, but PK interaction had significant influence on ascorbic acid content.

5.3.5 Total Sugar

Nitrogen application had significant influence on total sugar content of papaya. Nitrogen application decreased total sugar content. Increasing the level of nitrogen decreases total sugar content in papaya. This observation was in line with the finding of Jauhari and Singh (1970), who observed that in papaya variety Coorg Honeydew, nitrogen application alone significantly reduced the total sugar in fruits. It is an established fact that application of nitrogen decreases the carbohydrate, but increased the protein content of fruits.

Phosphorus had significant influence on total sugar content. Highest total sugar content was obtained with lowest level of phosphorus (200 g $plant^{-1}$ $year^{-1}$).

Potassium application had significant influence on total sugar content. Potassium application increased total sugar content. Highest total sugar content was obtained with highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$).

Jauhari and Singh (1970) noted in papaya variety Coorg Honeydew that potassium application increased sugar content. Potash is an integral part of sugars, its application is liable to favour the formation and transfer of sugars in plants. These findings obviously establish the importance of potassic doses for papaya plants. Yawalkar (1981) reported that potash helped in the formation of sugar.

NP, NK, PK and NPK interactions had significant influence on total sugar content in papaya.

Highest total sugar content was obtained with the application of lowest dose of nitrogen (200 g) combined with highest dose of phosphorus (300 g) and potassium (500 g). The probable reason for higher sugar content in fruits under this treatment would be due to higher level of phosphorus and lowest level of nitrogen.

Singh *et al.* (1998) reported in papaya variety Ranchi that, maximum sugar content in the fruit pulp was obtained by applying 200 g nitrogen, 300 g P_2O_5 and 150 g K_2O plant^{-1}.

5.3.6 Reducing Sugar

Nitrogen application had significant influence on reducing sugar content of papaya. Highest reducing sugar content was observed with lowest dose of nitrogen (200 g plant^{-1} year^{-1}).

Phosphorus application had significant influence on reducing sugar content in papaya. Highest reducing sugar content was noticed with highest dose of phosphorus.

Potassium application also had significant influence on reducing sugar content. Maximum reducing sugar content was obtained with highest dose of potassium (500 g plant^{-1} year^{-1}).

NP, NK, PK and NPK interactions had significant influence on reducing sugar content.

Highest reducing sugar content was noted with treatment $n_0p_2k_2$. Lowest dose of nitrogen (200 g plant^{-1} year^{-1}) combined with highest dose of phosphorus (300 g plant^{-1} year^{-1}) and highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum reducing sugar content.

5.3.7 Non Reducing Sugar

Nitrogen and potassium application had no significant influence on non reducing sugar content.

Phosphorus application had significant influence on non reducing sugar content. Maximum non reducing sugar content was noted with lowest dose of phosphorus (200 g plant^{-1} year^{-1}).

NP, NK, PK and NPK interactions had no significant influence on non reducing sugar content.

5.3.8 Colour of Peel

Peel colour of fruit at edible ripe stage varied from yellowish green to light yellow peel colour. Treatments $n_0p_0k_2$, $n_0p_1k_1$, $n_0p_2k_0$, $n_0p_2k_1$, $n_1p_1k_1$, $n_1p_2k_0$, $n_1p_2k_1$, $n_2p_0k_1$ and $n_2p_2k_0$ had yellowish green peel colour. Rest all the treatments had light yellow and colour.

Patil *et al.* (1995) noted that in papaya variety Washington, application of lower levels of nitrogen (158 N plant^{-1} month^{-1}) as groundnut cake helped to produce fruits with good colour on ripening.

5.3.9 Colour of Pulp

Colour of pulp ranged from yellowish orange to orange. Treatments $n_0p_0k_1$, $n_0p_0k_2$, $n_0p_1k_0$, $n_1p_0k_1$, $n_1p_1k_0$, $n_1p_1k_1$, $n_1p_2k_2$ and $n_2p_2k_0$ had yellowish orange pulp colour. Rest all the treatment had orange pulp colour. Thus it was observed that the doses of N, P and K did not show a trend in developing pulp colour.

