EFFECT OF BUNCH FEEDING OF MACRO AND MICRONUTRIENTS ON YIELD AND QUALITY OF TISSUE CULTURE BANANA Cv. GRAND NAINE (AAA)

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By

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Affectionately
Dedicated to my
Beloved ParentsSmt.
Ratnamma &
Sri Parameshwarappa,
Teachers and
Kiran K.N.

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C E R T I F I C A T E

This is to certify that the thesis entitled **"EFFECT OF BUNCH FEEDING OF MACRO AND MICRONUTRIENTS ON YIELD AND QUALITY OF TISSUE CULTURE BANANA Cv. GRAND NAINE (AAA)"** submitted in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE (Horticulture)** in **FRUIT SCIENCE** to the University of Horticultural Sciences, Bagalkot, is a record of *bonafied* research work carried out by **DEVRAJ, R. P., ID. No. UHS16PGM809** under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

Place: Bengaluru
Date: February, 2019

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EFFECT OF BUNCH FEEDING OF MACRO AND MICRONUTRIENTS ON YIELD AND QUALITY OF TISSUE CULTURE BANANA Cv. GRAND NAINE (AAA)

ABSTRACT

Banana owing to its large size and rapid growth rate require relatively large amount of nutrients for high yield. To supplement nutrients applied to banana plant through soil, foliage and post shooting feeding through the distal stalk-end of the rachis have gained importance. In this regard a field experiment was carried out during the year 2017-18 in the farmer's field at Agrahara playa, Dasanapurahobli of Bengaluru North Taluk and District, Karnataka. The results revealed that the bunches supplied with the of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost recorded significantly highest finger length (21.23 cm), finger girth (13.60 cm), finger weight (186.53 g), finger volume (162.17 cm^3), hand weight (3.62 kg), bunch weight (33.28 kg) and total fruit yield (74.88 t/ha). The highest pulp recovery (169.63 g), pulp to peel ratio (2.74), total soluble solids (22.11 ^{0}Brix), reducing (17.67%), total sugars and (20.46%,) number of days required for colour development (12.32), lowest titrable acidity (0.24 %) and maximum benefit cost ratio (3.85:1) was observed than the control. The bunches fed with dissolved vermicompost and micronutrients resulted in greater quality attributes such as highest TSS, low acidity, less PLW, good colour of fruit, maximum shelf life leading to long distance transport and marketing which attracts the consumers and ensures highest profitto the farmers.

Devraj, R. P.
(Student)

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(Major Advisor)

ಬಾಳೆಯ ಅಂಗಾಂಶ ಕೃಷಿ ತಳಿ ಗ್ರಾಂಡ್ ನೈನ್ ಬೇಸಾಯದಲ್ಲಿ ಪ್ರಧಾನ ಮತ್ತು ಲಘು ಪೋಷಕಾಂಷಂಗಳನ್ನು ಗೊನೆ ಮೂಲಕ ನೀಡುವುದರಿಂದ ಇಳುವರಿ ಹಾಗೂ ಗುಣಮಟ್ಟ ಹೆಚ್ಚಿಸುವ ಅಧ್ಯಯನ

ಸಾರಾಂಶ

ಬಾಳೆಯ ಬೃಹತ್ ಗಾತ್ರ ಮತ್ತು ವೇಗದ ಬೆಳವಣಿಗೆ ದರದ ಕಾರಣದಿಂದ ಹೆಚ್ಚಿನ ಪೋಷಕಾಂಗಳ ಅಗತ್ಯವಿರುತ್ತದೆ ಈ ಕಾರಣದಿಂದಾಗಿ ಬಾಳೆಗೆ ಮಣ್ಣು ಮತ್ತು ಎಲೆ ಮುಖಾಂತರ ಪೊಷಣೆಯ ಜೊತೆಗೆ ಗೊನೆಯ ಮೂತಿಯ ಮುಖಾಂತರ ನೀಡುವ ಪೋಷಣೆಯು ಮಹತ್ವ ಪಡೆದಿದೆ. ಈ ಪ್ರಭಾವದ ಬಗ್ಗೆ ಅಧ್ಯಯನ ಮಾಡಲು 2017-18ರ ಸಾಲಿನಲ್ಲಿ ಕರ್ನಾಟಕ ರಾಜ್ಯ ಬೆಂಗಳೂರು ಜಿಲ್ಲೆ ದಾಸನಾಪುರ ಹೋಬಳಿಯ ಅಗ್ರಹಾರ ಪಾಳ್ಯ ಗ್ರಾಮದ ರೈತರ ತೋಟದಲ್ಲಿಒಂದು ಕ್ಷೇತ್ರ ಪ್ರಯೋಗ ಕೈಗೊಳ್ಳಲಾಯಿತು. 10 ಗ್ರಾಂ ಯೂರಿಯ + 10 ಗ್ರಾಂ ಎಸ್ ಒ ಪಿ + 5 ಗ್ರಾಂ ಬಾಳೆ ಸ್ಪೆಷಲ್ + 300 ಗ್ರಾಂ ಎರೆಹುಳು ಗೊಬ್ಬರದಿಂದ ಪೋಷಿಸಲ್ಪಟ್ಟ ಬಾಳೆ ಗೊನೆಗಳು ಗಮನಾರ್ಹವಾಗಿ ಅತ್ಯಧಿಕ ಹಣ್ಣಿನ ಉದ್ದ (21.23 ಸೆಂ.ಮಿ.), ಹಣ್ಣಿನ ಸುತ್ತಳತೆ (13.60 ಸೆಂ.ಮಿ.), ಹಣ್ಣಿನ ತೂಕ (186.53 ಗ್ರಾಂ), ಹಣ್ಣಿನ ಪ್ರಮಾಣ (162.17 ಸೆಂ.3) ಕೈತೂಕ (3.62 ಕಿ. ಗ್ರಾಂ), ಗೊನೆ ತೂಕ (33.28 ಕಿ.ಗ್ರಾಂ), ಒಟ್ಟು ಇಳುವರಿ (74.88 ಟನ್/ಹೆ), ತಿರುಳು ತೂಕ (169.63 ಗ್ರಾಂ), ತಿರುಳು : ಸಿಪ್ಪೆ ಅನುಪಾತ (2.74 : 1)ದಾಖಲಾಗಿದೆ ಮತ್ತು ಹಣ್ಣು ಮಾಗಲು ಅಧಿಕ ದಿನಗಳು (12.32 ದಿನಗಳು)ಬೇಕಾಗುತ್ತವೆ, ಒಟ್ಟುಕರಗಬಲ್ಲ ಘನ ವಸ್ತುಗಳು (22.110 ಬಿ), ಒಟ್ಟು ಸಕ್ಕರೆ (20.46%), ಕರಗುವ ಸಕ್ಕರೆ (17.67%), ಕಡಿಮೆ ಆಮ್ಲೀಯತೆ (0.24%) ಹಾಗು ಗರಿಷ್ಠ ಲಾಭ ಮತ್ತು ವೆಚ್ಚ ಅನುಪಾತ (3.85 : 1) ದಾಖಲಾಗಿದೆ. ಕರಗಿಸಿದ ಎರೆಹುಳು ಗೊಬ್ಬರ ಮತ್ತು ಲಘು ಪೋಷಕಾಂಷಗಳನ್ನು ಗೊನೆಗೆ ಉಣಿಸುವುದರಿಂದ ಇಳುವರಿ ಹಾಗು ಗುಣಮಟ್ಟ ನಿಯತಾಂಕಗಳಾದ ಅಧಿಕ ಟಿ. ಎಸ್. ಎಸ್., ಕಡಿಮೆ ಆಮ್ಲೀಯತೆ, ಕಡಿಮೆ ಪಿ ಎಲ್‌ಡಬ್ಲ್ಯು, ಉತ್ತಮ ಬಣ್ಣ ಹಾಗು ಶೆಲ್ಫ್ ಲೈಫ್ ನೀಡುವುದರ ಮೂಲಕ ದೂರದ ಮಾರುಕಟ್ಟೆಗೆ ಸಾಗಿಸಲು ಹಾಗು ಗ್ರಾಹಕರನ್ನು ಆಕರ್ಷಿಸಲು ಸಹಕಾರಿಯಾಗಿದ್ದು ಹಾಗು ರೈತರಿಗೆ ಹೆಚ್ಚಿನ ಲಾಭ ಗಳಿಸಲು ನೆರವಾಗುತ್ತದೆಂದು ಸಾಭಿತಾಗಿದೆ.

(ದೇವ್‌ರಾಜ್‌ಆರ್. ಪಿ) **(ಡಾ. ಎಂ. ಕೆ. ಹೊನ್ನಭೈರಯ್ಯ)**

ವಿದ್ಯಾರ್ಥಿ **ಪ್ರಧಾನಮಾರ್ಗದರ್ಶಕರು**

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Introduction

I. INTRODUCTION

Banana (*Musa* spp.) is the world's largest monoecious, monocarpic and monocotyledonous perennial herb belongs to the family Musaceae has been reported to be originated in South-East Asia. It is one of the oldest fruits known to mankind. The name banana comes from the Arabic word 'BANANA', which means finger. It is also known by other synonyms like 'Adam's fig', 'Kalpataru', 'Tree of wisdom' and 'Apple ofParadise'.

The ripened banana fruits are used for table purpose as it helps in digestion. It is considered as gold mine of nutrients. Banana is the rich source of easily digestible carbohydrates with a calorific value of 67-137 per 100 g of fruit and it contains less fat, cholesterol, and sodium. The fruits contain all the eight amino acids which our body cannot produce and high amount of vitamin B_6, which provides protection and fights against infection and is essential for the synthesis of 'heme', iron containing pigment called haemoglobin (Samson, 1986).

Besides edible fresh fruits, banana has other uses for making dried chips, wine, beer, flour and juice. The pseudostems are used for thatching, fabric and mulch. The leaves are used as dining plates. Owing to its multifaceted uses from underground stem up to the male flower, it is referred as 'Kalpatharu' (a plant ofvirtues).

Banana is distributed throughout the warmer countries situated in the region between 30° N and 30° S of the equator. It is grown widely in 130 countries of the world, mainly Brazil, China, India, Ecuador, Columbia, Venezuela, Florida, Panama, Cuba, Uganda etc. The largest acreage of banana is in Africa where it is considered as a starchy food. India is the largest producer of banana in the world and cultivated in an area of 8,58,000 ha. with the production of 29.16 million tonnes wherein, Karnataka has 1,01,530 ha. with the production of 2.48 million tonnes. National productivity and state productivity of banana is 33.98 MT/ha and 24.55 MT/ha, respectively (Anon.2017).

A large number of cultivars are reported in banana which includes many exquisite cultivars, whose fruits as such make an irresistible dessert delicacy enjoyed universally.

One such cultivar is Grand Naine, which has won hearts of connoisseur's world over. It is a tall mutant of Dwarf Cavendish with AAA genotype and suited for export purpose. It is good taste variety, large in nature suitable to grow under windy environment

Now a day's tissue culture banana is gaining lot of importance in Karnataka because of its better suitability, quality of planting material, uniformity in growth, earliness in flowering, uniformity in harvesting, semi-dwarf stature, helps for better harvesting and also for its better yielding nature. Tissue culture plants produce twice the amount of roots than the normal plants. Hence, more nutrients absorbed by the plant and produce good yield. Little research has been conducted on bunch feeding of nutrients in banana crops and mainly in cv. Grand Naine

The optimum amount of nitrogen and potash fertiliser application is very much essential for better growth and production of quality bunch with total dry matter accumulation in plants. The total amount of nitrogen taken up by the plant is closely related to total dry matter production (Lahav, 1995), As banana plant cannot store nitrogen, this nutrient is considered to be in short supply even when the crop is grown on highly fertile soils (Robinson, 1996). Potassium is a key element in banana nutrition. Insufficient potassium supply reduces the total dry matter production of banana plants and the distribution of dry matter within the plant. The yield and quality of bunch is most drastically affected. Turner and Barkus (1980) found that, while low potassium supply halved the total dry matter produced, the bunch dry matter was reduced by 80 per cent and the roots wereunaffected.

Soil application of vermicompost is known to improve fruit quality and shelf life of banana as it is inducted with the secretions of earthworm which contains amino acids, vitamin B and other plant harmones helpful for production and quality (Athani and Hulamani, 2000). Micronutrients play a key role in nutrition of the plants. As a matter of fact, the plant life would not be possible without these elements. Adequate amount of micronutrients is also required to obtain good yield in banana (Kumar and Jeyakumar, 2002).

Currently bunch feeding technique is being practiced by using both macro and micronutrients to obtain good bunch (Kotur and Keshavamurthy, 2008). The uniform finger filling and growth is important to get maximum yield.

Inspite of feeding the banana plants with recommended quantity of major and micro nutrients through soil by mineral, organic and biological means, the uptake and utilization of nutrients by plants is inadequate resulting in poor growth of the bunch and fingers. Particularly the fingers at the distal end of the bunch remain poorly developed owing to an adverse competition of the top hands with those located at the lower end of the bunch. This reduces both the total weight as well as its overall appearance leading to a lowerprofitability.

Keeping these in view the present investigation on “Effect of bunch feeding on yield and quality attributes of tissue culture banana cv. Grand Naine (AAA)” is carried out with the followingobjectives.

1. To study the effect of bunch feeding of macro and micronutrients on growth and yield of tissue culture banana Cv. Grand Naine(AAA).
2. To know the effect of bunch feeding of macro and micronutrients on fruit quality of tissue culture banana Cv. Grand Naine(AAA).
3. To work out the cost benefitratio.

Review of literature

II. REVIEW OFLITERATURE

Banana being a surface and gross feeder, requires high amount of nutrients and water for proper growth and production. Under traditional farming system, banana crop receives its last dose of fertilizers (nitrogen and potassium) at 7^{th} month after planting *i.e.,* just before shooting, which has to support the requirement of nutrients until harvest since large quantity of photosynthates move from the source to the sink *i.e.,* developing bunches at this phase. Any limitation in the supply of nutrients at this crucial stage affects the bunch size andquality.

Because of this problem, poor filling and development of fingers is often reported. Hence, an additional dose of fertilizer after shooting has become imperative. However, it is not wise to go for soil application of fertilizers at finger development stage, since the uptake is slow and low (Veerannah *et al.*, 1976). Hence to supplement nutrients applied to banana plant through soil and foliage, de-navelling (removal of male inflorescence) and post-shoot feeding through the distal stalk-end of the rachis have gained importance. De-navelling saves mobilization of food into the unwanted sink of banana plant (Singh, 2001). Many reports have indicated the usefulness of post shooting application of various nutrients during fruit development in influencing the fruit yield, shelf life and quality (Kannan,1980).

2.1 Effect of urea on yield and quality of fruitcrops

Nitrogen is an essential element required for successful plant growth. Although inorganic nitrogen compounds (*i.e.*, NH_4^+, NO_2^-, and NO_3^-) account for less than 5% of the total nitrogen in soil, they are the main form of the element absorbed by most plants. Inorganic and organic fertilizers are applied to maintain the nutritional condition of different cropping systems. It is most imperative element for proper growth and development of plants which significantly increases and enhances the yield and its quality by playing a vital role in biochemical and physiological functions of plant (Leghari *et al.,* 2016). Urea is one of the most widely used dry granular sources of nitrogen. It has high nitrogen content in comparison to other popular nitrogen sources (i.e. ammonium nitrate).

2.1.1 Banana

Bunch feeding with 5 g urea + 5 g sulphate of potash + 5 g banana special + 500 g cow dung + 200 ml water was found superior with respect to finger weight and bunch weight and the application 10g urea + 10g SOP + 7.5g Banana Special + 500g Cow dung + 200ml Water is found to be on par with the above treatment (Rao and Swamy, 2017).

Adinarayana *et al*. (2016) studied the impact of denavelling and stalk-end nutrient application of urea and sulphate of potash on the improvement of bunch weight of banana cultivar cv. Grand Naine. The results show that when bunch was fed with urea (7.5 g), sulphate of potash (7.5 g) blended with 500 g fresh cow dung recorded maximum yield and all the yield attributing characters *viz.*, bunch weight (25.72 kg), number of hands per bunch (9.34), number of fingers per hand (13.43), hand weight (2.31kg), yield per plant and per hectare (64.10t).

Sandhya *et al.* (2016) conducted an experiment on effect of post-shooting spray of nitrogen and potassium on bunch characters and fruit yield of banana cv. Grand Naine. The bunch sprayed with combination of SOP (2 %) and urea (1 %) showed increased bunch characters *viz.*, bunch length (84.91cm), internodal length (12.0 cm), weight of hand (4.04 kg), finger length (23.50 cm), finger girth (13.88 cm), finger weight (18.90 gm), bunch weight (34.96 kg) and total yield (107.89 t/ha).

In a field experiment conducted in the farmer field to determine the effect of foliar spray on improvement of yield of tissue culture banana cv. Grand Naine found that foliar spray of 1 per cent urea resulted in maximum weight of hand (4.30 kg), weight of bunch (37.51 kg) and total yield (94.72 t/ha) (Geetha *et al.*, 2015).

Intisar and Elsadig (2015) conducted an experiment on effects of organic and chemical fertilizers on yield and total soluble solids (TSS) in Cavendish banana (AAA). The results indicated that the bunches supplied with urea showed significantly higher bunch weight (16.23 kg), bunch weight (17.83 kg) and weight of hand (2.8 kg) compared to other treatments.

Sreekanth *et al.* (2014) studied the effect of bunch feeding on yield of banana cv. Robusta (AAA group) under hill zone of Karanataka and observed that, at the time of harvest, bunch fed with 4 per cent urea recorded significantly highest finger length (21.96 cm).

In an experiment conducted to study the effect of bunch feeding and de-navelling on bunch characters and quality of Martman (AAB) banana revealed that the combination application of 500 g fresh cow dung and 20 g urea was effective in modifying the bunch characters thereby improving the quality and yield of banana cv. Martaman (Shira *et al.,* 2012).

Nandankumar *et al*. (2011) reported that bunch spray of urea 2.0 per cent twice on banana cv. Nanjangudu Rasabale (AAB) immediately after bunch emergence resulted in better finger length (12.70 cm).

Ganapathy *et al.* (2011) reported that, field experiment was conducted to gain information on the efficacy of different sources of nitrogen on yield and quality of banana. The results revealed that among the various treatments, 25% nitrogen as calcium ammonium nitrate, 25% nitrogen as urea, 50% nitrogen as ammonium sulphate recorded better values for growth, yield and qualityattributes.

Kumar and Bangarusamy (2006) observed that urea spray (4 %) hasten ripening of banana fruits and high non-reducing sugars content (7.55 %). Foliar spray of urea either alone or in combination with potassium di-hydrogen phosphate (KH_2PO_4) appeared to hasten fruit ripening in banana cv.Rasthali.

Ancy and Kurien (2000) studied the influence of urea feeding at the cut bunch stalk end of the rachis of banana in tissue culture `Nendran' banana. The results revealed that, application of 30 g urea on the cut stalk end at two weeks or at four weeks after complete emergence of the bunch resulted in maximum yield and other elite yield attributes. Bunch weight, finger weight, length and grade of `D' finger and filling index are the yield parameters mostly affected by the bunch stalk feeding.

2.1.2 Mango

Ghosh and Chattopadhyay (1999) studied the effect of three foliar applications of urea (2, 3 and 4 %) at panicle emergence, pea stage and marble stages on yield, physico-chemical characters of mango cv. Himasagar. They observed that, three applications of urea (4 %) resulted in higher fruit yield (41.7 kg/tree), total soluble solids and total sugar contents. However, the fruit weight was maximum (259 g) with urea (3 %).

2.1.3 Papaya

Bakshi *et al.* (2012) conducted an experiment on studies on the effect of different sources and levels of nitrogen on growth and yield of papaya cv. Coorg Honey Dew. The result revealed that, the highest average number of flowers (40.75), number of fruits per plant (26), average fruit weight (1624.75 g) and average fruit yield per plant (42.32 kg) was recorded under the treatment with nitrogen at 250g per plant per year as urea which was followed by treatment with nitrogen at 350 g per plant per year as ammonium sulphate). On the other hand, the minimum number of flowers per plant (28), number of fruits per plant (17), average fruit yield per plant (18.11 kg) was recorded in the control.

2.2 Effect of potash on yield and quality of fruit crops

Banana being a potassium loving plant, it requires more potassium for its growth, production and quality compared to nitrogen and phosphorus. Potassium is often referred as the quality element for crop production (Usherwood, 1985). Among the several factors affecting fruit quality, adequate potassium application is considered to be of at most importance in banana cultivation. Potassium is known to influence fruit yield in general and fruit quality in particular (Hegde and Srinivas, 1991).

