# NUTRIENT STANDARDIZATION IN BANANA
# (*Musa* AAB. POPOULU)

*by*

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**THESIS**

**Submitted in partial fulfillment of the**
**requirements for the degree of**

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**COLLEGE OF AGRICULTURE**

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**2019**

## DECLARATION

I, hereby declare that this thesis entitled **"NUTRIENT STANDARDIZATION IN BANANA (*Musa* AAB. POPOULU)"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associate ship, fellowship or other similar title, of any other University or Society.

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# <u>CERTIFICATE</u>

Certified that this thesis entitled **"NUTRIENT STANDARDIZATION IN BANANA (*Musa* AAB. POPOULU)"** is a record of research work done independently by Ms. Sruti S. Nair under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

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We, the undersigned members of the advisory committee of Ms. Sruti S. Nair a candidate for the degree of **Master of Science in Horticulture** with major in Fruit Science agree that the thesis entitled **"NUTRIENT STANDARDIZATION IN BANANA (*Musa* AAB. POPOULU)"** may be submitted by Ms. Sruti S. Nair, in partial fulfilment of the requirement for the degree.

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## LIST OF ABBREVATIONS

| | |
|---|---|
| AOAC | Association of Official Agricultural Chemists |
| B: C | Benefit cost ratio |
| C | Carbon |
| CD | Critical difference |
| cm | Centimeter |
| cv. | Cultivar |
| EC | Electrical Conductivity |
| *et al.* | Co-workers/co-authors |
| Fig. | Figure |
| FYM | Farm yard manure |
| Ha | Hectare |
| $ha^{-1}$ | Per hectare |
| *i.e.* | That is |
| K | Potassium |
| KAU | Kerala Agricultural University |
| Kg | Kilogram |
| kg $ha^{-1}$ | Kilogram per hectare |
| L | Litre |
| LAI | Leaf area index |
| M | Metre |
| $m^2$ | Square metre |
| MAP | Month after planting |

| | |
|---|---|
| Mm | Millimetre |
| MT | Metric Tons |
| N | Nitrogen |
| NS | Non-significant |
| No. | Number |
| P | Phosphorus |
| $Plant^{-1}$ | per plant |
| POP | Package of Practises |
| RBD | Randomized block design |
| RDF | Recommended doses of fertilizers |
| SEm | Standard Error of mean |
| Sl. | Serial |
| sp. or spp. | Species (Singular and Plural) |
| t | Tons |
| $t\ ha^{-1}$ | Tons per hectare |
| TSS | Total soluble solids |
| *viz.* | Namely |

**LIST OF SYMBOLS**

| | |
|---|---|
| @ | At the rate of |
| °C | degree Celsius |
| % | per cent |
| ₹ | Rupees |

# *Introduction*

# 1. INTRODUCTION

India is the largest country of indigenous diversified banana in the world. Banana is the second most important fruit crop in India next to mango. It is having great socio-economic significance in our country. The wonder berries (both banana and plantain) are the staple food for millions around the world. India leads the world in banana production with an output of 30 million MT in an area of 8.74 lakh ha and average productivity of 37 t $ha^{-1}$ (NHB, 2018). The production is highest in Karnataka followed by Tamil Nadu, Andhra Pradesh and Kerala. The area and production of banana in Kerala is estimated to 57158 ha and 489.32 MT respectively (FIB, 2019).

Banana is one of the most important fruit crops in Kerala. Among the different banana cultivars "Popoulu" is an exotic cultivar belonging to Maia/ Maoli Popoulu group with AAB genome. This is a dessert and cooking banana cultivar, highly suitable for the preparation of chips with a recovery of 33% similar to Nendran (Menon *et al.*, 2014). More yield of chips could be obtained from the heavier bunches of Popoulu. The variety is getting popular in many districts of Kerala. Popoulu has great potential for popularization amongst farmers of Kerala as a profitable cultivar to complement 'Nendran' ecotypes.

Balanced nutrition plays a vital role on plant growth, yield and fruit quality. Banana requires sufficient quantity of nutrients throughout its growth cycle being an exhaustive crop for its robust growth, high yield and biomass production. A greater level of soil fertility should be maintained since it is a surface feeder. It responds positively to the application of inorganic fertilizers as well as to organic manures. Split application of inorganic fertilizers along with organic manures increases the leaf nutrient content, uptake and distribution of nutrients and ultimately it results in better growth and yield. The application of sufficient amount of nutrients reduced the time taken for bunch emergence and crop cycle. The nutrients should be provided at appropriate growth stages for high banana productivity (Pandey *et al.*, 2005; Thangaselvabai *et al.*, 2009). The essential nutrients must be provided in a balance for the various physiological processes in plants. In the tropical conditions lower doses of fertilizers are applied in order to prevent the condition of nutrient leaching (Fageria *et al.*, 2006).

Thorough knowledge of the critical levels of different nutrient elements, time and method of application of nutrients is essential to get better growth, yield and also to maintain optimum nutrient balancing of soil. Or else it may lead to reduced productivity, deterioration of soil health and accelerated environmental pollution apart from the wastage of substantial quantity of costly and scarce inputs.

As the demand for Popoulu banana is increasing in the processing industry, there is a need to enhance its productivity. However no attempts have been made to standardize the nutrient requirement of Popoulu banana in our state. Keeping this in view, the present study is initiated,

- To standardize the nutrient requirement of banana cv. Popoulu.
- To study the effect of major plant nutrients on growth, yield and quality characters of banana cv. Popoulu.
- To work out the economics of cultivation.

# *Review of Literature*

## 2. REVIEW OF LITERATURE

Banana is one of the most important fruit crop of Kerala belonging to Musaceae family. "Popoulu" is an exotic cultivar belonging to Maia /Maoli Popoulu group with AAB genome. It is a potential dessert and cooking banana cultivar.

Popoulu is now slowly gaining importance in Kerala especially in processing industry. The review of literature on nutrient standardization of banana (*Musa* AAB Popoulu) is presented in relation to the following aspects:

### 2.1 BIOMETRIC CHARACTERS

#### 2.1.1 Height of psuedostem

A profound increase in pseudostem height was noticed in Nendran cultivar by the application of nitrogen and phosphorus fertilizers at the rate of 150 g $plant^{-1}$ and 90 g $plant^{-1}$ respectively (Bellie, 1987). Oubahou and Dafiri (1987) observed an increasing trend in the psuedostem height up to 425 g N $plant^{-1}$ for banana cv. Pradeep *et al.* (1992) had observed taller plants and maximum relative growth rate in tissue cultured Nendran cultivar than the sucker grown plants. Sheela (1995) revealed that an increase of 6.5% in height of Nendran cultivar over the sucker grown plants. The tissue culture cv. Robusta responded positively to the inorganic fertilizer application (NPK 165:52.5:495 g $plant^{-1}$) given in 4 split dosages and resulted in maximum height (111.62 cm) of pseudostem (Nalina, 2002). Kumar and Pandey (2008) claimed that the height of pseudostem increased (278.8 cm) by using 75% recommended doses of fertilizer (RDF) (NPK: 200:80:220 g $plant^{-1}$) applied in the ratio (NPK in the ratio (3:2:1), (1:3:2) and (2:1:3) at the vegetative, flowering and fruit development to maturation stage in cv. Rasthali.

Navneethakrishnan *et al.* (2013) recorded the maximum height of psuedostem (210.64 cm) in cv. Grand Naine when treated with 200 g N in 5 split doses and 60 g $P_2O_5$. Mayadevi *et al.* (2017) observed that the combined application of mineral fertilizers (300:115:450 g NPK plant$^{-1}$ in 6 equal split doses) and farm yard manure (FYM) recorded the highest pseudostem height (351.75 cm) in Nendran banana.

### 2.1.2 Girth of pseudostem

The thicker pseudostem of banana may point to better bunch characters and provide good anchorage to the plant (Krishnan and Shanmughavelu, 1979). Gaint Cavendish. Geetha and Nair (2000) observed an increase in pseudostem growth with application of nitrogen (190 g plant$^{-1}$) in cv. Nendran. A relative increase in pseudostem girth was observed with the application of nitrogen 200 g plant$^{-1}$ in cv. Cavendish (Singh and Suryanarayanan, 1999).

Nalina (2002) had reported the maximum girth (70.89 cm) of pseudostem in tissue culture cv. Robusta when they were treated with inorganic fertilizers (NPK 165:52.5:495 g plant$^{-1}$) in 4 split dosages. Kumar and Pandey (2008) confirmed that the girth of pseudostem increased (68.5 cm) by using 75% RDF (NPK 200:80:220 g plant$^{-1}$) scheduled as (NPK in the ratio (3:2:1), (1:3:2) and (2:1:3) at the vegetative, flowering and fruit development to maturation stage in banana cv. Rasthali. Kuttimani *et al.* (2013) claimed that 100% RDF and FYM (10 kg plant $^{-1}$) had a greater influence in girth of pseudostem (68.5 cm) of cv. Grand Naine.

### 2.1.3 Number of functional leaves

A significant increase in number of leaves was noticed in banana cv. Robusta by the application of inorganic fertilizers (Parida *et al.*, 1994). Patel (1996) reported the maximum number of functional leaves (15.94) in cv. Dwarf Cavendish when supplied with inorganic fertilizers at the rate of N (300 g plant$^{-1}$) and K (300 g plant$^{-1}$) in split application. More number of functional leaves were observed in tissue culture propagated banana plants as a result of faster development of leaves (Shakila and Manivannan, 2001). More number of functional leaves along with larger leaf area were retained in the cv. Njalipoovan at higher dosages of nitrogen

(300 g $plant^{-1}$) because increased N application resulted in more vegetative growth and maintained leaves for a longer period (Indira and Nair, 2008).

The Nendran cultivar had registered maximum number of functional leaves when supplied with inorganic fertilizers (NPK 250:80:350 g $plant^{-1}$) along with higher protein, amino acid and chlorophyll content which enhanced the growth and translocation of metabolites (Mahato *et al.*, 2014). Navneethakrishnan *et al.* (2013) observed more number of functional leaves (15.55) when the Grand Naine cultivar was treated with 200 g N in 5 split doses and 60 g $P_2O_5$.

### 2.1.4 Total functional leaf area and leaf area index

While experimenting with different levels of nitrogen, Kohli *et al.* (1982) had observed a maximum leaf area and leaf area index with 450 g N $plant^{-1}$ in banana cv. Robusta. Mustaffa (1988) had claimed a profound increase in number of functional leaves and leaf area with usage of inorganic fertilizers (N 300 g $plant^{-1}$ and K 300-400 g $plant^{-1}$) in the cv. Robusta. Application of inorganic fertilizers (NPK 165:52.5:495 g $plant^{-1}$ in 4 split application) had a profound effect on the growth characters and produced highest leaf number (12), leaf area (21.61 $m^2$) and leaf area index (6.67) (Nalina, 2002).

Potassium at higher rates (400 g $plant^{-1}$) played an important role in developing a vigorous crop with considerable increase in leaf area and leaf area index (Indira and Nair, 2008). Kuttimani *et al.* (2013) claimed higher leaf area and leaf area index when the 100% RDF and FYM were applied in the cv. Grand Naine.

### 2.1.5 Duration for bunch emergence

There was a reduction in duration for bunch emergence with the application of inorganic fertilizers in banana cv. Robusta (Parida *et al.*, 1994). The meristem derived cultivars of Williams and Dwarf Cavendish took less time for bunch emergence and harvest compared to the sucker derived plants (Robinson, 1990). Patel (1996) claimed that it took only 201.77 days for bunch emergence when the banana cv. Dwarf Cavendish was fed with N (300 g plant$^{-1}$) and K (350 g plant$^{-1}$) in two equal splits.

According to Kumar and Pandey (2008) the duration for bunch emergence was reduced (239.09 days) when the banana cv. Rasthali was treated with 75% RDF (NPK: 200:80:220 g plant$^{-1}$) given in schedule (NPK in the ratio (3:2:1), (1:3:2) and (2:1:3) at the vegetative, flowering and fruit development to maturation stage).

### 2.1.6 Crop duration

Singh *et al.* (1990) claimed that the application of optimal fertilizers at appropriate time accelerated early shooting and caused a reduction in crop duration. The response of banana cv. Grand Naine to the application of 225 g N plant$^{-1}$ and 300 g $K_2O$ plant$^{-1}$ reduced crop duration (Raju *et al.*, 1997). A decrease in crop duration was noticed in banana cv. Robusta with application of 200 g N plant$^{-1}$ and 400 g K plant$^{-1}$ (Arumugan *et al.*, 2001). According to Indira and Nair, (2008) the higher dosages of N (300 g plant$^{-1}$) and K (600 g plant$^{-1}$) profoundly reduced the crop duration (380.28 days) in banana cv. Njalipoovan and attributed this to higher potassium dosage which led to early flowering.

The tissue cultured plants of Robusta and Dwarf Cavendish registered early growth, early flowering and less crop duration when compared to the conventional suckers by 22 and 29 days respectively (Mustaffa and Kumar, 2012). According to Mayadevi *et al.* (2017) the total crop duration was 345 days when they were treated with the inorganic fertilizers ( 300:115:450 g NPK plant$^{-1}$ in 6 split dosage) in cv. Nendran.

### 2.18 Sucker production after bunch emergence

Nalina (2002) had noted the considerable increase in the number of suckers per plant (12) when provided with inorganic fertilizers (NPK 165:52.5:495 g plant$^{-1}$) in 4 split doses in tissue culture cv. Robusta. Mahato *et al.* (2014) claimed that the usage of nitrogen and potassium fertilizers (NPK 250:80:400 g plant$^{-1}$) at higher rate had resulted more number of suckers (8.33) in the banana cv. Nendran.

## 2.2 YIELD AND YIELD ATTRIBUTES

### 2.2.1 Weight of bunch.

The Robusta banana responded positively to the inorganic fertilizers and heaviest bunches were obtained by NPK doses (NPK 100 kg, 40 kg and 400 kg acre$^{-1}$) (Nanjan *et al.*, 1980). Nair *et al.* (1990) experimented with different levels of N and K in 6 splits to observe highest bunch weight of nendran (12.02 kg) as a result of treatment with NPK fertilizers (400:100:600 g plant$^{-1}$) in 6 split. Raju (1996) reported highest bunch weight of cv. Grand Naine when supplied with 300 g N plant$^{-1}$ and 400 g K plant$^{-1}$.

Hauser (2000) claimed that the combination of hot water treatment and application of inorganic fertilizers had a positive effect on plantain fresh bunch weight. Al-Harthi and Al-Yahyai (2009) noted considerable increase in bunch weight (14.98 kg) in cv.Williams with the application of NPK fertilizers (600:100:500 g NPK plant$^{-1}$). The experiment that compared the superiority of improved practice (NPK 544:227:494 kg$^{-1}$ ha$^{-1}$ year$^{-1}$) over farmers practice (NPK 381:227:93 kg$^{-1}$ ha$^{-1}$ year$^{-1}$) resulted in higher bunch weight (35.5 kg) in banana cv. Basrai (Memon *et al.*, 2010).

According to Kuttimani *et al.* (2013) the application of 100% RDF along with FYM had resulted in significant increase in bunch weight (23.8 kg). in the cv. Grand Naine. Millik *et al.* (2018) reported the maximum bunch weight of banana, when they were bunch fed with 500 g cow dung, 7.5 g urea and 7.5 g $K_2SO_4$.

### 2.2.2 Number of hands bunch$^{-1}$

Hernandez *et al.* (1981) reported maximum number of hands in cv. Giant Cavendish with 100 g N plant$^{-1}$. Cavendish banana when fed with 400 g N plant$^{-1}$, 300 g P plant$^{-1}$ and 250 g K plant$^{-1}$ recorded the highest number of hands (Pandit *et al.*, 1992). There was significant increase in number of hands in cv. Nendran with 200 g N $plant^{-1}$ (Prabhakar, 1996). Saad and Atwia (1999) experimented with different levels of $K_2O$ (400, 600, 800, 1000 g $plant^{-1}$) in banana cv. Grand Nain and observed an increase in number of hands per bunch with the application of 800 g $K_2O$. The number of hands were the highest with the application of 200:40:200 g NPK $plant^{-1}$ in banana cv. Nendran (Suma *et al.*, 2007).

Al-Harthi and Al-Yahyai (2009) reported that application of recommended dosage of NPK fertilizers (600:100:500 g NPK $plant^{-1}$) resulted in increased number of hands per bunch (9.6) in cv. Williams. Navneethakrishnan *et al.* (2013) observed the highest number of hands (10.61) per bunch in Grand Naine cultivar when they were treated with N 200 g in 5 split doses and 60 g $P_2O_5$ as a basal dose. In a study of *in situ* bioconversion of farm residues, the number of hands (6.33) were highest in the treatment (300:115:450 g NPK $plant^{-1}$ in 6 split doses) in Nendran cultivar (Mayadevi *et al.*, 2017).

### 2.2.3 Number of fingers $bunch^{-1}$

The application of 300 g $K_2O$ $plant^{-1}$ had accounted for an increase in number of fingers (33.7%) in banana crop (Obiefuna, 1984). The tissue cultured Nendran banana showed a great response to varying levels of N at 100, 300 and 400 g $plant^{-1}$ and recorded maximum number of fingers (50.20) with the application of 300 g N $plant^{-1}$ (Sheela, 1995). The application of 200:40:200 g NPK $plant^{-1}$ in cv. Nendran resulted highest number of fingers (Suma *et al.*, 2007).

Kumar and Pandey (2008) reported the number of fingers per bunch were highest by the application of 75% RDF (NPK: 200:80:220 g $plant^{-1}$) when given in a schedule of NPK in the ratio (3:2:1), (1:3:2) and (2:1:3) at the vegetative, flowering and fruit development to maturation stage in the cv. Rasthali. The application of 100% RDF and FYM had given better results with more number of fingers per bunch (135.4) in banana cv. Grand Naine (Kuttimani *et al.*, 2013).

### 2.2.4 Number of fingers in D hand

Al-Harthi and Al-Yahyai (2009) confirmed that the application of inorganic fertilizers (600:100:500 g NPK plant$^{-1}$) resulted highest number of fingers of D hand in cv. Williams. The number of fingers in D hand were highest (19.75) when treated with the mineral fertilizers (300:115:450 g NPK plant$^{-1}$) along with FYM (Mayadevi *et al.*, 2017).