5.3.10 Firmness of Pulp

Firmness of pulp of different treatment varied from fairly firm to firm flesh. Treatments $n_0p_0k_2$, $n_0p_1k_0$, $n_0p_1k_2$, $n_2p_2k_1$, $n_1p_0k_0$, $n_1p_0k_2$, $n_1p_1k_0$, $n_1p_2k_2$, $n_2p_0k_1$ and $n_2p_1k_2$ had fairly firm flesh. Rest all treatments had firm flesh. It may be possible that high nitrogen content reduces the firmness of the pulp.

Awáde *et al.* (1979) also observed that in papaya variety Solo flesh firmness of fruits was found to decrease with higher nitrogen levels.

5.3.11 Organoleptic Qualities

The organoleptic qualities of papaya under different treatments in the present study gave the following indications.

Treatment $n_0p_2k_2$ obtained highest score for appearance. Lowest score was for control plants.

The score for pulp colour was higher for treatment $n_0p_2k_2$. Lowest score was for control plants.

Highest score for flavour was secured by treatment $n_1p_1k_1$. Lowest score was for $n_1p_0k_1$.

The score for taste was high in treatment $n_0p_2k_2$. Lowest score was for treatment $n_2p_1k_0$. Maximum score for texture of pulp was secured by treatment $n_1p_1k_2$. Lowest score was secured by treatment $n_2p_2k_2$. Treatment $n_0p_2k_2$ had less papain odour. Highest papain odour was for $n_2p_1k_0$.

The results of overall assessment of organoleptic qualities indicated that among the different treatments tested, papaya that received lowest dose of nitrogen (200 g) combined with highest dose of phosphorus (300 g) and potassium (500 g) was the most acceptable. Least acceptable one was control.

In papaya, the personal preference and acceptability are largely decided by factors such as colour of pulp, firmness or softness of pulp, taste, flavour, freedom from objectional papain odour etc. Based on these characters, papaya that received lowest dose of nitrogen (200 g) combined with highest dose of phosphorus (300 g) and potassium (500 g) was the most acceptable one.

Patil *et al.* (1995) reported that in papaya variety Washington application of lower levels of nitrogen (158 N plant^{-1} month^{-1}) in the form of groundnut cake helped in the improvement of taste of fruits.

5.3.12 Shelf Life

Nitrogen application had significant influence on shelf life of papaya at ambient conditions. Highest shelf life was obtained with lowest dose of nitrogen (200 g plant^{-1} year^{-1}).

Phosphorus application had significant influence on shelf life of papaya. Highest shelf life was obtained with medium dose of phosphorus (250 g plant^{-1} year^{-1}).

Potassium application had significant influence on shelf life of papaya. Increasing the level of potassium application increased shelf life of papaya. Highest shelf life was obtained with highest dose of potassium application (500 g plant^{-1} year^{-1}).

NP, NK and PK interactions had significant influence on shelf life of papaya.

NPK interaction had significant influence on shelf life of papaya. Highest shelf life was obtained from treatment $n_2p_0k_0$ followed by treatment $n_0p_2k_2$.

From the present investigations, it was inferred that application of N 200 to 250 g, P 250-300 g and K 500 g plant^{-1} year^{-1} in six equal splits improved the quality of fruits and shelf life.

5.4 NUTRIENT UPTAKE

5.4.1 Soil nitrogen

Nitrogen application had significant influence on soil nitrogen content. Application of medium dose of nitrogen (250 g plant^{-1}) gave highest soil nitrogen content.

Phosphorus application had significant influence on soil nitrogen content. Increasing the level of phosphorus application increased soil nitrogen content.