Ramesh Kumar *et al.* (2008) reported that potassium is required for the activation of over sixty enzymes involved in the formation of carbohydrates, translocation of sugars, various enzyme actions, yield, quality parameters, storage life of banana, the tolerance of certain diseases, mechanisms to overcome the abiotic stresses and several other functions. Potassium deficiency impairs protein synthesis, since free amino acids (Freiberg and Steward, 1960) and soluble forms of nitrogen (Martin-Prevel, 1973) increase in low-

potassium plants. The main amino acid to accumulate was cysteine-methionine (Lahav, 1975). A parallel decrease of amino acids was found in the sap. Potassium supply affects the fruit quality by affecting the reducing, non-reducing and total sugars. As potassium supply increases, the sugar to acid ratio increases because of increase in sugars as well as decrease in acidity (Vadivelu and Shanmugavelu, 1978).

2.2.1 Banana

Paul and Jayachandran (2015) conducted a field experiment in the department of pomology and floriculture, college of agriculture, Vellayani during 2013-2015 to evaluate the effeciency of foliar nutrition on growth and yield of banana cv Nendran. The results revealed that, foliar sprays each at 2, 4 and 6 months after planting. The treatment with 3.0 % K_2SO_4 recorded the maximum TSS (31.50 ^{0}B) and less acidity (0.32 %). It also scored the maximum for sweetness and overall acceptability.

Jagadeesha *et al.* (2015) reported the combined foliar sprays of 2 per cent SOP and 2 ppm brassinosteroid significantly increased the bunch characters *viz.*, bunch weight (11.35 kg), finger weight (215.40 g), finger length (29.10 cm), pulp weight (180.22 g), pulp to peel ratio (5.13) and total bunch yield (29.38t/ha).

In one such experiment, Sreekanth *et al.* (2014) studied the effect of bunch feeding on yield of banana cv. Robusta (AAA group) under hill zone of Karanataka and reported that, at the time of harvest, bunch fed with 2 per cent sulphate of potash recorded significantly highest internodal length (8.93 cm), bunch length (85.20 cm), finger girth (12.79 cm), finger weight (170.10 g), hand weight (2.60 kg), bunch weight (24.21 kg), total yield (60.53 t/ha) and benefit cost ratio(2.68).

Sharma *et al.* (2014) conducted an experiment at farmer's field under on farm trial during 2011-12, in Jorhat district of Assam, to study the impact of post shooting application of urea and sulphate of potash on the improvement of bunch weight of banana cv. Borjahaji. The results showed that, when the bunch was fed with urea (7.50 g) and sulphate of potash (7.50 g) blended with 500 g fresh cow dung recorded significant improvement in yield parameters *viz.*, finger lengths (14 cm), finger weights of first hand

(203.06 g), finger weights of last hand (155.29 g), finger girths (13.19 cm), weight of first hand (3.04 kg), weight of last hand (2.33 kg) and maximum bunch weight (20.66 kg) and the minimum of all these characters and bunch weight were obtained in control, where male bud was retained till harvest.

Vivela *et al. (*2013) studied on quality characters of Martaman banana, the experiment was conducted at research station of AICRP on tropical fruits at Mondouri of BCKV, Mohanpur, West Bengal. The results revealed that, bunch feeding with 500 g fresh cow dung + 20 g urea +20 g sulphate of potash showed the increased total soluble solids (24.8 ^{0}Brix), total sugar content (17.6 %), non-reducing sugar (9.29 %) and ascorbic content levels (0.53 %).

Sreekanth *et al*. (2014) conducted a field experiment at farmer's field to determine the effect of different bunch stalk feeding with different growth regulaters on yield of banana cv. Robusta (AAA-group) under hill zone of Karnataka. Results revealed that, at the time of harvest, bunch fed with 2 per cent sulphate of potash recorded significantly the highest internodal length (8.93 cm), bunch length (85.20 cm), finger girth (12.79 cm), finger weight (170.10 g), hand weight (2.60 kg), bunch weight (24.21 kg), total yield (60.53 t/ha) and benefit cost ratio(2.68).

In an experiment conducted to study the effect of bunch feeding and de-navelling on bunch characters and quality of Martman (AA) banana revealed that the combination application of 500 g fresh cow dung and 20 g urea was effective in modifying the bunch characters thereby improving the quality and yield of banana cv. Martaman. Whereas the physico-chemical properties were positively influenced by combined application of 500 g fresh cow dung and 20 g K_2SO_4 (Shira *et al.*, 2012).

Nandankumar *et al.* (2011) concluded that, sulphate of potash (SOP) 2.0 per cent was sprayed on banana cv. Nanjangudu Rasabale (AAB) twice on bunch immediately after bunch emergence resulted in better finger girth (13 cm), green life (5.15 days), shelf life (5.6 days), total sugars (25.89 %), total soluble solids (26.1 ^{0}B) and lowest

physiological loss in weight (11.80). Meanwhile, maximum pulp to peel ratio (4.12) and reduced tritatable acidity (0.31 %) was recorded in 3.0 per cent SOP sprayed fruits.

Kotur and Keshavamurthy (2010) studied de-navelling and feeding ammonium sulphate (5-25 g/plant) with or without potassium sulphate (2.5-12.50 g/plant) blended in 500 g of fresh cow-dung and applied to the distal stalk-end of the bunch of ‘Ney Poovan’ banana (*Musa* sp.*).* Results showed that, application of 5 g ammonium sulphate and 2.5 g sulphate of potash blended in 500 g of fresh cow dung to the distal stalk-end of the bunch of ‘Ney Poovan’ banana was the most promising in boosting the yield, improving the nutritional composition in respect of N, K and S without adversely affecting the fruit quality.

Kotur and Keshavamurthy (2008) showed that, an application of 15 g of ammonium sulphate and 7.50 g of sulphate of potash in 500 g of fresh cow dung to distal stalk-end of the bunch of 'Robusta' banana was found to be promising to boost the bunch weight (29.71 kg) by 41.5 per cent without affecting the fruit quality in banana cv. Robusta.

Rameshkumar *et al*. (2008) reported that, foliar spray of sulphate of potash (SOP) at 1.5 per cent twice i.e., first immediately after opening of the last hand and second, 30 days after the first spray. The increased bunch weight (31.97 kg) with better bunch such as number of hands (10.00), total number of fingers (188.7), finger weight (167.3 g), pulp to peel ratio (5.37) and quality traits such as total soluble solids (22.62 %), reducing sugars (17.62 %), non-reducing sugars (2.18 %), total sugars (19.80 %), less acidity(0.16 %), shelf life (8.7 days) and with less number of days (103.7) to harvest from shooting. SOP at 1.5 per cent concentration produced heavier bunches which was on par with SOP at 1.0 per cent in banana cv. Robusta (AAA- Cavendish).

Rameshkumar and Kumar (2007) conducted an experiment to evaluate the effect of foliar spray of sulphate of potash (SOP) on banana cv. Ney Poovan and reported that, SOP at 1.5 per cent increased bunch weight (14.27 kg) with better bunch traits such as number of hands (13.00), total number of fingers (233.30), finger weight (75.10 g), finger

length (14.37 cm), finger girth (13.77 cm) and quality traits such as total soluble solids (28.9 %), total sugars (22.36 %), less acidity (0.16 %), green life (5.3 days) and shelf life (8.7 days) with less number of days to harvest from shooting (89.90).

Mustaffa *et al.* (2004) conducted an experiment at NRC banana, Trichy on Nendran cultivar. The results revealed that, potassium sulphate (2 %) as two sprays found to be best among the treatments and recorded significantly the highest bunch weight (9 kg), number of fingers (55.8), finger length (22.13 cm) and finger girth (13.6 cm), followed by 1.0 per cent of potassium sulphate spray.

2.2.2 Grapes

Sharma and Sindhu (2005) studied the effect of potassium salts super imposed on thinning and GA_3 and girdling in combination on the quality and maturity of grapes cv. Perlette. The K_2SO_4 at fruit set and various stages super imposed on recommended technology resulted in 2.4 per cent and 4.2 per cent more total soluble solids over recommended technology and control respectively. The recommended technology advanced the maturity period by six days over control, KNO_3 delayed the maturity by two to three days overK_2SO_4.

Beniwal *et al.* (1992) revealed that, 0.5 per cent urea and 1.0 per cent potassium sulphate (K_2SO_4) foliar spray in Perlette grapes was proved to be effective in increasing total soluble solids and reducing sugars. Acidity increased with urea spray, whereas K_2SO_4 decreased the acidity.

Singh *et al.* (1979) reported that, Perlette grapevines, sprayed with of 1.0 per cent sulphate of potash were given at weekly intervals after berry set significantly improved the average berry weight, juice percentage, reducing sugars, total soluble solids, and berry firmness were while total acidity increased as a result of sprays withSOP.

2.2.3 Guava

El-Sherif *et al.* (2000) reported that, potassium sulphate (K_2SO_4) (1%, 2% and 3%)andzincsulphate(0.5%,1%and2%)wassprayedtoMontakhabEl-Kanaterguava

trees at full bloom in both seasons. The yield as weight or number of fruits per tree was significantly increased with 1 % and 2 % K_2SO_4 as well as 0.5 and 1.0 % zinc sulphate sprays. Also, fruit quality was improved with potassium and zinc fertilizers.

Ahlawat and Yamdagni (1981) reported that, weekly spray of potassium (1% aqueous SOP solution) for seven weeks improved the quality of guava with respects to total soluble solids and total sugars.

2.2.4 Mango

Burondkar *et al*. (2002) studied the effect of different sources and doses of potassium on yield and quality of 'Alphonso' mango and reported that, trees which received recommended dose of K through sulphate of potash through soil application, when supplemented with KNO_3 (1%) foliar sprays, registered maximum yield (74.59 kg/tree) over rest of the treatments including control (39.38 kg/tree) and improved the total soluble solids of fruits.

Ghosh and Chattopadhyay (1999) studied the effect of three foliar applications of urea (2, 3 and 4 %) at panicle emergence, pea stage and marble stages on yield, physico-chemical characters of mango cv. Himasagar. They observed that, three applications of urea (4%) resulted in higher fruit yield (41.7 kg/tree), total soluble solids and total sugar contents. However, the fruit weight was maximum (259 g) with urea (3%).

Oosthuyse (1997) studied the effect of potassium nitrate (KNO_3) spray on fruit retention, fruit size, tree yield and fruit quality of six mango cultivars and reported that, two sprays of KNO_3 (2%) retained higher fruits till harvest with an increase in yield of all the six cultivars. There was no apparent effect of KNO_3 sprays on fruit quality such as total soluble solids, pH or skin colour.

2.2.5 Pomegranate

Potassium nitrate (250 mg/L) was sprayed on fruits with a diameter of 30 mm increased total soluble solids (16.18 ^{o}Brix), titratable acidity (1.11mg citric acid 100^{-1}mL juice) in 'MalasYazdi' pomegranate (Khayyat *et al.*, 2012.).

2.3 Effect of micronutrients on yield and quality of fruitcrops

Micronutrients play a key role in nutrition of the plants. As a matter of fact, the plant life would not be possible without these elements. Adequate quantity of micronutrients is also required to obtain good yield in fruit crops.

2.3.1 Banana

Bauri *et al*. (2015) studied the effect of micronutrient and growth regulators for yield and quality in banana cv. Martaman. The results revealed that maximum increase in bunch weight (17.72 kg), yield (44.30 t/ha), number of hands (8.88), number of finger per bunch (133.66) and finger length (13.45 cm) was recorded by $KHPO_4$ (0.5%) application. With regard to physicochemical characters of fingers, Borax (0.1%) showed maximum total soluble solids (26.72 ^{0}Brix), total sugar (14.57%), sugar: acid ratio (45.53), maximum vitamin C content (8.60 mg/100 g pulp) and higher shelf life (6.40 days).

Moreira *et al*. (2011) studied that application of boron fertilizer increased the yield and boran concentration in leaves and fruits. The application of 3.4 kg B ha^{-1} in the first cycle and 1.3 kg B ha^{-1} in the second cycle guarantees an adequate nutritional status in bananaplants.

The combined application of $FeSO_4$ (0.5 %) + $ZnSO_4$ (0.5 %) at three, five and seven months after planting of suckers in banana cv. Martaman (AAB, Silk) recorded the maximum bunch weight (16.30 kg), hands (9.21/bunch), fingers (129.21/bunch), yield (40.75 t/ha), finger length (14.80 cm), finger breadth (13.10 cm) and days to ripening (8.1 days) and quality parameters like sugar to acid ratio (47.70), non-reducing sugar (10.04 %) and reduced total titratable acidity (0.36 %). Application of $FeSO_4$ (0.5 %) alone showed considerable improvement on total soluble solids (25. 53 ^{0}Brix), reducing sugar (6.57 %) and total sugar (17.24 %) content of pulp (Pathak *et al*., 2011).

Yadav *et al.* (2010) during the course of experiment on effect of micronutrients on growth and crop duration of banana cv. Grand Naine recorded minimum number of days for inflorescence emergence to harvesting (77.50 days) 8 with the application of RDF + Zn (40 g) + Mn (20 g) + Cu (5 g) + Borax (10 g) in banana cv. Grand Naine.

Patel *et al*. (2010) found that the foliar application of $ZnSO_4$ (0.5 %) + $FeSO_4$ (0.5 %) recorded the maximum values for bunch weight (23.85 kg), bunch length (93.50 cm), bunch girth (114 cm), number of hands per bunch (11.70) and yield (149.078 t/ha) of banana cv. basrai. Foliar as well as soil application of $ZnSO_4$ (0.5 %) + $FeSO_4$ (0.5 %) treatments effectively increased the ascorbic acid (25 mg/100g) and total soluble solids (22.03 ^{0}B) in banana fruits.

Foliar application of $ZnSO_4$ (0.5%), $FeSO_4$ (0.2 %), $CuSO_4$ (0.2 %) and borax (0.1 %) (At 3rd, 5th and 7th month after planting) is recommended to get higher yield and quality fruits in banana (Thangaselvabai *et al.*,2009).

The maximum weight of mature finger (178.75 g), ripe finger (170.50 g), maximum total sugar (16.00 %) and reducing sugar (12.75 %) was found with two sprays of 1% micronutrient mixture which were significantly superior over all the treatments. Maximum pulp to peel ratio (2.80) was found in one spray of 1 % micronutrient mixture in banana (*Musa* sp.) cv. Ardhapuri (Yadlod and Kadam, 2009).

The two foliar spray of micronutrients mixture (1 %) on both the sides at flag leaf stage just before flowering by using a hand sprayer resulted in the early maturity (106 days), maximum length (21.95 cm) and girth (16.20 cm) of finger, weight of mature finger (145.30 g), pulp to peel ratio (2.87), weight of ripe finger (137.49 g), maximum reducing sugar (12.97 %) and non reducing sugar (3.58 %) in banana *(Musa* spp.) cv. Grand Naine (Yadlod and Kadam,2008).

According to Yadlod and Kadam (2008) the maximum non-reducing sugar (3.84 %) and weight of mature finger (185.60 g) was found in two sprays of micronutrient mixtures (1 %) followed by one spray (1 %) of micronutrient mixture It was found that application of IAA 80 ppm, GA_3 80 ppm and two sprays of (1 %) micronutrient mixtures were effective for physical and chemical characters of banana cv. Shrimanti.

Kumar and Jeyakumar (2002) studied the influence of using either individual or combinationfoliarspraysatthree,fiveandsevenmonthsafterplantingwith$ZnSO_4$(0.5 %),$FeSO_4$(0.2%),$CuSO_4$(0.2%)orH_3BO_3(0.1%)ongrowthandyieldofbananacv.

Robusta were studied in a field experiment, registering the greatest bunch weights and the highest total soluble solids content in ripe fruits.

2.3.2 Mango

Pawar *et al*. (2017) reported that the combined application of boron, zinc and iron showed maximum total sugar percentage in ambient stored fruits. Pre-harvest foliar application of all the four micronutrients gave the highest total soluble solids, β-carotene and vitamin A content at room temperature. At ambient storage conditions, combination of boron, zinc, iron and copper improved the TSS: acid and sugar: acid ratios in mango cv. Langra.

Talang et al. (2016) reported that foliar spray of boric acid (0.02 %) + sorbitol (2.0 %) were found to be most effective for enhancing fruit-set (1.58 %), yield (48.51 kg/tree), fruit weight (165.6 g), TSS (18.59°Brix), total sugars (14.92 %) and ascorbic acid content (20.32 mg 100 g/l), while, calcium nitrate (Ca-0.06 %) + boric acid (B-0.02 %) proved to be the most effective for increasing shelf life in mango cv. Himsagar, at ambient room temperature.

Anees *et al*. (2011) studied the effect of foliar application of micronutrients on the quality of mango (*Mangifera indica* L.) cv. Dashehari. Results revealed that the application of all micronutrients significantly increased the quality of fruit than the control. Whereas, trees sprayed with $FeSO_4$ (0.4%) + H_3BO_3 (0.8%) + $ZnSO_4$ (0.8%) showed the maximum pulp weight (169.2 g), total soluble solids (27.9 °Brix), ascorbic acid (150.3 mg/100 ml) and non-reducing sugars (8.83 %) & less stone weight (28.13 g) along with low acidity (0.178 %).

Camerina and Salvador (1997) evaluated the efficacy of two foliar applications of Ca as calcium polychelate (10 % Ca 1 % Mg 0.5 % B and 10 ppm Mo) at 30 and 60 days before harvest on Kent mango and found that spray at 10 ml/l, significantly improved the fruit weight.

2.3.3 Papaya

Singh *et al.* (2010) studied the effect of different micronutrients on growth, yield and quality of papaya (*Carica papaya l.*) cv. Ranchi. The results show that application of borax at 0.50 per cent + $ZnSO_4$ at 0.25 per cent was recorded the maximum plant growth (171.62 cm plant height and 39.74 cm girth) and fruit yield (37.20 kg/plant). The maximum values with respect to qualitative parameters like total soluble solids (6.81°Brix), total sugar (6.88 %) and TSS-acid ratio (58.41) were also obtained with the same combination.

Pauline *et al.* (2004) revealed that, the application of micronutrients B (0.1 %), Fe (0.1 %) and Zn (0.2 %) as foliar spray on papaya cv. Ranchi. The total and reducing sugars were found maximum with the application of Fe in both the years. In general, non-reducing sugar was recorded highest with the combined application of boron and Zinc. The acidity content of fruit did not show any variations with the micronutrient application.

Jeyakumar *et al.* (2002) reported that the influence of foliar application of zinc and boron on fruit yield in papaya cv. Co-5 was investigated. Staggered applications of zinc sulphate (0.5 %) in combination with borax (0.1 %) at four and eight months after planting found to increase in plant growth and fruit yield andquality.

2.3.4 Grapes

Janaki *et al.* (2002) conducted an experiment in grape cv. Muscat at Mathapatti (Coimbatore). They revealed that the combined application of 2.0 kg boran along with 0.2 per cent foliar spray registered the maximum yield (24.6 t/ha) in winter and 26.15 (t/ha) in summer season. This application also helped to increase the brix and total sugar of berries and reduced acidity in the fruits.

Singh *et al.* (2002) conducted an experiment at ICAR, New Delhi to study the effect of foliar application of macro and micronutrients and their combination on yield characters and fruit quality of grape cv. Perlette. They revealed that the nutrient treatment improved average fruit weight per bunch significantly over the control though, Mg (0.02

%), Fe (0.2 %) and B (0.4 %) were better than other treatment and also observed that no unripe short berries and total sugar, acidity, juice and tannin content was also better in micro and macronutrient sprayed vines. Thereby, these micro and macronutrients improved the fruit yield and quality of fruits.

Foliar application of $ZnSO_4$ (0.5 %) and borax (0.2 %) increased the weight of cluster (245 g/cluster), volume of cluster (173 ml), weight of berry (3.01 g) and quality characters with higher juice per cent, total soluble solids, total sugars and lower acidity in grapes cv. Muscat (Prabhu and Singaram, 2001).

Rana and Sharma (1999) revealed that, the growth, yield, weight of cluster, volume of cluster, weight of berry, volume of berry, juice percentage, specific gravity of juice and total soluble solids were increased with 0.05 per cent of $FeSO_4$ spray in grapes. However, pH of juice acidity, total sugars, reducing sugars, non-reducing sugars and sugar to acid ratio were not affected by iron sprays.

Sindhu *et al.* (1999) observed in grapes that, the maximum bunch weight, yield and total soluble solids of fruit were found in vines which received 1.5 and 0.5 per cent urea and zinc sulphate spray, respectively. Acidity decreased with increase in concentrations of urea and zinc sulphate spray.

2.3.5 Citrus

Nawaz *et al*. (2008) studied the effect of exogenous application of growth regulators (2, 4-D, GA_3 and NAA) in Kinnow mandrin (*Citrus reticulata Blanco*). They found that significantly decreased percentage of preharvest fruit drop, leading to increase in total number of fruits per plant, fruit weight, juice percentage, total soluble solids, acidity, reducing sugars and non-reducing sugars. Auxin (2,4-D and NAA) performed better compared to gibberellins.

Tariq *et al.* (2007) obtained the maximum fruit yield when 0.4 kg zinc ha^1, 0.2 kg manganese per ha. and 0.04 kg boran per ha. was sprayed on foliage along with 1.56 kg Nperha.and0.4kgsurfactantsperha.in400litreofwater.Theminimumpercentpeel

was obtained with boron alone and maximum fruit size with zinc + boron and maximum fruit volume with zinc + manganese. Similarly, per cent juice in sweet oranges was increased significantly by boron alone, reducing sugar by manganese alone through foliar spray, suggested that each micronutrient had different role on the quality of citrus cv. Blood red.