### 2.2.5 Weight of finger

Obiefuna (1984) reported an increase in weight of finger (44.2%) of banana over control with 300 g $K_2O$ plant$^{-1}$. The increasing levels of nitrogen (143 and 190 g plant$^{-1}$) had shown an increase in fruit weight (Geetha and Nair, 2000). Nalina (2002) revealed that the weight of the finger (242.84 g) was the highest with the application of inorganic fertilizers (NPK 165:52.5:495 g plant$^{-1}$) in 4 split dosages in tissue cultured cv. Robusta.

Kuttimani *et al.* (2013) noticed an increase in finger weight (174.3 g) with the application of 100% RDF and FYM in the Grand Naine cultivar. Mahato *et al.* (2014) claimed a positive response in getting highest finger weight (315.81 g plant$^{-1}$) with the optimal application of fertilizers in the cv. Nendran. Potassium had significant role in the translocation, accumulation of sugars, filling of fingers and other yield attributes. Millik *et al.* (2018) observed the heaviest fingers (148.73 g) with bunch feeding of 500 g cow dung, 7.5 g urea and 7.5 g $K_2SO_4$. The removal of male bud after the bunch formation resulted in more accumulation of photosynthates while the application of potassium increased the sugar and starch content.

### 2.2.6 Length and girth of finger

There was a significant increase in length of fingers in banana cv. Nendran by bunch feeding with urea (Ancy and Kurien, 2000). Kumar and Kumar (2007) observed the highest length and girth of finger in banana with the foliar sprays of sulphate of potash. Al-Harthi and Al-Yahyai (2009) noticed that inorganic fertilizer dosage (600:100:500 g NPK plant$^{-1}$) had a greater influence on the length and girth of finger in cv. Williams.

Mahato *et al.* (2014) noticed an increase in length (25.12 cm) and girth (4.91 cm) of finger in the cv. Nendran due to the interaction of NPK fertilizers at higher dosages (NPK 250:80:400 g plant$^{-1}$). Navneethakrishnan *et al.* (2013) experimented with different dosages of N and P and observed the highest length of finger (20.30 cm) with 200 g N in 5 split dosages and 60 g $P_2O_5$ in Grand Naine cultivar. Millik *et al.* (2018) confirmed that bunch feeding with 500 g cow dung, 7.5 g Urea and 7.5 g $K_2SO_4$ resulted in significant increase in length (22.28 cm) and girth (14.10 cm) of finger.

**2.2.7 Yield per hectare**

Singh and Kashyap (1992) reported maximum yield 69.32 t ha$^{-1}$ in banana cv. Robusta with 400 g N plant$^{-1}$. Sheela (1995) claimed that the interaction of inorganic fertilizers (N 250 g plant$^{-1}$ and K 450 g $^{-1}$plant) at optimum dosages had promoted the growth and yield parameters to the maximum. Hasan and Chattopadhyay (2000) had claimed highest yield in banana with 300-600 g K plant$^{-1}$.

Shelke and Nahate (1996) noticed highest yield in Dwarf Cavendish banana with the application of 200 g N, 40 g $P_2O_5$ and 200 g $K_2O$ plant$^{-1}$. A significant increase in yield of banana cv. Grand Naine was obtained with the application of 800 g $K_2O$ plant$^{-1}$ (Saad and Atwia, 1999). The Robusta banana showed a positive influence on fruit yield (88.5 t ha$^{-1}$) with N and K fertigation up to 200 g (Srinivas *et al.*, 2001). Kuttimani *et al.* (2013) had observed an increase in yield per hectare when 100% RDF and FYM was applied in cultivar Grand Naine.

Patil and Patil (2017) concluded that application of recommended dose of fertilizers NPK (200:40:200 g NPK plant$^{-1}$) and FYM had recorded the highest yield (102.22 t ha$^{-1}$) in banana. The use of 500 g cow dung, 7.5 g urea and 7.5 g

$K_2SO_4$ as bunch feed has resulted in significant increase in yield (58.65 t $ha^{-1}$) in banana. (Millik *et al.*, 2018).

### 2.2.8 Pulp peel ratio

Patel (1996) conducted an experiment in Dwarf Cavendish and claimed that the pulp peel ratio (2.85) was highest with the application of inorganic fertilizers N (200 g $plant^{-1}$) and K (300 g $plant^{-1}$) in 3 split dosage. Srinivas *et al.* (2001) observed highest pulp peel ratio in banana cv. Robusta with the application 150 g N and K at 1:1 ratio. Positive influence of inorganic fertilizers (NPK 165:52.5:495 g $plant^{-1}$ in 4 splits) on the pulp peel ratio (2.98) in the tissue cultured banana cv. Robusta was observed by Nalina (2002).

Kumar and Pandey (2008) reported that the pulp peel ratio was considerably high (6.49) when the banana cv. Rasthali was treated with 75% RDF (NPK: 200:80:220 g $plant^{-1}$) given in scheduled as NPK in the ratio (3:2:1), (1:3:2) and (2:1:3) at the vegetative, flowering and fruit development to maturation stage. Millik *et al.* (2018) revealed high pulp peel ratio (3.4) with the bunch feeding of 500 g cow dung, urea 7.5 g and $K_2SO_4$ 7.5 g. The high dosage of potassium had resulted in increased pulp content.

## 2.3 QUALITY PARAMETERS

According to Patel (1996) higher dosage of nitrogen (300 g $plant^{-1}$) and potassium (400g $plant^{-1}$) given in 3 split application resulted superior quality with respect to higher TSS, total sugar, reducing sugar and sugar acid ratio in cv. Dwarf Cavendish. Agarwal *et al.* (1997) concluded that the total sugar, TSS and reducing sugar had enhanced with N and K 450 g $plant^{-1}$ each in 5 splits in banana cv. Robusta. The fertilizer dosage 300:200:250 g NPK $plant^{-1}$ in 5 equal splits had shown an increase in TSS, total sugar, reducing sugar and sugar acid ratio in banana cv. Dwarf Cavendish (Tirkey *et al.*, 1998).

In banana cv. Robusta the quality parameters where enhanced with the application of nitrogen and potassium nutrition (Srinivas *et al.*, 2001). The inorganic fertilizers (NPK 165:52.5:495 g plant$^{-1}$ in 4 split dosages) positively influenced the fruit quality characters like TSS (20.50%), total sugar (19.20%), reducing sugar (16.40%), ascorbic acid (15.03 mg 100 g$^{-1}$), non-reducing sugar (2.90%), sugar acid ratio (174.55) and reduced acidity (0.11%) in the tissue cultured cv. Robusta (Nalina, 2002).

The increase in nitrogen and potassium fertilizer dosages positively influenced the quality parameters of banana fruits (Kumar *et al.*, 2008). Indira and Nair (2008) claimed an increase in TSS, total sugar and reducing sugar with the application of N (300 g plant$^{-1}$) and K (600 g plant$^{-1}$) in the cv. Njalipoovan. Mahato *et al.* (2014) suggested the application of inorganic fertilizers (NPK 250:80:400 g plant$^{-1}$) to improve total sugar (17.89 %), TSS (18.25 °B), sugar/acid ratio (57.03) and decrease the titrable acidity (0.32 %) in banana cv. Nendran. Millik *et al.* (2018) reported that the peel thickness (3.73 mm) was the highest when the banana cv. Barjahaji (*Musa* AAA) was bunch fed with 500 g cow dung, 7.5 g urea and 7.5 g $K_2SO_4$.

## 2.4 ORAGANOLEPTIC EVALUATION

Mayadevi *et al.* (2017) observed that the overall acceptability characters of Nendran cultivar was highest (8.5 out of 9) when they were treated with optimal dosage of inorganic fertilizers (NPK 300:115:400g plant$^{-1}$) along with FYM.

## 2.5 SHELF LIFE OF FRUITS AT AMBIENT CONDITIONS

The banana cv. Grand Naine responded positively to 225 g N and 300 g $K_2O$ and enhanced the shelf life of banana cv. Dwarf Cavendish (Raju *et al.*, 1997). Indira and Nair (2008) reported the highest shelf life (6.47 days) of banana cv. Njalipoovan with the application of nitrogen (200 g plant$^{-1}$).

## 2.6 SOIL ANALYSIS.

Nalina (2002) confirmed that the highest available nitrogen (571.80 kg $ha^{-1}$), phosphorus (142.20 kg $ha^{-1}$) and potassium (1280 kg $plant^{-1}$) with the soil application of inorganic fertilizers (NPK 220:70:660 g $plant^{-1}$ in 3 split dosage) in the tissue cultured plantlets of cv. Robusta. The supply of nitrogen fertilizers along with potassium at greater concentrations resulted in greater concentrations of N in the soil (Suresh and Hassan, 2002).

Memon *et al.* (2010) noticed the superiority of improved fertilization (NPK 544:227:494 kg $ha^{-1}$ $year^{-1}$) over the farmer's practice (NPK 381:227:93 kg $ha^{-1}$ $year^{-1}$). He reported that fertilization increased the available phosphorus and potassium from 5.86 to 9.75 mg $kg^{-1}$ and 0.450 to 0.516 mg $100g^{-1}$ respectively. The top soil (0-15 cm) recorded the highest percentage of nitrogen (0.085%) and phosphorus (9.96 mg $kg^{-1}$) than the sub soil (15-30 cm). Mahato *et al.* (2014) observed significant increase in NPK (249.35 kg $ha^{-1}$, 23.91 kg $ha^{-1}$ and 894.56 kg $ha^{-1}$ respectively) content of soil with the application of inorganic fertilizers (NPK 250:80:400 g $plant^{-1}$) in banana cv. Nendran.

The nitrogen and potassium efficiency could be increased by the application of 60% nitrogen and potassium as urea and MOP respectively through fertigation in cv. Nendran (Shimi and Sheela, 2017)

## 2.7 PLANT ANALYSIS

Sheela and Aravindakshan (1990) reported that the treatment which received 200:200:400 g NPK $plant^{-1}$ showed highest uptake in phosphorus and potassium. Nalina (2002) reported increased nitrogen (22.5g $plant^{-1}$), phosphorus (4.22g $plant^{-1}$) and potassium (30.86 g $plant^{-1}$) content in the leaf lamina at 5 month stage and at harvest. The uptake of nitrogen (39.69 g $plant^{-1}$), phosphorous (1.92 g $plant^{-1}$) and potassium (48.14 g $plant^{-1}$) was also enhanced with inorganic fertilizers (NPK 165:52.5:945 g $plant^{-1}$) in 4 split dosages in the tissue culture cv. Robusta.

There was a significant increase in the nutrients of index leaf and uptake by tissue cultured banana cv. Robusta (Shakila and Manivannan, 2001).

Baiyeri and Tenkouano (2008) confirmed that the quantity of NPK in banana leaf lamina had significant correlation with the growth and biomass production in PITA-14 plantain hybrid. Selvamani and Manivannan (2009) concluded that the leaf nitrogen content gradually lowered towards the harvesting stage with the application of N and K fertilizers (200 g plant$^{-1}$ and 300 g plant$^{-1}$ respectively) in 7 equal splits the banana cv. Poovan. Thangaselvabai *et al.* (2009) recommended the split application of inorganic fertilizers (NPK 200:35:330 g plant$^{-1}$ in 3 splits) along with organic manures (FYM 20 t, 5 kg Azospirillum and 250 g neem cake per plant) for increasing the leaf nutrient status, uptake, distribution of nutrients, growth and yield.

Mahato *et al.* (2014) claimed that the leaf NPK content was highest at 9 month stage (3.36, 0.5, 4.37 % respectively) and that reduced gradually to harvest stage (2.35, 0.36, 2.033% respectively) with application of inorganic fertilizers (NPK 250:80:400 g plant$^{-1}$) in cv. Nendran.

## 2.8 ECONOMIC ANALYSIS

The combination of inorganic fertilizers 600 kg ha$^{-1}$ N, 320 kg ha$^{-1}$ P and 320 kg ha$^{-1}$ K gave the highest net income (Sharma and Roy, 1973). Nalina (2002) reported the maximum net income and B: C ratio (2.98) with the application of inorganic fertilizers (NPK 165:52.5:495 g plant$^{-1}$) in 4 split application in tissue cultured banana cv. Robusta.

The application of inorganic fertilizers (NPK 200:200:400 g plant$^{-1}$) resulted in considerably higher profit and B: C ratio (1.96) in banana cv. Njalipoovan. The low cost of cultivation and higher yield obtained contributed to this (Indira and Nair, 2008). Patil and Patil (2017) observed the highest net profit and B: C ratio (1.77) in banana with the application of recommended dose of fertilizers (200:40:200 g NPK plant$^{-1}$) and FYM.

# Materials and Methods

# 3. Materials and Methods

The study on "Nutrient standardization in banana (*Musa* AAB. Popoulu)" was conducted at the Instructional Farm of College of Agriculture, Vellayani, Thiruvananthapuram, during 2017-2019. The programme aims to standardize the nutrient requirement of banana cv. Popoulu and to study the effect of major plant nutrients on growth, yield and quality of banana. The details of experimental site as well as the materials and methods adopted are discussed in this chapter.

## 3.1 EXPERIMENTAL SITE

The experimental location is situated at 8.5° North latitude and 76.9° East longitude at an altitude of 29 m above mean sea level. The predominant soil type is laterite belonging to the Vellayani series. At the experimental site, soil is acidic with a pH of 4.6 and the texture is sandy clay loam.

## 3.2 EXPERIMENTAL MATERIALS

The experiment was conducted using the tissue cultured Popoulu banana plantlets collected from BMFC (Biotechnology and Model Floriculture Center), Kazhakuttam.

## 3.3 EXPERIMENTAL DESIGN AND LAYOUT

| | |
|---|---|
| Design | : RBD |
| Number of treatments | : 14 |
| Number of replications | : 3 |
| Number of plants per replication | : 6 |
| Spacing | : 2m×2m |
| Plot size | : 26m$^2$ |

**Field experiment:**

The experiment was conducted in combinations of A and B (NK levels and time of application of fertilizers).

**a) NK levels ( N )**

The NK levels were fixed based on the N and K recommendation (KAU, 2016) for Nendran banana maintaining the N: K ratio as 1:1.5

1) $N_1$ –250: 375 g NK plant$^{-1}$ year$^{-1}$

2) $N_2$ –300: 450 g NK plant$^{-1}$ year$^{-1}$

3) $N_3$– 350: 525 g NK plant$^{-1}$ year$^{-1}$

4) $N_4$– 400: 600 g NK plant$^{-1}$ year$^{-1}$

**b) Time of application (S)**

1) $S_1$- 2splits (2 and 4 month after planting)

2) $S_2$- 4 splits (2, 4, 6 month after planting and after bunch emergence)

3) $S_3$- 6 splits (1, 2, 3, 4, 5 month after planting and after bunch emergence)

**Treatment combinations:**

$T_1$ - $N_1S_1$, $T_2$- $N_1S_2$ $T_3$ - $N_1S_3$

$T_4$ - $N_2S_1$, $T_5$- $N_2S_2$ $T_6$ –$N_2S_3$

$T_7$ - $N_3S_1$, $T_8$- $N_3S_2$ $T_9$ –$N_3S_3$

$T_{10}$ - $N_4S_1$ $T_{11}$-$N_4S_2$ $T_{12}$ -$N_4S_3$

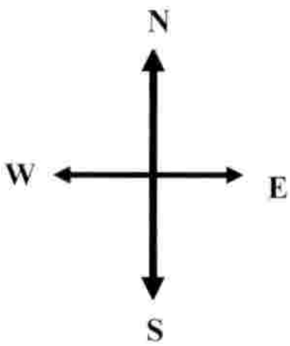
$T_{13}$ - Absolute control (no fertilizer application)

$T_{14}$ - Recommendation of Nendran banana applied as organic

Organic manure (15 Kg FYM plant$^{-1}$) and P (115 g plant$^{-1}$) as per KAU (2016) were given uniformly to all treatments except $T_{13}$ and $T_{14}$ as basal. Urea,

Plate 1. General view of field (vegetative stage)

Plate 2. Field view at bearing stage




| Replication I | | Replication II | | Replication III | |
|---|---|---|---|---|---|
| $T_1R_1$ | $T_8R_1$ | $T_3R_2$ | $T_{13}R_2$ | $T_8R_3$ | $T_{14}R_3$ |
| $T_2R_1$ | $T_9R_1$ | $T_5R_2$ | $T_{10}R_2$ | $T_6R_3$ | $T_{12}R_3$ |
| $T_3R_1$ | $T_{10}R_1$ | $T_7R_2$ | $T_4R_2$ | $T_3R_3$ | $T_{11}R_3$ |
| $T_4R_1$ | $T_{11}R_1$ | $T_1R_2$ | $T_9R_2$ | $T_2R_3$ | $T_{10}R_3$ |
| $T_5R_1$ | $T_{12}R_1$ | $T_2R_2$ | $T_{11}R_2$ | $T_5R_3$ | $T_4R_3$ |
| $T_6R_1$ | $T_{13}R_1$ | $T_6R_2$ | $T_{14}R_2$ | $T_1R_3$ | $T_{13}R_3$ |
| $T_7R_1$ | $T_{14}R_1$ | $T_8R_2$ | $T_{12}R_2$ | $T_7R_3$ | $T_9R_3$ |

Fig.1 Layout of the experiment

Rajphos and Muriate of Potash were used as fertilizer sources. 240 g of lime based on soil analysis was applied in pits 10 days prior to planting.

## 3.4 OBSERVATIONS

### 3.4.1. Biometric observations

Observations on biometric characters like plant height, girth and number of leaves were taken at two, four, six months after planting and also at harvest.

#### 3.4.1.1 *Height of psuedostem*

Height of the psuedostem was recorded from the soil level to the base of the unopened leaf and expressed in centimeters.

#### *3.4.1.2 Girth of psuedostem*

The girth of the psuedostem was measured from the base at 20 cm height above the ground level and expressed in centimeters.

#### *3.4.1.3. Number of functional leaves*

The total number of fully opened functional leaves retained by the plant was recorded.

#### *3.4.1.4. Total functional leaf area*

The formula developed by Murray (1960) was used for calculating the functional leaf area and was expressed in $cm^2$. The leaf area of index leaf, which is the third fully opened leaf from the top is calculated.

$LA = L \times W \times 0.8$

Where, LA – Leaf area of index leaf

L- Length of leaf

W- Width of leaf

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

*3.4.1.5. Leaf area index (LAI)*

The calculations for leaf area index was done using the formula suggested by Watson (1952).

$$\text{Leaf area index} = \frac{\text{Total functional leaf area plant}^{-1}}{\text{Land area occupied plant}^{-1}}$$

*3.4.1.6. Duration for bunch emergence*

The total duration for bunch emergence was recorded from the date of planting to the date of visual bunch emergence and is expressed in days.