Potassium application had significant influence on soil nitrogen content. Application of highest dose of potassium (500 g plant^{-1} year^{-1}) resulted in the maximum nitrogen content in the soil.

NP, NK and PK interactions had significant influence on soil nitrogen content. NPK interaction also had significant influence on soil nitrogen content. Highest soil nitrogen content was obtained by the application of 250 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

Veerannah and Selvaraj (1984) reported that the nutrient removed by whole papaya plant at harvest were 305, 103, 524, 327 and 183 kg N, P, K, Ca and Mg respectively ha^{-1}.

5.4.2 Soil Phosphorus

Nitrogen application had significant influence on soil phosphorus content. Application of medium dose of nitrogen (250 g plant^{-1} year^{-1}) resulted in highest soil phosphorus content.

Phosphorus application had significant influence on soil phosphorus content. Increasing the level of phosphorus, increased the soil phosphorus content.

Potassium application had significant influence on soil phosphorus content. Increasing level of potassium increased soil phosphorus content.

NP, NK, PK and NPK interactions had significant influence on soil phosphorus content. Highest soil phosphorus content was obtained from treatment $n_1p_1k_2$ *i.e.*, by the combined application of 250 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

5.4.3 Soil Potassium

Nitrogen application had significant influence on soil potassium content. Increasing the level of nitrogen application, increased soil potassium content.

Phosphorus application had significant influence on soil potassium content. Increasing the level of phosphorus, increased soil potassium content.

Potassium application had significant influence on soil potassium content. Highest soil potassium content was noticed with highest dose of potassium (500 g $plant^{-1}$ $year^{-1}$).

NP, NK, PK and NPK interactions had significant influence on soil potassium content. Maximum soil potassium content was obtained with the combined application of 200 g nitrogen, 300 g phosphorus and 500 g potassium $plant^{-1}$ $year^{-1}$.

5.4.4 Leaf petiole nitrogen

Nitrogen application had significant influence on leaf petiole nitrogen content. Highest petiole nitrogen content was obtained with medium dose of nitrogen (250 g $plant^{-1}$ $year^{-1}$).

Awada and Long (1971b) stated that in papaya variety Solo, concentrations of petiole nitrogen increased with nitrogen applications. According to Lopez and Jurado (1984) in papaya variety P.R. 7-65, petiole nitrogen content increased with nitrogen and boron application.

Phosphorus application had significant influence on leaf petiole nitrogen content. Highest value for leaf petiole nitrogen was noticed with medium dose of phosphorus (250 g $plant^{-1}$ $year^{-1}$). Awada *et al.* (1975) revealed that phosphorus fertilization raised the petiole concentrations of P, N, Mn and Zn but lowered K and Cu.

Potassium application had significant influence on leaf petiole nitrogen content. Increasing the level of potassium, increases leaf petiole nitrogen content.

Reddy *et al.* (1989) observed that in papaya variety Coorg Honeydew application of N, P and K increased the concentration of respective elements in petioles.

Interactions NP, NK and PK had significant influence on leaf petiole nitrogen content. NPK interaction also had significant influence on leaf petiole nitrogen content. Highest leaf petiole nitrogen content was recorded by treatment $n_1p_1k_2$ *i.e.*, by the combined application of 250 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

5.4.5 Leaf Petiole Phosphorus

Nitrogen application had significant influence on leaf petiole phosphorus content.

Phosphorus application had significant influence on leaf petiole phosphorus content. Highest leaf petiole phosphorus was obtained with medium dose of phosphorus (250 g plant^{-1} year^{-1}).

Awada *et al.* (1975) revealed that phosphorus fertilization raised the petiole concentrations of P, N, Mn and Zn but lowered K and Cu.

Potassium application had significant influence on leaf petiole phosphorus content. Highest leaf petiole phosphorus was obtained with highest dose of potassium (500 g plant^{-1} year^{-1}). Increasing the level of potassium, increased leaf petiole potassium content.