Malik *et al.* (2000) found the maximum number of Kinnow fruits and yield per tree which received 1.5 and 0.4 per cent urea and zinc sulphate spray, respectively. The maximum content of juice and total solids were found in trees sprayed with 1.0 and 0.8 per cent urea and $ZnSO_4$ respectively. Ascorbic acid content however, decreased with foliar spray of urea and $ZnSO_4$.

In an investigation studied the effect of foliar spraying with urea (0.5 %)**,** a mixture of Zn (0.4 %), Mn (0.3 %), Fe (0.5 %) and Cu (0.3 %) in sulphates form and two growth regulators (GA_3 at 25 ppm and α-NAA at 10 ppm) on Washington Navel Orange trees. The results showed that trees receiving urea, micronutrients or both gave fruit with significantly larger volume and slightly reduced juice acidity and increased total soluble solids and sugars when compared with the control (Ahmed *et al.*, 1995).

2.3.6 Guava

The maximum fruit retention (57.27 %), fruit length (6.07 cm), fruit width (5.92 cm), fruit weight (98.48 kg), fruit yield (48.63 kg/tree), total soluble solids (11.70 ^{o}Brix), ascorbic acid (172.00 mg/100g), reducing sugar (3.98 %), non reducing (3.53 %), total sugars (7.51 %) and acidity (0.30 %) were recorded with foliar application of borax (0.4 %) followed by zinc sulphate (0.8%) in guava cv. L-49 (Yadav *et al*., 2011).

Bhatia *et al.* (2001) conducted an experiment to study the effect of micronutrients on guava cv. L-49 at Hissar (Haryana) with K_2SO_4 (0.5, 1.0 and 1.5 %), $ZnSO_4$ (0.5, 0.75 and 1.0 %), H_3BO_3 (0.3, 0.5 and 1.0 %) and water (control) which were sprayed on the trees during winter season crops at the stage when the fruit was of walnut size and second after 15 days. The increased fruit weight and the yield (73.0 kg/tree) were observed in the

treatment with H_3BO_3 at 1.0 per cent. The total soluble solids and sugars were more with H_3BO_3 followed by K_2SO_4.

2.4 Effect of vermicompost onbanana

Earthworms vermicompost is proving to be highly nutritive ‘organic fertilizer’ and more powerful ‘growth promoter’ over the conventional composts and a ‘protective’ farm input (increasing the physical, chemical & biological properties of soil, restoring & improving its natural fertility) against the ‘destructive’ chemical fertilizers which has destroyed the soil properties and decreased its natural fertility over the years. Vermicompost is rich in NKP (nitrogen 2-3 %, potassium 1.85-2.25 % and phosphorus 1.55-2.25 %), micronutrients, beneficial soil microbes and also contain ‘plant growth hormones &enzymes’. It is scientifically proving as ‘miracle growth promoter & also plant protector’ from pests and diseases. The vermicompost retains nutrients for long time and while the conventional compost fails to deliver the required amount of macro and micronutrients including the vital NKP to plants in shorter time, the vermicompost does (Sinha *et al.*,2009)

The field experiment was conducted by Marak *et al.* (2017) to assess the effect of organic and inorganic fertilizers on survivability of Banana (Musa paradisica) cv. Red Banana. The results of six month experimentation revealed that the integration of organic and inorganic fertilizer was more effective than the inorganic fertilizers alone. Among the various combinations, 50 percent RDF through inorganic fertilizers + 15.2 kg FYM + 3 kg Vermicompost + 1.0 kg Neem cake was found to be the best overall treatments in respect of survival percentage (89.07 %) which may be due to easy breakdown of available nutrients in organic and inorganic sources and easy uptake by theroots.

Butani and Chovatia (2014) conducted an experiment on effect of chemical fertilizer and vermicompost on biochemical parameters of banana (*Musa paradisiaca* L.) cv. Grand Naine. Application of vermicompost @ 8 kg/ plant recorded significantly the highest total soluble solids, total sugar, reducing sugars and non reducing sugar but it was statistically at par with application of 6kg/ plant during both the years as well as in pooled results.

In an experiment on use of vermicompost in banana cv. Rajapuri indicated that the fruit quality parameters and yield per hectare in both plant and ratoon crops varied significantly. The treatment *in-situ* vermiculturing at 1,25,000 worms per hectare recorded the maximum shelf life (days), total soluble solids (TSS) and TSS: acid ratio and minimum acidity in plant crop and reducing sugar, non-reducing sugar and total sugar in ratoon crop (Athani and Hulimani,2000).

2.5 Benefit-costratio

Adinarayana *et al.* (2016) studied the impact of de navelling and stalk-end nutrient application of urea and sulphate of potash on the improvement of bunch weight of banana cultivar cv. Grand Naine. The results revealed that the nutrients moved from the blend into the bunch and significantly enhanced the weight of fruits and bunch. When the bunch was fed with urea 7.5 g, sulphate of potash 7.5 g blended with cow dung 500 g has recorded highest yield with higher benefit cost ratio(1.17:1).

Shetty *et al.* (2015) conducted an experiment to evaluate the effect of bunch spray of urea and potash on tissue culture banana cv. Grand Naine under hill zone of Karnataka. The result revealed that bunch sprayed with combination of SOP (2 %) and urea (1 %) appeared to be increased cost benefit ratio (3.04), which was followed by 2 per cent SOP and 2 per cent urea (2.93), 1 per cent urea (2.90), 2 per cent urea (2.87) and 2 per cent of SOP (2.79), Whereas, the minimum benefit cost ratio (2.37) was obtained in thecontrol.

Kotur (2015) reported that three types of direct nutrient-feeding methods [applying 500 g fresh cow-dung and 100 ml water enriched with (i) 2.5 g each of urea + SOP; (ii) 100 ml of panchangavya; and (iii) 100 ml of cow urine] were evaluated in ‘Ney Poovan’ banana grown under organic or conventional farming. Results indicated that, conventional farming with adequate organic manuring, and adopting direct nutrient-feeding of the banana bunch using cow-dung slurry enriched with 2.5 g each of urea and SOP, achieved high bunch yield, pulp:peel ratio, and wasprofitable.

Jagadeesha *et al.* (2015) reported the combined foliar sprays of 2 per cent SOP and 2 ppm brassinosteroid significantly increased the bunch characters *viz.*, bunch weight (11.35 kg), finger weight (215.40 g), finger length (29.10 cm), pulp weight (180.22 g), pulp to peel ratio (5.13) and total bunch yield (29.38 t/ha) with relatively higher benefit:cost ratio(2.87:1).

Geetha *et al.* (2015) conducted an experiment to evaluate the effect of bunch spray of urea and potash on tissue culture banana cv. Grand Naine under hill zone of Karnataka. The result revealed that bunch sprayed with combination of SOP (2 %) and urea (1 %) appeared to be increased cost benefit ratio (3.04), which was followed by 2 per cent SOP and 2 % urea (2.93), 1 per cent urea (2.90), 2 per cent urea (2.87) and 2 per cent of SOP (2.79), Whereas, the minimum benefit cost ratio (2.37) was obtained in the control.

Sreekant *et al.* (2014) observed the maximum benefit cost ratio (2.68) was obtained in bunch feeding with 2.0 per cent sulphate of potash in banana cv. Robusta under hill zone of Karnataka.

Pathak *et al*. (2011) reported that, the combined application of $FeSO_4$ (0.5%) + $ZnSO_4$ (0.5 %) at 3^{rd}, 5^{th} and 7^{th} month after planting of suckers in banana cv. Martaman (AAB, Silk) at Gangetic plain of West Bengal recorded the highest benefit cost ratio (3.61).

Post shooting foliar spray twice, first at the time of last hand emergence and repeated after 30 days with sulphate of potash at 1.5 per cent resulted in obtaining highest benefit cost ratio in banana cv. Ney Poovan (Rameshkumar and Kumar, 2010).

Patel *et al.* (2010) conducted the experiment on effect of micronutrients on yield and fruit quality of banana (*Musa paradisica* L.) cv. Basrai under pair row planting method and recorded the highest benefit: cost ratio (1:1.94) in foliar spray of $ZnSO_4$ (0.5 %) + FeSO4 (0.5 %) at 5^{th} and 7^{th} months after planting.

Rameshkumar *et al*. (2008) stated that, the foliar spray of sulphate of potash at 1.5 per cent concentration twice, first immediately after opening of the last hand and second, 30 days after the first spray was resulted in realizing a higher benefit cost ratio (4.19) in banana cv. Robusta.

Foliar application of nitrogen and phosphorus as 2.0 per cent di-ammonium phosphate in the fourth month recorded the highest benefit cost ratio (2.7) in banana cv. Nendran (Selvarajan and Azhakiamanavalan, 1992).

Material and methods

III. MATERIAL ANDMETHODS

The details of the material used and methods adopted in the study entitled “Effect of bunch feeding on yield and quality attributes of tissue culture banana cv. Grand Naine (AAA)” conducted during the year 2017 to 2018 at the farmer’s field at Agrahara playa, Dasanapura hobli of Bengaluru North Taluk and District, Karnataka are presented in this chapter.

3.1 Geographical location of the experimentalsite

Agrahara playa, Dasanapura hobli of Bengaluru North Taluk and District, Karnataka state is situated at 13° 7' North latitude and 77° 27' East longitude at an altitude of 902 m above mean sea level (MSL), which comes under the Eastern Dry zone (Zone- 5) of Karnataka state. The general view of the experimental plot is shown in Plate1.

3.2 Climaticconditions

The meteorological data from August 2017 to September 2018 are presented in Appendix-I. The mean maximum temperature during the period of experimentation was 29.33 ^{o}C whereas, the mean minimum temperature was 18.45 ^{o}C. The mean maximum relative humidity during the period of experimentation was 78.41% whereas, the mean minimum relative humidity was 52.20%. The total rainfall of 1599 mm was received during crop growth period from August 2017 to September 2018.

3.3 Planting

Before planting, the land was ploughed twice and harrowed to bring the soil to a fine tilth, about 30 kg well decomposed farm yard manure (FYM) was added to each pit. Later, the tissue culture plants of banana cv. Grand Naine were procured from the State Department of Horticulture, Hulimavu, Bengaluru and planted on 03rd of August 2017 by maintaining 2.0 X 2.0 m spacing.

3.4 Cultural practices

The plots were kept free from weeds by regular hand weeding. Irrigation schedule was followed according to the requirements. Earthing up was followed whenever soil became compact. De-suckering was done regularly till shooting and a single sucker was allowed to grow after shooting. Along with de-suckering, other cleaning activities were also carried out accordingly. Fertilizers were applied at monthly intervals after planting to till two months before shooting with recommended dose per plant NPK (200:100:300 g), They were supplied in the form of 19:19:19, 12:61:0, 54:32:0 through drip irrigation.

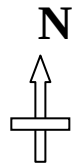
3.5 Experimental details

The experiment was laid out in a Randomized Complete Block Design (RCBD) with eleven treatments, replicated thrice. Three plants were selected randomly for recording observations from each treatment. The layout of the experiment is given in the fig. 1 and the details of different treatments imposed in the present investigation are presented.

3.5.1 Details of the treatments imposed during theexperimentation

Treatment No.	Treatment
T_1	Control
T_2	7.5g urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)
T_3	7.5g urea + 7.5g SOP + 5g banana special + 100g vermicompost
T_4	7.5g urea + 7.5g SOP + 5g banana special + 200g vermicompost
T_5	7.5g urea + 7.5g SOP + 5g banana special + 300g vermicompost
T_6	10g urea + 10g SOP + 5g banana special + 100g vermicompost
T_7	10g urea + 10g SOP + 5g banana special + 200g vermicompost
T_8	10g urea + 10g SOP + 5g banana special + 300g vermicompost
T_9	12.5g urea + 12.5g SOP + 5g banana special + 100g vermicompost
T_{10}	12.5g urea + 12.5g SOP + 5g banana special + 200g vermicompost
T_{11}	12.5g urea + 12.5g SOP + 5g banana special + 300g vermicompost

Note: The prepared solution was placed in the thick polythene bag and tied to the cut end of de-navelled bunch immediately. The vermicompost was dissolved in 500 ml of water along with the prepared solution.



R_1	T_1	T_9	T_3	T_4	T_6	T_8	T_2	T_{10}	T_5	T_{11}	T_7
R_2	T_6	T_{11}	T_8	T_7	T_5	T_1	T_{10}	T_4	T_9	T_{10}	T_2
R_3	T_4	T_1	T_5	T_9	T_3	T_2	T_{11}	T_6	T_8	T_7	T_{10}

Fig. 1: Layout of experimental plot

Plate 1. General view of the experimental plot

3.5.2 Preparation of cow dung slurry with urea andSOP

The 7.5 g Urea and 7.5 g of SOP is weighed and added to the solution containing 500 g of fresh cow dung and 100 ml water and mixed thoroughly to prepare slurry.

3.5.3 Preparation of combination of urea, sulphate of potash, banana special and vermicompostsolution

Urea, sulphate of potash and banana special were used to supplement N, K and micronutrients combined nutrient solution. For preparation of bunch feeding solution, urea and sulphate of potash weighed 7.5 g, 10 g and 12.5 g separately and dissolved in 500 ml solution containing vermicompost of 100 g, 200 g and 300 g according to the treatment combination. Then 5 g of banana special is added to these solutions.

In present investigation, water soluble sulphate of potash containing 50 per cent potassium and urea containing 46 per cent of nitrogen was used for bunch feeding treatments.

3.5.4 Treatmentsimposition

For bunch stalk feeding, uniform bunches for each treatment were selected. Rachis at the distal end of the bunch was excised along with male bud giving a slant cut. (De-navelling by excision of rachis 10 cm after the last hand) immediately after all the pistillate (female) flowers had set fruits. *i.e.*, after four bracts were shed (about 15 days after flower emergence). The 500 ml solution is poured into polythene bag and tied securely by dipping the excised rear end of the bunch and maintained till harvest according to the treatments. The methodology of bunch feeding technique is shown below in Plate2.

3.5.5 Harvesting

Even though, all the plants did not reach harvest maturity at the same time, the harvesting process was spread over for a period of 15 days. Perfectly filled fingers with clear fullness of the angles in the fingers were kept in mind for deciding the stage for

Fully opened bunch Bunch preparation for feeding Tied with nutrient solution Bunch with nutrient solution

Plate 2. Technique involved in nutrients bunch feeding of banana

harvesting. Bunches were harvested by leaving 15-20 cm peduncle from base for easy handling of bunches.

3.6 Observations recorded

Bunches were harvested treatment wise and replication wise. Each bunches were considered for recording the different yield and quality parameters from each replications for all the treatments.

3.6.1 Vegetativeparameters

The observations on vegetative growth parameters were recorded at the time of shooting stage. The observations on vegetative growth parameters *viz*., plant height, pseudostem girth and number of leaves per plant, days taken for complete opening of bunch and number of days taken from shooting to harvest were recorded for all the treatments.

3.6.1.1 Plant height(cm)

Plant height was recorded by using measuring tape from base of pseudostem leaving 30 cm from the ground up to bifurcation of leaves finally the 30 cm was compensated by adding it to the total height of the plants at the time of shooting and expressed in centimetre.

3.6.1.2 Pseudostem girth(cm)

Circumference of pseudostem was measured at 5cm above the ground level using measuring tape at the time of shooting and expressed in centimetre.

3.6.1.3 Number of leaves perplant

The leaves were counted from each tagged plants. The average number of leaves were calculated and expressed as number of leaves per plant.

3.6.1.4 Days taken for complete opening ofbunch

The number of days taken for complete opening of bunch since planting was recorded.

3.6.1.5 Days taken from shooting toharvest

The duration of time taken from initiation of shooting to harvest is recorded and expressed as number of days.

3.6.2 Yieldparameters

The observations on yield parameters *viz*., total number of fingers per hand, total number of fingers per bunch, finger length, finger girth, finger volume, weight of finger, number of hands per bunch, weight of hands, length of bunch, weight of bunch, total yield per hectare were recorded for all the treatments. The finger characters namely, length, girth and finger weight, were measured in `D' finger, *i.e.* middle finger in top and bottom row of the third hand of the bunch (Gottreich *et al*.,1964).

3.6.2.1 Finger length(cm)

The `D' finger length was measured from base of the fruit to the tip, where it is attached to the stalk and expressed in centimetre. `D' finger is the middle finger in top and bottom row of the second hand of the bunch (Gottreich *et al*.,1964).

3.6.2.2 Finger girth(cm)

The finger girth was measured at the middle of the fruit by using a thread and expressed in centimetre.

3.6.2.3 Finger weight(g)

The finger weight was recorded by using weighing machine immediately after harvest of the bunches and expressed in gram.

3.6.2.4 Finger volume(cm^3)

The finger volume is determined by water displacement method and expressed in cm^3.

3.6.2.5 Length of bunch(cm)

The bunch length was recorded by using measuring tape after harvest from peduncle to tip of the bunch from tagged plants and the average bunch length was worked out and expressed in centimetre.

3.6.2.6 Number of hands perbunch

The total number of hands per bunch was counted and expressed in number.

3.6.2.7 Total number of fingers perhand

The number of fingers in each hand was counted and average value is recorded.

3.6.2.8 Total number of fingers perbunch

The number of fingers in each bunch was counted and average number is calculated.

3.6.2.9 Weight of hand(kg)

The hands of top, middle and bottom part of the bunch from the labelled plant was weighed, averaged and was expressed in kilogram.

3.6.2.10 Weight of bunch(kg)

The bunch weight was recorded after harvest of fully matured bunches. Bunches were cut when the fingers had fully developed and devoid of any ridges on its surface and weighed. Weight of bunch was expressed in kilogram.

3.6.2.11 Yield (tonnes/ha.)

The plant yield was calculated by multiplying the yield per plant (bunch weight/plant) with the total number harvested bunches of plants per hectare and expressed in tonnes perhectare.

3.6.3 Quality parameters

The post harvest parameters such as total soluble solids, ascorbic acid, total sugars, pulp and peel weight, pulp to peel ratio, colour of finger, firmness, physiological loss in weight and shelf life were recorded after harvest of bunch. The quality parameters such as total soluble solids, ascorbic acid and total sugars were recorded from randomly selected ripened fruits from all thetreatments.

3.6.3.1 Physiological loss in weight(%)

The physiological loss in weight of fruit was expressed in per cent loss of weight from day of harvest to the end of shelf life.

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Weight at the end of the shelflife}}{\text{Initialweight}} \text{ x100}$$

3.6.3.2 Firmness (kg/cm^2)

The firmness of a fruit was recorded by using penetrometer and the readings were expressed in kg/cm^2.

3.6.3.3 Weight of pulp (g)

The pulp weight was recorded from the ripened fruits and expressed in gram.

3.6.3.4 Weight of Peel(g)

The peel weight was recorded from the ripened fruits and expressed in gram.

3.6.3.5 Pulp: peelratio

The pulp to peel ratio was worked out by dividing the mean weight of pulp by mean weight of peel.

3.6.3.6 Total soluble solids(^{0}Brix)

The total soluble solids was recorded with the extracted juice using a digital hand refractometer at room temperature and expressed in ^{0}Brix.

3.6.3.7 Acidity (%)

Two gram of fruit pulp was ground well and filtered through Whatman No. 1 filter paper and volume was made upto 20 ml in a volumetric flask. An aliquot of 15 ml was taken into conical flask and titrated against 0.1 N NaOH using phenolphthalein indicator to a pink colour end point (Ranganna, 1977) and the titrable acidity was estimated in terms of percent.

$$\text{Acidity (\%)} = \frac{\text{Titre value x Normality of NaOH x meq of acid x 100}}{\text{Volume of aliquot taken}}$$

3.6.3.8 Total sugars (%)

The reducing sugars, non reducing sugars and total sugar content of the fruit was estimated by following Anthrone method and expressed in percentage.

3.6.3.9 Colourdevelopment

The fully matured hands were taken and kept for ripening under ambient condition and the days taken for change of colour from green to yellow was recorded. Days to ripe (green life) has been defined as the time in which, the harvested fingers take to reach maturity under defined conditions (Turner,1997).

3.6.3.10 Shelf life(days)

The shelf life can be defined as the time over which the ripe fruits remain acceptable for consumption (Turner, 1997).

Shelf life of fruits was decided based on the appearance and marketability of the fruits. The shelf life of fruits was determined by recording the number of days the fruits remained in good condition in storage. The stage where in more than 50 per cent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days.

3.6.3.11 Sensoryevaluation

The organoleptic evaluation of ripe fruits of banana was conducted on the basis of colour, flavour, aroma, taste and overall acceptability by a panel of ten judges using a nine point Hedonic scale. The chart used for evaluating the premix powder is given bellow.