*3.4.1.7. Crop duration*

The total duration of the crop was recorded from the date of planting to harvest and was expressed in days.

*3.4.1.8. Sucker production after the bunch emergence*

The total number of suckers produced per plant after the bunch emergence in each treatment was recorded.

*3.4.2. Yield and yield attributes*

*3.4.2.1 Weight of bunch*

The weight of the bunch was recorded including the portion of the peduncle up to the first scar and expressed in kg.

*3.4.2.2. Number of hands bunch$^{-1}$*

The number of hands per bunch was counted and recorded after the harvest.

*3.4.2.3 Number of fingers bunch$^{-1}$*

The number of fingers per bunch was counted and recorded after the harvest.

#### *3.4.2.4 Number of fingers in D hand*

D hand is the second hand from the top of the bunch (Dadzie and Orchard, 1997). The number of fingers in this was counted and recorded after the harvest.

For the finger characters, the middle finger in the top row of the D hand was selected as representative finger or index finger (Gottriech *et al*., 1964).

#### *3.4.2.5 Weight of the finger*

The index finger's weight was measured and recorded in gram.

#### *3.4.2.6 Length of finger*

The length of index finger was measured through the convex side by using a thread and scale and expressed in cm.

#### *3.4.2.7 Girth of the finger*

The index finger's girth was measured at the thickest portion of the finger and expressed in cm.

#### *3.4.2.8 Pulp-peel ratio*

The pulp to peel ratio was recorded by working out the ratio between the weight of pulp and peel.

#### *3.4.2.9 Yield per hectare*

The yield per hectare was recorded by harvesting the banana at full maturity when angle disappeared on the fingers (Stover and Simmonds, 1987).

#### *3.4.2.10 Days taken for ripening*

The period from harvest of the fruit to ripening at room temperature, indicated by the change in colour from light green to yellow was recorded (Stover and Simmonds, 1987).

### 3.4.3 Quality parameters of fruit

The index finger was selected as the representative sample. Ripe fruit was used for quality analysis and raw fruit was subjected for starch analysis. From each fruit sample (top, middle and bottom) portions were pooled and macerated and used for analysis.

#### *3.4.3.1 Total soluble solids (TSS)*

Hand refractometer was used to measure the total soluble solids and expressed in degree brix (°B) as per the procedure given by Ranganna (1977).

#### *3.4.3.2 Acidity*

The titrable acidity of the fruit pulp was determined by the procedure proposed by Ranganna (1977) and was expressed as the percent anhydrous citric acid.

#### *3.4.3.3 Total carotenoids*

Total carotenoid present in the fruit was estimated using the procedure suggested by Saini *et al*. (2001) and expressed in mg $100g^{-1}$.

#### *3.4.3.4 Starch content*

The estimation of starch content in raw banana was done using the Potassium ferricyanide method (Ward and Pigman, 1970) and values were expressed as percent on fresh weight basis.

#### *3.4.3.5 Peel thickness*

Screw gauge was used to measure the peel thickness and it is expressed in millimeters.

#### *3.4.3.6 Total sugars*

The method described by A.O.A.C (1975) was used to determine the total sugars of the sample and expressed as percentage on fresh weight basis.

*3.4.3.7 Reducing sugar*

The method described by A.O.A.C (1975) was used to determine the reducing sugars of the sample and expressed as percentage on fresh weight basis.

*3.4.3.8 Non reducing sugar*

The estimation of non-reducing sugar was done by deducting the values of reducing sugars from the values of total sugars (A.O.A.C, 1975).

*3.4.3.9 Sugar Acid ratio*

The values of total sugars were divided by values of acidity to compute the sugar acid ratio.

*3.4.3.10 Ascorbic acid*

The estimation of ascorbic acid was done by the procedure proposed by A.O.A.C (1975) and expressed as mg $100g^{-1}$ of pulp.

*3.4.4 Organoleptic evaluation of fruit and chips for sensory qualities*

A ten member panel of judges were selected from a group of students and teachers of College of Agriculture, Vellayani for the organoleptic evaluation of Popoulu fruits and chips. The chips and peeled ripe banana slices were evaluated for taste, flavour, texture, appearance and overall acceptability on a nine point headonic scale as suggested by Srivastava and Kumar (2002), the score card is presented as (Appendix II).

*3.4.5 Shelf life of fruits at ambient conditions*

It was estimated by calculating the number of days from harvest till the appearance of black spots on the surface of peel and retention of edible qualities without decaying at normal atmospheric conditions (Stover and Simmonds, 1987).

*3.4.6 Soil analysis before and after the experiment*

The soil samples were collected from field before the planting of the banana plantlets to analyze the available N, P and K as per the standard procedures mentioned in table 1.

Table 1. Initial status of soil and methods followed for soil analysis

| Particulars | Value | Method adopted |
|---|---|---|
| Soil reaction (pH) | 4.6 (Acidic) | pH meter with glass electrode (Jackson,1973) |
| Organic C (%) | 0.64 (Low) | Walkley and Black titration method (Jackson, 1973) |
| Electrical conductivity (dS $m^{-1}$) | 0.26 | Soil water suspension of 1:2.5 and read in EC meter (Jackson, 1973) |
| Available N (kg $ha^{-1}$) | 250.88 (Low) | Alkaline permanganate method (Subbiah and Asija, 1956) |
| Available P (kg $ha^{-1}$) | 30.12 (Medium) | Bray's colorimetric method (Jackson, 1973) |
| Available K (kg $ha^{-1}$) | 288.00 (Medium) | Ammonium acetate method (Jackson, 1973) |

*3.4.7 Plant analysis*

*3.4.7.1 Nutrient content (N, P, K) in the index leaf at 4 month after planting*

Tissue samples (10 cm wide) from both the sides of the central vein of index leaf at 4 month after planting (Twyford and Walmsley, 1973). The collected tissue samples were dried at 65°C in hot air oven and were analyzed for N, P and K contents. The procedure followed for the chemical analysis is given in Table 2.

Table 2. Plant nutrient status estimation

| Particulars | Method | Reference |
|---|---|---|
| N (%) | Modified Kjeldahl method | (Jackson, 1973) |
| P (%) | Vando-molybdo phosphoric yellow colour method using spectrophotometer | (Jackson, 1973) |
| K (%) | Flame photometry method | (Piper, 1966) |

#### *3.4.7.2 N, P, K uptake at harvest*

The rhizome, pseudostem, leaves and fruits of the plant samples were chopped and dried separately. The N, P, K content in each plant sample was estimated as per the methods in Table 2. The values of dry matter content and per cent nutrient content of each plant part were used to calculate the uptake of nutrients and was expressed as kg $ha^{-1}$.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Concentration of nutrient (\%)} \times \text{Dry matter production (kgha}^{-1})}{100}$$

### *3.4.8 Pest and Diseases incidence*

The pest and disease incidences were observed frequently and correction measures were undertaken.

### *3.4.9 Economic analysis*

#### *3.4.9.1 Net income*

The total economics for the cultivation of banana crop was worked out.

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

*3.4.9.2 B: C ratio*

$$BCR = \frac{\text{Gross income (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

*3.4.10 Statistical analysis*

The observations collected were analyzed by applying the technique of analysis of variance for Randomized Block Design (Panse and Sukhatme, 1985).

# Results

## 4. RESULTS

The present investigation "Nutrient standardization in banana (*Musa* AAB. Popoulu) was carried out to study the effect of major plant nutrients on growth, yield, quality and to work out the economics of cultivation. The study was conducted at the Instructional Farm, College of Agriculture, Vellayani during 2018 March to 2019 April. The results are presented below.

### 4.1 BIOMETRIC CHARACTERS

#### 4.1.1 Height of pseudostem

The effect of major plant nutrients on height of pseudostem is illustrated in table 3. The height of pseudostem was recorded at 2 MAP, 4 MAP, 6 MAP and at the time of harvest and significant difference were observed among different treatments.

At 2 MAP, the highest pseudostem height was recorded with $T_9$ (111.76 cm). This was followed by treatment $T_3$ (92.16 cm) which was at par with $T_6$ (89.13 cm), $T_{12}$ (87.40 cm) and $T_{11}$ (82.16 cm). The lowest pseudostem height was noted for absolute control $T_{13}$ (37.16cm).

The results of data on pseudostem height at 4 MAP suggested taller plants for $T_9$ (197.76 cm) but was at par with $T_{12}$ (189.20 cm) and differed significantly from all other treatments. This was followed by $T_3$ (178.50 cm) which was at par with $T_6$ (169.80cm) and $T_{11}$ (168.50cm). Absolute control $T_{13}$ (75.50cm) recorded the least height of pseudostem.

During 6 MAP the highest pseudostem height was observed for $T_9$ (297.76 cm) but was on par with $T_{12}$ (284.53 cm).The absolute control $T_{13}$ (117.16 cm) recorded the lowest height.

At the time of harvest $T_9$ (314.4 cm) recorded taller pseudostem but was on par with $T_{12}$ (309.16 cm). This was followed by $T_3$ (296.56 cm) which was on par

Table 3. Effect of different N K levels and its time of application on pseudostem height of banana cv. Popoulu, cm

| Treatments | Pseudostem height (cm) of banana cv. Popoulu | | | |
|---|---|---|---|---|
| | 2 MAP | 4 MAP | 6 MAP | At harvest |
| $T_1$ | 66.16 | 121.50 | 155.70 | 197.60 |
| $T_2$ | 60.76 | 115.83 | 176.03 | 258.70 |
| $T_3$ | 92.16 | 178.50 | 276.53 | 296.56 |
| $T_4$ | 52.43 | 133.93 | 186.60 | 269.26 |
| $T_5$ | 71.33 | 138.33 | 195.00 | 277.00 |
| $T_6$ | 89.13 | 169.80 | 267.50 | 291.16 |
| $T_7$ | 61.80 | 130.46 | 183.30 | 266.46 |
| $T_8$ | 76.50 | 166.10 | 245.76 | 281.23 |
| $T_9$ | 111.76 | 197.76 | 297.76 | 314.43 |
| $T_{10}$ | 70.40 | 123.96 | 174.63 | 257.16 |
| $T_{11}$ | 82.16 | 168.50 | 259.50 | 286.16 |
| $T_{12}$ | 87.40 | 189.20 | 284.53 | 309.16 |
| $T_{13}$ | 37.16 | 75.50 | 117.16 | 164.50 |
| $T_{14}$ | 62.26 | 128.90 | 178.96 | 259.96 |
| SEm(±) | 5.42 | 7.20 | 8.38 | 7.29 |
| CD (0.05) | 11.198 | 14.882 | 17.336 | 15.081 |

with $T_6$ (291.16 cm) and $T_{11}$ (286.16 cm). The least height was noted for $T_{13}$ (164.50 cm).

During 6 MAP the highest pseudostem height was observed for $T_9$ (297.76 cm) but was on par with $T_{12}$ (284.53 cm).The absolute control $T_{13}$ (117.16 cm) recorded the lowest height.

At the time of harvest $T_9$ (314.4 cm) recorded taller pseudostem but was on par with $T_{12}$ (309.16 cm). This was followed by $T_3$ (296.56 cm) which was on par with $T_6$ (291.16 cm) and $T_{11}$ (286.16 cm). The least height was noted for $T_{13}$ (164.50 cm).

**4.1.2 Girth of pseudostem**

The data regarding the influence of major plant nutrients on girth of pseudostem of banana is depicted in table 4. The girth of pseudostem was recorded at 2 MAP, 4 MAP, 6 MAP and at the time of harvest and significant differences were observed among the different treatments.

Results of the data on girth of pseudostem at 2 MAP recorded the highest for $T_9$ (27.83 cm) however was on par with $T_{12}$ (27.40 cm) and $T_3$ (27.16 cm). The least girth was observed for absolute control $T_{13}$ (12.76 cm).

Observations noted at 4 MAP showed that $T_9$ (43.80 cm) recorded the thicker pseudostem which was significantly different from all other treatments. This was followed by $T_{12}$ (41.30 cm) which also differed significantly from other treatments. The absolute control $T_{13}$ (24.86 cm) recorded the least girth which was on par with $T_2$ (26.73 cm).

At 6 MAP, $T_9$ (70.83cm) showed the highest girth which was significantly different from all other treatments. This was followed $T_{12}$ (68.30 cm) which was at par with $T_3$ (67.16 cm) and $T_6$ (66.83 cm). The least girth was observed with $T_{13}$ (44.76 cm) which was on par with $T_2$ (46.50 cm).

Table 4. Effect of different N K levels and its time of application on girth of Pseudostem of banana cv. Popoulu, cm

| Treatments | Pseudostem girth (cm) of banana cv. Popoulu | | | |
|---|---|---|---|---|
| | 2 MAP | 4 MAP | 6 MAP | At harvest |
| $T_1$ | 20.96 | 34.13 | 55.30 | 67.70 |
| $T_2$ | 21.60 | 26.73 | 46.50 | 61.12 |
| $T_3$ | 27.16 | 38.63 | 67.16 | 79.83 |
| $T_4$ | 20.86 | 27.23 | 52.20 | 62.00 |
| $T_5$ | 21.46 | 34.80 | 52.60 | 66.93 |
| $T_6$ | 24.06 | 36.06 | 66.83 | 78.86 |
| $T_7$ | 16.50 | 31.23 | 55.50 | 67.83 |
| $T_8$ | 18.26 | 36.93 | 60.43 | 71.20 |
| $T_9$ | 27.83 | 43.80 | 70.83 | 84.50 |
| $T_{10}$ | 17.23 | 33.23 | 52.90 | 65.50 |
| $T_{11}$ | 24.16 | 37.43 | 57.83 | 71.00 |
| $T_{12}$ | 27.40 | 41.30 | 68.30 | 82.36 |
| $T_{13}$ | 12.76 | 24.86 | 44.76 | 59.76 |
| $T_{14}$ | 18.90 | 30.60 | 52.20 | 62.50 |
| SEm(±) | 0.80 | 0.978 | 1.13 | 0.60 |
| CD (0.05) | 1.656 | 2.012 | 2.330 | 3.561 |

At the time of harvest, the pseudostem girth was found to be highest with $T_9$ (84.50 cm) which differed significantly from all other treatments. This was followed by $T_{12}$ (82.36 cm) which was on par with $T_3$ (79.83 cm) and $T_6$ (78.86 cm). The least plant girth was noticed with absolute control $T_{13}$ (59.76 cm), which was statistically on par with $T_2$ (61.12 cm), $T_4$ (62.00 cm) and $T_{14}$ (62.50 cm).

**4.1.3 Number of functional leaves**

The influence of major plant nutrients on number of functional leaves is mentioned in table 5. The observations were noted regularly at 2 MAP, 4 MAP, 6 MAP and at the time of harvest and the treatments differed significantly.

The results recorded during 2 MAP showed more number of functional leaves for $T_{12}$ (8.16) which was at par with $T_9$ (7.83). The lowest number of functional leaves were noted for $T_{13}$ (4.56).

The statistical analysis at 4 MAP revealed that the highest number of leaves was noticed for $T_9$ (9.76) which was at par with $T_{12}$ (9.40) and $T_6$ (9.10). The least number of leaves were recorded for $T_{13}$ (6.48) which was at par with $T_4$ (6.77), $T_{11}$ (6.81), $T_5$ (6.85) and $T_{14}$ (7.11).

At 6 MAP $T_9$ (12.93) produced maximum number of leaves which was statistically on par with $T_{12}$ (12.56) and differed significantly from all other treatments. The lowest number of leaves were recorded for absolute control $T_{13}$ (9.67) followed by $T_{14}$ (10.06) and $T_5$ (10.53).

The treatment $T_9$ (6.78) recorded the maximum number of leaves at the time of harvest which was at par with $T_{12}$ (6.62). This was followed by $T_3$ (6.21). Absolute control $T_{13}$ (4.66) recorded the least number of leaves which was at par with $T_{10}$ (4.82).

**4.1.4 Total functional leaf area**

The results of data on total functional leaf area is presented in table 6. The

Table 5. Effect of different N K levels and its time of application on number of functional leaves of banana cv. Popoulu

| Treatments | Number of functional leaves | | | |
|---|---|---|---|---|
| | 2 MAP | 4 MAP | 6 MAP | At harvest |
| $T_1$ | 7.16 | 8.58 | 11.46 | 5.71 |
| $T_2$ | 7.20 | 8.26 | 11.23 | 5.62 |
| $T_3$ | 7.33 | 8.83 | 11.66 | 6.21 |
| $T_4$ | 5.63 | 6.77 | 10.86 | 5.35 |
| $T_5$ | 6.66 | 6.85 | 10.53 | 4.68 |
| $T_6$ | 7.50 | 9.10 | 11.50 | 5.91 |
| $T_7$ | 7.00 | 7.45 | 11.30 | 5.56 |
| $T_8$ | 7.53 | 7.72 | 11.76 | 6.46 |
| $T_9$ | 7.83 | 9.76 | 12.93 | 6.78 |
| $T_{10}$ | 7.16 | 7.68 | 10.83 | 4.82 |
| $T_{11}$ | 6.80 | 6.81 | 11.50 | 5.87 |
| $T_{12}$ | 8.16 | 9.40 | 12.56 | 6.62 |
| $T_{13}$ | 4.56 | 6.48 | 9.67 | 4.66 |
| $T_{14}$ | 7.00 | 7.11 | 10.06 | 5.11 |
| SEm(±) | 0.25 | 0.32 | 0.53 | 0.16 |
| CD (0.05) | 0.512 | 0.662 | 1.088 | 0.308 |

observations were recorded regularly at 2 MAP, 4 MAP, 6 MAP and at the time of harvest and have statistically differed with each other.

At 2 MAP the treatment $T_{12}$ (27,988.25 $cm^2$) recorded the highest functional leaf area which differed significantly from all other treatments. This was followed by $T_9$ (23,766.52 $cm^2$) which was at par with $T_6$ (22,200.43 $cm^2$) and $T_3$ (21,790.25 $cm^2$). The least functional leaf area was noticed with $T_{13}$ (6,999.19$cm^2$), which was statistically on par with $T_4$ (9419.29 $cm^2$) and $T_5$ (10,948.08 $cm^2$).

The highest leaf area at 4 MAP was recorded for $T_9$ (70,039.39 $cm^2$) but was at par with$T_{12}$ (68,923.12 $cm^2$). The least functional leaf area was recorded for absolute control $T_{13}$ (41,398.90 $cm^2$).

At 6 MAP the highest functional leaf area was recorded for $T_9$ (1, 52,819.80 $cm^2$) which was at par with $T_{12}$ (1, 47,026.00 $cm^2$). The lowest functional leaf area was noticed for absolute control $T_{13}$ (41,398.90 $cm^2$) and differed significantly from all other treatments.