NP, NK, PK and NPK interactions had significant influence on leaf petiole phosphorus content. Highest leaf petiole phosphorus content was obtained from treatment $n_2p_1k_2$ *i.e.*, by the combined application of 300 g nitrogen 250 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

5.4.6 Leaf Petiole Potassium

Application of nitrogen had significant influence on leaf petiole potassium content. Increasing the level of nitrogen, increased the petiole potassium content.

Phosphorus application had significant influence of leaf petiole potassium content. Increasing the level of phosphorus, increased the petiole potassium content.

Potassium application had significant influence on leaf petiole potassium content. Increasing the level of potassium, increased the petiole potassium content.

Awada (1977) noted that in papaya variety Solo, potassium fertilization resulted in increased petiole concentrations of potassium. Reddy *et al.* (1989) observed that in papaya variety Coorg Honeydew, application of N, P and K increased the concentration of respective elements in petioles.

NP, NK, PK and NPK interactions had significant influence on leaf petiole potassium content. Highest leaf petiole potassium content was obtained from treatment $n_0p_2k_2$ *i.e.*, by the combined application of 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

The petiolar content of the major nutrients was found to be positively influenced up to an NPK level of 250 : 250 : 500 g plant^{-1} year^{-1} in six equal splits as soil application.

5.5 ECONOMICS OF CULTIVATION

Application of nitrogen had significant influence on benefit : cost ratio. Medium dose of nitrogen (250 g plant^{-1} year^{-1}) gave maximum benefit : cost ratio.

Phosphorus application had significant influence on benefit : cost ratio. Application of medium dose of phosphorus (250 g plant^{-1} year^{-1}) gave highest benefit : cost ratio.

Potassium application had significant influence on benefit : cost ratio. Application of highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum benefit : cost ratio

NK and PK interaction had significant influence on benefit : cost ratio. NP interaction had no influence on benefit : cost ratio.

NPK interaction also had significant influence on benefit : cost ratio. Highest benefit : cost ratio was obtained from treatment $n_1p_1k_2$. Medium dose of nitrogen and phosphorus (250 g plant^{-1} year^{-1}) combined with highest dose of potassium (500 g plant^{-1} year^{-1}) gave maximum benefit : cost ratio.

Auxcilia and Sathiamoorthy (1999b) reported in papaya variety CO-2 that, application of 300 g nitrogen, 25 mg Paclobutrazol and 0.4 per cent amino acids gave the highest cost : benefit ratio (1 : 3.03).

The results of the present investigations indicate that application of NPK in the proportion of 250 : 250 : 500 g plant^{-1} year^{-1} in six equal splits resulted in a more favourable benefit : cost ratio.

The overall assessment of the effect of major plant nutrients on papaya variety CO-2 under Kerala conditions indicate that the application of N, P and K at the rate of 250 : 250 : 500 g plant^{-1} year^{-1} in six equal splits from the time of transplantation in the main field positively influenced the growth, yield as well as quality. From the economic point of view also, this dosage was found to be optimum.

SUMMARY

6. SUMMARY

The present investigation on response of papaya (*Carica papaya* L.) to major mineral nutrients were carried out to study the effect of nitrogen, phosphorus and potassium on growth, yield and quality of papaya. The experiment was conducted in the Department of Pomology and Floriculture, College of Agriculture, Vellayani, Thiruvananthapuram during 2001 to 2002. Major findings of the study are summarised below.

The study revealed that during early growth stages, nitrogen requirement was 250 g plant^{-1}upto 8 months after planting (MAP) and 300 g plant^{-1}thereafter. Phosphorus was required at 250 g plant^{-1}upto 10 MAP and thereafter there was no significant effect. Application of potassium at 500 g plant^{-1}resulted in highest plant height at all stages of growth. NP, NK, PK and NPK interactions had significant influence on plant height. Highest plant height was obtained by applying 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

In general, nitrogen at the rate of 250 g plant^{-1}influenced plant girth at early stages of growth. Thereafter there was no significant effect. Effect of phosphorus at 200 g level had notable effect on girth upto 8 MAP and thereafter there was no significant effect. Potassium at 500 g plant^{-1}had influence on plant girth. NP, NK, PK and NPK interactions had significant influence on plant girth. Combined application of 250 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1} produced maximum plant girth.