9-Point Hedonic Scale

Scoring Description	Score
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

3.6.4 Nutrient uptake

The amount of nutrients namely nitrogen, potassium and sulphur were estimated before applying to the bunch and after the harvest to quantify the amount of nutrients

absorbed by the bunch. The nitrogen is estimated by Kjeldahl method, potassium by using flame photometry and sulphur by turbidometry method and expressed ingrams.

3.6.4 Benefit-Cost ratio

The benefit-cost ratio for the different treatments was worked out based on the expenditure and return in order to study the economics of banana production.

3.7 Statistical analysis

The data in respect of all the above parameters were tabulated and subjected to the statistical analysis using methods of analysis of variance (ANOVA) for randomized block design by Fisher and Yates (1963). Whenever, 'F' test was found significant for comparing the means of two treatments the critical difference (C.D. at 5 %) was worked out.

Experimental results

IV. EXPERIMENTALRESULTS

The results obtained in the study entitled “Effect of bunch feeding on yield and quality attributes of tissue culture banana cv. Grand Naine (AAA)” are presented in this chapter. This investigation was conducted during the year 2017 to 2018 at the farmer’s field at Agrahara playa, Dasanapura hobli of Bengaluru North Taluk and District, Karnataka,.

4.1 Effect of bunch feeding on vegetativeparameters

The data on effect of bunch feeding on vegetative growth parameters of banana *viz.*, plant height, pseudostem girth, number of leaves at the time of shooting, days taken for complete opening of bunch and number of days taken from shooting to harvest is furnished in Table 1.

4.1.1 Pseudostem height(m)

The effect of bunch feeding on pseudostem height are presented in Table 1. There were no significant differences among the treatments with respect to height of the plant, as the height of the plant was recorded before bunch feeding and also it was not affected by bunch feeding. Although highest height was observed in treatment provided with 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (2.33 m) and lowest height was observed in treatment with 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost (2.23m).

4.1.2 Pseudostem girth(cm)

The effect of bunch feeding on pseudostem girth are presented in Table 1. There were no significant differences among the treatments with respect to pseudostem girth, as the pseudostem girth was recorded before bunch feeding and also it was not affected by bunch feeding. Although highest pseudostem girth was seen in the treatments supplied with 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (60.60 cm) and lowest pseudostem girth was seen in the treatment with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (57.08 cm).

Table 1: Effect of bunch feeding on vegetative characters of banana Cv. Grand Naine

Treatments details	Pseudostem height (m)	Pseudostem girth (cm)	Number of leaves at the time of shooting	Days taken for complete opening of bunch	Number of days taken from shooting to harvest
T_1: Control	2.28	58.43	14.67	239.50	127.17
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	2.31	59.83	14.22	241.00	122.73
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	2.23	57.90	13.87	242.83	126.00
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	2.27	58.87	14.26	236.66	125.33
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	2.31	57.08	14.59	237.16	122.33
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	2.24	57.12	14.03	238.16	124.50
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	2.33	60.60	14.61	240.66	122.77
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	2.32	59.69	14.50	237.83	121.58
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	2.27	57.38	14.17	239.00	124.08
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	2.24	57.69	13.89	237.66	124.32
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	2.26	58.44	14.87	238.33	125.00
S.Em.±	0.03	1.36	1.36	1.41	0.66
C.D. at 5 %	NS	NS	NS	NS	1.94

NS= Non significant

4.1.3 Number of leaves at the time ofshooting

The effect of bunch feeding on number of leaves per plant is presented in Table 1. There were no significant differences among the treatments with respect to number of leaves at shooting, as the number of leaves was recorded before bunch feeding and also it was not affected by bunch feeding. More number of leaves were observed in treatment provided with 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost (14.87) and less number of leaves was observed in 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost(13.87).

4.1.4 Days taken for complete opening ofbunch

The effect of bunch feeding on days taken for complete opening of bunch is presented in Table 1. There were no significant differences among the treatments with respect to days taken for complete opening of bunch as this duration was recorded before bunch feeding and also it was not affected by bunch feeding. Although more days taken for complete bunch opening were recorded in treatment provided with 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost (242.83) and less number of days were recorded in treatment supplied with 10g Urea+ 10g SOP + 5g banana special + 100g vermicompost (238.16).

4.1.5 Number of days taken from shooting toharvest

The number of days taken from shooting to harvest was found to differ significantly among the treatments and the observations were depicted in Table 1. An early harvesting (121.58 days) was recorded in the bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was followed by treatment with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (122.33 days), 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (122.73 days) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (122.77 days). While, highest number of days (127.17 days) from shooting to harvest was recorded in control.

4.2 Effect of bunch feeding on yield parameters

The observations on effect of bunch feeding on yield parameters of banana *viz* total number of fingers per hand, total number of fingers per bunch, finger length, finger girth, finger volume, weight of finger, number of hands per bunch, weight of hands, length of bunch, weight of bunch, total yield per hectare were furnished in Table 2, 3 and 4.

4.2.1 Finger length (cm)

The data on the mean finger length on effect of bunch feeding on banana cv. Grand Naine are presented in Table 2 and Fig. 2. It could be noticed from the table that there were significant differences in finger length between the treatments. The longest finger (21.23 cm) was obtained in the bunches provided with the nutrient combination of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with dipping the cut end in 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (20.87 cm), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (20.70 cm), 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (20.57 cm), 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (19.83cm) and 10g Urea + 10g SOP + 5g banana special + 100g vermicompost (19.68 cm). While, the shortest finger (17.37 cm) was obtained in control.

4.2.2 Finger girth (cm)

The data on mean girth of finger recorded after harvest are presented in Table 2 and Fig. 2. The highest finger girth (13.60 cm) was recorded in bunch fed with dipping the cut end in 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with bunches fed with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (13.40 cm), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (13.32 cm) and 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (13.17 cm). Whereas, the lowest finger girth (11.55 cm) was recorded in control (plants without bunchfeeding).

Table 2: Influence of bunch feeding on finger characters of banana Cv. Grand Naine

Treatments details	Finger length (cm)	Finger girth (cm)	Weight of finger (g)	Finger volume (cm^3)
T_1: Control	17.37	11.55	164.8	136.37
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	20.57	13.17	182.76	158.47
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	19.13	12.73	174.12	145.83
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	19.83	13.32	178.66	151.78
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	20.87	13.40	184.61	159.87
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	19.67	12.98	179.31	149.78
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	20.70	13.32	180.66	158.80
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	21.23	13.60	186.53	162.17
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	18.77	12.63	172.63	145.60
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	18.60	12.37	170.60	142.17
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	17.77	12.00	168.26	139.60
S.Em.±	0.72	0.34	5.19	4.31
C.D. at 5 %	2.05	1.12	15.17	13.15

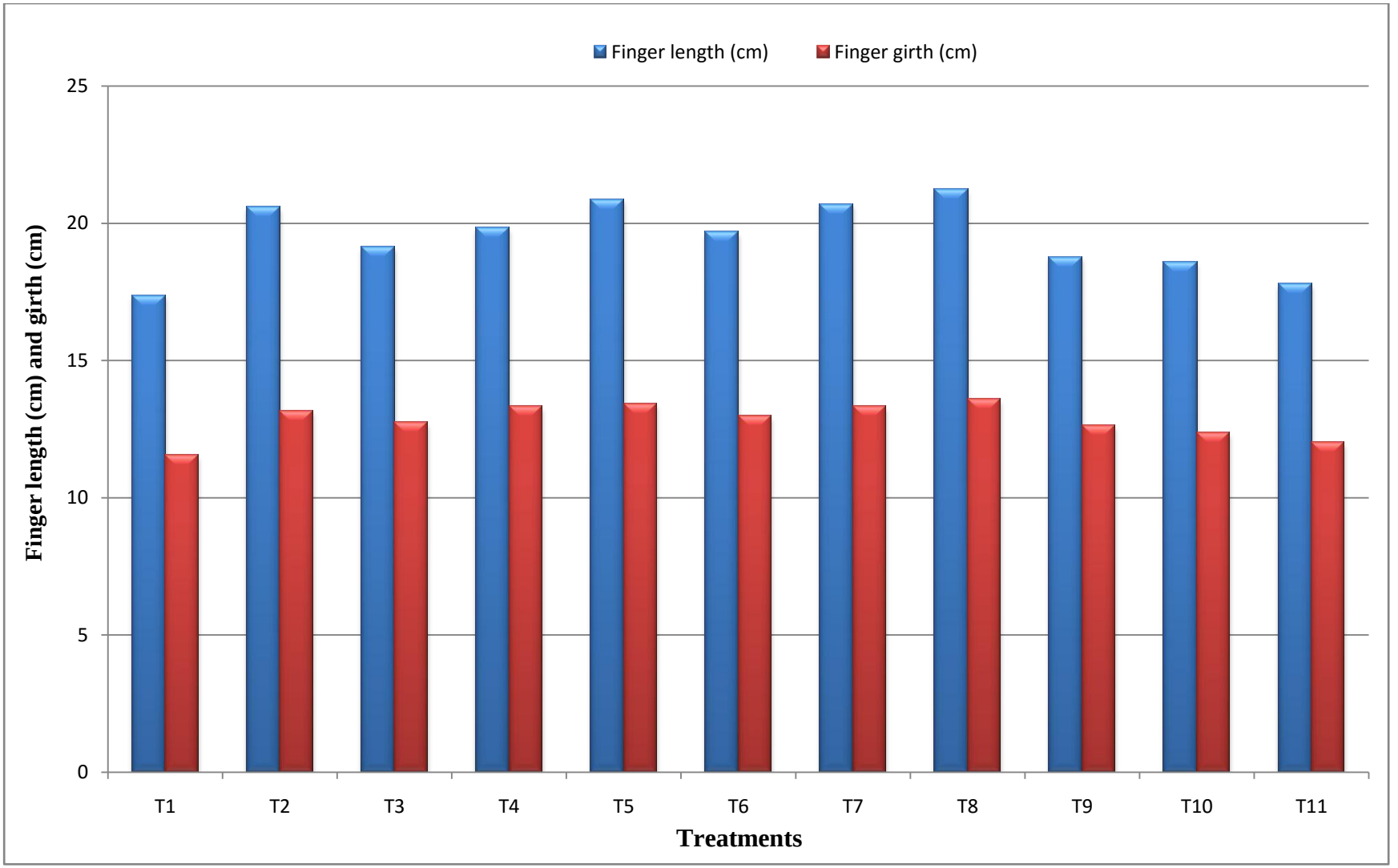


Fig. 2: Effect of bunch feeding on finger length (cm) and finger girth (cm) of banana cv. Grand Naine

4.2.3 Finger weight(g)

The observations on finger weight recorded after harvest are presented in Table 2 and Fig. 3. The highest finger weight (186.53 g) was recorded in bunch supplied with nutrient combination of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with the supply of 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (159.87 g) and 7.5 g Urea +7.5 g SOP + 500 g cow dung +100 ml of water (182.76 g). Whereas, the lowest finger weight (164.8 cm) was recorded in control.

4.2.4 Finger volume(cm^3)

The data on the mean finger volume on effect of bunch feeding on banana cv. Grand Naine are presented in Table 2. It could be inferred from the table that there were significant differences in finger volume between the treatments. The highest finger volume (162.17 cm^3) was observed in the bunches catered with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with the supply of 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (159.87 cm^3), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (158.80 cm^3)and 7.5 g Urea +7.5 g SOP + 500 g cow dung +100 ml of water (158.47 cm^3).While, the lowest finger volume (164.80 cm^3) was noticed in control.

4.2.5 Length of bunch (cm)

The data on the effect of bunch feeding on mean length of bunch is presented in Table 3. It could be noticed from the table that there were significant differences in bunch length between the treatments. The increased bunch length (84.48 cm) was noticed in the bunchesprovidedwithnutrientcombinationof10gUrea+10gSOP+5gbananaspecial +300gvermicompost,whichwasonparwith7.5gUrea+7.5gSOP+500gcowdung +100 ml of water (81.40 cm), 7.5g Urea + 7.5g SOP + 5g banana special+ 300g vermicompost (81.33 cm) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (80.75 cm). While, the lowest bunch length (68.43 cm) was noticed in control.

Table 3: Effect of bunch feeding on bunch length, number of hands and number of fingers of banana Cv. Grand Naine

Treatments details	Length of bunch (cm)	Number of hands per bunch	Number of fingers per hand	Number of fingers per bunch
T_1: Control	68.43	8.51	17.33	144.00
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	81.40	8.63	16.89	146.17
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	74.20	8.40	17.11	143.67
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	78.63	8.74	16.77	144.33
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	81.33	8.46	17.33	145.17
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	77.49	8.51	16.89	143.00
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	80.75	8.72	16.66	144.33
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	84.48	8.66	17.22	143.83
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	71.40	8.63	17.10	144.67
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	73.72	8.66	16.89	143.67
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	71.21	8.45	16.77	143.00
S.Em.±	2.83	0.20	0.37	2.20
C.D. at 5 %	8.14	NS	NS	NS

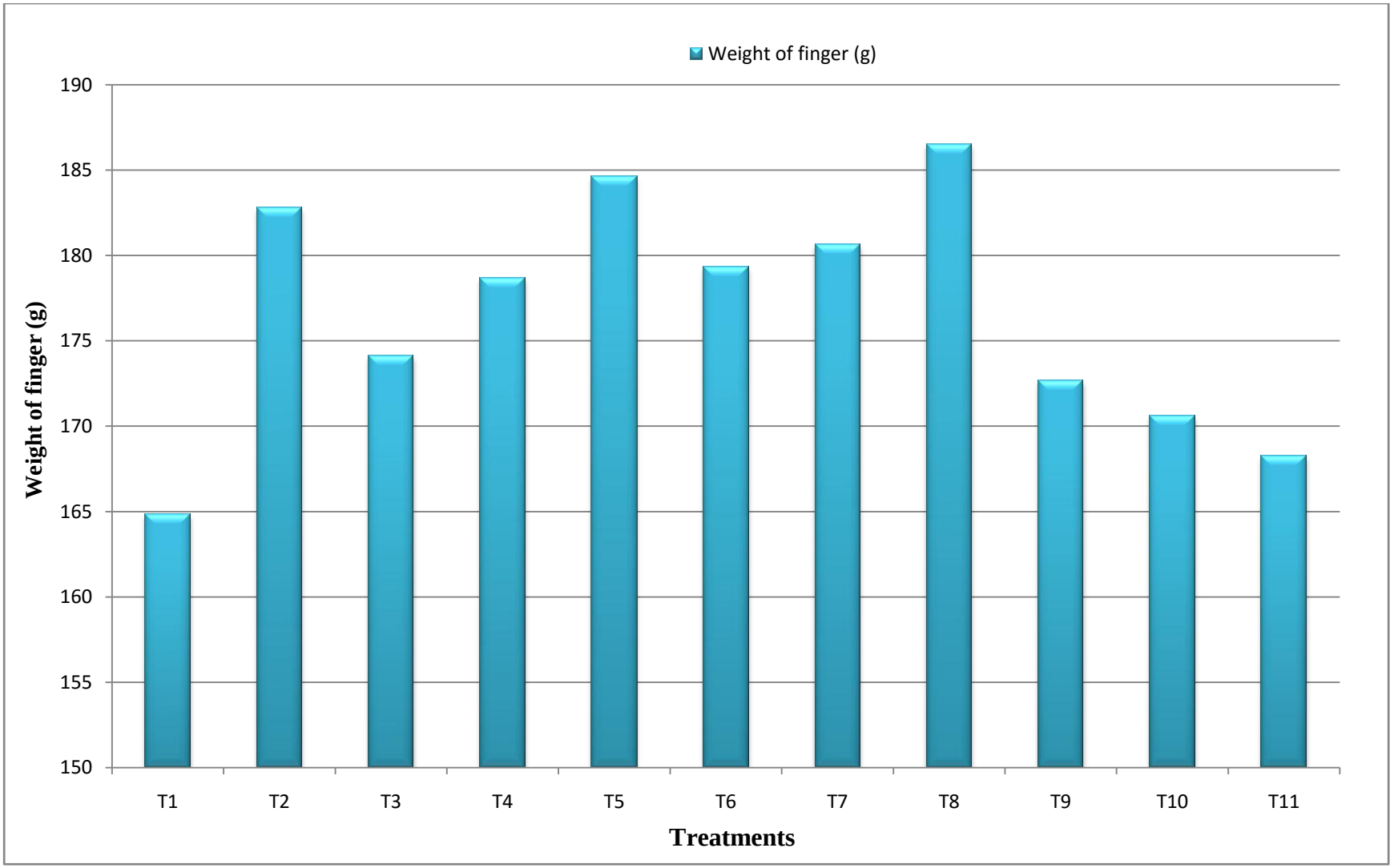


Fig. 3: Effect of bunch feeding on finger weight (g) of banana cv. Grand Naine

4.2.6 Number of hands perbunch

The effect of bunch feeding on number of hands per bunch is presented in Table 3. There were no significant differences among the treatments with number of hands per bunch, as the hands were completely opened during the imposition of treatments. Although, the number of hands per bunch ranged from 8.40 to 8.74.

4.2.7 Number of fingers perhand

The data pertaining to number of fingers per hand is furnished in Table 3. Treatments do not differ significantly for number of fingers per hand. However, number of fingers per hand varied from 16.66 to 17.33 among different treatments of bunch feeding.

4.2.8 Number of fingers perbunch

The data pertaining to the number of fingers per bunch is furnished in Table 3. Treatments do not differ significantly for number of fingers per bunch, as the number of fingers per bunch was recorded before bunch feeding and also it was not influenced by bunch feeding. However, the number of fingers per bunch ranged from 143 to 146.17 in the treatment supplied with 10g Urea + 10g SOP + 5g banana special + 100g vermicompost and 7.5 g Urea +7.5 g SOP + 500 g cow dung +100 ml of water, respectively.

4.2.9 Weight of hands(kg)

The data pertaining to mean weight of hands recorded after harvest is presented in Table 4, Fig. 4 and Plate 3. The highest hand weight (3.62 kg) was recorded in bunch provided with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5 g Urea + 7.5 g SOP + 500 g cowd ung+100 ml of water (3.53 kg), 7.5gUrea+7.5gSOP+5gbananaspecial+300gvermicompost(3.53kg)and10gUrea + 10g SOP + 5g banana special + 200g vermicompost (3.45 kg). Whereas, the lowest hand weight (2.87 kg) was recorded in control (plants without bunch feeding).

Table 4: Effect of bunch feeding on hand weight, bunch weight and total yield of banana Cv. Grand Naine

Treatments details	Weight of hands (kg)	Weight of bunch (kg)	Total yield (tons/ha)
T_1: Control	2.87	29.23	65.77
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	3.53	32.87	73.96
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	3.34	30.97	69.68
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	3.44	32.23	72.52
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	3.53	32.82	73.85
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	3.39	31.23	70.27
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	3.45	32.47	73.06
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	3.62	33.28	74.88
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	3.28	30.59	68.83
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	3.13	30.37	68.33
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	3.02	30.10	67.73
S.Em.±	0.14	1.03	0.85
C.D. at 5 %	0.41	2.23	2.63

Note: The total yield per hectare was calculated with 10% mortality of plant population.