Statistical analysis at the time of harvest revealed the highest functional leaf area for $T_9$ (1, 28,230.40 $cm^2$) which differed significantly from all other treatments. This was followed by $T_{12}$ (1, 13,715 $cm^2$). The lowest observation for functional leaf area was recorded with $T_{13}$ (40,543.58 $cm^2$) which was at par with $T_{14}$ (41,009.06 $cm^2$) and $T_{10}$ (45,887.93 $cm^2$).

**4.1.5 Leaf area index (LAI)**

The result of data on LAI influenced by plant nutrients is illustrated in table 7. The observations were recorded at 2 MAP, 4 MAP, 6 MAP and at the time of harvest. The plant nutrients given in different dosages had a significant effect on leaf area index.

At 2 MAP the LAI was the highest for $T_{12}$ (0.69) which was at par with $T_9$ (0.59) and differed significantly from all other treatments. The LAI was least for absolute control $T_{13}$ (0.17) but was at par $T_4$ (0.23), $T_5$ (0.27) and $T_{14}$ (0.28).

Table 6. Effect of different N K levels and its time of application on total functional leaf area of banana cv. Popoulu, $cm^2$

| Treatments | Total functional leaf area ($cm^2$) | | | |
|---|---|---|---|---|
| | 2 MAP | 4 MAP | 6 MAP | At harvest |
| $T_1$ | 15,803.76 | 36,855.11 | 84,067.44 | 57,559.31 |
| $T_2$ | 15,705.68 | 41,045.92 | 80,520.17 | 59,237.27 |
| $T_3$ | 21,790.25 | 50,446.61 | 1,13,453.40 | 92,904.15 |
| $T_4$ | 9419.29 | 23,325.22 | 72,682.55 | 56,690.58 |
| $T_5$ | 10,948.08 | 31,237.25 | 81,034.65 | 53,454.7 |
| $T_6$ | 22,200.43 | 55,525.17 | 1,06,446.10 | 81,417.22 |
| $T_7$ | 12,776.40 | 35,176.72 | 78,968.58 | 53,094.27 |
| $T_8$ | 17,506.16 | 42,604.60 | 98,445.78 | 83,697.44 |
| $T_9$ | 23,766.52 | 70,039.39 | 1,52,819.80 | 1,28,230.40 |
| $T_{10}$ | 12,514.73 | 34,081.71 | 76,571.07 | 45,887.93 |
| $T_{11}$ | 15,599.79 | 36,921.87 | 1,00,720.6 | 76,393.35 |
| $T_{12}$ | 27,988.25 | 68,923.12 | 1,47,026.00 | 1,13,715.00 |
| $T_{13}$ | 6999.14 | 19,365.05 | 41,398.90 | 40,543.38 |
| $T_{14}$ | 11,334.91 | 35,647.10 | 61,561.32 | 41,009.06 |
| SEm(±) | 1921.90 | 3460.55 | 3212.32 | 5352.484 |
| CD (0.05) | 3951.429 | 7114.894 | 6604.531 | 10972.593 |

The highest LAI at 4 MAP was recorded for $T_9$ (1.75) which was at par with $T_{12}$ (1.72). This was followed by $T_6$ (1.38). The lowest LAI was recorded for $T_{13}$ (0.48) which was at par with $T_4$ (0.58).

The results at 6 MAP revealed the highest LAI for $T_9$ (3.82) however at par with $T_{12}$ (3.67). This was followed by $T_3$ (2.83). The least value for LAI was recorded with absolute control $T_{13}$ (1.03).

At the time of harvest the maximum LAI was noted for $T_9$ (3.63) which was at par with $T_{12}$ (2.84). The least LAI was observed for $T_{13}$ (1.01) but was at par with $T_{14}$ (1.02), $T_{10}$ (1.14), $T_7$ (1.32) and $T_5$ (1.33).

### 4.1.6 Duration for bunch emergence

The data on duration for bunch emergence is presented in table 8 which showed significant difference among treatments. The shortest duration for bunch emergence was found recorded for $T_9$ (241.73 days) and was at par with $T_{12}$ (247.23 days). The highest duration was observed with absolute control $T_{13}$ (328 days), which differed significantly from all other treatments.

### 4.1.7 Crop duration

The effect of major plant nutrients on crop duration is illustrated in table 8. The crop duration was the shortest in $T_9$ (302.40 days) followed by $T_{12}$ (306.90 days) which were statistically on par and differed significantly from all other treatments. The highest crop duration was recorded with $T_{13}$ (368.33 days) which was at par with $T_7$ (359.60 days).

### 4.1.8 Sucker production after the bunch emergence

The data regarding the sucker production after the bunch emergence has been inscribed in table 8. The results of the data revealed the highest sucker production for $T_9$ (8.90) which was at par with $T_3$ (8.60) and $T_{12}$ (8.56). The lowest number of suckers were found in $T_{13}$ (6.28) but was at par with $T_4$ (6.50).

Table 7. Effect of different N K levels and its time of application on LAI (Leaf area index) of banana cv. Popoulu

| Treatments | Leaf area index | | | |
|---|---|---|---|---|
| | 2 MAP | 4 MAP | 6 MAP | At harvest |
| $T_1$ | 0.40 | 0.92 | 2.10 | 1.43 |
| $T_2$ | 0.39 | 1.02 | 2.01 | 1.48 |
| $T_3$ | 0.54 | 1.26 | 2.83 | 2.32 |
| $T_4$ | 0.23 | 0.58 | 1.81 | 1.41 |
| $T_5$ | 0.27 | 0.78 | 2.02 | 1.33 |
| $T_6$ | 0.55 | 1.38 | 2.66 | 2.03 |
| $T_7$ | 0.31 | 0.87 | 1.97 | 1.32 |
| $T_8$ | 0.43 | 1.06 | 2.46 | 2.09 |
| $T_9$ | 0.59 | 1.75 | 3.82 | 3.63 |
| $T_{10}$ | 0.31 | 0.85 | 1.91 | 1.14 |
| $T_{11}$ | 0.38 | 0.92 | 2.51 | 1.90 |
| $T_{12}$ | 0.69 | 1.72 | 3.67 | 2.84 |
| $T_{13}$ | 0.17 | 0.48 | 1.03 | 1.01 |
| $T_{14}$ | 0.28 | 0.89 | 1.53 | 1.02 |
| SEm(±) | 0.05 | 0.09 | 0.08 | 0.18 |
| CD (0.05) | 0.112 | 0.178 | 0.165 | 0.375 |

Table 8. Effect of different N K levels and its time of application on duration for bunch emergence, crop duration and sucker production after bunch

| Treatments | Duration for bunch emergence (days) | Crop duration ( days) | Sucker production after bunch emergence |
|---|---|---|---|
| $T_1$ | 277.23 | 341.90 | 7.06 |
| $T_2$ | 274.86 | 336.66 | 7.56 |
| $T_3$ | 257.36 | 318.03 | 8.60 |
| $T_4$ | 305.80 | 337.56 | 6.50 |
| $T_5$ | 269.93 | 331.80 | 7.93 |
| $T_6$ | 266.50 | 327.40 | 8.13 |
| $T_7$ | 280.23 | 359.60 | 8.33 |
| $T_8$ | 270.53 | 334.23 | 7.66 |
| $T_9$ | 241.73 | 302.40 | 8.90 |
| $T_{10}$ | 267.00 | 350.66 | 7.06 |
| $T_{11}$ | 257.23 | 321.66 | 8.00 |
| $T_{12}$ | 247.23 | 306.90 | 8.56 |
| $T_{13}$ | 328.00 | 368.33 | 6.28 |
| $T_{14}$ | 273.90 | 345.56 | 7.10 |
| SEm(±) | 5.90 | 5.42 | 0.28 |
| CD (0.05) | 12.131 | 11.154 | 0.584 |

## 4.2 YIELD AND YIELD ATTRIBUTES

### 4.2.1 Weight of bunch

The bunch weight influenced by major plant nutrients are presented in table 9. The bunch weight recorded showed a significant difference among various treatments.

The results indicated the heaviest bunch for $T_9$ (19.26 kg) which differed significantly from other treatments. This was followed by $T_{12}$ (18.46 kg) which also differed significantly from other treatments. The lowest bunch weight was recorded in $T_{13}$ (7.36 kg), followed by $T_2$ (11.16 kg), and both differed significantly over the other treatments.

### 4.2.2 Number of hands bunch$^{-1}$

The results of data on number of hands per bunch has been presented in table 9. The number of hands per bunch recorded among different treatments showed significant difference.

The highest number of hands per bunch was recorded for $T_9$ (8.20) which was at par with $T_{12}$ (7.93). The least number of hands were found in absolute control $T_{13}$ (4.76) but was at par with $T_2$ (4.93).

### 4.2.3 Number of fingers bunch$^{-1}$

The results on number of fingers are presented in table 9. The number of fingers varied significantly based on the treatments provided.

The highest number of fingers per bunch was counted in $T_9$ (69.36), which varied significantly from rest of the treatments. This was followed by $T_{12}$ (67.13) which was at par with $T_3$ (66.46). The least number of fingers were counted for $T_{13}$ (33.63).

Table 9. Effect of different N K levels and its time of application on weight of bunch, number of hands per bunch, number of fingers per bunch, number of fingers in D hand and pulp peel ratio of banana cv. Popoulu

| Treatments | Weight of bunch (kg) | Number of hands per bunch | Number of fingers per bunch | Number of fingers in D hand | Pulp peel ratio |
|---|---|---|---|---|---|
| $T_1$ | 15.30 | 6.76 | 53.90 | 8.60 | 2.80 |
| $T_2$ | 11.16 | 4.93 | 56.33 | 10.0 | 3.06 |
| $T_3$ | 17.16 | 7.16 | 66.46 | 12.83 | 3.86 |
| $T_4$ | 13.53 | 7.03 | 53.10 | 7.16 | 2.70 |
| $T_5$ | 15.93 | 6.36 | 57.40 | 9.83 | 3.14 |
| $T_6$ | 16.23 | 6.76 | 64.43 | 12.10 | 3.78 |
| $T_7$ | 16.06 | 6.86 | 55.30 | 9.50 | 2.96 |
| $T_8$ | 16.36 | 7.03 | 57.06 | 11.00 | 3.35 |
| $T_9$ | 19.26 | 8.20 | 69.36 | 14.50 | 3.94 |
| $T_{10}$ | 15.00 | 6.16 | 54.66 | 10.33 | 2.98 |
| $T_{11}$ | 15.46 | 7.00 | 60.83 | 9.00 | 3.54 |
| $T_{12}$ | 18.46 | 7.93 | 67.13 | 14.40 | 3.90 |
| $T_{13}$ | 7.36 | 4.76 | 33.63 | 6.23 | 2.47 |
| $T_{14}$ | 13.36 | 5.83 | 42.30 | 8.45 | 2.67 |
| SEm(±) | 0.31 | 0.22 | 0.35 | 0.54 | 0.05 |
| CD (0.05) | 0.650 | 0.469 | 0.723 | 1.120 | 0.100 |

#### 4.2.4 Number of fingers in D hand

The results of data on number of fingers in D hand has been illustrated in table 9. The different treatments varied significantly with the application of major plant nutrients in various dosages.

The number of fingers in D hand varied from 6.23 in $T_{13}$ to 14.50 in $T_9$. The highest number of fingers in D hand was found in $T_9$ (14.50) which was at par with $T_{12}$ (14.40). The least observations were recorded for absolute control $T_{13}$ (6.23) which was statistically at par with $T_4$ (7.16).

#### 4.2.5 Pulp peel ratio

The data on pulp peel ratio influenced by major plant nutrients are represented in table 9. The pulp peel ratio differed significantly among different treatments. The highest pulp peel ratio was recorded in $T_9$ (3.94) which was statistically at par with $T_{12}$ (3.90) and $T_3$ (3.86).The least observations were recorded for $T_{13}$ (2.47) which was significantly different from all other treatments.

#### 4.2.6 Weight of finger

The weight of finger varied significantly from 168.42 g in $T_{13}$ to 256.38 g in $T_9$ and results are presented in table 10.

The maximum weight was obtained in $T_9$ (256.38 g) which differed significantly from all other treatments. This was followed by $T_{12}$ (254.48 g). The minimum finger weight was noticed in $T_{13}$ (168.42 g), which also differed significantly from other treatments.

#### 4.2.7 Length of finger

The result of data on length of finger are presented in table 10. Statistical analysis showed significant variation among the different treatments in length of finger.

Table 10. Effect of different N K levels and its time of application on weight of finger, length of finger, girth of finger, yield per hectare and days taken for ripening in banana cv. Popoulu

| Treatments | Weight of finger (g) | Length of finger (cm) | Girth of finger (cm) | Yield per hectare (kg) | Days taken for ripening |
|---|---|---|---|---|---|
| $T_1$ | 193.28 | 17.60 | 14.50 | 38,250.29 | 6.70 |
| $T_2$ | 188.07 | 14.46 | 15.60 | 33,250.00 | 7.50 |
| $T_3$ | 234.32 | 19.63 | 18.46 | 43,500.40 | 8.50 |
| $T_4$ | 174.66 | 17.83 | 17.03 | 33,750.20 | 6.70 |
| $T_5$ | 221.55 | 18.03 | 17.13 | 39,750.37 | 7.70 |
| $T_6$ | 227.89 | 19.13 | 17.90 | 41,000.46 | 8.00 |
| $T_7$ | 225.40 | 18.03 | 16.86 | 40,150.30 | 6.90 |
| $T_8$ | 236.03 | 20.00 | 18.50 | 40,950.16 | 7.10 |
| $T_9$ | 256.38 | 21.50 | 19.83 | 48,375.30 | 9.10 |
| $T_{10}$ | 223.44 | 17.86 | 16.86 | 37,500.43 | 6.80 |
| $T_{11}$ | 232.73 | 19.93 | 18.26 | 38,750.40 | 8.20 |
| $T_{12}$ | 254.48 | 21.26 | 19.81 | 46,425.33 | 8.70 |
| $T_{13}$ | 168.42 | 13.71 | 12.39 | 16,250.18 | 6.20 |
| $T_{14}$ | 197.92 | 16.66 | 16.50 | 22,900.34 | 6.60 |
| SEm(±) | 0.48 | 0.42 | 0.46 | 954.03 | - |
| CD (0.05) | 1.003 | 0.875 | 0.957 | 1961.43 | NS |

The highest length of finger was found in $T_9$ (21.50 cm) but was at par with $T_{12}$ (21.26 cm). The absolute control $T_{13}$ (13.71 cm) recorded the lowest finger length which was at par with $T_2$ (14.46 cm) and differed significantly from all other treatments.

### 4.2.8 Girth of finger

The results indicated significant variation in girth of finger among the various treatments and the data is presented in table 10.

The girth of finger varied from 12.39 cm in $T_{13}$ to 19.83 cm in $T_9$ and the highest finger girth was found in $T_9$ (19.83 cm) which was at par with $T_{12}$ (19.81 cm). The least girth of finger was obtained in absolute control $T_{13}$ (12.39 cm) which varied significantly from other treatments.

### 4.2.9 Yield $ha^{-1}$

The result of the studies on yield per hectare has been illustrated in table 10. The analysis of data on yield per hectare varied significantly among different treatments.

The treatment $T_9$ (48,375.30 kg $ha^{-1}$) recorded the highest yield but was on par with the treatment $T_{12}$ (46,425.33 kg $ha^{-1}$). The lowest yield per hectare was recorded in absolute control $T_{13}$ (16,250.18 kg $ha^{-1}$) which was significantly different from all other treatments.

### 4.2.10 Days taken for ripening

The application of different levels of N and K had no significant influence on the days taken for ripening (table 10).

T 9

- N:P:K - 350:115:525 g $plant^{-1}$
- 6 equal splits

T 12

- N:P:K – 400:115:600 g $plant^{-1}$
- 6 splits

T 13

- Control plants
- No fertilizers

Plate 3: Bunch of banana cv. Popoulu

T 9

- N:P:K - 350:115:525 g $plant^{-1}$
- 6 equal splits

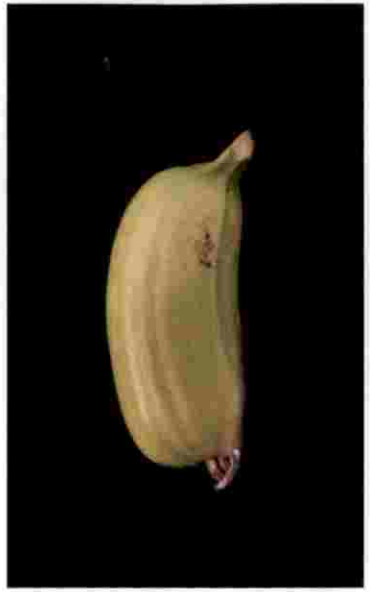
T 12

- N:P:K – 400:115:600 g $plant^{-1}$
- 6 splits

T 13

- Control plants
- No fertilizers

Plate 4: D hand of banana cv. Popoulu of different treatments



T 9

- N:P:K - 350:115:525 g $plant^{-1}$
- 6 equal splits

T 12

- N:P:K – 400:115:600 g $plant^{-1}$
- 6 splits

T 13

- Control plants
- No fertilizers

Plate 5: D finger of banana cv. Popoulu of different treatments

4.3 QUALITY PARAMETERS OF FRUIT

### 4.3.1 Total soluble solids (TSS)

The TSS of the fruits varied significantly with the application of major plant nutrients and the result is illustrated in table 11

The highest value for TSS was found with $T_6$ (25.80 °Brix) which was significantly different from other treatments. This was followed by $T_9$ (24.94 ° Brix). The treatment $T_{13}$ (21.91° Brix) recorded the lowest value for TSS which was at par with $T_2$ (22.12 ° Brix) and varied significantly from other treatments.

### 4.3.2 Acidity

The result of acidity influenced by the application of major plant nutrients is presented in table 11.

Statistical analysis revealed the lowest value of acidity in $T_9$ (0.38 %) but was at par with $T_6$ (0.39 %), $T_{12}$ (0.39%) and $T_3$ (0.42%) respectively. The highest value of acidity was recorded in $T_{13}$ (0.61 %) which was at par with $T_7$ (0.59 %), $T_4$ (0.58 %), $T_1$ (0.58 %), $T_5$ (0.57%) and $T_{14}$ (0.57 %).

### 4.3.3 Total carotenoids

The observations for carotenoid content is illustrated in table 11. The combination of different major plant nutrients had shown significant effect on the carotenoid content.