In the present study it was observed that at all stages of growth, application of the highest level of nitrogen (300 g), phosphorus (300 g) and potassium (500 g) resulted in the production of maximum number of leaves. NP, NK and NPK interaction had significant influence on leaf

production. Combined application of 300 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1} resulted in maximum number of leaves.

The experiment showed that application of 250 g nitrogen, 300 g phosphorus and 500 g potassium reduced days taken for flowering. NP, NK, PK and NPK interactions were significant. Combined application of 250 g N, 250 g P and 500 g K resulted in the lowest duration for flowering.

Different levels of nitrogen, phosphorus and potassium did not significantly influence height of first flowering and the number of flowers cluster^{-1}.

Nitrogen at 250 g plant^{-1}, phosphorus at 300 g plant^{-1}and potassium 500 g plant^{-1}considerably shortened the time for harvesting the first fruit.

The data revealed that application of medium dose of nitrogen (250 g) and the highest dose of phosphorus (300 g) as well as potassium (500 g) resulted in maximum number of fruits plant^{-1}. NP, NK, PK and NPK interactions had significant influence on number of fruits plant^{-1}. The highest number of fruits were obtained with the combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

The results of the experiment revealed that application of medium dose of nitrogen (250 g), lowest dose of phosphorus (200 g) and the highest dose of potassium (500 g) resulted in highest fruit weight. NP, NK, PK and NPK interactions had significant influence on fruit weight. Highest fruit weight was obtained from combined application of 250 g N, 250 P and 500 g K plant^{-1} year^{-1}.

The present study revealed that none of the treatments differed significantly with respect to fruit length.

The experiment also showed that application of the lowest dose of nitrogen (200 g) and phosphorus (200 g) as well as the highest dose of potassium (500 g) resulted in the maximum fruit girth. NP, PK and NPK interactions had significant influence on fruit girth. Highest fruit girth was obtained from combined application of 200 g N, 200 g P and 500 g K plant^{-1} year^{-1}.

The current experiment revealed that application of medium dose of nitrogen (250 g), lowest dose of phosphorus (200 g) and highest dose of potassium (500 g) gave maximum fruit volume. NP, NK, PK and NPK interactions had significant influence on fruit volume. Highest fruit volume was obtained from the combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

Results of present studies showed that highest pulp percentage was attained with 250 to 300 g nitrogen, medium dose of phosphorus (250 g) and the lowest dose of potassium (300 g). NP, NK, PK and NPK interactions had significant influence on pulp percentage. Highest pulp percentage was observed with 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

In the present studies application of medium dose of nitrogen (250 g) and phosphorus (250 g) and the highest dose of potassium (500 g) resulted in highest yield plant^{-1}. NP, NK, PK and NPK interactions had significant influence on total yield plant^{-1}. Highest yield was obtained by the combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

The data revealed that application of medium dose of nitrogen (250 g), highest level of phosphorus (300 g) and potassium (500 g) gave maximum papain yield. Different levels of P was not significant. NP, NK, PK and NPK interactions had significant influence on papain yield. Highest papain yield was obtained from the combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

The experiment showed that nitrogen and phosphorus had no significant influence on TSS content of fruits. Application of highest dose of potassium (500 g) gave highest TSS content of fruits. NP and NK interactions had significant influence on TSS content of fruits.