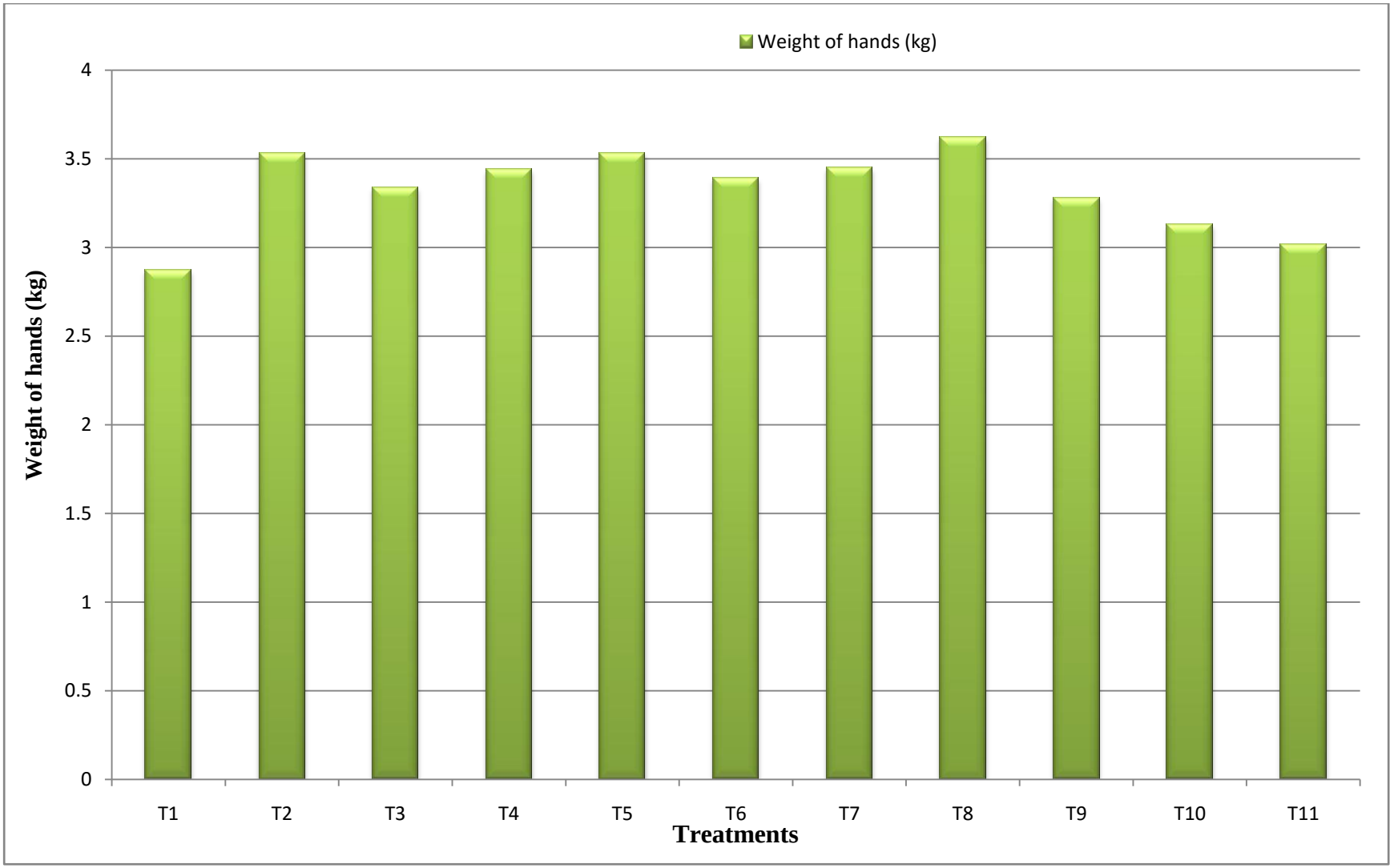
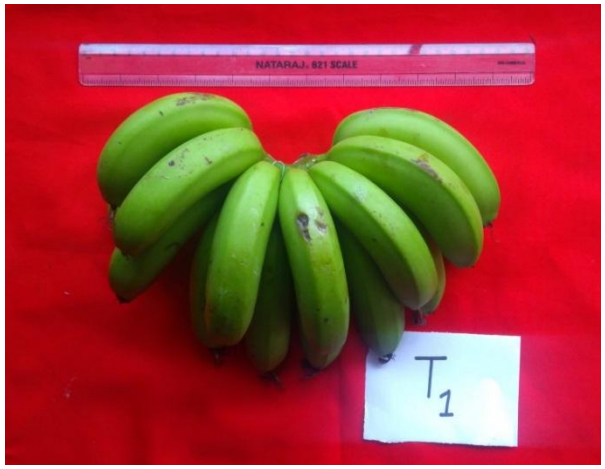
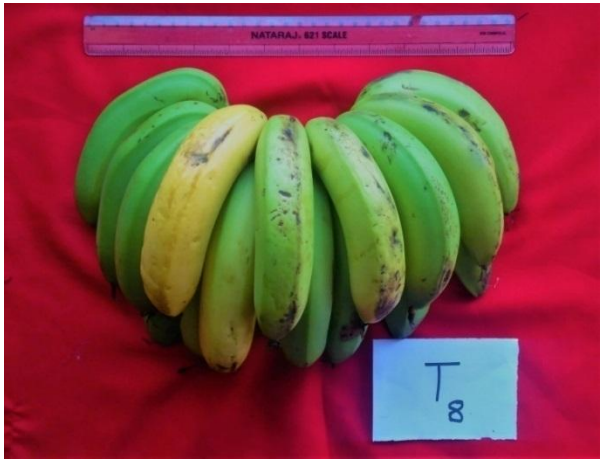


Fig. 4: Influence of bunch feeding on weight of hands (kg) of banana cv. Grand Naine



T_1- Control T_2- 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water



T_5- 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost T_8- 10g Urea + 10g SOP + 5g banana special + 300g vermicompost

Plate 3. Effect of bunch feeding on hand weight of banana

4.2.10 Weight of bunch(kg)

Bunch weight was significantly influenced by bunch feeding technique. The data pertaining to mean weight of bunch recorded after harvest is presented in Table 4, Fig. 5 and Plate 4. The highest bunch weight (33.28 kg) was recorded in bunches catered with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5 g Urea +7.5 g SOP + 500 g cow dung +100 ml of water (32.87 kg), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (32.82 kg) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (32.47 kg). Whereas, the lowest bunch weight (29.23 kg) was recorded in T_1- control.

4.2.11 Total yield per hectare (t/ha)

The yield of Grand Naine banana significantly differed due to bunch feeding with different quantity fertilizers and the data on total yield is presented in Table 4 and Fig. 6. The highest yield (74.88 t/ha) was recorded by the bunches supplied with the nutrient combination of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (73.96 t/ha), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (73.85 t/ha) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (73.06 t/ha). Least yield (65.77 t/ha) was recorded incontrol.

4.3 Effect of bunch feeding on qualityparameters

4.3.1 Physiological loss in weight(%)

The physiological loss in weight was found to differ significantly among the treatments and the data on physiological loss in weight are presented in Table 5. The highest PLW (15.58 %) was recorded in the bunches supplied with 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost, which was on par with control (15.34 %), 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost (15.31 %) and 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost (15.20 %). Meanwhile, the least PLW (12.26 %) was observed in bunches fed with7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost.

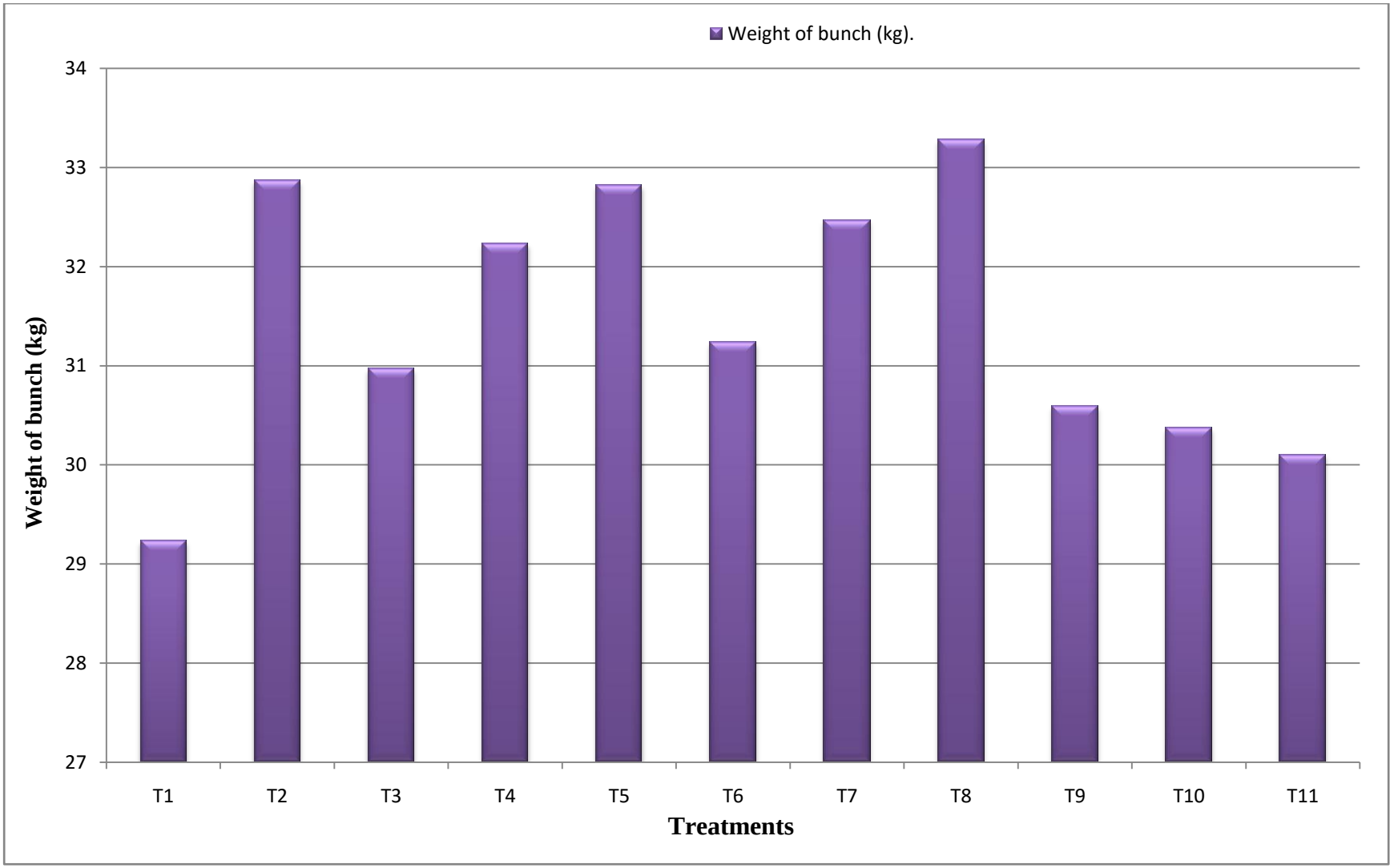


Fig. 5: Effect of bunch feeding on weight of bunch (kg) of banana cv. Grand Naine

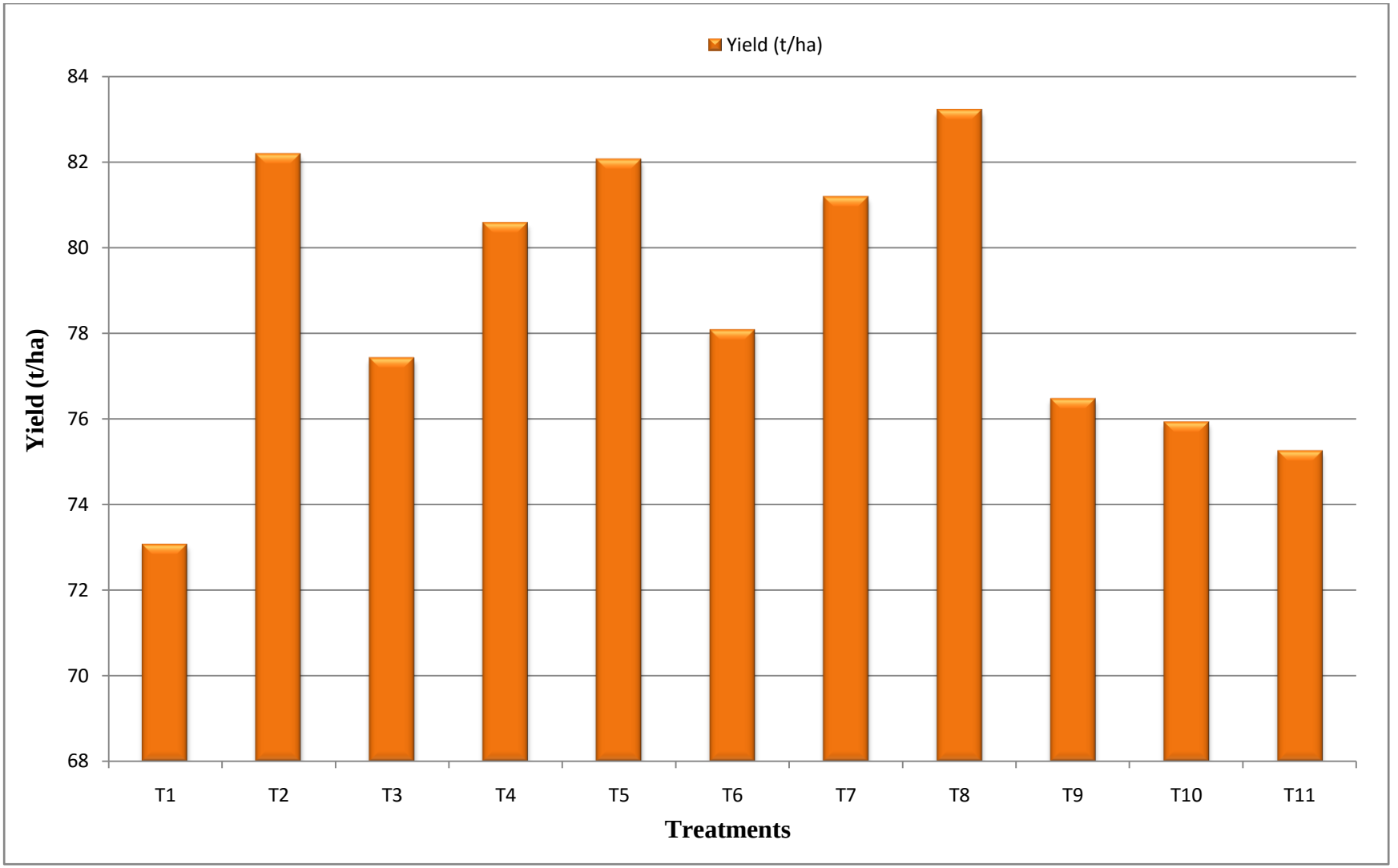


Fig. 6: Effect of bunch feeding on yield (t/ha) of banana cv. Grand Naine

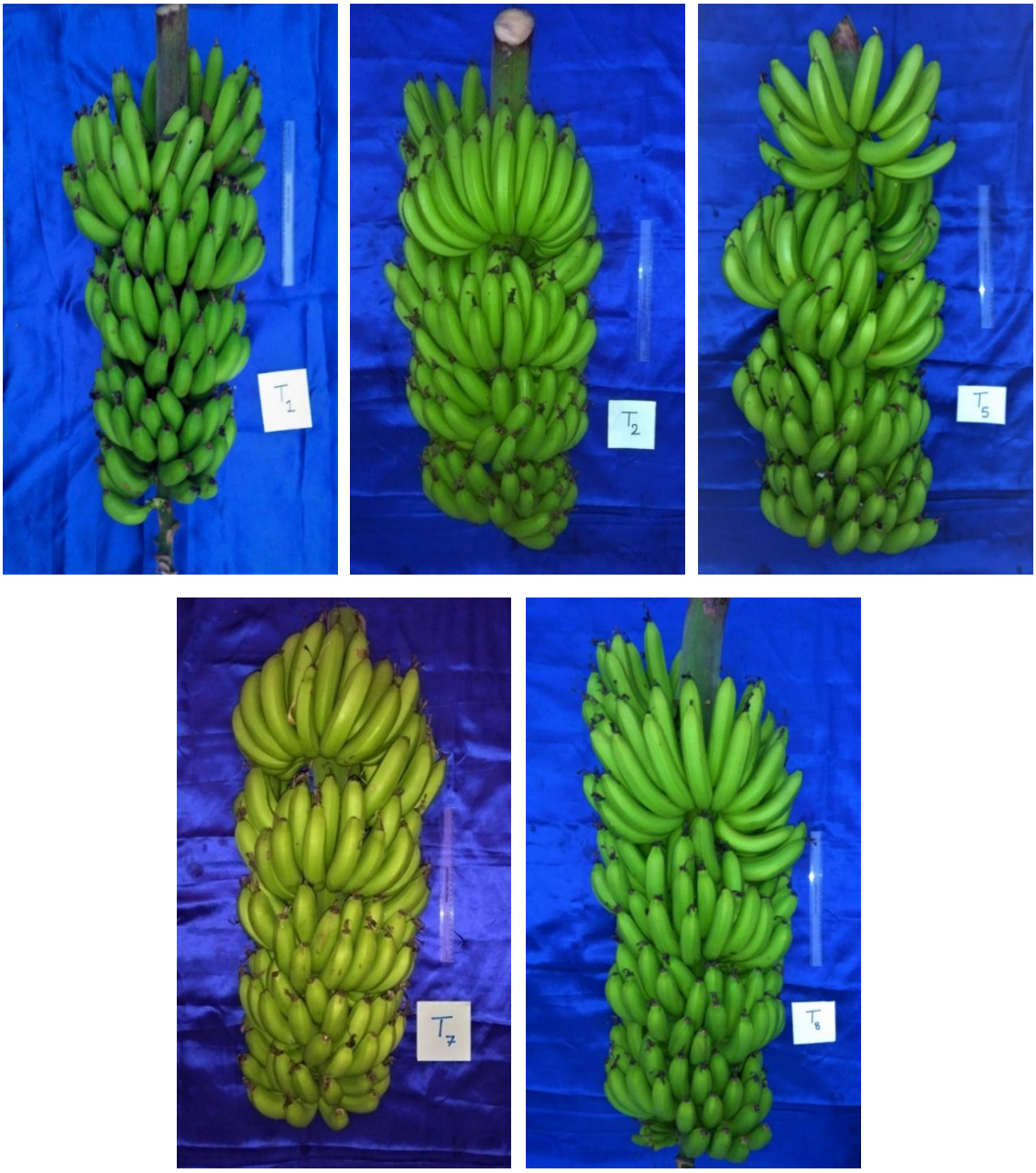


Plate 4. Influence of bunch feeding on bunch weight of banana

T_1- Control

T_2- 7.5 g Urea + 7.5 g SOP + 500 g cow dung +100 ml of water

T_5- 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost

T_7- 10g Urea + 10g SOP + 5g banana special + 200g vermicompost

T_8- 10g Urea + 10g SOP + 5g banana special + 300g vermicompost

Table 5: Influence of bunch feeding on PLW and firmness of fruit of banana Cv. Grand Naine

Treatments details	PLW (%)	Firmness (kg/cm^2)
T_1: Control	15.34	2.17
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	12.38	3.62
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	13.68	3.23
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	13.29	3.52
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	12.26	3.76
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	13.38	3.41
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	12.61	3.63
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	12.52	3.57
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	15.20	2.96
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	15.31	2.83
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	15.58	2.65
S.Em.±	0.20	0.06
C.D. at 5 %	0.65	0.21

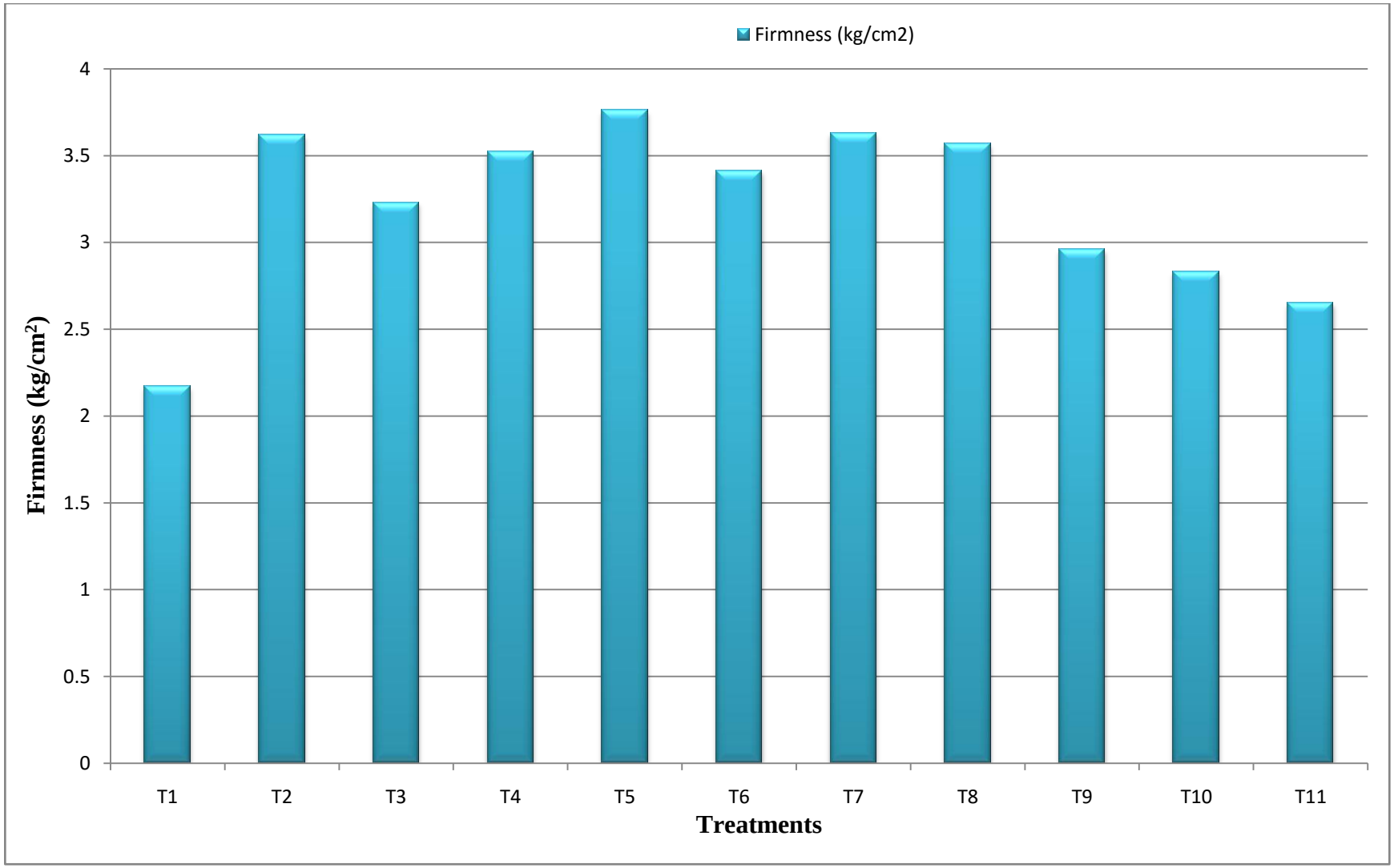


Fig. 7: Influence of bunch feeding on fruit firmness (kg/cm^2) of banana cv. Grand Naine

4.3.2 Firmness(kg/cm^2)

The firmness of the fruit (textural analysis) was measured by using penetrometer. There was a significant difference between the effect of treatments on firmness of fruits and the data pertained to this is presented in the Table 5 and Fig. 7. The maximum firmness of fruit was recorded in the treatment where, the bunches supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.76 kg/cm^2) which was on par with, 10g Urea + 10g SOP + 5g banana special+ 200g vermicompost (3.63 kg/cm^2), 7.5gUrea+7.5gSOP+500gcowdung+100mlofwater(3.62kg/cm^2)and10gUrea + 10g SOP + 5g banana special + 300g vermicompost (3.57 kg/cm^2). The minimum firmness of fruit (2.17 kg/cm^2) was recorded in control.