The highest carotenoid content was observed in $T_9$ (1.34 mg 100 $g^{-1}$) which was on par with $T_{12}$ (1.25 mg 100 $g^{-1}$) and varied significantly from other treatments. The least carotenoid content was recorded for absolute control $T_{13}$ (0.36 mg 100 $g^{-1}$) was on par with $T_4$ (0.41 mg 100 $g^{-1}$) and $T_{10}$ (0.42 mg 100 $g^{-1}$) and significantly varied from other treatments.

Table 11. Effect of different N K levels and its time of application on TSS, acidity, total carotenoids, starch content and peel thickness

| Treatments | TSS (°B) | Acidity (%) | Carotenoids (mg $100g^{-1}$) | Starch (%) | Peel thickness (mm) |
|---|---|---|---|---|---|
| $T_1$ | 23.75 | 0.58 | 0.49 | 22.10 | 2.81 |
| $T_2$ | 22.12 | 0.49 | 0.64 | 25.11 | 2.80 |
| $T_3$ | 24.48 | 0.42 | 0.96 | 27.00 | 2.62 |
| $T_4$ | 24.00 | 0.58 | 0.41 | 24.50 | 2.75 |
| $T_5$ | 23.60 | 0.57 | 0.69 | 25.67 | 2.64 |
| $T_6$ | 25.80 | 0.39 | 1.17 | 27.50 | 2.52 |
| $T_7$ | 23.90 | 0.59 | 0.69 | 22.78 | 2.77 |
| $T_8$ | 24.61 | 0.41 | 0.92 | 26.30 | 2.74 |
| $T_9$ | 24.94 | 0.38 | 1.34 | 29.06 | 2.61 |
| $T_{10}$ | 23.61 | 0.61 | 0.42 | 20.67 | 2.90 |
| $T_{11}$ | 24.20 | 0.45 | 0.84 | 25.30 | 2.86 |
| $T_{12}$ | 24.51 | 0.39 | 1.25 | 28.56 | 2.70 |
| $T_{13}$ | 21.91 | 0.61 | 0.36 | 19.60 | 2.95 |
| $T_{14}$ | 24.56 | 0.57 | 0.61 | 23.60 | 2.87 |
| SEm(±) | 0.13 | 0.02 | 0.059 | 0.67 | 0.04 |
| CD (0.05) | 0.286 | 0.044 | 0.123 | 1.387 | 0.091 |

### 4.3.4 Starch content

The result of starch content influenced by major plant nutrients is presented in the table 11. The starch content of banana was highest in $T_9$ (29.06 %) however was at par with $T_{12}$ (28.56 %) and were significantly different from all the other treatments. The treatment $T_{13}$ (19.60 %) recorded the lowest starch content and was at par with $T_{10}$ (20.67 %) and differed significantly from other treatments.

### 4.3.5 Peel thickness

The data of peel thickness influenced by the major plant nutrients are inscribed in table 11. The lowest peel thickness was indicated by the treatment $T_6$ (2.52 mm) but was at par with $T_9$ (2.61 mm) and differed significantly from other treatments. The highest peel thickness was noted in $T_{13}$ (2.95 mm) which was on par with T10 (2.90 mm), $T_{14}$ (2.87 mm) and $T_{11}$ (2.86 mm) and differed significantly from other treatments.

### 4.3.6 Total sugars

The data on total sugar is inscribed on table 12. The combination of major plant nutrients resulted in significant variation among different treatments of total sugar. The highest total sugar content was observed for $T_9$ (14.89 %) which was at par with $T_{12}$ (14.82 %) and $T_6$ (14.80 %) and differed significantly from other treatments. The absolute control $T_{13}$ (12.09 %) recorded the least total sugar content.

### 4.3.7 Reducing sugar

The observations of reducing sugar is presented on table 12. The major plant nutrients had favorably influenced the reducing sugar content.

The highest value of reducing sugar was noted in $T_6$ (8.70 %). This was followed by $T_9$ (8.55%) which was at par with $T_{12}$ (8.41 %). The lowest reducing sugar content was noted in $T_{13}$ (6.69 %) and was at par with $T_{10}$ (6.82 %).

Table 12. Effect of different N K levels and its time of application on total sugar, reducing sugar, non-reducing sugar, sugar acid ratio and ascorbic acid

| Treatments | Total sugar (%) | Reducing sugar (%) | Non reducing sugar (%) | Sugar acid ratio | Ascorbic acid (mg $100g^{-1}$) |
|---|---|---|---|---|---|
| $T_1$ | 13.90 | 7.62 | 6.28 | 24.17 | 15.07 |
| $T_2$ | 13.52 | 7.31 | 6.21 | 27.63 | 17.03 |
| $T_3$ | 14.61 | 8.34 | 6.27 | 35.36 | 18.15 |
| $T_4$ | 12.93 | 6.96 | 5.96 | 21.38 | 16.74 |
| $T_5$ | 13.46 | 7.44 | 6.02 | 23.64 | 16.86 |
| $T_6$ | 14.80 | 8.70 | 6.10 | 37.41 | 18.35 |
| $T_7$ | 13.13 | 7.18 | 5.95 | 22.05 | 16.38 |
| $T_8$ | 13.88 | 7.63 | 6.25 | 32.93 | 17.24 |
| $T_9$ | 14.89 | 8.55 | 6.44 | 38.29 | 19.69 |
| $T_{10}$ | 12.86 | 6.82 | 5.84 | 20.96 | 15.47 |
| $T_{11}$ | 13.16 | 7.26 | 5.90 | 29.17 | 17.24 |
| $T_{12}$ | 14.82 | 8.41 | 6.41 | 37.96 | 19.41 |
| $T_{13}$ | 12.09 | 6.69 | 5.75 | 19.64 | 14.15 |
| $T_{14}$ | 12.75 | 7.02 | 5.93 | 22.13 | 15.72 |
| SEm(±) | 0.07 | 0.07 | 0.06 | 1.37 | 0.06 |
| CD (0.05) | 0.149 | 0.148 | 0.138 | 2.831 | 0.120 |

#### 4.3.8 Non reducing sugar

The data on non-reducing sugar influenced by major plant nutrients are illustrated in table 12. The results showed significant variation among different treatments.

The treatment $T_9$ (6.44 %) reported the highest non-reducing sugar content but was at par with $T_{12}$ (6.41 %). This was followed by $T_3$ (6.27 %). The absolute control $T_{13}$ (5.75 %) recorded the least non-reducing sugar and was at par with the treatment $T_{10}$ (5.84 %).

#### 4.3.9 Sugar acid ratio

The analysis of data revealed significant differences among treatments for sugar acid ratio and is presented in table 12.

The chemical analysis of the fruit resulted in highest sugar acid ratio for treatment $T_9$ (38.29) but was at par with $T_{12}$ (37.96) and $T_6$ (37.41) and was significantly different from all other treatments. The absolute control $T_{13}$ (19.64) recorded the least sugar acid ratio and was on par with $T_{10}$ (20.96), $T_4$ (21.38), $T_7$ (22.05) and $T_{14}$ (22.13).

#### 4.3.10 Ascorbic acid

The results of data obtained showed significant differences among different treatments for ascorbic acid content and is presented in table 12.

The ascorbic acid content was found to be highest in $T_9$ (19.69 mg 100 $g^{-1}$) followed by $T_{12}$ (19.41 mg 100 $g^{-1}$) and both the treatments are significantly different from all other treatments. The treatment $T_{13}$ (14.15 mg 100 $g^{-1}$) resulted in least ascorbic acid content.

## 4.4 ORGANOLEPTIC EVALUATION OF FRUIT AND CHIPS FOR SENSORY QUALITIES

### 4.4.1 Organoleptic evaluation of fruit for sensory qualities

The scoring of banana cv. Popoulu for organoleptic qualities are presented in table 13. The mean score for taste and overall acceptability varied significantly. The characters appearance, texture and flavour did not vary significantly.

The mean score of taste ranged from 7 in $T_{13}$ to 8.6 in $T_9$ and for overall acceptability the mean score was 6.7 in $T_{13}$ to 8.5 in $T_9$. The highest score for taste (8.6) was recorded in $T_9$ which was at par with $T_{12}$, $T_6$, $T_8$, $T_3$ and $T_2$. The least score was obtained in treatment $T_{13}$. The score for overall acceptability was highest in $T_9$ (8.5) but was at par with $T_{12}$, $T_6$, $T_8$ and $T_3$ were significantly different from other treatments. Absolute control $T_{13}$ marked the least score for overall acceptability.

### 4.4.2 Organoleptic evaluation of chips for sensory qualities

The mean scores of characters for organoleptic evaluation of chips are illustrated in table 14. The mean scores of taste and overall acceptability varied significantly and the characters appearance, texture and flavour did not show significant variation.

The taste of chips recorded the score of 7.3 in $T_{13}$ to 8.7 in $T_9$ and overall acceptability ranged from 6.8 in $T_{13}$ to 8.6 in $T_9$. The highest score for the character taste was obtained for treatment $T_9$ (8.7) which was on par with $T_{12}$, $T_6$, $T_8$, $T_3$ and $T_2$. The score for overall acceptability was highest in $T_9$ (8.6) and was at par with $T_3$, $T_5$, $T_6$, $T_8$ and $T_{12}$.

## 4.5 SHELF LIFE OF FRUITS AT AMBIENT CONDITIONS

The combination of major plant nutrients did not have a significant effect on the shelf life of fruits at ambient conditions. The data is presented in table 15.

Table 13. Organoleptic evaluation of fruit of banana cv. Popoulu

| Treatments | Appearance | Colour | Flavour | Texture | Taste | Over all acceptability |
|---|---|---|---|---|---|---|
| $T_1$ | 7.6 (76.50) | 7.9 (71.80) | 7.8 (64.15) | 7.8 (71.75) | 8.0 (129.90) | 7.8 (131.00) |
| $T_2$ | 7.7 (76.10) | 8.0 (69.30) | 8.0 (64.70) | 7.9 (76.15) | 8.2 (157.10) | 8.0 (133.78) |
| $T_3$ | 8.0 (71.90) | 8.1 (79.25) | 8.3 (82.40) | 8.1 (78.60) | 8.4 (172.60) | 8.2 (171.80) |
| $T_4$ | 7.4 (68.50) | 7.8 (67.25) | 7.5 (58.75) | 7.6 (69.30) | 7.7 (125.90) | 7.6 (128.50) |
| $T_5$ | 7.6 (74.00) | 7.9 (73.95) | 7.6 (63.60) | 7.7 (71.45) | 7.8 (127.80) | 7.8 (131.00) |
| $T_6$ | 8.3 (92.60) | 8.1 (80.90) | 8.5 (86.10) | 8.2 (85.25) | 8.4 (176.30) | 8.2 (173.60) |
| $T_7$ | 7.0 (61.45) | 7.8 (74.30) | 7.5 (61.60) | 7.3 (63.05) | 7.5 (120.10) | 7.4 (123.20) |
| $T_8$ | 7.8 (79.05) | 8.0 (73.90) | 8.2 (77.55) | 8.1 (80.85) | 8.4 (178.30) | 8.1 (160.40) |
| $T_9$ | 8.5 (91.45) | 8.3 (85.40) | 8.8 (97.80) | 8.4 (91.80) | 8.6 (191.80) | 8.5 (196.00) |
| $T_{10}$ | 6.7 (55.95) | 7.5 (60.35) | 7.4 (60.20) | 7.0 (52.10) | 7.1 (96.00) | 7.0 (93.40) |
| $T_{11}$ | 6.8 (53.50) | 7.4 (64.15) | 7.4 (61.90) | 7.2 (60.90) | 7.2 (93.00) | 7.2 (121.40) |
| $T_{12}$ | 8.4 (90.15) | 8.2 (80.85) | 8.7 (95.80) | 8.3 (87.80) | 8.5 (185.90) | 8.3 (180.10) |
| $T_{13}$ | 6.4 (40.75) | 6.7 (39.05) | 6.9 (51.10) | 6.8 (47.00) | 7.0 (95.30) | 6.7 (74.20) |
| $T_{14}$ | 6.6 (55.30) | 7.5 (66.55) | 7.3 (61.35) | 7.0 (51.00) | 7.0 (99.00) | 6.9 (92.80) |
| K W value | 21.54 | 11.54 | 19.37 | 17.12 | 57.96 | 55.42 |
| | NS | NS | NS | NS | | |
| $\chi^2$ - 22.36 (13, 0.05), CD – 61.48 | | | | | | |

*The value in the parenthesis is the mean rank

Table 14. Organoleptic evaluation of chips of banana cv. Popoulu

| Treatments | Appearance | Colour | Flavour | Texture | Taste | Over all acceptability |
|---|---|---|---|---|---|---|
| $T_1$ | 7.5 (63.70) | 7.3 (62.20) | 7.6 (57.75) | 7.4 (61.70) | 7.7 (109.80) | 7.7 (132.40) |
| $T_2$ | 8.0 (68.50) | 8.0 (75.40) | 8.1 (66.60) | 7.9 (74.60) | 8.1 (138.60) | 7.9 (136.70) |
| $T_3$ | 8.3 (86.25) | 8.1 (83.80) | 8.4 (81.90) | 8.2 (81.30) | 8.5 (174.60) | 8.2 (167.70) |
| $T_4$ | 7.8 (66.80) | 7.5 (66.60) | 7.8 (64.70) | 7.7 (70.00) | 7.8 (124.50) | 7.6 (126.70) |
| $T_5$ | 7.9 (71.70) | 7.8 (75.00) | 8.0 (74.70) | 7.8 (72.10) | 8.0 (131.70) | 8.0 (147.10) |
| $T_6$ | 8.4 (86.10) | 8.1 (85.65) | 8.5 (83.55) | 8.2 (83.65) | 8.6 (184.50) | 8.3 (176.50) |
| $T_7$ | 7.6 (65.10) | 7.4 (66.30) | 7.7 (62.75) | 7.5 (65.75) | 7.7 (124.20) | 7.4 (118.50) |
| $T_8$ | 8.0 (68.50) | 8.0 (79.40) | 8.3 (79.95) | 8.0 (77.10) | 8.3 (164.40) | 8.1 (155.90) |
| $T_9$ | 8.6 (95.50) | 8.4 (92.30) | 8.6 (88.55) | 8.5 (92.70) | 8.7 (194.40) | 8.6 (199.30) |
| $T_{10}$ | 7.5 (63.70) | 7.2 (59.95) | 7.5 (59.55) | 7.3 (59.95) | 7.6 (111.90) | 7.4 (110.20) |
| $T_{11}$ | 7.5 (63.70) | 7.0 (53.60) | 7.6 (64.55) | 7.2 (59.80) | 7.6 (108.30) | 7.2 (117.90) |
| $T_{12}$ | 8.5 (93.00) | 8.2 (85.85) | 8.5 (86.60) | 8.4 (90.60) | 8.6 (194.30) | 8.4 (185.70) |
| $T_{13}$ | 7.1 (46.45) | 6.6 (47.25) | 7.2 (57.85) | 6.9 (48.00) | 7.3 (101.00) | 6.8 (71.10) |
| $T_{14}$ | 7.2 (47.60) | 6.8 (53.70) | 7.4 (58.00) | 7.0 (49.75) | 7.4 (101.70) | 7.0 (90.80) |
| K W value | 19.70 | 16.87 | 12.26 | 16.65 | 54.29 | 56.48 |
| | NS | NS | NS | NS | | |
| $\chi^2$ - 22.36 (13, 0.05), CD – 61.48 | | | | | | |

*The value in the parenthesis is the mean rank

Table 15. Effect of different N K levels and its time of application on shelf life of fruits of banana cv. Popoulu at ambient conditions

| Treatments | Shelf life (days) |
|---|---|
| $T_1$ | 5.70 |
| $T_2$ | 6.30 |
| $T_3$ | 7.50 |
| $T_4$ | 5.80 |
| $T_5$ | 6.60 |
| $T_6$ | 6.80 |
| $T_7$ | 6.00 |
| $T_8$ | 7.10 |
| $T_9$ | 7.90 |
| $T_{10}$ | 6.10 |
| $T_{11}$ | 6.80 |
| $T_{12}$ | 7.60 |
| $T_{13}$ | 5.20 |
| $T_{14}$ | 5.50 |
| SEm(±) | - |
| CD (0.05) | NS |

4.6 SOIL ANALYSIS BEFORE AND AFTER THE EXPERIMENT

The data on soil available N, P, and K after the experiment are presented in table 16. The results of soil available N, P and K varied significantly.

The soil available nitrogen content after the experiment resulted highest for the treatment $T_9$ (249 kg $ha^{-1}$) but was at par with $T_{12}$ (239.26 kg $ha^{-1}$) and varied significantly from other treatments. The treatment $T_{13}$ (126.40 kg $ha^{-1}$) recorded the least soil available nitrogen which was at par with $T_4$ (136.49 kg $ha^{-1}$).

The highest soil available phosphorus content was obtained in treatment $T_9$ (58.33 kg $ha^{-1}$) which was at par with $T_6$ (57.96 kg $ha^{-1}$), $T_2$ (56.83 kg $ha^{-1}$) and $T_{12}$ (55.44 kg $ha^{-1}$). The treatment $T_{13}$ (18.74 kg $ha^{-1}$) observed the least soil available phosphorus

The application of major plant nutrients resulted in highest soil available potassium in $T_9$ (1011.03 kg $ha^{-1}$) but was at par with $T_{12}$ (1007.30 kg $ha^{-1}$). The least soil available potassium content was obtained in $T_{13}$ (378.66 kg $ha^{-1}$).

4.7 PLANT ANALYSIS

**4.7.1 Nutrient content (N, P, K) in the index leaf at 4 month after planting (MAP)**

The data on estimation of plant analysis is presented on table 17. The nutrient content in the index leaf at 4 MAP showed significant difference among the treatments.

The leaf analysis revealed the highest nitrogen content in $T_9$ (3.18 %) which was at par with $T_{12}$ (2.82 %), $T_6$ (2.77 %) and $T_3$ (2.64 %). The lowest nitrogen content in index leaf was observed in absolute control $T_{13}$ (1.57 %) and was at par with $T_1$ (2.14 %) and $T_5$ (2.15 %) and significantly differed from other treatments.