A dose of 200 g nitrogen and 250 g phosphorus plant^{-1}resulted in low acidity of fruits, while K did not significantly affect this quality character. Interactions NK and NPK had significant influence on acidity. Lowest acidity was obtained with combined application of 250 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

Nitrogen and phosphorus application had no significant effect on total carotenoids. Highest carotenoid content was obtained with highest dose of potassium (500 g). Interactions of PK and NPK had significant influence on the carotenoid content. The highest carotenoid content was produced by combined application of 200 g N, 300 g P and 500 g K plant^{-1} year^{-1}.

The data showed that nitrogen and phosphorus application had no influence on ascorbic acid content. Highest ascorbic acid content was observed with highest dose of potassium (500 g). Interaction PK had significant influence on ascorbic acid content.

The present study revealed that nitrogen application decreased total sugar content in papaya. Highest total sugar content was obtained with lowest level nitrogen (200 g), phosphorus (200 g) and the highest dose of potassium (500 g). NP, NK, PK and NPK interactions had significant influence on total sugar in papaya. Highest total sugar was obtained with combined application of 200 g N, 300 g P and 500 g K plant^{-1} year^{-1}.

The results of the present studies showed that highest reducing sugar content was obtained with lowest dose of nitrogen (200 g) and the highest dose of phosphorus (300 g) as well as potassium (500 g). NP, NK, PK and NPK interactions had significant influence on reducing sugar content. Highest reducing sugar content was noted with combined application of 200 g N, 300 g P and 500 g K plant^{-1} year^{-1}.

Only phosphorus application had significant influence on non reducing sugar content. Application of 200 g phosphorus resulted in maximum non reducing sugar.

The experiment showed that most of the treatments had light yellow peel colour, orange pulp colour and firm flesh. $n_0p_2k_2$ *i.e.*, application of 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1} obtained highest score for appearance, taste and pulp colour. High score for flavour was record by $n_1p_1k_1$ *i.e.*, by application of 250 g nitrogen, 250 g phosphorus and 400 g potassium plant^{-1} year^{-1}. Maximum score for texture of pulp was secured by $n_1p_1k_2$ *i.e.*, by applying 250 g nitrogen, 250 g phosphorus and 500 g potassium plant^{-1} year^{-1}. Less papain colour was observed in $n_0p_2k_2$ *i.e.*, by application of 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1}. The overall acceptability was improved by the application of 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1}.

In the present studies it was observed that highest shelf life of papaya was obtained with the lowest dose of nitrogen (200 g), medium dose of phosphorus (250 g) and the highest dose of potassium (500 g). NP, NK, PK and NPK interactions had significant influence on shelf life of papaya. Highest shelf life was obtained from combined application of 300 g N, 200 g P and 300 g K plant^{-1} year^{-1}.

In the present studies it was observed that application of medium dose of nitrogen (250g) and highest dose of potassium (500 g) resulted in maximum nitrogen content in the soil. Increasing the level of phosphorus application, increased soil nitrogen content. NP, NK, PK and NPK interactions had significant influence on soil nitrogen content. Highest soil nitrogen content was obtained with combined application of 200 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

Application of medium dose of nitrogen (250 g) resulted in highest soil phosphorus content. NP, NK, PK and NPK interactions had significant influence on soil phosphorus content. Highest soil phosphorus content was obtained from combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

Increasing the level of nitrogen, phosphorus and potassium increased soil potassium content. NP, NK, PK and NPK interactions had significant influence on soil potassium content. Maximum soil potassium content was obtained with combined application of 200 g N, 300 g P and 500 g K plant^{-1} year^{-1}.

The experiment showed that the highest leaf petiole nitrogen content was obtained with application of medium dose of nitrogen and phosphorus (200 g). Increasing the level of potassium, increased leaf petiole nitrogen content. NP, NK, PK and NPK interactions had significant influence on leaf petiole nitrogen content. Highest leaf petiole nitrogen content was reported by combined application of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

Increasing the level of nitrogen, increased leaf petiole phosphorus content. Highest leaf petiole phosphorus content was obtained from medium dose of phosphorus (250 g) and with highest dose of potassium (500 g). NP, NK, PK and NPK interactions had significant influence on leaf petiole phosphorus content. Highest leaf petiole phosphorus content was obtained from the combined application of 300 g N, 250 g P an 500 g K plant^{-1} year^{-1}.