4.3.3 Weight of pulp(g)

The bunch feeding with the different quantity of nutrients had significant effects on pulp weight (Table 6 and Fig. 8). The maximum pulp weight (169.63 g) was observed in the bunches provided with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (169.41 g), 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (168.16 g), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (165.21 g) and 10g Urea + 10g SOP + 5g banana special + 100g vermicompost (160.98 g). However, the minimum sugar (148.78 g) was observed incontrol.

4.3.4 Weight of peel(g)

Bunch feeding had a significant effect on weight of peel. Observations regarding peel weight were furnished in Table 6 and Fig. 8. The maximum peel weight (62.06 g) was observed in the bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (61.92 g), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (61.65 g) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (61.62 g). The minimum peel weight (57.66 g) was observed in control.

Table 6: Effect of bunch feeding on pulp weight, peel weight and pulp to peel ratio of banana Cv. Grand Naine

Treatments details	Weight of pulp (g)	Weight of peel (g)	Pulp to peel ratio
T_1: Control	148.78	57.66	2.56
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	168.16	61.92	2.71
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	156.30	59.26	2.62
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	161.75	60.60	2.68
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	169.41	61.65	2.73
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	160.98	60.74	2.64
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	165.21	61.62	2.71
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	169.63	62.06	2.74
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	154.75	59.31	2.64
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	153.13	58.56	2.62
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	150.48	58.23	2.60
S.Em.±	2.67	1.04	0.02
C.D. at 5 %	8.11	3.20	0.06

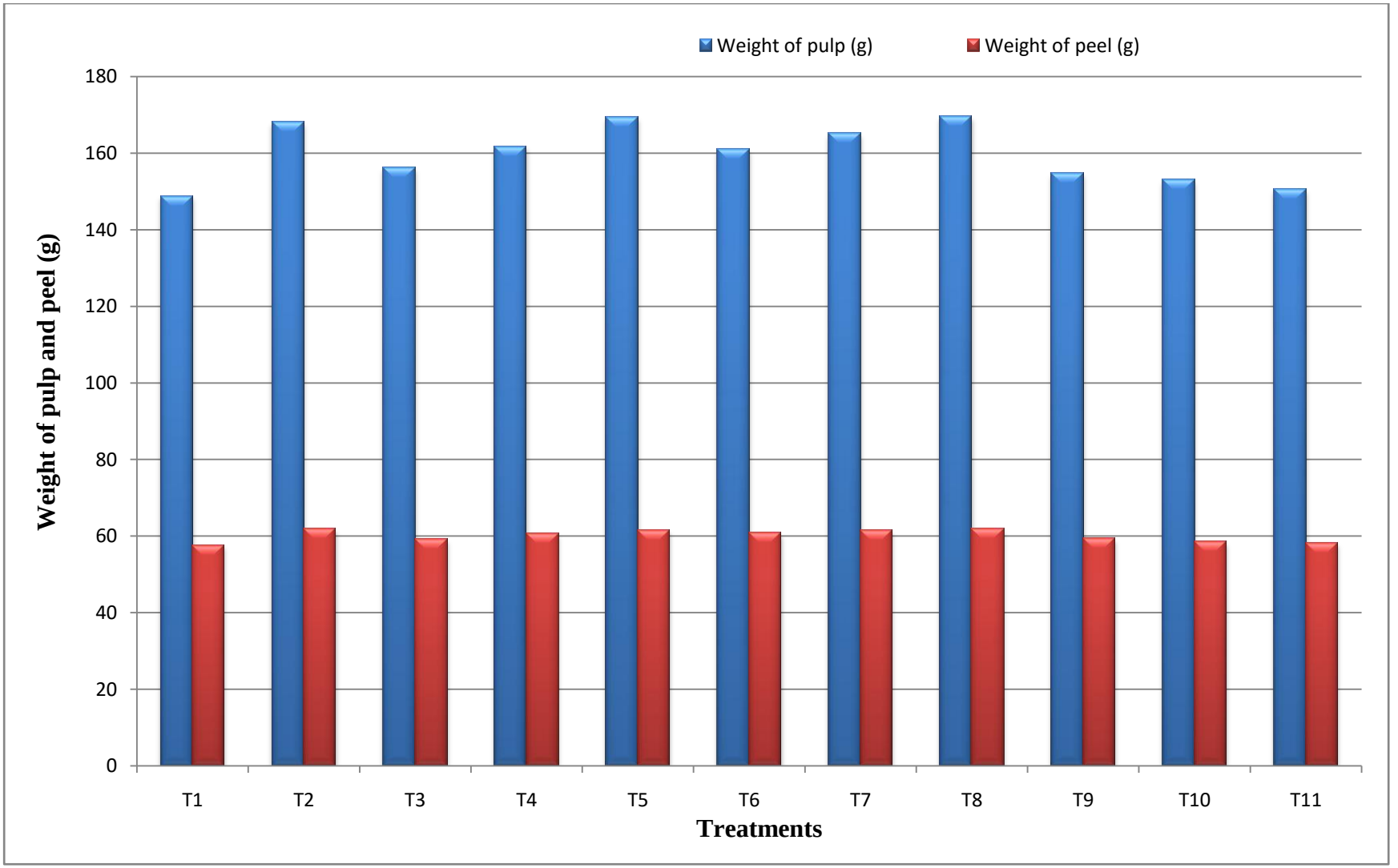


Fig. 8: Effect of bunch feeding on pulp weight (g) and peel weight (g) of banana cv. Grand Naine

4.3.5 Pulp to peelratio

The data pertaining to pulp to peel ratio is furnished in Table 6 and Fig. 8. The treatments differed significantly for pulp to peel ratio. The highest pulp to peel ratio (2.74) was recorded in bunches catered with the nutrient combination of 10g Urea+ 10g SOP+ 5g banana special+ 300g vermicompost, which was on par with 7.5g Urea+ 7.5g SOP+ 5g banana special+ 300g vermicompost (2.73), 10g Urea + 10g SOP+ 5g banana special + 200g vermicompost (2.71), 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (2.71) and 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost (2.68) . The Least pulp to peel ratio (2.56) was observed incontrol.

4.3.6 Total soluble solid(^{0}Brix)

Total soluble solids of fruit exhibited significant differences among the treatments and the data is presented in the Table 7 and Fig. 9. The highest TSS (22.11 ^{0}Brix) was recorded in the bunches provided with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (22.05 ^{0}Brix), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (21.90 ^{0}Brix), 7.5 g Urea + 7.5 g SOP + 500 g cow dung +100 ml of water (101.43 ^{0}Brix) and the bunch fed with 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (21.73 ^{0}Brix). The least TSS (19.60 ^{0}Brix) was recorded in control.

4.3.7 Acidity (%)

The data pertaining to total titrable acidity is furnished in Table 7 and Fig. 10. The percentage of titrable acidity varied significantly among the treatments. Lowest titrable acidity (0.24 %) was obtained from the bunches fed with dipping the cut end in 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with the bunch fed with 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (0.25 %), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (0.25 %), 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (0.26 %) and 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (0.27 %). The highest titrable acidity (0.31 %) was noticed in control.

Table 7: Influence of bunch feeding on TSS and acidity of fruit of banana Cv. Grand Naine

Treatments details	Total soluble solid (ºBrix)	Acidity (%)
T_1: Control	19.60	0.31
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	21.85	0.26
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	20.32	0.29
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	21.73	0.27
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	22.05	0.25
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	20.81	0.28
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	21.90	0.25
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	22.11	0.24
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	20.80	0.29
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	21.25	0.28
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	21.48	0.28
S.Em.±	0.34	0.01
C.D. at 5 %	1.05	0.03

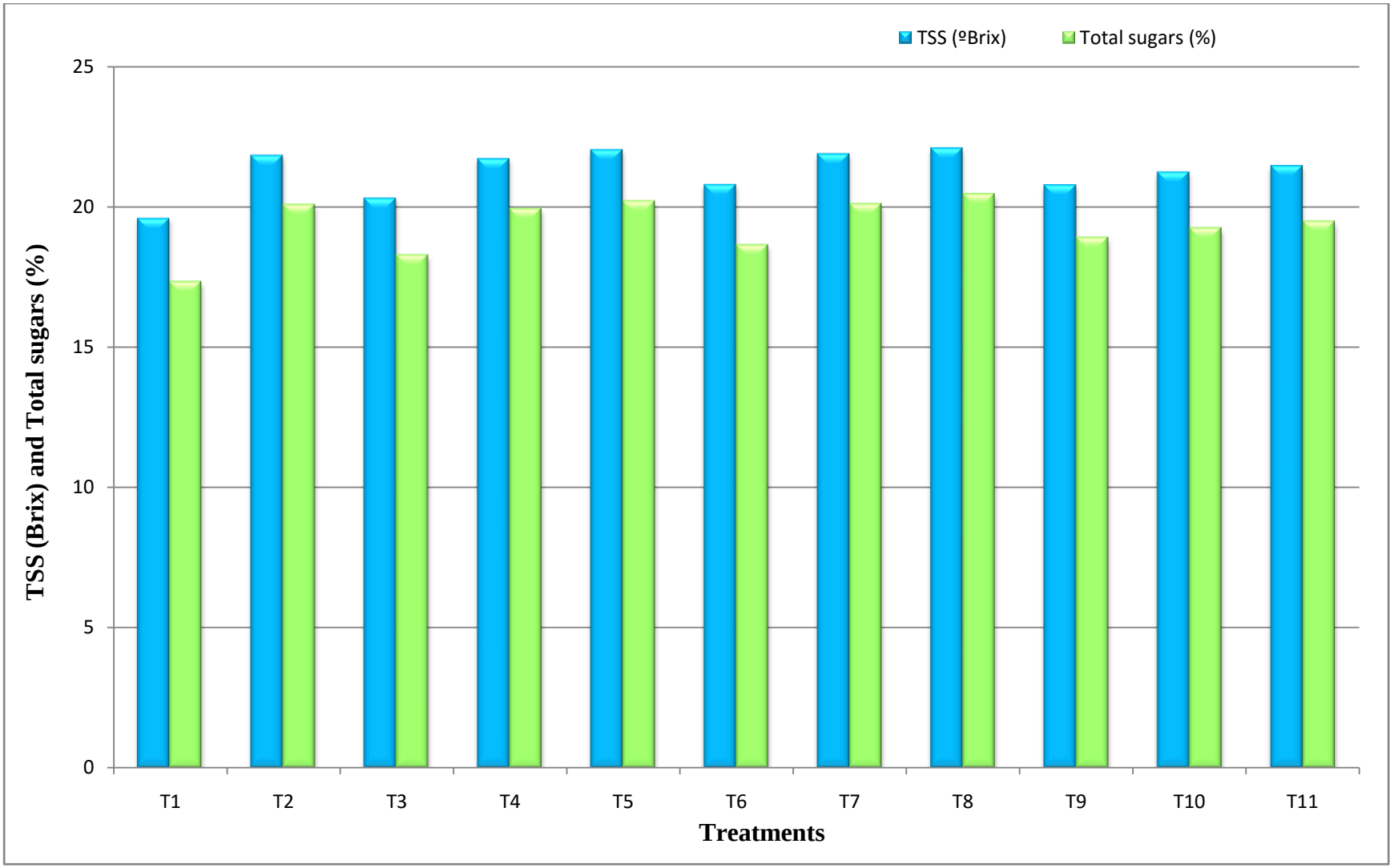


Fig. 9: Influence of bunch feeding on TSS (^{0}Brix) and total sugar content (%) of banana fruits cv. Grand Naine

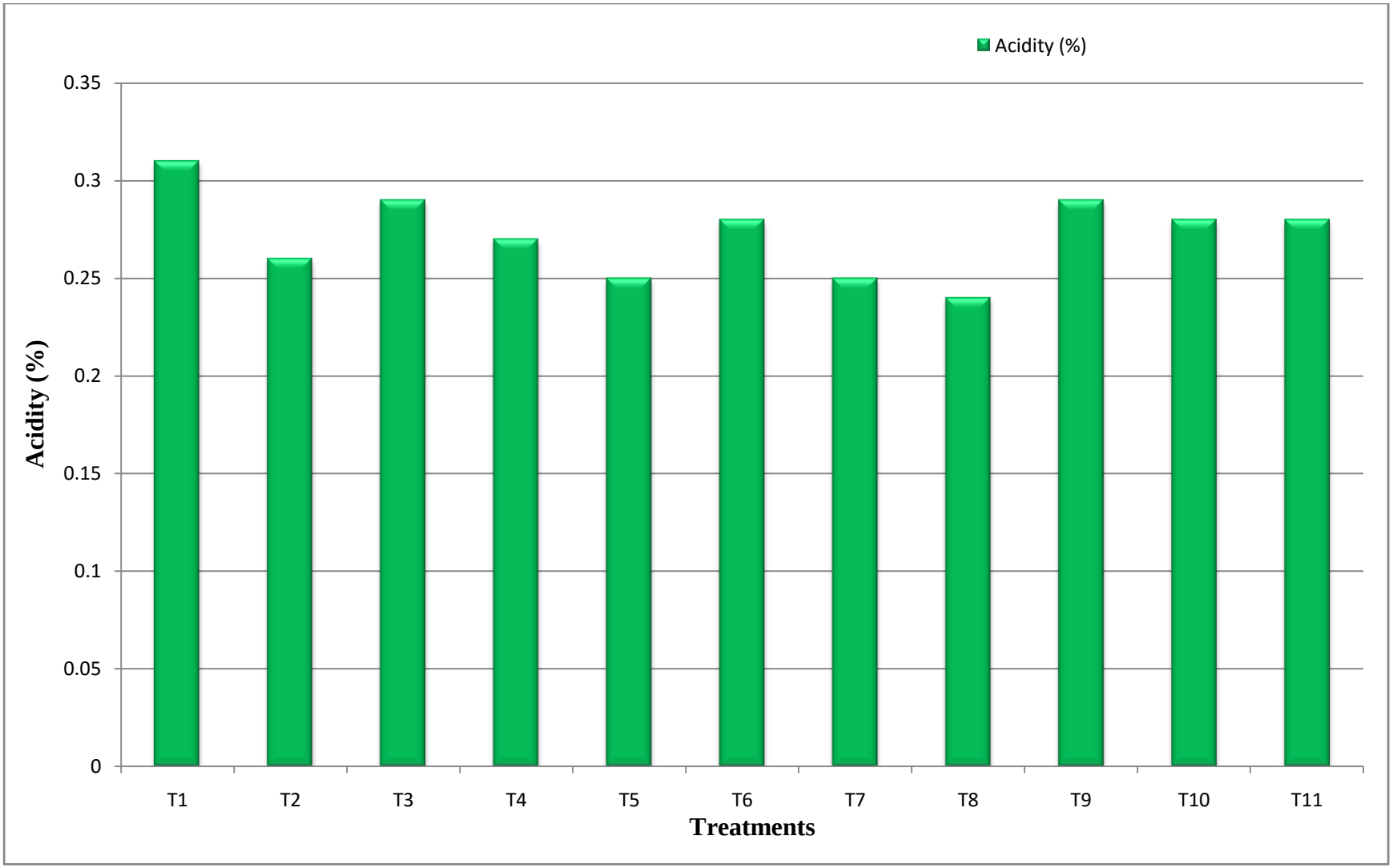


Fig. 10: Influence of bunch feeding on acidity (%) of banana cv. Grand Naine

4.3.8 Reducing sugars(%)

Significant differences were observed among the treatments with respect to reducing sugar content and the data is presented in the Table 8 and Fig. 9. The maximum reducing sugar (17.67 %) was observed in the treatment combination of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (17.48 %), the 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (17.39 %), 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (17.39 %) and 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (17.26 %). However, the minimum reducing sugar (15.10 %) was recorded in control.

4.3.9 Non-reducing sugars(%)

Significant differences were observed among the treatments with respect to non-reducing sugars content and the data is depicted in the Table 8 and Fig. 9. The maximum reducing sugar (2.79 %) was observed in the bunches supplied with the nutrient combination of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (2.72 %), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (2.71 %) and 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost (2.68 %). However, the minimum non-reducing sugar (2.23 %) was recorded in control.

4.3.10 Total sugars(%)

Significant differences were observed among the treatments with respect to total sugars content and the data is furnished in the Table 8 and Fig. 9. The maximum sugar (20.46 %) was observed in the bunches fed with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (20.20 %), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (20.10 %) and bunch fed with 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (20.07 %). However, the minimum sugar (17.33 %) was observed incontrol.

Table 8: Effect of bunch feeding on sugar content in fruits of banana Cv. Grand Naine

Treatments details	Reducing sugars (%)	Non reducing sugars (%)	Total sugars (%)
T_1: Control	15.10	2.23	17.33
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	17.39	2.68	20.07
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	15.72	2.56	18.28
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	17.26	2.67	19.93
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	17.48	2.72	20.20
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	16.09	2.55	18.64
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	17.39	2.71	20.10
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	17.67	2.79	20.46
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	16.32	2.58	18.9
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	16.59	2.65	19.24
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	16.78	2.70	19.48
S.Em.±	0.48	0.06	0.69
C.D. at 5 %	1.49	0.20	2.04

4.3.11 Colour development of fingers (Number ofdays)

The number of days required to change the colour of banana from green to yellow was recorded. There was a significant difference between the effect of treatments on colour development of fruits and the data pertained to this is presented in the Table 9. The maximum number of days (12.32) required for colour development was recorded in bunches provided with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, which was on par with 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (12.06 days), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (11.95 days), 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water (11.63 days) and 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (11.25 days). While, the minimum days required for colour development (8.21 days) was recorded incontrol.

4.3.12 Shelf life(Days)

The data pertaining to the shelf life in banana as influenced by bunch feeding with nutrients are furnished in Table 9. Significantly higher shelf life (6.71 days) was recorded in bunches supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost which was on par with, 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (6.46days), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (6.45 days) and 10g Urea + 10g SOP + 5g banana special + 300g vermicompost (6.39 days). The lowest (5.66 days) shelf life was observed incontrol.

4.3.13 Sensory evaluation

Organoleptic evaluation of ripe fruits of banana was conducted on the basis of colour, flavour, aroma, taste and overall acceptability by a panel of ten judges using a nine point Hedonic scale. Result regarding sensory evaluation was furnished in Table 10 and Fig. 11. The treatments with bunch feeding of nutrient combination involving 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost, 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost were found to have greatest preferences among all other nutrientcomposition.