The data on leaf phosphorus content influenced by the combination of major plant nutrients noticed the highest for $T_9$ (0.39 %) but was at par with $T_6$ (0.35 %)

Table 16. Effect of different N K levels and its time of application on available NPK of soil after the experiment

| Treatments | Nitrogen (kg $ha^{-1}$) | Phosphorous (kg $ha^{-1}$) | Potassium (kg $ha^{-1}$) |
|---|---|---|---|
| $T_1$ | 162.34 | 34.62 | 651.03 |
| $T_2$ | 176.40 | 56.83 | 738.23 |
| $T_3$ | 214.56 | 51.46 | 875.00 |
| $T_4$ | 136.49 | 34.92 | 465.90 |
| $T_5$ | 188.30 | 44.48 | 784.66 |
| $T_6$ | 227.06 | 57.96 | 942.10 |
| $T_7$ | 200.00 | 32.78 | 593.80 |
| $T_8$ | 224.36 | 43.22 | 817.10 |
| $T_9$ | 249.00 | 58.33 | 1011.03 |
| $T_{10}$ | 150.50 | 40.53 | 537.66 |
| $T_{11}$ | 212.23 | 48.01 | 917.63 |
| $T_{12}$ | 239.26 | 55.44 | 1007.30 |
| $T_{13}$ | 126.40 | 18.74 | 378.66 |
| $T_{14}$ | 165.10 | 28.22 | 662.03 |
| SEm(±) | 0.94 | 2.49 | 2.01 |
| CD (0.05) | 11.949 | 5.124 | 4.140 |

Table 17. Effect of different N K levels and its time of application on nutrient content (NPK) in index leaf at 4 month after planting in banana cv. Popoulu

| Treatments | N (%) | P (%) | K (%) |
|---|---|---|---|
| $T_1$ | 2.14 | 0.27 | 1.09 |
| $T_2$ | 2.24 | 0.31 | 1.15 |
| $T_3$ | 2.64 | 0.32 | 1.35 |
| $T_4$ | 2.41 | 0.30 | 1.23 |
| $T_5$ | 2.15 | 0.26 | 1.23 |
| $T_6$ | 2.77 | 0.35 | 1.35 |
| $T_7$ | 2.29 | 0.29 | 1.24 |
| $T_8$ | 2.52 | 0.32 | 1.30 |
| $T_9$ | 3.18 | 0.39 | 1.35 |
| $T_{10}$ | 2.56 | 0.31 | 1.22 |
| $T_{11}$ | 2.31 | 0.26 | 1.26 |
| $T_{12}$ | 2.82 | 0.34 | 1.33 |
| $T_{13}$ | 1.57 | 0.15 | 0.78 |
| $T_{14}$ | 2.26 | 0.22 | 0.85 |
| SEm(±) | 0.30 | 0.03 | 0.05 |
| CD (0.05) | 0.619 | 0.062 | 0.102 |

and $T_{12}$ (0.34 %). The absolute control $T_{13}$ (0.15 %) recorded the least phosphorus content in the index leaf.

The treatment $T_9$ (1.35 %) recorded the highest potassium content in the index leaf at 4 MAP and was on par with $T_3$ (1.35 %), $T_6$ (1.35 %), $T_{12}$ (1.33 %), $T_8$ (1.30 %) and $T_{11}$ (1.26 %). The least leaf potassium content was observed in $T_{13}$ (0.78 %).

**4.7.2 N, P, K uptake at harvest**

The data on N P K uptake at harvest is illustrated in table 18. The combination of major plant nutrients had positively influenced the N, P, K uptake at harvest and had significant difference over other treatments.

The highest nitrogen uptake at harvest was recorded in treatment $T_9$ (498.44 kg $ha^{-1}$) but was at par with $T_{12}$ (487.76 kg $ha^{-1}$). The lowest value of nitrogen uptake was obtained from $T_{13}$ (215.26 kg $ha^{-1}$) and was on par with $T_2$ (232.10 kg $ha^{-1}$), $T_1$ (241.39 kg $ha^{-1}$) and $T_5$ (249.54 kg $ha^{-1}$).

The treatment $T_9$ (52.14 kg $ha^{-1}$) resulted in highest phosphorus uptake at harvest and was at par with $T_{12}$ (47.30 kg $ha^{-1}$) and $T_6$ (45.23 kg $ha^{-1}$). The lowest uptake was obtained for $T_{13}$ (26.41 kg $ha^{-1}$) which was on par with $T_2$ (30.56 kg $ha^{-1}$), $T_1$ (32.11 kg $ha^{-1}$), $T_{14}$ (33.66 kg $ha^{-1}$) and $T_7$ (34.43 kg $ha^{-1}$).

The potassium uptake after the harvest was highest for $T_9$ (1136 kg $ha^{-1}$) but was at par with $T_{12}$ (1121.13 kg $ha^{-1}$). The absolute control $T_{13}$ (776.31 kg $ha^{-1}$) showed the lowest uptake and was at par with $T_1$ (812.32 kg $ha^{-1}$).

4.8 PEST AND DISEASE

The major disease noticed was sigatoka leaf spot and its incidence was less than 5 %. The banana pseudostem weevil attack was noticed in three plants. The control measures were taken and the pest and disease were controlled.

Table 18. Effect of different N K levels and its time of application on N P K uptake at harvest in banana cv. Popoulu

| Treatments | N (kg ha$^{-1}$) | P (kg ha$^{-1}$) | K (kg ha$^{-1}$) |
|---|---|---|---|
| $T_1$ | 241.39 | 32.11 | 812.32 |
| $T_2$ | 232.10 | 30.56 | 853.20 |
| $T_3$ | 412.52 | 43.22 | 987.76 |
| $T_4$ | 338.22 | 37.56 | 912.43 |
| $T_5$ | 249.54 | 36.22 | 846.34 |
| $T_6$ | 444.34 | 45.23 | 1043.23 |
| $T_7$ | 287.44 | 34.43 | 864.54 |
| $T_8$ | 356.12 | 39.54 | 945.87 |
| $T_9$ | 498.44 | 52.14 | 1136.00 |
| $T_{10}$ | 387.56 | 41.87 | 965.45 |
| $T_{11}$ | 304.43 | 34.71 | 887.00 |
| $T_{12}$ | 487.76 | 47.3 | 1121.13 |
| $T_{13}$ | 215.26 | 26.41 | 776.31 |
| $T_{14}$ | 263.21 | 33.66 | 832.12 |
| SEm(±) | 19.97 | 3.95 | 21.39 |
| CD (0.05) | 41.066 | 8.124 | 43.986 |

4.9 ECONOMIC ANALYSIS

The results of data on net income and B: C ratio are presented in table 19.

**4.9.1 Net income**

The application of major plant nutrients in split application has shown a favourable influence on net income. The highest net income was obtained from $T_9$ (2, 97,331.10 ₹ $ha^{-1}$). This was followed by $T_{12}$ (2, 71,409.60 ₹ $ha^{-1}$) which was also significantly different from other treatments. The least net income was noted for the treatment $T_{13}$ (1930.71 ₹ $ha^{-1}$).

**4.9.2 B: C ratio**

The B: C ratio was the highest for $T_9$ (2.05) treatment which was at par with $T_{12}$ (1.95). This was followed by $T_6$ (1.87).The lowest B: C ratio was recorded for the absolute control $T_{13}$ (1.01) which differed significantly from other treatments.

Table 19. Effect of different N K levels and its time of application on net income and B: C ratio of banana cv. Popoulu

| Treatments | Net income (₹ $ha^{-1}$) | B:C ratio |
|---|---|---|
| $T_1$ | 1,13,888.10 | 1.33 |
| $T_2$ | 1,36,500.00 | 1.52 |
| $T_3$ | 2,33,604.40 | 1.81 |
| $T_4$ | 1,27,603.50 | 1.46 |
| $T_5$ | 1,71,232.40 | 1.56 |
| $T_6$ | 2,28,901.00 | 1.87 |
| $T_7$ | 1,88,020.90 | 1.64 |
| $T_8$ | 1,98,900.80 | 1.68 |
| $T_9$ | 2,97,331.10 | 2.05 |
| $T_{10}$ | 1,68,752.00 | 1.60 |
| $T_{11}$ | 1,97,760.70 | 1.74 |
| $T_{12}$ | 2,71,409.60 | 1.95 |
| $T_{13}$ | 1930.71 | 1.01 |
| $T_{14}$ | 61,943.54 | 1.22 |
| SEm(±) | 2,859.17 | 0.08 |
| CD (0.05) | 5,878.457 | 0.175 |

# Discussion

## 5. DISCUSSION

Plant of virtues, 'Kalpatharu' is another synonym for banana which has great socio-economic significance in India. Among the different banana cultivars "Popoulu" is an exotic cultivar belonging to Maia/ Maoli Popoulu group with AAB genome. Being a dessert and cooking banana it has a great similarity to cv. Nendran. Balanced nutrition is required for banana since it's a heavy surface feeder. Different research experiments has shown that the nutrients should be provided at the critical growth stages in order to enhance the yield and quality characters of fruit. In the present experiment, the major plant nutrients were applied in split doses in order to standardize the nutrient requirement of Popoulu banana. The results of this experiment on growth, yield, quality, soil, plant analysis and economic status are analyzed and discussed below.

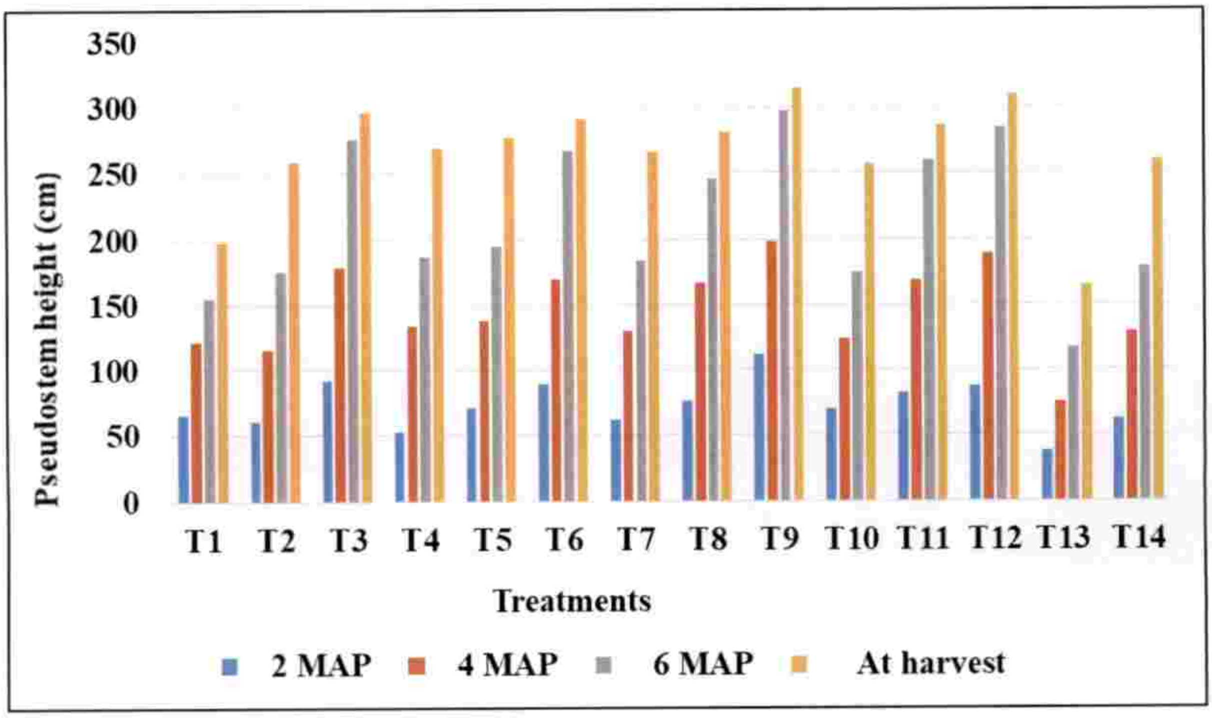
### 5.1 BIOMETRIC CHARACTERS

#### 5.1.1 Height and girth of pseudostem

In the present investigation, the height and girth of pseudostem were significantly different at all the stages of growth (Fig 1). The major plant nutrients applied at the rate of N – 350 g plant$^{-1}$, P-115 g plant$^{-1}$, K – 525 g plant$^{-1}$ and higher dosage of N – 400 g plant$^{-1}$, P – 115 g plant$^{-1}$, K – 600 g plant$^{-1}$ along with organic manure (FYM 15 kg plant$^{-1}$) in six equal splits recorded the highest height. The thickest girth was noticed with the application of major plant nutrients at the rate of N – 350 g plant$^{-1}$, P-115 g plant$^{-1}$, K – 525 g plant$^{-1}$ along with organic manure (FYM 15 kg plant$^{-1}$) in six equal splits.

Nitrogen has influenced positively and favoured the growth of biometric parameters in the banana cv. Robusta (Srinivas, 1997) and (Chandrakumar *et al.*, 2001). Navneethakrishnan (2010) observed an increase in plant height and girth with N at the rate 200 g plant$^{-1}$ and $P_2O_5$ 60g plant$^{-1}$ in 5 equal split doses in the cv. Grand Naine. The increased plant height and girth was noted with the higher dosages of nitrogen and potassium fertilizers. Nitrogen plays an important role in

Fig. 2. Effect of different N K levels and its time of application on pseudostem height of banana cv. Popoulu



the synthesis of chlorophyll, amino acids and proteins which in turn increases the translocation of metabolites to the growing points (Mahatao *et al*., 2014).

The uptake of nutrients, especially nitrogen increased the height and girth which might be due to the formation of complex substances which helps in the tissue generation (Nalina, 2002). The result of the present experiment are in conformity with the findings of Indira (2003), who noted a significant increase in the height and girth of pseudostem of Njanlipoovan with the application of higher doses of N P and K (N at 300 g plant$^{-1}$, P 200 g plant$^{-1}$ and K 600 g plant$^{-1}$). It is also suggested that the cambial and the meristematic processes of the apex region are governed by potassium and hence plays significant role in the increase in height and girth of pseudostem. A similar report was put forward by Salem and Khoreiby (1991) and Ram *et al*. (1998).

The increase in pseudostem girth supports heavy bearing and provides better anchorage to the crop (Mahalakshmi, 2000). The application of nitrogen and potassium fertilizers at optimum levels enhanced the tissue formation which increased the circumference of pseudostem (Babu and Sharma, 2005).

### 5.1.2 Number of functional leaves, total functional leaf area and leaf area index

Present study revealed that application of NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits during the early stages of growth (2 MAP) increased the total number of leaves, total functional leaf area and leaf area index. However, the reduced dosage of major plant nutrients N – 350 g plant$^{-1}$, P-115 g plant$^{-1}$, K – 525 g plant$^{-1}$ along with organic manure (FYM 15 kg plant$^{-1}$) in six equal splits produced the highest number of functional leaves, total functional leaf area and leaf area index in banana cv. Popoulu in the later stages of growth.

The higher accumulation of nitrogen in the leaves builds up the phosphorus content and hastens the protein synthesis, meristematic growth and increases leaf area index (Parida *et al*., 1994). The optimum number of functional leaves should be produced in a banana crop in order to utilize the solar energy for biomass production (Sathyanarayanan, 1985).

Thippesha (2004) reported that the application of major nutrients at higher dosages (360:250:500 g $plant^{-1}$ NPK) registered maximum number of functional leaves, leaf area and leaf area index. Nitrogen and potassium when supplied in lower dosages, shortened the life span of leaves whereas, at higher dosages accelerated the leaf growth which in turn favoured the increase in leaf area and leaf area index. These results were supported by Asphara (1997), Kumar and Nalina (2001).

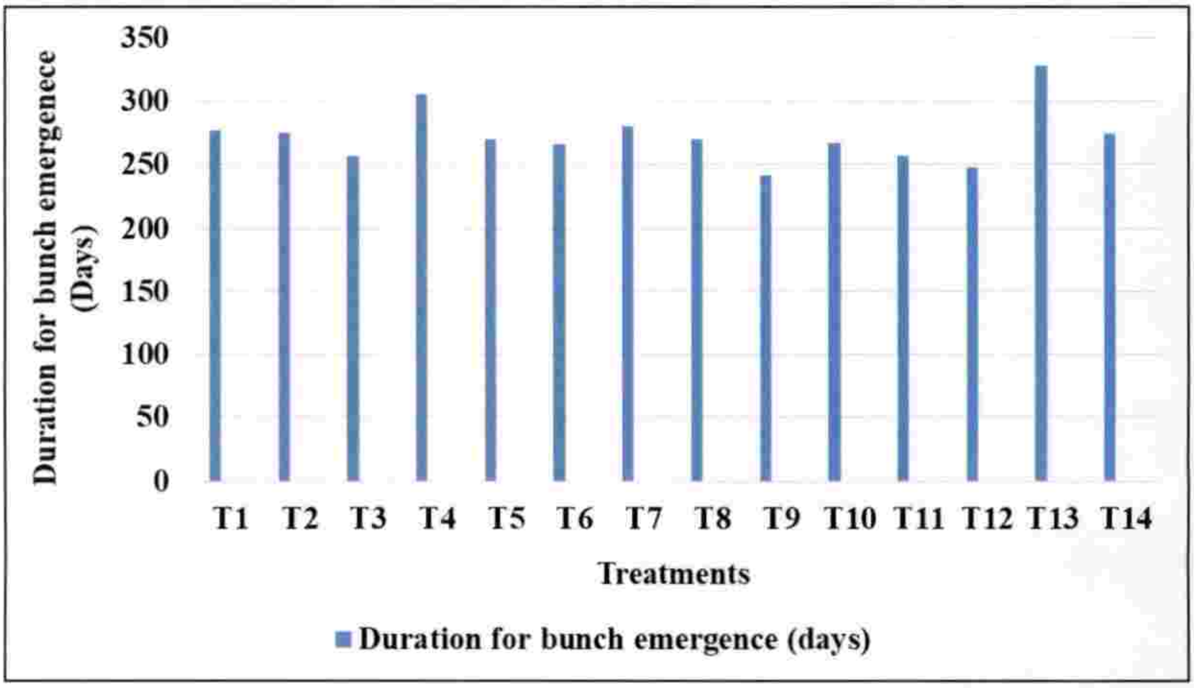
In a similar experiment, Nalina (2002) recorded highest leaf number, leaf area and leaf area index with 165:52.5:495 g NPK $plant^{-1}$ in 4 equal splits, which favoured the growth of plant positively. The results of the present experiment is in conformity with Indira (2003) who noticed improvement in number of leaves with the application of nitrogen along with higher levels of potassium.