The experiment showed that increasing the level of nitrogen, phosphorus and potassium increased the leaf petiole potassium content. NP, NK, PK and NPK interactions had significant influence on leaf petiole potassium content. The highest leaf petiole potassium content was obtained from combined application of 200 g N, 300 g P and 500 g K plant^{-1} year^{-1}.

The present studies showed that application of medium dose of nitrogen (250 g) and phosphorus (250 g) and highest dose of potassium (500 g) gave maximum benefit : cost ratio. NK, PK and NPK interactions had significant influence on benefit : cost ratio. Highest benefit : cost ratio was obtained from the combined application of 250 g N, 250 g P and 500 g K $plant^{-1}$ $year^{-1}$.

The overall assessment of the effect of major plant nutrients on papaya indicate that application of N, P and K at the rate of 250 : 250 : 500 g $plant^{-1}$ $year^{-1}$ in six equal splits at two months interval had beneficial effects on growth, yield and quality of papaya under Kerala conditions.

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*Original not seen

RESPONSE OF PAPAYA (*Carica papaya* L.) TO MAJOR MINERAL NUTRIENTS

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Abstract of the
thesis submitted in partial fulfilment of the requirement
for the degree of

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8. ABSTRACT

An experiment was conducted in the Department of Pomology and Floriculture, College of Agriculture, Vellayani during 2001-2002, to study the response of major plant nutrients *viz.*, nitrogen, phosphorus and potassium on growth, yield and quality of papaya under Kerala conditions and to standardise the optimum dose of these nutrients. The experiment was conducted in 3^3 confounded factorial RBD, confounding NPK in replication 1 and NP^2K^2 in replication 2.

The present study revealed that application of nitrogen, phosphorus and potassium increased plant height, girth and number of leaves. The highest plant height was obtained with the combined application of 200 g N, 300 g P and 500 g K $plan^{-1}$ $year^{-1}$, while the highest plant girth was obtained with application of 250 g N, 300 g P and 500 g K. Combined application of 300 g N, 250 g P and 500 g K $plant^{-1}$ $year^{-1}$ resulted in the maximum number of leaves. Plants receiving a dose of nitrogen at 250 g, 300 g phosphorus and 500 g potassium $plant^{-1}$ took the shortest time for flowering. Combined application of nitrogen at 250 g $plant^{-1}$, phosphorus at 250 g $plant^{-1}$ and potassium at 500 g $plant^{-1}$ considerably shortened the time for harvesting the first fruit.

Fruit weight, number of fruits $plant^{-1}$, yield $plant^{-1}$ and papain yield increased by application of nitrogen, phosphorus and potassium. Application of 250 g N, 250 g P and 500 g K $plant^{-1}$ $year^{-1}$ gave highest yield. Maximum fruit girth was obtained from 200 g N, 200 g P and 500 g K, whereas maximum fruit volume and pulp percentage was obtained from 250 g N, 250 g P and 500 g K.

Levels of nitrogen and phosphorus tried had no significant influence on TSS and ascorbic acid content of fruits. Nitrogen at 200 g, phosphorus at 250 g $plant^{-1}$ produced fruits of low acidity, while potassium had no

significant influence. The combination of 200 g nitrogen, 300 g phosphorus and 500 g potassium plant^{-1} year^{-1} increased carotenoids, total sugars, reducing sugars and organoleptic qualities of fruits.

Most of the treatments had light yellow peel colour, orange pulp colour and firm flesh. Nitrogen at 200 g, phosphorus at 250 g and potassium at 500 g plant^{-1} was found to increase the shelf life of fruits.

Application of nitrogen, phosphorus and potassium increased soil and leaf petiole content of the respective elements. Highest benefit : cost ratio was obtained from the combination of 250 g N, 250 g P and 500 g K plant^{-1} year^{-1}.

Over all assessment indicated that application of N, P and K at the rate of 250 : 250 : 500 g plant^{-1} year^{-1} in six equal splits was economically viable and improved growth, yield and quality of papaya.

APPENDICES

APPENDIX – I

SCORE CARD FOR ORGANOLEPTIC QUALITIES OF PAPAYA

	Criteria	Treatments													
		T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}	T_{11}	T_{12}	T_{13}	T_{14}
1	Appearance														
	Very good – 4														
	Good – 3														
	Fair – 2														
	Poor – 1														
2	Colour														
	Most acceptable – 4														
	Acceptable – 3														
	Fairly acceptable – 2														
	Not acceptable – 1														
3	Flavour														
	Most acceptable – 4														
	Acceptable – 3														
	Fairly acceptable – 2														
	Not acceptable – 1														
4	Taste														
	Very good – 4														
	Good – 3														
	Fair – 2														
	Poor – 1														
5	Texture														
	Firm, crisp, melting – 4														
	Firm, crisp, not melting – 3														
	Fairly firm, crisp, not melting – 2														
	Too soft or too hard – 1														
6	Papain odour														
	Not at all present – 4														
	Very mildly present – 3														
	Mildly present – 2														
	Strongly present – 1														

APPENDIX – I Continued

	Criteria	Treatments													
		T_{15}	T_{16}	T_{17}	T_{18}	T_{19}	T_{20}	T_{21}	T_{22}	T_{23}	T_{24}	T_{25}	T_{26}	T_{27}	T_{128}
1	Appearance														
	Very good – 4														
	Good – 3														
	Fair – 2														
	Poor – 1														
2	Colour														
	Most acceptable – 4														
	Acceptable – 3														
	Fairly acceptable – 2														
	Not acceptable – 1														
3	Flavour														
	Most acceptable – 4														
	Acceptable – 3														
	Fairly acceptable – 2														
	Not acceptable – 1														
4	Taste														
	Very good – 4														
	Good – 3														
	Fair – 2														
	Poor – 1														
5	Texture														
	Firm, crisp, melting – 4														
	Firm, crisp, not melting – 3														
	Fairly firm, crisp, not melting – 2														
	Too soft or too hard – 1														
6	Papain odour														
	Not at all present – 4														
	Very mildly present – 3														
	Mildly present – 2														
	Strongly present – 1														

APPENDIX – II

Evaluation card for triangle test

In the triangle test three sets of sugar solution of different concentrations were used. Of the three sets, two solutions were of identical concentrations and the members were asked to identify the third sample which was of different concentration.

Name of product : Sugar solution

Note : Two of the three samples are identical, identify the odd sample

Sl. No.	Code No. of the samples	Code No. of the identical samples	Code No. of the odd samples
1	XYZ		
2	ABC		

APPENDIX – III

Weather data prevailed during the cropping period

Year and month	Maximum temperature (°C)	Minimum temperature (°C)	Total rain fall (mm)	Total day-length (hours)	Relative humidity (%)
2001 August	29.60	21.20	189.50	191.80	84.20
September	30.1	23.80	558.20	207.30	80.90
October	30.0	24.00	256.90	203.90	83.19
November	30.39	23.48	238.10	185.00	77.00
December	30.85	23.10	20.60	227.30	79.90
2002 January	31.05	22.19	-	248.50	78.69
February	30.50	22.26	15.00	237.60	75.80
March	32.95	23.50	16.70	264.10	74.95
April	33.10	24.80	50.60	236.90	76.97
May	31.50	25.00	200.10	177.40	80.08
June	30.50	24.14	161.10	216.30	82.30
July	30.39	23.94	47.00	205.70	83.77
August	29.83	23.39	101.40	216.10	81.51