Table 9: Effect of bunch feeding on colour development and shelf life of banana Cv. Grand Naine

Treatments details	Colour of finger (Days)	Shelf life (days)
T_1: Control	8.21	5.66
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	11.63	6.46
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	9.77	5.91
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	11.25	5.95
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	11.95	6.71
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	10.40	5.92
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	12.06	6.45
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	12.32	6.39
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	10.3	6.05
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	10.12	5.96
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	9.8	5.79
S.Em.±	0.39	0.27
C.D. at 5 %	1.20	0.84

Table 10: Influence of bunch feeding of nutrients on sensory parameters of banana cv. Grand Naine

Treatments details	Colour	Flavour	Aroma	Taste	Overall acceptability
T_1: Control	6.2	6.2	7.6	7.2	6.8
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	6.8	7.4	8.2	7.8	7.55
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	6.8	7.6	8	8	7.6
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	7.4	8.2	8.2	8.2	8.25
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	7.6	8.4	8.4	8.6	8.3
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	7.4	8	8	8.2	7.8
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	7.8	8.4	8.4	8.2	8.2
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	7.8	8.4	8.4	8.4	8.3
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	7.4	8	8	8	7.85
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	7.6	8	8	8	7.9
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	7.4	8.2	8.2	7.8	7.9
S.Em.±	0.25	0.21	0.35	0.26	0.17
C.D. at 5 %	0.75	0.64	NS	0.82	0.53

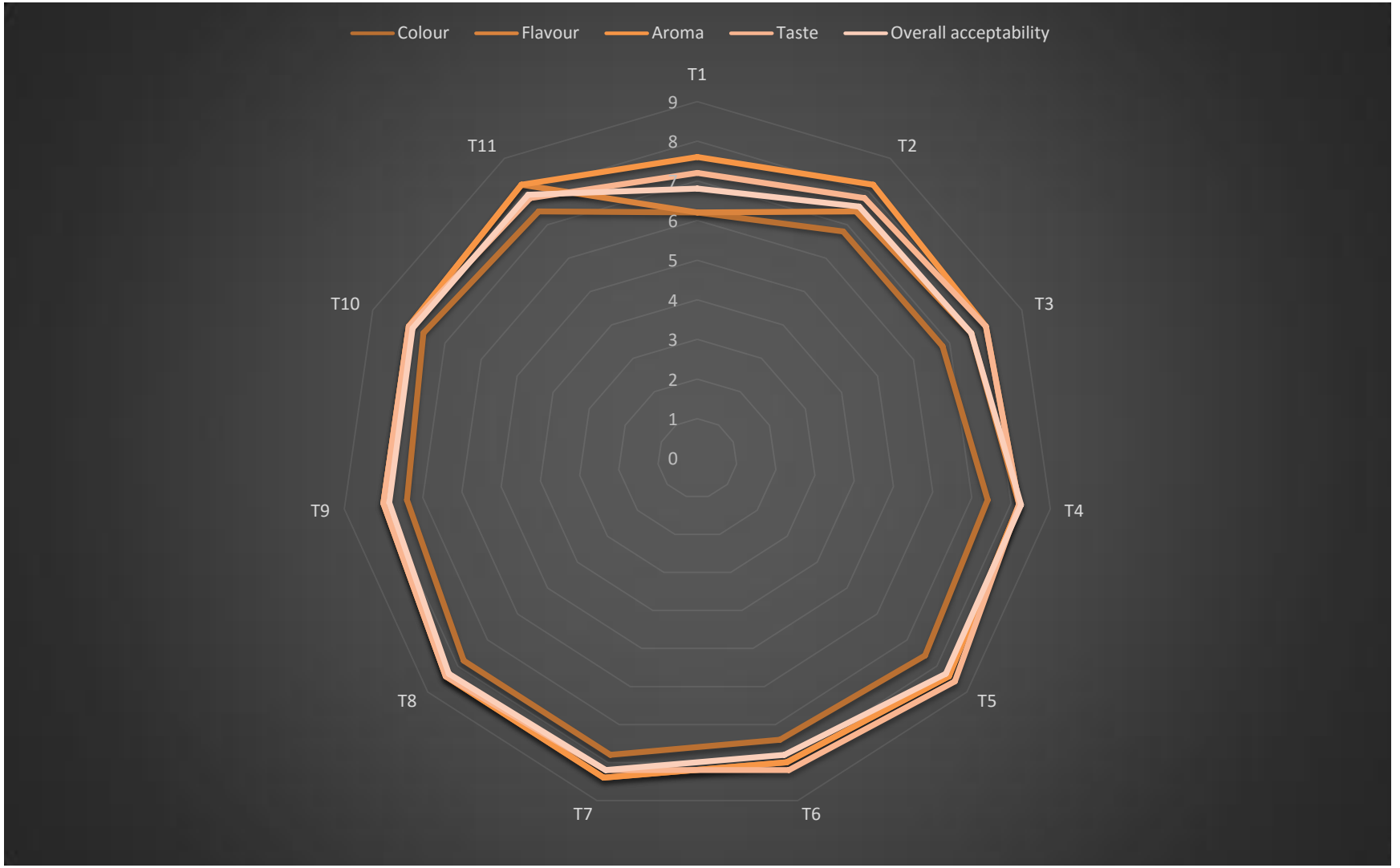


Fig. 11: Influence of bunch feeding of nutrients on sensory parameters of banana cv. Grand Naine

4.4 Nutrientuptake

The amount of nutrients namely nitrogen, potassium and sulphur were estimated before applying to the bunch and after the harvest to quantify the amount of nutrients absorbed by the bunch. The data pertaining to nutrient uptake was furnished in Table 11. The uptake of nutrients ranged from 44 percent to 63 percent in different treatments.

4.5 Effect of bunch feeding on benefit costratio

The benefit cost ratio seen to be significantly differed among the treatments due to bunch feeding of nutrients and the data pertained to benefit-cost ratio are presented in the Tables 12,13 and Fig. 12. The maximum benefit cost ratio (3.85:1) was obtained by bunch feeding with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost. The treatments with bunch feeding of 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.81:1), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (3.80:1) and7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (339:1), were found to be subsequent best treatments. Whereas, the minimum benefit cost ratio (2.94:1) was obtained in dipping the cut end with 12.5g Urea + 12.5g SOP + 5g banana special + 300gvermicompost.

Table 11: Nutrient content of bunch feeding solution before feeding and after harvest

Treatments details	Before bunch feeding			After the harvest		
	N (g)	K (g)	S (g)	N (g)	K (g)	S (g)
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	11.25	6.92	3.57	5.8	3.11	1.99
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	5.52	4.65	1.08	2.23	2.41	0.56
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	8.22	6.38	1.53	3.61	3.12	0.73
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	11.64	8.23	2.17	4.77	3.29	0.92
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	6.84	5.36	1.98	3.28	2.78	1.02
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	9.41	7.56	2.42	4.14	3.7	1.16
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	11.34	9.14	2.84	4.64	3.65	1.3
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	9.18	7.84	2.65	4.4	3.84	1.27
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	11.13	9.56	3.04	4.78	4.3	1.33
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	14.06	11.21	3.66	5.2	4.25	1.53

Table 12: Cost incurred for the respective treatments for production of banana Cv. Grand Naine per hectare during 2017-18

Treatments details	Cost of the treatments (Rs/ ha)			Total cost of Cultivation (Rs/ ha)
	Chemical / nutrients	Labour	Total	
T_1: Control	-	-	-	2,35,535
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	3,117	1,500	4,617	2,40,152
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	8,517	1,500	10,017	2,45,552
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	11,603	1,500	13,103	2,48,638
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	14,689	1,500	16,189	2,51,724
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	9,566	1,500	11,066	2,46,601
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	12,652	1,500	14,152	2,49,687
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	15,738	1,500	17,238	2,52,773
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	10,616	1,500	12,116	2,47,651
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	13,702	1,500	15,202	2,50,737
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	16,788	1,500	18,288	2,53,823

Table 13: Influence of bunch feeding on benefit–cost ratio of banana Cv. Grand Naine

Treatment details	Total cost (₹/ha)	Fruit yield (tonnes / ha)	Gross income (₹/ha)	Net returns (₹/ha)	Benefit : Cost ratio
T_1: Control	2,35,535	65.77	723442.5	487907.5	3.07
T_2: 7.5g Urea + 7.5g SOP + 500g cow dung + 100 ml of water (IIHR Bunch feeding recommendation)	2,40,152	73.96	813532.5	573380.5	3.39
T_3: 7.5g Urea + 7.5g SOP + 5g banana special + 100g vermicompost	2,45,552	69.68	766507.5	520955.5	3.12
T_4: 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost	2,48,638	72.52	942727.5	694089.5	3.79
T_5: 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost	2,51,724	73.85	959985	708261	3.81
T_6: 10g Urea + 10g SOP + 5g banana special + 100g vermicompost	2,46,601	70.27	772942.5	526341.5	3.13
T_7: 10g Urea + 10g SOP + 5g banana special + 200g vermicompost	2,49,687	73.06	949747.5	700060.5	3.80
T_8: 10g Urea + 10g SOP + 5g banana special + 300g vermicompost	2,52,773	74.88	973440	720667	3.85
T_9: 12.5g Urea + 12.5g SOP + 5g banana special + 100g vermicompost	2,47,651	68.83	757102.5	509451.5	3.06
T_{10}: 12.5g Urea + 12.5g SOP + 5g banana special + 200g vermicompost	2,50,737	68.33	751657.5	500920.5	3.00
T_{11}: 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost	2,53,823	67.73	744975	491152	2.94

Note: The detailed cost of cultivation and the cost of the different chemicals or nutrients during the experimentation period is enclosed in the appendix –II and appendix –III respectively. The fruits of the treatments (T_4, T_5, T_7 and T_8) with best quality were sold at Rs. 13.00 per kg and the rest were sold at 11.00 Rs./kg.

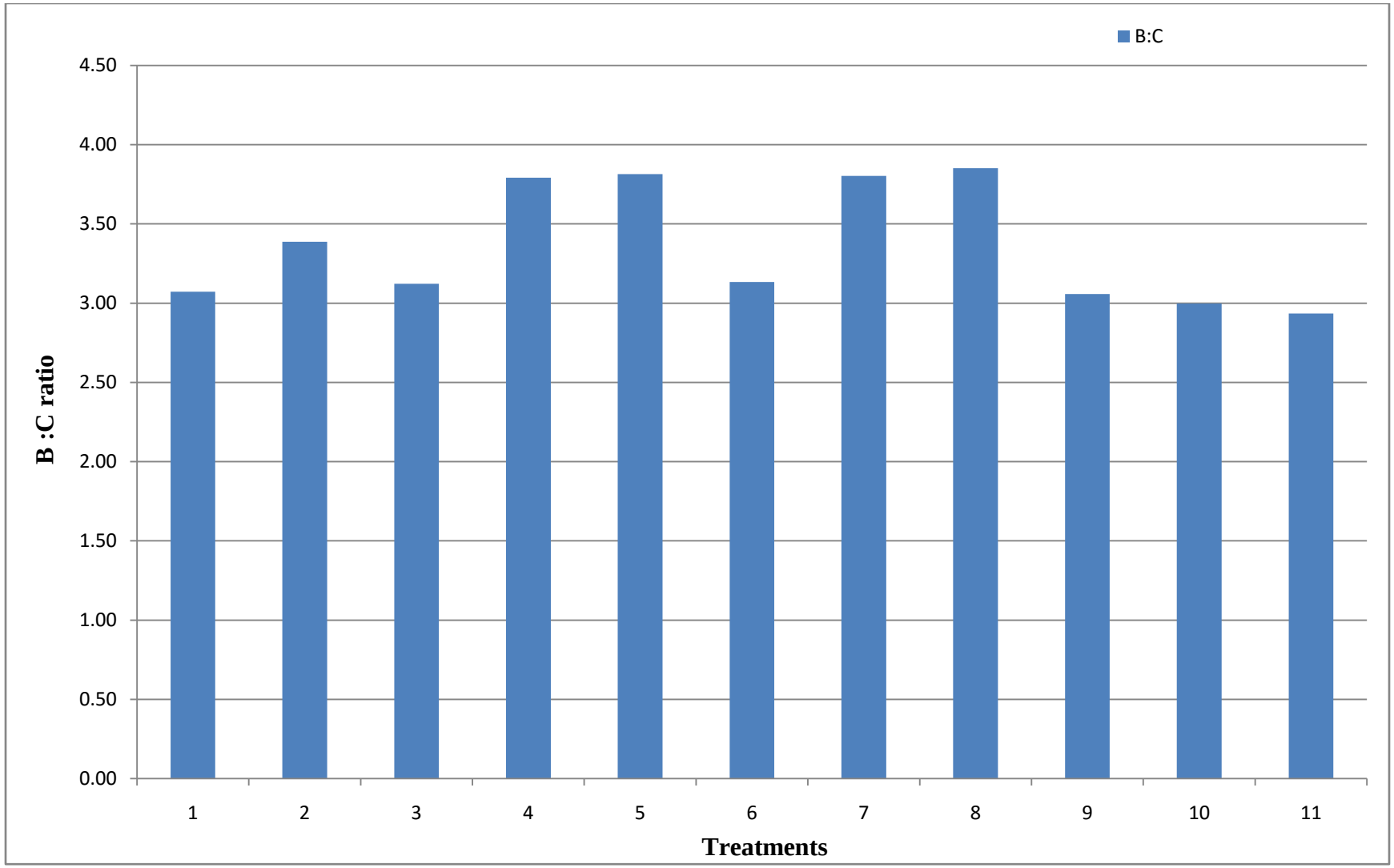


Fig. 12: Effect of bunch feeding on benefit : cost ratio of banana cv. Grand Naine

Discussion

V. DISCUSSION

Banana cv. Grand naine is becoming much popular variety because of its high yield potential and good adoptability. As tissue cultured banana plants are heavy nutrient feeders due their large roots compared to normal banana plants, nutrient management plays a vital role in obtaining its potential yield with attractive fingers and delicious quality. In this regard, the banana bunch feeding technique is getting much attention among farming community. Keeping this in view the present study was taken up with an objective to improve the yield and quality of banana cv. Grand Naine. The results obtained in this investigation are discussed in this chapter.

5.1 Effect of bunch feeding on vegetativeparameters

5.1.1 Plant height(cm)

There were no significant differences among the treatments with respect to plant height, as the height of the plant was recorded before bunch feeding and also it was not influenced by bunch feeding. Since the experimented plants given the same treatment from planting till to flower. Similar observations were noticed by Sreekanth (2013).

5.1.2 Pseudostem girth(cm)

Pseudostem girth was seen to be non significant with different treatments imposed, as the pseudostem girth was recorded before bunch feeding and the uniform plants were selected forexperimentation.

5.1.3 Number of leaves at the time ofshooting

There were no significant differences among the treatments with respect to number of leaves at shooting, as the number of leaves was recorded before bunch feeding and also it was not affected by bunchfeeding.

5.1.4 Days taken for complete opening ofbunch

There were no significant differences among the treatments with respect days taken for complete opening of bunch as this duration was recorded before bunch feeding and also it was not influenced by treatments imposed.

5.1.5 Number of days taken from shooting toharvest

The results revealed that the number of days taken from shooting to harvest were significantly differed among the treatments. An early harvesting (121.58 days) was recorded in the bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost and control has taken more days for harvesting (127.17 days). Whereas, bunches supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (122.33 days) was the next best treatment. Similar results on days taken for maturity of the bunches reported by Garasangi *et al.* (2018) in cv. Rajapuri, Nandan Kumar *et al.* (2011) in cv. Nanjangudu Rasbale, Ramesh and Kumar (2007 and 2010) in cv. Neypoovan, they found that reduction in duration from shooting to harvest might be due to the presence of nitrogen in Urea, increased the auxin concentration in plant, which might have helped in cell elongation and inturn enhanced the faster growth rate of the banana spadix, efficient source sink relationship may be attributed for minimum number of days for maturity. The above finding was in conformity with Bhalerao *et al.* (2009) in cv. Grand Naine.

5.2 Effect of bunch feeding on yieldparameters

5.2.1 Finger length(cm)

Finger length was significantly influenced by application of different bunch feeding treatments. The increase in finger length (21.23 cm) was observed in the bunches provided with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost. The minimum finger length (17.37 cm) was noticed in control. However, bunch supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (20.87 cm) was found to be the next best treatment which was found to be on par with best treatment. The results were in close confirmity with Ramesh Kumar and Kumar (2007) in cv.Ney

Poovan and Nandankumar *et al.* (2011) in cv. Nanjangudu rasabale (AAB), who have reported that nutrients supplied would have been utilized for cell elongation of fruits and formation of larger intercellular spaces during later part of fruit growth.

It can be inferred that, the nutrient supplied in the form of Urea was utilized more for cell elongation of the fruits rather than cell multiplication and the cell enlargement which resulted in more length than girth of the finger. The Urease activity also coincided with lengthening of fruits as reported by Ancy *et al.* (1998).

4.2.2 Finger girth (cm)

The results revealed that the highest finger girth (13.60 cm) was recorded in bunches catered with nutrient solution of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost and the lowest finger girth (11.55 cm) was recorded in control (plants without bunch feeding). Bunch fed with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost was on par with the highesttreatment.

The increase in girth intern reflected on final weight of the finger, which clearly indicated that potassium is involved in cell enlargement rather than cell division as there was not much increase in length of fruit when compared to other treatments. The increase in finger girth might be due to the exogenous potassium supply which acted as an activator of several enzymes. Presence of sulphur in sulphate of potash has a synergistic effect with zinc which is essential for carbon dioxide absorption and utilization, synthesis of RNA and auxin, which increased the girth of fruit. Similar observations were made by Ancy and Kurein (2000) in cv. Nendran, Rameshkumar and Kumar (2007) in cv. Ney Poovan, Nandankumar *et al*. (2011) in cv. Nanjanagudu Rasabale, Sharma *et al.,* (2014) in cv. Borjahaji and Garasangi *et al.* (2018) in cv.Rajapuri.

The increase in length and diameter of guava fruit may be due to the micronutrients (Boron and Zinc) appear to have indirect role in hastening the process of cell division and cell elongation due to which size and weight would have improved in guava (*Psidium guajava* L.) cv. L-49 was reported by Yadav *et al*. (2011).

5.2.3 Finger weight(g)

The highest finger weight (186.53 g) was recorded in bunches supplied with 10g Urea+ 10g SOP+ 5g banana special+ 300g vermicompost and the lowest finger weight (164.8 cm) was recorded in control. Bunches supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (159.87 g) was on par with best treatment. Similar results on fruit weight were found by Rameshkumar and Kumar (2007 and 2010) in cv. Ney Poovan, Nandan Kumar *et al*. (2011) in Nanjanagudu Rasabale, Ramesh kumar *et al*. (2008) in cv. Robusta and Garasangi *et al.* (2018) in cv. Rajapuri.

The increase in finger weight supported with the findings by Calvin *et al.* (1952), Mothes (1961) and Harper (1984), who reported that in plants alointoin and allantonic acid seems to be more immediately concerned with the synthesis and use of nitrogen they contain and these compounds may be derived from glycoxylic acid with Urea as a possible donor (nonUrease pathway). In a study on the morpho-physiological aspects of finger development it was observed that, in the final stage of development, cell enlargement took place thus, reducing the available air space followed by starch filling in the cells. The late application of Urea, coinciding with or after the stages of cell division, when the early nitrogen pool becomes exhausted, may be involved in fruit development as a nitrogen source (Kurien *et al.,* 1999). The results were in close confirmity with Ancy and Kurien (2000) in cv.Nendran.

The increase in finger weight might be due to the rapid multiplication and enlargement of cells and greater acculmulation of sugars or carbohyadrates and water in the expanded cells (Ramesh Kumar and Kumar, 2007). The results are in confirmity with those reported by Sandhya *et al.* (2016) in banana cv. Grand Naine, Nandankumar *et al.* (2011) in cv. Nanjangudu rasabale.

5.2.4 Finger volume(cm^3)

It was inferred from the results that there were significant differences in finger volume between the treatments. The highest finger volume (162.17 cm^3) was observed in the bunches provided with added nutrient combination of 10g Urea + 10g SOP + 5g

banana special + 300g vermicompost and the lowest finger volume (164.80 cm^3) was noticed in control. Bunch feeding with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost was on par with best treatment.

The increase in length, girth and weight of finger reflected on finger volume. The increase in finger weight might be due to the rapid multiplication and enlargement of cells and greater acculmulation of photosynthates and water in the expandedcells.

5.2.5 Length of bunch (cm)

It could be noticed from the results that there were significant differences in bunch length among the treatments. The increased bunch length (84.48 cm) was noticed intreatmentwithadditionalnutrientsupplyof10gUrea+10gSOP+5gbananaspecial + 300g vermicompost as bunch feeding. While, the lowest bunch length (68.43 cm) was noticed in control. The increased bunch length might be due to the additional supply of potassium which helps in cell division and cell expansion by treatment effect on RNA and DNA synthesis. This was in conformity with the findings of Nalina and Kumar (2007) in cv.Robusta.

5.2.6 Number of hands perbunch

The effect of bunch feeding on number of hands per bunch is found to be non significant among the treatments as the hands were completely opened during the imposition of treatments. Similar observations were noticed by Sreekanth (2013).

5.2.7 Number of fingers perhand

The number of fingers per hand did not have any significant differences among the bunch feeding treatments due to the imposition of treatments after complete emergence ofbunch.

5.2.8 Number of fingers perbunch

The results inferred that the treatments do not differ significantly for number of fingers per bunch, as the number of fingers per bunch was recorded before bunch feeding and also it was not influenced by bunch feeding.

5.2.9 Weight of hands, and bunch and yield perhectare

The results depicted that the bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost has recorded highest hand weight (3.62 kg), bunch weight (33.28 kg) and total yield per hectare (74.88 t/ha). Whereas, the lowest hand weight (2.87 kg), bunch weight (29.23) kg and total yield per hectare (65.77 t/ha) were recorded in control. Treatments with the bunch feeding of nutrient solution containing 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water and 7.5g Urea + 7.5g SOP + 5g banana special+ 300g vermicompost were found to be subsequent best treatments.