### 5.1.3 Duration for bunch emergence, crop duration and sucker production after bunch emergence

The present experiment recorded the shortest duration for bunch emergence and crop life cycle for the treatment N–350 g $plant^{-1}$, P-115 g $plant^{-1}$, K–525 g $plant^{-1}$ along with organic manure FYM 15 kg $plant^{-1}$ in six equal splits but was at par with the higher dosage (NPK at the rate of 400:115:600 g $plant^{-1}$ $year^{-1}$ in 6 equal splits). The highest sucker production after the bunch emergence was noted with the dosage N–350 g $plant^{-1}$, P-115 g $plant^{-1}$, K–525 g $plant^{-1}$ along with organic manure (FYM) 15 kg $plant^{-1}$ in six equal splits but was at par with higher dose of major plant nutrients (NPK at the rate of 400:115:600 g $plant^{-1}$ $year^{-1}$ in 6 equal splits) and also with the lower dosage NPK @ of 250:115:375 g $plant^{-1}$ $year^{-1}$ in 6 equal splits. .

Singh *et al.* (1990) reported that the early initiation of inflorescence and shorter crop life cycle with the application of ideal dosage of fertilizers in banana.

Fig. 3. Effect of different N K levels and its time of application on crop duration of banana cv. Popoulu



Similar results were obtained from the present experiment also. The higher dosages of nitrogen resulted in higher number of leaves with more leaf area and thus increased the concentrations of net assimilates which enhances the early initiation of inflorescence (Parida *et al.*, 1994). When the major plant nutrients were provided in split doses at the major growth stages, it reduced the number of days to bunch emergence, crop duration and enhanced robust growth of crop (Thangaselvabhai *et al.*, 2009).

Hasan *et al.* (2001) noted that, the time period for bunch emergence was reduced by 31 days with the application of nitrogen at lower levels (100 g plant$^{-1}$) and potassium at higher levels (400 g plant$^{-1}$). Potassium enhances the respiration process, photosynthesis activity, favours the early emergence of inflorescence and hence known as metabolic accelerator (Nalina, 2002).

The major plant nutrients applied at the rate of nitrogen 240 g plant$^{-1}$ and $K_2O$ 330 g plant$^{-1}$ in banana increased the sucker production tremendously (Baruah and Mohan, 1985). The increasing number of sucker production in banana crop was accounted for the enhanced production of photo-assimilates (Hasan *et al.*, 2001). Mahato (2011) reported the maximum sucker production with the application of potassium (400 g plant$^{-1}$) along with nitrogen which was in accordance with results obtained from the present study.

## 5.2 YIELD AND YIELD ATTRIBUTES

### 5.2.1 Weight of bunch, Weight of finger and Yield ha$^{-1}$

The current study revealed the application of NPK at the rate of 350:115:525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 Kg FYM resulted in highest weight of finger and yield which was at par with a higher dosage (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits). The heaviest bunch was obtained from the treatment NPK at the rate of 350:115:525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 Kg FYM. Probable reason may be the role of potassium in the process of sugar translocation and its build up in the crop which in turn increases the fruit weight as observed by Mahato *et al.* (2014).

Martin (1973) suggested that the application of potassium fertilizers in lower dosages will restrict the process of transportation of carbohydrates from source to sink and further their transformation into starch. The nitrogen dose ranging from 100-300 g plant$^{-1}$ increased the finger weight and added to the final bunch weight (Nalina, 2002). Nitrogen and potassium plays an important role in doubling the yield ha$^{-1}$ in banana (Ganeshmurthy *et al.*, 2011).

The highest yield ha$^{-1}$ was noticed in the treatments with higher dosages of major plant nutrients in 6 split application. This findings were in agreement with the results of Raju (1996) and Nalina (2002). Khandare *et al.* (1999) recorded the highest yield with the increase in application of major plant nutrients. The heaviest bunch obtained could be associated to the increase in number of fingers per hand, weight of single fruit and number of hands per bunch (Geetha and Kannappan, 2002). The increase in availability of major plant nutrients and uptake by plants reflected positively on the yield and its character (Indira, 2003). Milik *et al.* (2018) attributed the highest weight of bunch to the higher levels of potassium which on the other hand improved the uptake of nitrogen and protein synthesis.

### 5.2.2 Number of hands bunch$^{-1}$, number of fingers bunch$^{-1}$ and number of fingers in D hand

In the present investigation, the highest number of hands per bunch and number of fingers in D hand were observed with the application of NPK at the rate of 350:115:525 g plant$^{-1}$ year$^{-1}$ along with organic manure FYM 15 kg plant$^{-1}$ in six equal splits dosages but was at par with a higher dosage of major plant nutrients (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits). The highest number of fingers were obtained from the treatment NPK 350:115:525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 Kg FYM. The result of the present study is in conformity with the findings of Patel *et al.* (1999) and Suma *et al.* (2007)

Fig. 4. Effect of different N K levels and its time of application on weight of bunch of banana cv. Popoulu

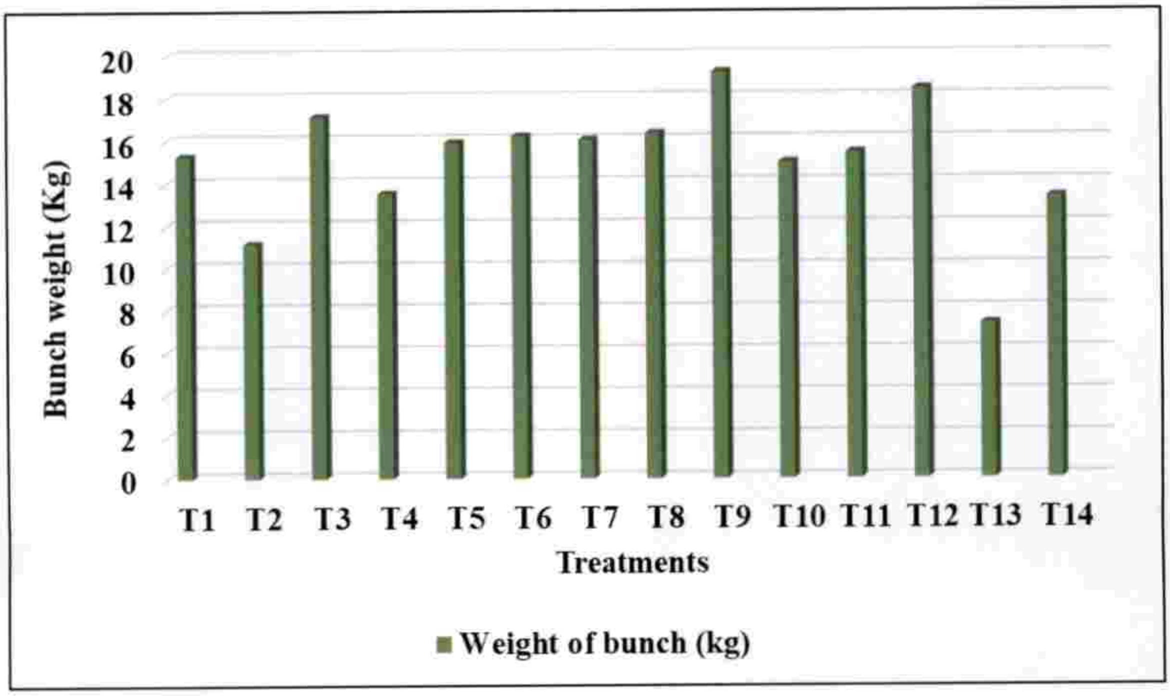
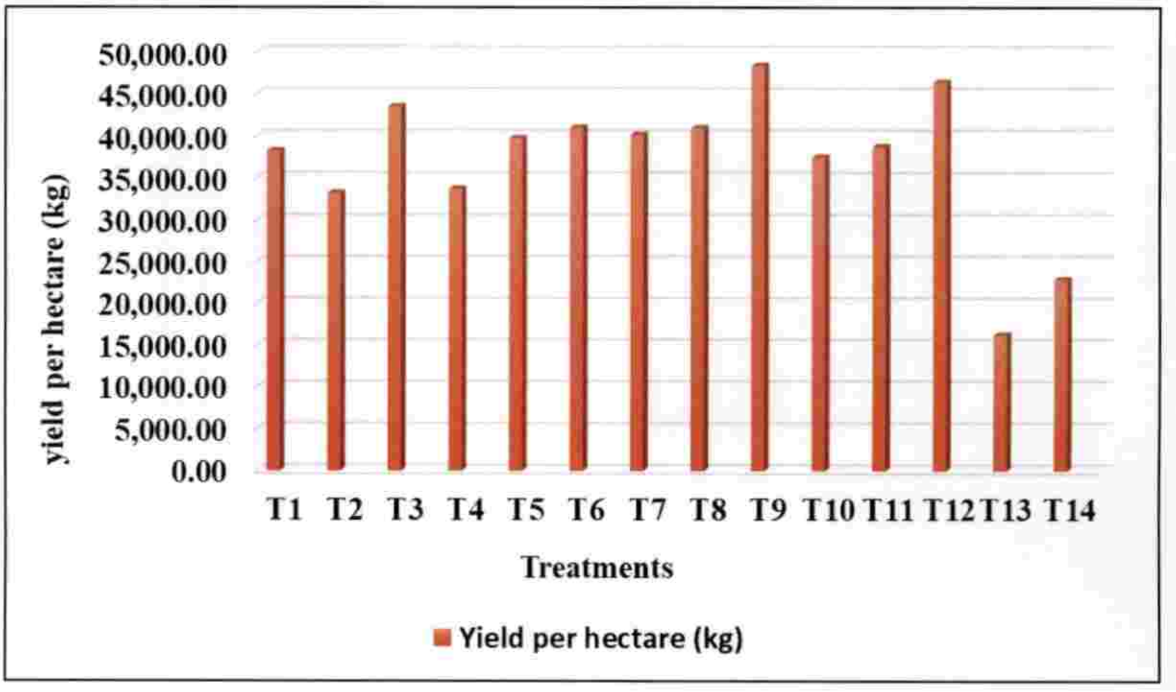


Fig. 5. Effect of different N K levels and its time of application on yield per hectare of banana cv. Popoulu



who noticed that the banana cv. Nendran recorded highest number of fingers and hands per bunch with 200:40:200 g NPK plant$^{-1}$.

The major plant nutrients supplied in the optimum doses in equal splits at the flowering stage could be the reason for increase in number of hands and fingers in banana (Tirkey *et al.*, 1998). Martin (1973) reported the lower number of fingers and hands per bunch with lower amount of inorganic fertilizers. This could be due to the inadequate supply of potassium which may hinder the carbohydrate transport from source to sink and there by restricting the formation of sugar. The findings of Naresh and Sharma (2004) is in conformity with the findings of present study, were they noticed that an increase in number of fingers in D hand and number of hands per bunch with the application of nitrogen (60-240 g plant$^{-1}$) in Jahajee banana.

**5.2.3 Length and girth of finger, pulp peel ratio and days taken for ripening**

In the present study, the length and girth of finger increased with the application of 350 g N plant$^{-1}$, 115 g P plant$^{-1}$, 525 g K plant$^{-1}$ in six equal split doses along with organic manure 15 Kg FYM plant$^{-1}$ and was at par with higher dosage (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits).

Ancy *et al.* (1998) observed a direct proportionality between the urease activity and increase in length of banana fruit. The gradual increase in nitrogen application stimulated the process of cell expansion and advanced the pulp growth resulting in increased length and girth of fruits (Al-Harthi and Al-Yahyai, 2009). Nandan *et al.* (2011) clearly expressed the role of potassium in stimulating various enzymes and also in cell enlargement.

In the present experiment the pulp peel ratio was highest with the application of 350 g N plant$^{-1}$, 115 g P plant$^{-1}$, 525 g K plant$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ but was at par with higher dose of major plant nutrients (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) and also with the lower dosage NPK @ of 250:115:375 g plant$^{-1}$ year$^{-1}$ in 6 equal splits.

This can be best explained by the capacity of potassium in pulp restoration and also due to less physiological weight loss in banana fruit (Kumar *et al.*, 2008). The result of the current experiment is in accordance with Mahato (2014) who observed that the highest pulp peel ratio was recorded with [N 250 g plant$^{-1}$, $P_2O_5$ 80 g plant$^{-1}$ and $K_2O$ 400 g plant$^{-1}$ in cv. Nendran. A similar result was also noticed by Millik *et al.* (2018).

The present study revealed that the application of different levels of N and K had no significant effect on the days taken to ripening of banana fruit. Kumar (2016) also reported similar results in banana.

## 5.3 QUALITY PARAMETERS

In the current investigation, the fruit analysis of banana cv. Popoulu revealed the highest total sugar, non-reducing sugar, ascorbic acid, starch content, carotenoid content, sugar acid ratio and least titrable acidity for the treatment (NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with FYM 15 kg plant$^{-1}$). TSS, reducing sugar and peel thickness were more pronounced in the treatment with lower dose of major plant nutrients (NPK 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$).

The increased levels of quality parameters were observed with the utilization of potassium, which contributes a major part in the carbohydrate formation, transportation of starch and in counteracting the effects of organic acids (Nalina, 2002). Tirkey *et al.* (2003) noticed that TSS, reducing sugar, total sugar and sugar acid ratio accelerated with the utilization of nitrogen at the rate of 300 g plant$^{-1}$ in 5 split doses. The higher intake of nitrogen and potassium by cv. Rasthali, contributed to the rise in total sugars (Kumar and Pandey, 2008).

The potassium content at higher levels counteracts the effects of organic acids which reduces the acidity of the fruit in banana (Tisdale and Nelson, 1966). The addition of potassium fertilizers enhanced the TSS and starch content of banana (Bhargava *et al.*, 1993). Patel (1996) reported that the combination of N 300 g plant$^{-1}$ and K 400 g plant$^{-1}$ resulted in the highest reducing sugar content in banana which was in conformity with the results of present study. Rumee and Baruah (2006) noted the increase in sugar acid ratio with the higher levels of potassium as the total sugar content rises and reduces the acidity levels. The application of potassium fertilizers lowered the enzyme process which resulted in more buildup of ascorbic acid content (Sandhya, 2016). Millik *et al.* (2018) noticed the lowest peel thickness with control plants, this could be probably due to the non-availability of nutrients.

## 5.4 ORGANOLEPTIC EVALUATION OF FRUIT AND CHIPS FOR SENSORY QUALITIES

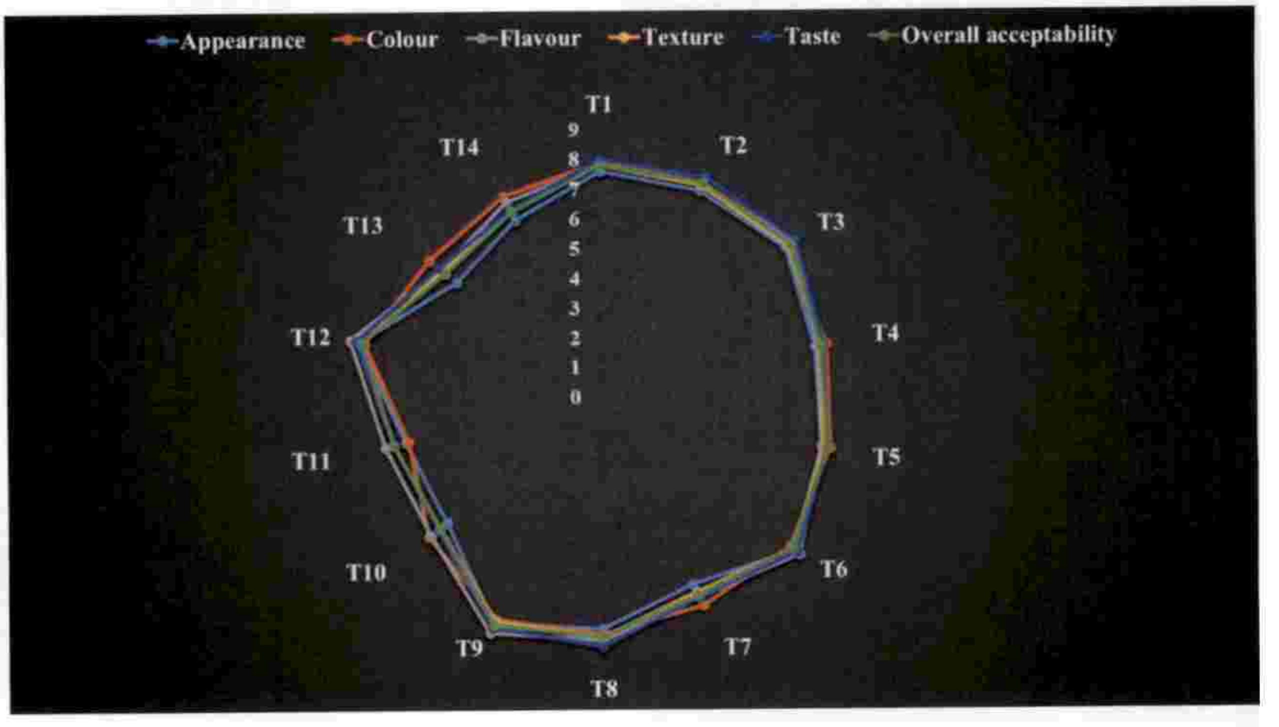
The organoleptic evaluation of fruit and chips recorded the highest scores for taste and overall acceptability with the application of 350 g N, 115 g P and 525 g K plant$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ and a similar observations were recorded for the dosages NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits and NPK @ of 250:115:375 g plant$^{-1}$ year$^{-1}$ in 6 equal splits along with 15 kg FYM plant$^{-1}$ year$^{-1}$. The different fertilizer doses had no significant effect on the characters *viz.,* appearance, color, flavour and texture of fruit and chips in banana cv. Popoulu.

The addition of potassium sources balanced the sugar acidity levels which contributed towards the highest scores for taste in fruits (Patil and Patil, 2017). The current findings are in harmony with the results of Mayadevi *et al.* (2017) who noticed that the scores for overall acceptability was maximum for Nendran banana with NPK at the rate 300:115:450 g plant$^{-1}$.

## 5.5 SHELF LIFE OF FRUITS AT AMBIENT CONDITIONS

Application of different levels of N and K had no significant effect on the shelf life of fruits at ambient conditions. The conclusion of the present study was paradoxical to the results of Mahato (2011).