Bunch feeding with nutrients aided the additional supply of N which has shown higher Urease activity in fruits (Ancy *et al*., 1998). This may facilitate hydrolysis of Urea to ammonia (NH_3) for easy absorption and assimilation of N, hence enhanced bunch yield. The results were in close confirmity with Kottur and Keshavamurthy (2010) in cv. Ney Poovan and Sreekanth *et al.,* (2014) in cv.Robusta.

Increase in the weight of hand, bunch weight and yield per hectare is due to Sulphur present in the sulphate of potash (SOP) might be responsible for the formation of ferridoxin (Iron - sulphur protein) in plants which might have a direct impact in activating the catalase and peroxidase enzymes. Presence of sulphur in SOP had a synergistic effect with zinc, which is essential for carbon dioxide absorption and utilization, synthesis of RNA and auxin. Zinc is also essential for chlorophyll formation, which improves the photosynthetic activity (Pandey and Sinha, 1999). Sulphur helps in energy transformation and activation of enzymes in carbohydrate metabolism and subsequently greater partitioning of photosynthates. Sulphur application increased the yield since it is a constituent of amino acid and protein production (Ahmed *et al.,* 1995). The influence of sulphur in enhancing fruit yield in bananas was stressed by Lahav and Turner (1983).

SOP also triggered the maximum nitrate reductase in the majority of growth stages. Since nitrate reductase is the key enzyme of nitrate assimilation, the maintenance of the high rate of enzyme activity is imperative for enhanced protein content of the plants. The role of the K^+ ion in this enzyme activity was stressed by Evans and Sorger (1966). Soluble protein is considered as an indirect measure of Ribulose-1, 5-bisphosphate (RuBP) carboxylase activity as the enzyme constitutes more than 60 per cent of the soluble protein content and hence, it serves as an indicator of the photosynthetic rate (Evans *et al*., 1975). The present findings are in close confirmity with Alagarsamy and Neelakandan (2008) in cv. Robusta, Rameshkumar and Kumar (2007 and 2010) in cv. Neypoovan , Rameshkumar *et al*. (2008) in cv. Robusta and Bhalerao *et al.* (2009) in cv. GrandNaine.

Vermicompost and Micronutrients viz. Zn, Fe, Cu and B play an important role in regulating plant growth hormones and reaction involving cell division and growth of banana, which helps increasing in the yield of banana in term of increasing the weight of bunch. Similar type of study was done by Haripriya (1996) and Pathak *et al.* (2011).

5.3 Effect of bunch feeding on qualityparameters

5.3.1 Physiological loss in weight(%)

Weight loss from harvested fruits *i.e.* PLW, especially under tropical conditions causes severe loss to the producer and seller which also leads to quality deterioration with low consumer preference (Swietilk and Faust, 1984). The physiological loss in weight was found to differ significantly among the treatments and the highest PLW (15.58 %) wasrecordedinthebunchesprovidedwith12.5gUrea+12.5gSOP+5gbananaspecial
+ 300g vermicompost, which was on par with control (15.34). Meanwhile, the least PLW (12.26 %) was observed in the bunch supplied with 7.5g Urea+ 7.5g SOP+ 5g banana special+ 300g vermicompost. Increased PLW (%) might be due to the exceeded nutrient supply of potassium and nitrogen results in blackening and rotting. Similar report was opined by Ancy and Kurien (2000) in cv. Nendran. Reduced PLW might be due to the improvement in number of phellem layers and more number of crystals in phellem cells and scattered starch granules throughout the parenchyma, which reduced the rateof

transpiration. The reduction in transpiration was helpful in improving the storability by reducing weight loss (Ravichandran *et al.,* 2011). This was in corroboration with the findings of Ramesh Kumar *et al.* (2008) in cv. Robusta (AAA-Cavendish).

5.3.2 Firmness(kg/cm^2)

There was a significant difference among the treatments regarding firmness of fruits. The maximum firmness of fruit was recorded in the bunches catered with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.76 kg/cm^2). Whereas, the minimum fruit firmness (2.17 kg/ cm^2) was recorded in control.

Potassium also has positive effects on firmness and texture, and can decrease transport damage. However, a high K amount leads to decreases in Ca and Mg contents, which might have a negative effect on produce quality. Similar results were noticed by Rameshkumar and Kumar (2007).

5.3.3 Weight of pulp, weight of peel and pulp to peelratio

The results inferred that the dipping the cut end in 10g Urea + 10g SOP + 5g banana special + 300g vermicompost has recorded highest weight of pulp (169.63 g), weight of peel (62.06 g) and pulp to peel ratio (2.74). While, the least pulp weight (148.78 g), peel weight (57.66 g) and pulp to peel ratio (2.56) were recorded in control. A study on morpho-physiological aspects of finger development it was observed that, in the final stage of development, cell enlargement took place thus reducing the available air space followed by starch filling in the cells (Kurien *et al.,* 2000). The increase in pulp thickness may be related to the role of potassium in influencing the developing fruit, which act as a strong sink for potassium than for other nutrients (Kumar *et al.*,2006).

Peel thickness was significantly influenced by potassium application, which has multiple enzymatic and catalytic functions used in many photosynthetic and metabolic processes in plants and increased the peel thickness of orange fruit (Omaima and Metwally, 2007).

Additional supply of potassium shown a favourable role to get good pulp recovery. This might be due to less experienced physiological loss in weight by fruits may contribute towards the more pulp weight. The results were in confirmity with those obtained by Rameshkumar *et al*. (2008) in Robusta, Nandankumar *et al*. (2011) in cv. Nanjanagudu Rasabale and Rameshkumar and Kumar (2007 and 2010) in cv. Neypoovan.

5.3.4 Total soluble solid(^{0}Brix)

The highest TSS (22.11 ^{0}Brix) was recorded in bunches treated with 10g Urea + 10g SOP + 5g banana special+ 300g vermicompost. The least TSS (19.60 ^{0}Brix) was recorded in control.

Increased TSS due to exogenous application of sulphate of potash when supplied which augumented the flow of plant assimilates into the developing fruits especially when assimilate flow from other parts of plant becomes limited. These results were in closely conformity with Nandankumar *et al*., (2011) in cv. Nanjangudu Rasabale, Rameshkumar and Kumar (2007 and 2010) in cv. Ney Poovan and Rameshkumar *et al*., (2008) in cv.Robusta.

5.3.5 Acidity (%)

The percentage of titrable acidity varied significantly among the treatments. Lowest titrable acidity (0.24 %) was obtained from the bunches provided with 10g Urea+ 10g SOP+ 5g banana special+ 300g vermicompost. The highest titrable acidity (0.31 %) was noticed in control. The decrease in titrable acidity might be due to the additional supply of potash as bunch feeding resulted in reduced acid content of fruits. This might be due to that, under low K regime, phosophenol pyruvate (PEP) was appearantly shunted into alternate pathways resulting in shortage of acetyl CO-A. Hence, oxalo-acetate appeared to be preferentially formed from PEP in plants with low levels of K and this organic acid deriavative is accumulated. Neutralization of organic acids due to high K level in tissues could have also resulted in reduction in acidity. The similar findings were also reported by Rameshkumar *et al.* (2008) in banana cv.Robusta.

5.3.6 Reducing sugars, non-reducing sugars and total sugars(%)

The results revealed that the bunches supplied with additional 10g Urea+ 10g SOP+ 5g banana special+ 300g vermicompost have recorded increased reducing sugars (17.67 %), non-reducing sugars (2.79 %) and total sugars (20.46 %). Whereas, lowest reducing sugars (15.10 %), non-reducing sugars (2.23 %) and total sugars (17.33 %) were recorded in control. Treatments with the bunch feeding of 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost were found to be next best treatments.

Application of potash was also found to be good in increasing sugar content as potassium played a major role in carbohydrates synthesis, breakdown and translocation and synthesis of protein and neutralization of physiologically important organic acids. This finding agreed with that of Tisdale and Nelson (1966). Further, potassium when supplied in the form of sulphate of potash favoured conversion of starch into simple sugars during ripening by activating the sucrose synthatase enzyme thus resulted in higher sugar percentage. In plants supplied with potassium, the osmotic potential of the phloem sap and the volume flow were higher than in bunches with low K supply and as a result, sucrose concentration in content of fruits was increased (Marschner, 1995). The similar results were found by Ramesh and Kumar (2007 and 2010) in banana cv. Ney Poovan, Nandankumar *et al*., (2011) in cv. Nanjanagudu Rasabale and Rameshkumar *et al*., (2008) in cv.Robusta.

Enhanced sugar content might be due to the role of sulphate (SO_4) ions released from sulphate of potash as sulphate favoured the activity of anabolic enzymes and resulted in accumulation of highly polymerized carbohydrates (starch), which would have subsequently disintegrated into sugars on ripening (Alagarsamy and Neelakandan,2008).

5.3.7 Colour development of fingers(Days)

Colour development of finger is desired take more time as it favours longer transit time from field to consumer. Bunch feeding with the nutrient combination of 10g Urea+ 10g SOP+ 5g banana special+ 300g vermicompost took maximum number of days

(12.32) required for colour development of fingers whereas, the minimum number of days for colour development (8.21 days) was recorded incontrol.

Increase in green life of fruit might be due to reduced rate of respiration and ethylene production by potassium application, as reported by Singh and Chuhan (1982). In addition to this, potassium element is also responsible for maintaining cytokinin level concentration in the plants which delays senescence, inturn contributing to enhanced green life. Turner (1997) reported that high levels of N have been shown to reduce days to ripe *i.e*., greenlife.

5.3.8 Shelf life(Days)

Shelf life in banana was influenced by bunch feeding with additional amount of nutrients. Higher shelf life (6.71 days) was recorded in the bunches supplied with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost while, the lowest (5.66 days) shelf life was observed in control.

The highest shelf life could be attributed to the potassium nutrient supplied through bunch feeding enhances storage and shipping quality of bananas and also extends their shelf life (Mengel, 1997). Among the various nutrients, potassium not only improves yields but also benefits various aspects of quality. It also promotes long shelf life and adequate processing quality for industry. In the present experiment, extended shelf life of bunch treated with K_2SO_4 might be due to lesser physiologiacal loss in weight experienced in the fruits. As reported by Rameshkumar and Kumar (2007 and 2010) in cv. Ney Poovan, Rameshkumar *et al.* (2008) in Robusta and Nandankumar *et al.* (2011) in cv. Nanjangudurasabale.

However, higher doses of Urea, i.e. > 50 g/ l lead to fast absorption of large quantity of nutrients by the last hands. As the concentration of nutrients may have exceed certain critical limits which results in blackening and rotting leading to lesser shelf life in cv. Nendran (Ancy and Kurein, 2000).

5.3.9 Sensoryevaluation

The sensory parameters such as colour, flavour, aroma, taste and overall acceptability were more appreciated in fruits which were supplied with additional amount of macro and micronutrient combination. The treatments with bunch feeding of nutrient combination involving 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, 7.5gUrea+7.5gSOP+5gbananaspecial+300gvermicompost,7.5gUrea+7.5gSOP +5gbananaspecial+200gvermicompostand10gUrea+10gSOP+5gbananaspecial + 200g vermicompost were found to have greatest preferences among all other nutrient composition. Application of macro and micronutrients enhanced the quality attributes leading to better consumer acceptability. Similar results were reported by Yadlod *et al*. (2008) in Grand Naine.

5.4 Nutrientuptake

The amount of nutrients namely nitrogen, potassium and sulphur were estimated before applying to the bunch and after the harvest to quantify the amount of nutrients absorbed by the bunch. The uptake of nutrients ranged from 44 percent to 63 percent in different treatments. Vermicompost may favoured the mineralisation and uptake of nutrients by bunch resulting increased yield and quality attributes. Similar pattern of nutrient uptake was reported by Kotur and Keshavamurthy (2008) and Ancy and Kurien (2000).

5.5 Effect of bunch feeding on benefit costratio

The maximum benefit cost ratio (3.80:1) was obtained by bunch feeding with additional nutrition of 7.5 g Urea + 7.5 g SOP + 500 g cow dung + 100 ml of water. The treatments with bunch feeding of 10g Urea + 10g SOP + 5g banana special + 300g vermicompost (3.66:1), 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.62:1), 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (3.61:1) and 7.5g Urea + 7.5g SOP + 5g banana special + 200g vermicompost (3.60:1) were foumd to be subsequent best treatments. Whereas, the minimum benefit cost ratio (3.29:1) was

obtained in dipping the cut end with 12.5g Urea+ 12.5g SOP+ 5g banana special+ 300g vermicompost.

Increased B: C ratio was reported in bunch feeding with additional nutrition of 7.5 g Urea+7.5 g SOP + 500 g cow dung+100 ml of water due to less expenses involved and the synchronous yield in this treatment. The mentioned treatments which involved vermicompost (T_8, T_5, T_7 and T_4) given highest yield but the cost incurred was more as the vermicompost is comparatively expensive to cowdung.

It was due to sulphate of potash is an important nutrient and amount of nutrient required to a greater extent for increasing the bunch characters and yield attributes. The present investigation was agreed with the following findings of Rameshkumar and Kumar (2007) in which they reported that post-shooting spray of sulphate of potash (SOP) at 1.5 per cent twice recorded the highest benefit cost ratio in banana cv.Robusta.

Those treatments with supply of higher nutrients such as 12.5 g of Urea and 12.5 g of SOP were found to decline in yield, as the quantity of additional nutrient exceeds results in declining pattern of yield attributes. Similar results were reported by Ancy and Kurien (2000) in cv. Nendran.

Future line of work

1. The study may initiate on the integrated nutrient management along with growth regulators to enhance the yield inbanana.
2. The study may initiate on bunch feeding with different organic, inorganic nutrients and growth regulators on different varieties under different under agro-climatic conditions.
3. Standardization of concentration and amount of solution is required for bunch feeding of nutrients, growth regulators andorganics.
4. The study may be taken under high density planting along with different nutrients and growthregulators.

Summary

VI. SUMMARY

The study entitled “Effect of bunch feeding on yield and quality attributes of tissue culture banana cv. Grand Naine (AAA)” was conducted during the year 2017 to 2018 at the farmer’s field at Agrahara playa, Dasanapura hobli of Bengaluru North Taluk and District, Karnataka.

1. Thehighestfingerlength,fingergirth,fingerweightandfingervolume(21.23cm, 13.60 cm, 186.53 g and 162.17 cm^3, respectively) were obtained in the bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost.

2. The maximum hand weight (3.62 kg), bunch weight (33.28 kg) and total yield (74.88 t/ha) was recorded in the bunches provided with 10g Urea + 10g SOP + 5g banana special + 300gvermicompost.

3. The highest physiological loss in weight (15.58 %) was recorded with the application of 12.5g Urea + 12.5g SOP + 5g banana special + 300g vermicompost, followed by control (15.34 %). The least PLW (12.26 %) was observed in those bunches fed with 7.5g Urea + 7.5g SOP + 5g banana special + 300gvermicompost.

4. The maximum firmness of fruit was recorded in the bunches provided with 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.76 kg/cm^2) followed with, the application of 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (3.63kg/cm^2).

5. The maximum pulp recovery (169.63 g) and pulp to peel ratio (2.74) were observed in the treatment with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost. Highest peel weight (62.06 g) was observed in bunches fed with 10g Urea + 10g SOP + 5g banana special + 300gvermicompost.

6. The highest total soluble solids (22.11 ^{0}Brix) was observed in bunches catered with dipping the cut end in 10g Urea + 10g SOP + 5g banana special + 300g vermicompost.

7. The lowest titrable acidity (0.24 %) was obtained by dipping the cut end in 10gUrea + 10g SOP + 5g banana special + 300g vermicompost.

8. The highest reducing, non-reducing and total sugars (17.67%, 2.79% and 20.46%, respectively) were obtained by supplying the bunches with additional nutrition of 10g Urea + 10g SOP + 5g banana special + 300gvermicompost.

9. The maximum number of days (12.32) required for colour development was recorded in bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost.

10. The higher shelf life (6.71 days) was recorded in the bunches provided with 7.5g Urea + 7.5g SOP + 5g banana special + 300gvermicompost.

11. The greatest overall acceptability of fruits was recorded in the bunches supplied with the involving 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost and 7.5g Urea + 7.5g SOP + 5g banana special + 200gvermicompost

12. The maximum benefit cost ratio (3.85:1) was obtained by bunch feeding with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost. The treatments with bunch feeding of 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (3.81:1) and 10g Urea + 10g SOP + 5g banana special + 200g vermicompost (3.80:1) were found to be subsequent besttreatments.

Conclusion

This study inferred that, dipping the cut end in the nutrient solution containing 10g Urea + 10g SOP + 5g banana special + 300g vermicompost increased the yieldby 13.85 per cent (74.88 t/ha), which was followed by supply of 7.5 g Urea +7.5 g SOP + 500 g cow dung + 100 ml of water (73.96 t/ha) and 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost (73.85 t/ha) with the yield increase by 12.45 and 12.28 per cent, respectively.

Overall, it may be concluded that the banana bunches supplied with 10g Urea + 10g SOP + 5g banana special + 300g vermicompost, 7.5g Urea + 7.5g SOP + 5g banana special + 300g vermicompost and 7.5 g Urea +7.5 g SOP + 500 g cow dung +100 ml of water improved the yield and quality parameters of banana cv. Grand Naine. Treatments involving vermicompost and micronutrients resulted in greater quality attributes such as highest TSS, low acidity, less PLW, good colour of fruit, maximum shelf life leading to long distance transport which attracts the consumers and ensures highest profit.

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Appendices

APPENDIX - I

Meteorological data during the period of investigation at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bangalore- 89, 2017- 2018

Month	Temperature (°C)		Relative Humidity (%)		Mean wind speed (km/h)	Total Rainfall (mm)
	Max.	Min.	7.30 hrs	14.00 hrs		
2017						
August	28.49	20.96	82.90	64.23	2.98	244.55
September	28.52	20.40	85.69	65.37	2.86	250.2
October	28.66	19.53	82.52	61.87	1.64	242.0
November	27.58	17.51	77.67	56.37	1.03	11.65
December	27.20	14.17	79.97	45.32	2.45	5.6
2018						
January	28.35	12.7	76.9	36.5	1.69	0.0
Feburary	30.22	12.7	67.3	27.22	2.12	0.5
March	32.6	19.0	66.08	27.01	2.31	80.55
April	33.6	20.0	68.05	34.4	1.16	14.8
May	32.35	21.05	80.1	50.9	2.59	266.5
June	28.8	20.45	80.5	64.5	7.47	60.6
July	28.15	20.45	82.0	66.6	7.68	88.6
August	27.65	19.95	85.05	69.2	2.57	86.1
September	28.55	19.45	82.95	61.4	2.05	178.4

APPENDIX II

Cost of cultivation of banana cv. Grand Naine during 2017-18

No.	Materials / works	Main Crop
		Per hectare (3086 pl.)
A.	**Variable cost**	
I	**Land preparation**	
1	Ploughing tractor rent and leveling	7,500
II	**Inputs**	
1	FYM –50tonnes/hactare**@** ₹500/ t	25,000
2	Plantingmaterial@ ₹ 12.00/ plant	37,050
3	Fertilizers (200:100:300 gm NPK/plant)	
	a. Urea (1340 kg/ha)@ ₹ 6.00/ kg	8,040
	b. SSP (1930/ha)@ ₹ 9.00/ kg	17,370
	c. MOP (1537.5 /ha)@ ₹ 16.00/ kg	24,600
4	Plant protection chemicals	10,000
5	Staking / proppingpoles(@ ₹ 2.5 / pole)	7715
6	Irrigation / water charges	6,250
III	**Labour charges**	
1	Digging of pits andplanting@ ₹ 5.00/ plant	15,438
2	Weeding and fertilizer application – (20 labours / ha)	4,600
3	Staking and Desuckering – (20 labours / ha)	4,600
4	Plant protection measures – (10 labours/ ha)	2,300
5	Harvesting and matocking –(20 labours / acre)	4,600
IV	**Transportation**	12,500
V	**Interest on working capital @ 12%**	22,147
	Total Variable cost	**2,06,710**
B	**Fixed Capital**	
1	Land rent	25,000
2	Land revenue	65
3	Interest on fixed capital @ 15 %	3760
	Total Fixed Cost	**28,825**
	TotalCost (₹)	**2,35,535**

APPENDIX III

Cost of different chemicals or nutrients used for bunch feeding

Sl. No.	Component	Amount (Rs)
I.	Urea	5.2 /kg
II.	Sulphate of potash	130 /kg
III.	Banana special-micronutrient mix	150 /kg
IV.	Vermicompost	10 /kg
V.	Polythene bag	120 /kg

APPENDIX IV

LIST OF SYMBOLS AND ABBREVIATIONS

Symbols	Abbreviations
%	Per cent
@	At
^{0}C	Degree centigrade
CD	Critical difference
cm	Centimeter
cm^2	Centimeter square
cm^3	Centimeter cube
cv.	Cultivar
et al.	Et alia (and other)
g	Gram
ha	Hectare
i.e.	That is
kg	Kilogram
m^2	Meter square
PLW	Physiological loss in weight
S.Em.	Standard Error of Mean
t	Tonnes
viz.	As follows