Fig. 6. Effect of different N K levels and its time of application on organoleptic evaluation of fruit of banana cv. Popoulu



5.6 SOIL ANALYSIS

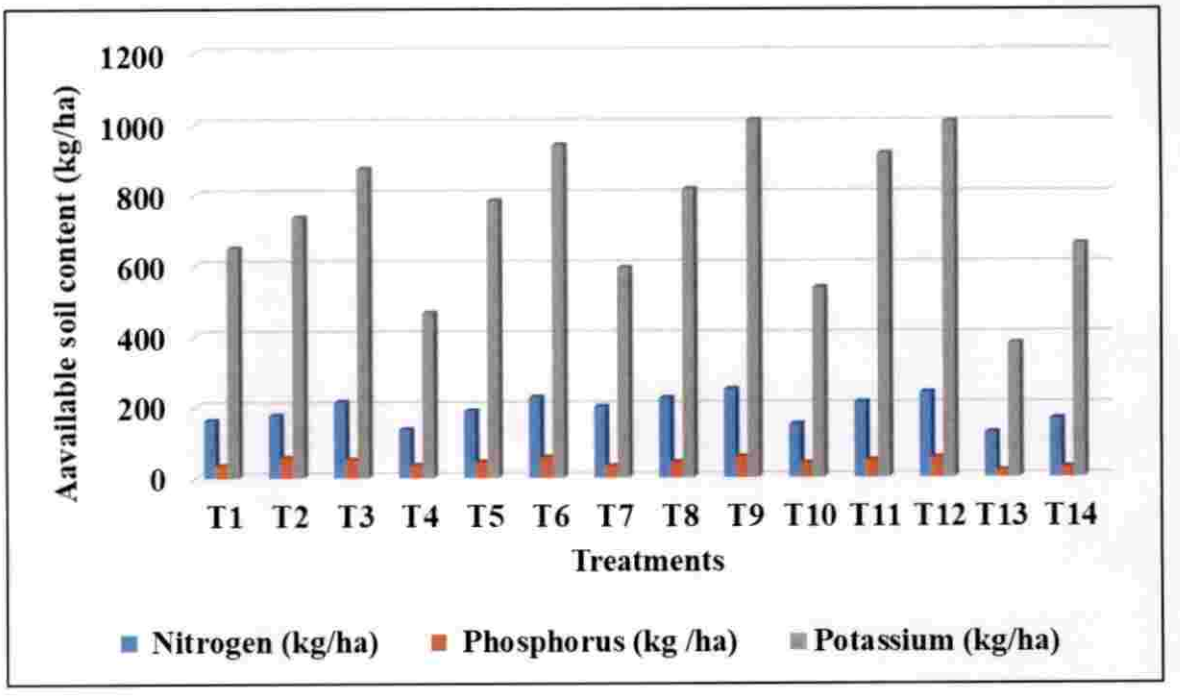
In the present investigation, the available N P K content in the soil boosted up with the application of 350 g N plant$^{-1}$, 115 g P plant$^{-1}$, 525 g K plant$^{-1}$ along with organic manure FYM 15 kg plant$^{-1}$, in six equal splits dosages and was at par for a higher dose of major plant nutrients (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits). The soil analysis resulted in similar results for available phosphorus content at lower dosages (NPK 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$ and NPK 250: 115:375 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$). The results are in agreement with the findings of Mahato *et al*. (2016) who noticed an increase in the available NPK content with the application of NPK 250:80:400 g plant$^{-1}$ respectively.

The available nitrogen content in the soil was highest when supplied with higher dosages of fertilizers along with organic manure which can attributed to lower percolation, volatilization and leaching (Nalina, 2002). The nitrogen fertilizers applied in higher dosages along with potassium contributed to the increase in soil available nitrogen content. Moreover potassium plays major role in the production of organic substance required for the nitrogen absorption (Suresh and Hasan, 2002). The findings of Thipesha (2004) is in accordance to the current investigation, where the available NPK content increased with the usage of NPK 350:250:500 g respectively.

5.7 PLANT ANALYSIS

In the current study the application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ increased the nutrient content of index leaf at 4 MAP and similar results were obtained with a higher dosage (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) and lower dosages of major plant nutrients (NPK 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$ and NPK 250: 115:375 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$). The highest NPK

Fig. 7. Effect of different N K levels and its time of application on available NPK content of soil after the experiment of banana cv. Popoulu



uptake at harvest was obtained with NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ which was on par with the high dosage of major plant nutrients (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits). Ziauddin (2009) reported a similar result with the application of 100 percent recommended dose of fertilizer along with organic slurry.

The increased application of nitrogen doses enhanced the maximum uptake of nitrogen by the plant (Babu and Sharma, 2005). Nalina (2002) recorded lowest nitrogen, phosphorus and potassium content at the harvest stage, probably due to the transfer of metabolites from source to sink (fruit). The highest storage of potassium content was in the psuedostem due to the luxurious absorption of potassium. The phosphorus uptake boosted up with increased application of nitrogen fertilizers and was maximum up to bunch emergence (Thangaselvabai *et al.*, 2007).

The nitrogen and phosphorus that required for vegetative development was maximum at the juvenile and shooting stage while highest potassium content was recorded at harvest due to the transfer of assimilates to the sink for the flowering and fruit development (Tywford and Walmsley, 1973). Nitrogen played a significant role in enhancing the uptake of potassium which may be due to the harmonious effect of nitrogen on potassium (Hazarikka and Mohan, 1992). Suresh and Hasan, (2002) recorded the higher levels of NPK content in the vegetative stage of the index leaf in banana.

5.8 ECONOMIC ANALYSIS

Present study revealed that the highest net income and B: C ratio was recorded for the treatment NPK at the rate of 350:150: 525 g plant$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$. A similar increase in net income was obtained in the treatment with higher dosage of major plant nutrients (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits).

A similar result was recorded by Indira and Nair (2008) who noticed that the major plant nutrients when supplied in higher dosages with split applications at the critical growth stages resulted in heavier bunches which contributed to the high BCR (1.96) and net income. Similar results were also reported by Patel (1996), Nalina (2002) and Patil and Patil (2017).

# *Summary*

# 6. SUMMARY

The research work titled "Nutrient standardization in banana (*Musa* AAB Popoulu)" was conducted to standardize the nutrient requirement of banana cv. Popoulu and to assess the effect of major plant nutrients on growth, yield and quality of banana cv. Popoulu under Kerala conditions. The research was conducted in the Instructional Farm, College of Agriculture, Vellayani from 2018 March to 2019 April. Tissue cultured plantlets of banana cv. Popoulu were used for the study. The prominent findings of the experiment are summarized as follows.

The study revealed that application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ and N – 400 g plant$^{-1}$, P – 115 g plant$^{-1}$, K – 600 g plant$^{-1}$ along with organic manure (FYM 15 kg plant$^{-1}$) in six equal splits resulted in highest pseudostem height at all the stages of growth.

In the present study, it was also observed that the application of major plant nutrients had shown a prominent increase in girth of pseudostem at all the stages of growth. Combined application of 350 g N 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ resulted in highest girth of pseudostem in 2 MAP, 4 MAP, 6 MAP and at the time of harvest.

In general, application of major plant nutrients had shown a positive response with respect to the number of functional leaves, leaf area and leaf area index. Highest number of functional leaves, leaf area and leaf area index at 2 MAP were noticed with the application of NPK at the rate of 400: 115: 600 g plant$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$ year$^{-1}$. However, a lower dose of NPK at the rate of 350: 115: 525 g plant $^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ was enough in later stages of growth.

The major plant nutrients NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ and NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits significantly reduced the time period for bunch emergence and crop duration.

The application of NPK at the rate of 350:115:525g N K plant$^{-1}$ year$^{-1}$ in 6 equal splits along with 15 kg FYM plant$^{-1}$ year$^{-1}$, a higher dose (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) and a lower dose (NPK @ of 250:115:375 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) were equally effective in improving emergence of suckers after the bunch production in banana cv. Popoulu.

In the present study the application of 350 g N 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ resulted in heavier bunches.

A remarkable performance was shown by the application of major plant nutrients with respect to bunch characters. The number of hands per bunch, number of fingers per bunch and number of fingers in D hand were the highest when banana cv. Popoulu was applied with NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$. Higher dose of NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits could only produce on par result for number of hands per bunch and number of fingers in D hand.

The finger characters like weight of finger, length of finger and girth of finger along with the pulp peel ratio were enhanced prominently with the application of 350 g N 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$. Application of higher dose (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) failed to improve finger characters further.

The highest yield per hectare was observed with the dosages of 350 g N 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ and higher dose of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits and 15 kg FYM plant$^{-1}$ year$^{-1}$ was ineffective for further enhancement of yield.

The study also revealed that the application of major plant nutrients did not show any significant effect on number of days taken to ripening.

The qualitative analysis of the fruit showed a positive response to the application of major plant nutrients. The quality aspects total sugar, non-reducing sugar, ascorbic acid, carotenoid, starch content and sugar acid ratio were highest and least titrable acidity was recorded by the application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$.

In the present study it was observed that the application of NPK at the rate of 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant $^{-1}$ year$^{-1}$ registered the highest TSS, reducing sugar content and peel thickness.

The organoleptic evaluation of fruit and chips was recorded for the characters like appearance, texture, taste, flavour and over all acceptability. The highest scores for both fruit and chips for the characters taste and overall acceptability were noticed with the application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ and statistically similar observations were recorded with higher dose NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits and lower dose NPK @ of 250:115:375 g plant$^{-1}$ year$^{-1}$ in 6 equal splits along with 15 kg FYM plant$^{-1}$ year$^{-1}$. The major plant nutrients did not show any significant effect on the rest of the characters. The shelf life of the fruit at ambient conditions did not show appreciable variation with the various combinations of major plant nutrients.

The application of 350 g N 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ and NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits resulted in highest soil available NPK after the experiment. The soil analysis also resulted in similar results for available phosphorus content at lower dosages (NPK 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$ and NPK 250: 115:375 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$).

The leaf nutrient NPK content at 4 MAP was enhanced with the application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ in 6 equal splits along with 15 kg FYM and similar results were obtained with a higher dosage (NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits) and lower dosages of major plant nutrients (NPK 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$ and NPK 250: 115:375 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with FYM 15 kg plant$^{-1}$). Moreover, NPK 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal split doses along with 15 kg FYM plant$^{-1}$ and NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits recorded the highest NPK uptake at harvest

The major disease observed was sigatoka leaf spot but its incidence was less than 5 percent. Pseudostem weevil attack was observed in three plants could also be controlled.

The economic analysis recorded appreciable variation with the application of major plant nutrients. The highest net income and B: C ratio was observed when banana cv. Popoulu was applied with NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$.

The application of major plant nutrients NPK at the rate of 300: 115: 450 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ has shown a significant increase in some of the quality characters (TSS, reducing sugar and peel thickness) of banana cv. Popoulu.

As evident from the above observations, NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal spilt doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ can be adjudged as the optimal dose of nutrition since prominent increase was observed in biometric characters, yield, quality, soil and plant nutrient content as well as in economics of cultivation. The higher dosage NPK at the rate of 400:115:600 g plant$^{-1}$ year$^{-1}$ in 6 equal splits along with 15 kg FYM plant$^{-1}$ year$^{-1}$ could not yield further improvement. Hence, application of N P K at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in 6 equal split doses along with 15 kg FYM plant$^{-1}$ were economically viable and it improved the growth, yield and quality of banana cv. Popoulu under Kerala conditions.

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# Abstract

# NUTRIENT STANDARDIZATION IN BANANA
# (*Musa* AAB. POPOULU)

*by*

**SRUTI S. NAIR**

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**Abstract of the thesis**
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## MASTER OF SCIENCE IN HORTICULTURE

**Faculty of Agriculture**

**Kerala Agricultural University**

**DEPARTMENT OF POMOLOGY AND FLORICULTURE**

**COLLEGE OF AGRICULTURE**

**VELLAYANI, THIRUVANANTHAPURAM-695522**

**KERALA, INDIA**

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## ABSTRACT

## NUTRIENT STANDARDIZATION IN BANANA (*Musa* AAB. Popoulu)

The study entitled 'Nutrient standardization in banana (*Musa* AAB. Popoulu)' was carried out in the Department of Pomology and Floriculture, College of Agriculture, Vellayani during March 2018 to April 2019, with an objective to standardize the nutrient requirement of banana cv. Popoulu, to study the effect of major plant nutrients on growth, yield and quality and to work out the economics of cultivation. The cultivar "Popoulu" is an exotic cultivar belonging to Maia/ Maoli Popoulu group of the AAB genome.

The field experiment was conducted at the in Randomized Block Design (RBD) with 14 treatments and 3 replications. The tissue cultured Popoulu plantlets were used for the experimental purpose. The trial was conducted in combinations of NK levels and time of application of fertilizers. The NK levels were fixed based on the N and K recommendation as per Kerala Agricultural University, Package Of Practices for Nendran banana maintaining the N: K ratio as 1: 1.5. Different NK levels tried were $N_1$-250: 375 g NK plant$^{-1}$ year$^{-1}$, $N_2$-300: 450 g NK plant$^{-1}$ year$^{-1}$, $N_3$-350: 525 g NK plant$^{-1}$ year$^{-1}$ and $N_4$-400: 600 g NK plant$^{-1}$ year$^{-1}$. The time of application of fertilizers tried were $S_1$-2 splits (2 and 4 month after planting), $S_2$-4 splits (2, 4, 6 month after planting and after bunch emergence) and $S_3$-6 splits (1, 2, 3, 4, 5 month after planting and after bunch emergence). Organic manure (15 kg FYM plant$^{-1}$) and P (115 g plant$^{-1}$) as per KAU POP were given uniformly to all treatments as basal except $T_{13}$ (absolute control - no fertilizer application) and $T_{14}$ (recommendation of Nendran banana applied as organic). Urea, Rajphos and Muriate of Potash were used as fertilizer sources. Lime 240g per plant, based on soil analysis was applied in pits 10 days prior to planting.

The results indicated that the application of NPK at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in six equal split doses increased the height and girth of pseudostem at 2, 4, 6 month after planting and also at harvest. At 2 month after planting the total number of functional leaves, leaf area and leaf area index (LAI) were higher with

the application of N, P and K at the rate of 400: 115: 600g plant $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$. The application of N, P and K at the rate of 350: 115: 525g N K $plant^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$ at 4, 6 MAP and at harvest produced more number of functional leaves, leaf area and leaf area index (LAI) and reduced the duration for bunch emergence, crop duration and increased the number of suckers after the bunch emergence.

With regard to yield and yield attributes studied, bunch weight, number of hands per bunch, number of fingers per bunch, number of fingers in D hand, pulp peel ratio, weight, length and girth of finger, yield per hectare were highest with the application of N P and K at the rate of 350: 115: 525g N K $plant^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$.

The application of 350g N 115 g P and 525g K $plant^{-1}$ $year^{-1}$ in 6 equal splits reduced the titrable acidity and recorded highest total sugar, non-reducing sugar, ascorbic acid, carotenoid, starch content and sugar acid ratio. Application of N, P and K at the rate of 300: 115: 450g $plant^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM plant $^{-1}$ $year^{-1}$ resulted in higher TSS and reducing sugar with lesser peel thickness.

The organoleptic evaluation score for fruits and chips were highest for taste and over all acceptability with the application of 350 g N 115 g P and 525g K plant $^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$ and all other characters (appearance, colour, flavour and texture) did not vary significantly with respect to the application of major plant nutrients. The shelf life of the fruit also had no significant effect with the different fertilizer levels added.

The soil analysis after the experiment revealed that the available nitrogen, phosphorus and potassium content were more with the application of 350g N, 115 g P and 525g K $plant^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$. The leaf nutrient content of nitrogen, phosphorus and potassium at 4 MAP and N P K uptake at harvest were highest with the application of N P K at the rate of 350: 115: 525 g $plant^{-1}$ $year^{-1}$ in 6 equal splits along with 15 kg FYM $plant^{-1}$ $year^{-1}$.

Sigatoka leaf spot disease and pseudostem weevil incidence were noted during the study and necessary control measures were adopted.

The net income and B: C ratio were highest with the application of 350 g N, 115 g P and 525 g K plant$^{-1}$ year$^{-1}$ in 6 equal splits along with 15 kg FYM plant$^{-1}$ year$^{-1}$ .

The above results indicated that the application of N, P and K at the rate of 350: 115: 525 g plant$^{-1}$ year$^{-1}$ in 6 equal splits doses along with 15 kg FYM plant$^{-1}$ year$^{-1}$ increased the growth, yield, quality and economics of cultivation of banana cv. Popoulu under Kerala conditions.

# *Appendices*

## APPENDIX-I

### Weather data during the cropping period

| Month | Temperature (°C) | | Relative humidity (%) | | Rainfall (mm) |
|---|---|---|---|---|---|
| | Max | Min | Max | Min | |
| March-18 | 33.23 | 24.28 | 92.94 | 74.72 | 2.95 |
| April-18 | 34.00 | 26.19 | 87.78 | 72.00 | 0 |
| May-18 | 33.87 | 26.12 | 88.43 | 75.12 | 15.34 |
| June-18 | 32.22 | 24.34 | 93.34 | 82.33 | 12.34 |
| July-18 | 31.54 | 23.78 | 91.54 | 78.76 | 9.87 |
| August-18 | 30.65 | 23.45 | 93.32 | 79.54 | 10.23 |
| September-18 | 32.00 | 23.67 | 91.67 | 77.54 | 9.78 |
| October-18 | 31.65 | 24.12 | 93.54 | 82.12 | 11.13 |
| November-18 | 30.13 | 23.87 | 94.56 | 83.45 | 15.43 |
| December-18 | 30.32 | 22.56 | 93.55 | 76.66 | 8.89 |
| January-19 | 31.00 | 20.12 | 92.65 | 74.87 | 0 |
| February-19 | 32.12 | 22.67 | 91.76 | 76.43 | 0 |
| March-19 | 33.43 | 24.87 | 91.54 | 73.76 | 0 |
| April-19 | 34.67 | 26.87 | 86.45 | 72.10 | 0 |

## APPENDIX II

## COLLEGE OF AGRICULTURE, VELLAYANI

### Department of Pomology and Floriculture

**Score card for assessing the organoleptic qualities of fruit and chips of banana cv. Popoulu.**

Title: Nutrient standardization in banana (*Musa* AAB. Popoulu)

| Criteria | Samples | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| Appearance | | | | | | | | | | | | | | |
| Colour | | | | | | | | | | | | | | |
| Flavour | | | | | | | | | | | | | | |
| Texture | | | | | | | | | | | | | | |
| Taste | | | | | | | | | | | | | | |
| Overall acceptability | | | | | | | | | | | | | | |

Score (9 point hedonic scale)

Like extremely -9
Like very much -8
Like moderately -7
Like slightly -6
Neither like nor dislike -5
Dislike slightly -4
Dislike moderately -3
Dislike very much -2
Dislike extremely -1

Date:

Name:

Signature: