INTEGRATED NUTRIENT MANAGEMENT FOR PAPAYA (*Carica papaya* L.) VARIETY : RANCHI DWARF

A

THESIS SUBMITTED TO

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MASTER OF SCIENCE IN AGRICULTURE
(FRUIT SCIENCE)

BY

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Dedicated To

Lord Venkateswara

&

My Beloved Parents

DEPARTMENT OF FLORICULTURE AND LANDSCAPING
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CERTIFICATE - I

This is to certify that the thesis entitled "**INTEGRATED NUTRIENT MANAGEMENT FOR PAPAYA (*Carica papaya* L.) VARIETY RANCHI DWARF**" submitted in partial fulfilment of the requirements for the award of the Degree of **MASTER OF SCIENCE IN AGRICULTURE**(**FRUIT SCIENCE**) of the Orissa University of Agriculture and Technology, Bhubaneswar is an authentic record of *bonafide*research work carried out by **MISSMULLANGI SUPRIYA Adm. No 01FSC/11** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma or published in any other form.

It is further certified that the help and assistance as well as sources of information availed during the course of this investigation have been duly acknowledged by her.

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CERTIFICATE – II

This is to certify that the thesis entitled **"INTEGRATED NUTRIENT MANAGEMENT FOR PAPAYA (*Carica papaya* L.) VARIETY: RANCHI DWARF"** submitted by **MISS MULLANGI SUPRIYA Adm. No. 01FSC/11** to the Orissa University of Agriculture and Technology, Bhubaneswar in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE IN AGRICULTURE** in the discipline of **FRUIT SCIENCE** has been approved by the Student's Advisory Committee after an oral examination on the same in collaboration with the External Examiner.

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ABSTRACT

Title of the thesis	:	**Integrated Nutrient Management for Papaya (*Carica papaya* L.) variety: Ranchi Dwarf**
Name of the student	:	Mullangi Supriya
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ABSTRACT

An field experiment was carried out at Horticulture Research Station, Orissa University Of Agriculture and Technology, during 2012-2013 to study "**Integrated Nutrient Management For Papaya (*carica papaya* L.) Variety: Ranchi dwarf**" under Bhubaneswar condition. The field experiment was laid out in Randomised Block Design (RBD) with seven treatments replicated three times. The soil of the site is sandy loam with 90.71 kg available N, 176.4 kg available P, and 93 kg available K per hectare. The crop was fertilized with Recommended Dose Fertilizer of 200 g N, 200 g P and 250 g K and also Biofertilizers (Azotobacter + Azospirillum + Phosphorous solubilising bacteria) are applied as per treatments. Observations were recorded on plant biometrical parameters, leaf nutrient concentration at different growing stages, yield parameters, fruit quality, nutrient concentration in fruit, uptake of nutrients by papaya crop.

The results revealed that papaya plants treated with treatment T_7 (100%NPK+ AZO+AZS+PSB) exhibited maximum results in the following parameters like plant height (69.72 cm), number of functional leaves (23.8), leaf area (708 sq cm), stem girth (5.81 cm), petiole length(38.2 cm) and petiole girth (2.94 cm), number of fruits per plant (20.6),unit fruit weight(1.35 kg), fruit length (26.1cm), fruit circumference (36 cm), fruit width (16.9 cm), fruit yield (38,955 kg ha^{-1}) and dry matter yield(4500 kg ha^{-1}), reducing sugar (9.3) and TSS content (9.2^0 Brix). Acidity in papaya fruit is found higher (0.31) in control treatment T_1, non-reducing sugars is higher in (4.08) T_3 (50%NPK+ AZO+AZS+PSB).

Leaf is tested at three month stage, four month stage and at harvest for nutrient concentration it is revealed that higher concentration of N(8.7%) was observed in treatment T_7(100%NPK+ AZO+AZS+PSB).P(0.62%),S(0.37%) was observed in treatment T_3(50%NPK+ AZO+AZS+PSB), K(3.55%) was observed, in treatment T_4 (75%NPK) at three month stage of papaya crop where as higher concentration of Ca (1.82%) and Mg (1.2%) was observed in treatment T_2 (50% NPK) at four month stage. Fruits of papaya are tested for nutrient concentration. Higher N Concentration of (2.67%) is observed in treatment T_5 (75% NPK+ AZO+AZS+PSB) where as K (2.08%), Na (2.08%) is observed in treatment T_7 (100% NPK+ AZO+AZS+PSB), P (0.34%) in control treatment, S (0.16%) was recorded in treatment T_6 (100%NPK). Uptake of Nitrogen by papaya crop is 118.7 kg ha^{-1} where as other nutrients like phosphorous (13.49 kg $ha^{-1)}$, potassium (93.5 kg ha^{-1}), Sulphur(6.74 kg ha^{-1}) is recorded maximum in treatment T_7 (100% NPK+ AZO+AZS+PSB). The treatment T_7 (100% NPK+ AZO+AZS+PSB) was found superior to other treatments and T_1 recorded lowest values in all parameters.

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ABBREVIATIONS

%	-	Percentage
cm	-	Centimeter
mm	-	Millimeter
m	-	Meter
nm	-	nanometer
ha	-	hectare
kg	-	Kilogram
g	-	Gram
mg	-	Miligram
q	-	Quintal
MAP	-	Months after planting
Max	-	Maximum
Min	-	Minimum
MOP	-	Muriate of Potash
MAP	-	Months after planting
FYM	-	Farm yard manure
Sqm	-	Square meter
Fig.	-	Figure
BF	-	Biofertilizers
RDF	-	Recommended dose of Fertilizer
AZO	-	*Azotobacter*
AZS	-	*Azospirillum*
PSB	-	Phosphorus solubilising bacteria
RBD	-	Randomized Block Design
S.E.	-	Standard error
CD	-	Critical Difference
CV	-	Coefficient of variation
@	-	At the rate of
Wt	-	Weight
No	-	Number

INTRODUCTION

Papaya (*Carica papaya* L.*)* is one of the important delicious fruit crop grown in the tropical and subtropical parts of the world. It is believed to be originated in Mexico and spread to almost all the corners of the tropical world. Papaya (*Carica papaya* L.*)* belonging to the family caricaceae was introduced in India in 16th century by Portuguese. It is one of the few plants which produces fruits throughout the year. It owes its popularity to various simple reasons like, it requires less area per tree, comes to fruiting within a year, easy to cultivate, provides per hectare income next only to banana and has a high nutritive and medicinal value. Regular consumption of papaya can ensure a good supply of vitamin A and C, which are essential for good health. Moreover it is a cheap fruit available in all seasons, in all places to all the people.

Papaya is rich in enzyme papain which helps in the digestion of proteins, thus being useful in pharmacy for preparing digestive medicines, Papain (alkaloid obtained from the milky latex of papaya) is an effective stimulant and diuretic. It is used to remove skin blemishes and scar. Papain is also beneficial for the treatment of stomach ulcers, diptheria even cancer. The ripe fruit and seed have medicinal properties against disorders of liver, spleen and digestive tract. Papain prepared from dried latex of its immature fruits is used in meat tenderizing, manufacture of chewing gum, cosmetics, for degumming natural silk and to give shrink resistance to wool. It is also used in pharmaceutical industries, textile and garment cleaning paper and adhesive manufacture, sewage disposal etc. It contains vitamin:1.750IU. Papaya contains calories 39 per 100gm of fruit. It has fat 0.1gm, carbohydrates 10gm,protein 0.6gm per 100gm of fruit.

Papaya ranks fourth in fruit production in India and 8th rank in area among the fruit crops grown in India. In India papaya grown in area of 1,06,000 ha and production is around 41,96,000 MT and productivity is 39.6 MT/ha (Indian Horticulture Database-2011). Global production of papaya is 11.2 million tonnes. Papaya is also grown in other countries like Brazil, Indonesia, Nigeria, Mexico and Ethiopia. Andhra Pradesh is leading producer of papaya followed by Gujarat, Karnataka, West Bengal, Chattisgarh and Madhya Pradesh in India. In Odisha the area under papaya cultivation is around 3709 ha and total production is around 81526 MT and productivity is around 24.24 MT/ha (Horticulture scenario of Odisha , 2011-12).The area and production of papaya in Odisha is substantially fluctuating, mainly because of frequent erratic rain, cyclonic weather, drought and floods occurring in the state. Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components .Fertilizers are in some regions applied in doses and with methods that are far from efficient, and in other areas the lack of fertilizers is still the main constraint to have a higher productivity.

Integrated plant Nutrient Management aims to use nutrient in a more rational way (yield targeted, site and soil specific) understanding the interaction of different nutrients; use combinations of minerals and organic fertilizers; provide nutrients on a cropping system /rotation basis and use on-farm waste through recycling. Nutrient cycling is an important component of conservation Agriculture, in which minimum soil disturbance, intercropping, crop rotations and a permanent soil cover minimize the need for chemical fertilizers.

Biofertilizer play a very significant role in improving soil fertility by fixing atmospheric nitrogen both in association with plant roots and without it. It solubilizes insoluble soil phosphate and produces plant growth substances in the soil. They are playing friendly environment with a significant role in crop production. The soil lose its biological dynamism owing to repeated and indiscriminate use of inorganic source of fertilizer. The global mandate (Dorrel and Besson, 1996) today is to use organic source of plant nutrients to restore the soil health. The fertilizers are not only short in supply but costly too and produced at the cost of irreparable loss of non-renewable energy are able to fix atmospheric nitrogen in the range of 20- 200 kg/ha/year, solubilize P in the range of 30- 50 kg P_2O_5/ha/year; mobilize p "Zn, Fe, Mo to varying extent. They also help host plants to resist diseases and withstand stress conditions by different mechanism which vary depending upon the type of biofertilizer agent involved. Nitrogen fixing bacteria and phosphate solubilizer are the main biofertilizers for horticultural crops. These micro-organisms are either free living in soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of the plants.

According to Hazarika and Ansaris (2007) the response of any crop to added nutrients largely depends on nutrient supplying capacity of soil and crop requirement and is also highly influenced by several ecoadaphic factors and management practices owing to increase cost of fertilizers ,their short supply and sustainability issues gaining importance. The complementary use of chemical fertilizers, organic manures, biofertilizers is important to maintain and sustainability issues gaining importance .The complementary use of chemical fertilizer, organic manures, biofertilizers and other organic is important to maintain and sustain a higher level of soil fertility and crop productivity .

The productivity of papaya in the state is low as compared to National productivity. To achieve economic yield from papaya, suitable varieties can be exploited by addition of integrated nutrient management. The objectives of present investigation are as follows:

1. To study the influence of bioinoculation, fertilizers application and their integration with suboptimal doses on growth of papaya plants.

2. To study the influence of bioinoculation, fertilizers application and their integration with suboptimal doses on fruit yield of papaya.

3. Influence of bioinoculation, fertilizers application and their integration with suboptimal doses on fruit quality.

REVIEW OF LITERATURE

The literature referred to the present experiment "Integrated nutrient management for papaya (*Carica papaya* L.) variety Ranchi dwarf" and discussing the results have been reviewed here under appropriate heading in succeeding pages. These are given below ;

A) Effect of Integrated nutrient management on vegetative growth of papaya.

B) Effect of Integrated nutrient management on yield of papaya.

C) Effect of Integrated nutrient management on quality of papaya.

A. Effect of Integrated nutrient management on growth of papaya

In a fertilizer trial conducted by Tripathi (1962) in order to explore the possibility of utilizing both organic and inorganic with biofertilizers for different growth parameters of papaya are reviewed here mentioned that19 combinations of N,P and K were tested. Plant girth was increased significantly only by Nitrogen applications. Nitrogen at 0.6 lb/plant /year gave better results than double this rate. The time of sex expression was not affected by any of the treatments.

Paterno *et al.* (1996) experimented on the growth stimulating effect of two rhizobacteria, *Azotobacter vinelandii* MAC 259 and a local isolate TS 3, on papaya cv. Sinta, and observed that Rhizobacterial inoculation alone and fertilization alone failed to improve shoot and root growth parameters. The effect of rhizobacterial inoculation was compared with nitrogen fertilizer, when combined with fertilizer, *A. vinelandii* MAC 259 significantly increased shoot height and weight, stem diameter, total leaf area, root weight and root surface area over the controls and performed better than the TS 3.

Lius *et al*. (1997) conducted an experiment on Transgenic *Carica papaya* plants (cv. Sunsett, R0 clone 55-1) carrying the coat protein gene ring spot virus (strain HA 5-1) remained symptomless and ELISA-negative for 24 months after inoculation with Hawaiian strains of papaya ring spot virus under field conditions. Mean trunk diameter was significantly greater in cloned 55-1 plants compared with virus –infected controls (14.7 cm versus 9.3 cm after 18 months).

Santos et al. (1997) reported that Cartagena Ombligua' papaya (*Carica papaya* L.) plants were applied with N, P_2O_5, K_2O fertilizers 20days after transplanting at rates 0, 6, 12, 18, and 24 g per plant. Plant height, stem diameter, leaf area, and root and shoot dry weight responded to N and K in a quadratic fashion (N:Y= 30.79+ 1.35X-0.07X^2; K_20:Y = 30.02 +1.6X - 0.06X^2). Maximum growth was obtained with 6 and 18 g of N and K_2O, respectively. P fertilization did not significantly affect shoot growth, but it stimulated root growth ($Y = 2.02 + 0.41X - 0.013X^2$).

Goramnagar *et al.* (2000) studied on integrated nutrient management in Nagpur oranges and reported that application of 15 kg FYM + 360 g N + 180 g P_2O_5 plant^{-1} produced tall bushy plants with increased leaf area, spread and good scionic relationship.

Growth medium and fertilizer effects on papaya seedlings growth in cv. 'Sunrise Solo' and 'Tainung 1' studied by Yamanishi *et al*. (2004).) seedlings grown in polystyrene trays (72 cells) in the growth medium (Plantmax® = pine bark + vermiculite + peat) amended with 4% of organic fertilizer (Humus; composted cattle manure and Nutriplanta) combined with 0.05% of inorganic fertilizer (Osmocote- slow release - NPK 14-14-14 and normal release NPK 14-14-14). Germination occurred in cv. 'Sunrise Solo' and hybrid 'Tainung 1' occurred 12 and 14 days after sowing. Higher germination rate in both materials was obtained in the growth medium fertilized with Osmocote plus humus and composted cattle manure. The seedlings grown in growth medium amended with composted cattle manure + normal release NPK showed the poorest results in almost all analyzed parameters such as height, stem diameter, dry weight - root and top - and total leaf area. The nutrient contents (NPK) found in the leaf analyses samples were higher in treatments using slow release fertilizer (~20% for hybrid Tainung 1 and ±10% for cv. Sunrise Solo) compared with the normal one.

The effects of rate combinations of nitrogen (N) and a soil-applied biostimulant based on seaweed (*Ascophyllum nodosum*) extract (SSE) on the growth of papaya seedlings for transplant production studied by Pablo Morales-Payan *et al*. (2005). Seedlings were grown in 180-mL Styrofoam containers filled with a sphagnum/vermiculite/perlite growing medium. N (0 to 2 g per plant) and SSE (drench, 0 to 1 ml per plant) were applied at sowing and 15 days after emergence. N rates resulted in increased growth, and adding SSE enhanced N effects. In terms of increasing overall transplant growth and decreasing the time required from emergence to adequate transplanting size, the best results were found at the highest N and SSE rates.

Mendonca *et al.* (2006) to evaluate responses of nitrogen and phosphorus fertilization on papaya 'Formosa' seedling growth one experiment was carried out . Four doses of nitrogen (0; 800; 1600 and 3200 mg N dm^{-3} of substrate) and 4 doses of SS (0; 2.5; 5.0; and 10.0 kg m^{-3} of substrate) was used. The following characteristics: plant height (cm), root length (cm), number of leaves/plant, dry matter of aerial part and root (g/plant) was evaluated. Nitrogen covering fertilization given best quality of papaya seedling and higher doses promoted negative effects. The SS given good seedlings qualities when was used at 10 kg m^{-3} in substrate

Faleono (2007) hypothesized that in a tropical fruit plant *Carica papaya* L., organic fertilizer applied on a weekly basis would generate a faster growth rate in Brazillian sunshine papaya plants compared to inorganic fertilizer and Alaska Fish Emulsion as the organic fertilizer. The results were compared among the inorganic, organic, and water treatments which did not show significant differences among the growth and development of papaya plants treated with water, organic fertilizer, or inorganic fertilizer. Also, there were no differences in the growth and development of the papaya plants between the use of either fertilizer or water. All the papaya plants steadily increased in size.

A field experiment was conducted to assess the effect of different fertilizer levels and number of splits on tissue cultured banana cv. Robusta. Application of NPK @ 165:52.5:495 g $plant^{-1}$ in four splits(T_4) recorded better growth of the tissue cultured plants followed by T_3 (165:52.5:495 g NPK $plant^{-1}$) in three splits. Higher number of functional leaves at shooting stage with shorter phyllochron, greater leaf area index and leaf area index coupled with reduced crop duration were recorded with the application of N @165 g, @ 52.5 g and K @ 495 g $plant^{-1}$ given at four split doses. (Nalina *et al*., 2009).

Vielma *et al.* (2009) evaluated the vermicompost as an alternative organic amendment to the chemical fertilization on the initial growth and yield of papaya plants using certified seeds of the cv. 'Maradol Amarilla'. Plant height, stem diameter, flowering initiation, fruiting initiation and number of fruits per plant were measured. The results showed a positive effect on usage of vermicompost on the initial growth and yield of papaya plants. Plant height (71.6 cm), stem diameter (19,1cm) and number of fruits/plants (26) were obtained when T_1 was used. The only application of chemical fertilizer (T_3) was observed less effective to the variables considered, with no reproductive activity observed.

Amiri *et al*. (2010) conducted an experiment to test the effect of four bio-inoculants Endroots soluble , Mycorrhiza Roots, Mycocoplex and *Trichoderma* on growth and performance of papaya (cv. Solo) seedling in the nursery stage. A combination of these bioinoculants in the nursery media will help to get strong, healthy, disease free seedlings in the nursery. The treatment with Mycorhiza roots at 20g/cft of coir pith media influenced most of the characters positively, *viz*. higher plant height (46.86 cm at 60 DAS). higher stem girth (1.90 cm at 60 DAS), more leaf area (99.53 cm^2 at 60 DAS), more number of roots per plant (17.06),higher root length (16.06 cm), higher fresh (4.5g) and dry weight (0.92 g) of roots per plant. The mentioned treatment accumulated higher N (3.77%), P(8.37%) and K (4.00%) in the seedlings .

Constantino *et al*. (2010) evaluated the effect of three biofertilizers applied single or in combination (*Azotobacter chroococcum*, *Azospirillum brasilense* and *Glomus intraradices*) and a plant growth bioregulator, the gibberelic acid (GA_3) on the germination and subsequent growth of papaya seedlings cv. Maradol. The results revealed that combined application of *A. Brasilense* and *G. intraradices* improved the seed germination rate as well as the uniformity of seedlings emergence. The colonization of plants inoculated with *G. intraradices* was reported to be highest and ranged from 18.53 to 26.67% in this treatment. The population of *A. Chroococcum* was higher in the combined inoculation with *G. intraradices.*

Studies on nursery management in papaya (*Carica papaya* L.) Var. Co_2 revealed the superiority of single seedling grown with potting mixture, treated with vermicompost registered higher seedling height (28.50 cm), seedling diameter (0.639 cm), petiole diameter (0.186 cm), petiole length (6.410 cm),number of leaves (11.65),shoot dry weight (1.254g), root length (29.715 cm) root dry weight (0.392g) and root shoot ratio(0.340). In main field condition, three seedlings per polybag grown with potting mixture and vermicompost was found to have early flowering development (86.69 days) and first bearing height (96.695cm) with minimum 90.930 cm plant height (Rajamanickam *et al*., 2008).

Suresh *et al.* (2010) studied the efficacy of phosphate solubilizing microbes and VAM fungi with graded levels of phosphorus on growth, yield and nutrient uptake of papaya (*Carica papaya* L.) Maximum plant height (192.67 cm), girth (24.00 cm) and total number of leaves (25.17) were observed in VAM+200 g P_2O_5. Although VAM was also found more effective in increasing height and girth than phosphate solubilizing microbes. Highest yield (64.85 tonnes/ha) was resulted due to the inoculation effect of PSM and 200g p_2o_5 treatment. Phosphorous and potassium content of leaves increased with increasing phosphorous level and biofertilizer application.

Constantino *et al*. (2011) studied the effect of time of inoculation of Azotobacter and mycorhizal fungi on growth and content nutrient of papaya seedlings in nursery phase. All treatments were applied as single or combined inoculants (*A. chroococcum* and *G. intraradices*) for a total of 20 treatments, in a completely randomized design. The double inoculation (seed and seedling) promoted higher growth and biomass of the crop than single inoculation (only seedlings), when organic matter was added at an intermediate dose (25 or 35%) and *G. intraradices* was applied as a single inoculant. However, the single or double inoculation did not modify the nutrient content in papaya seedlings.

The effect of Arbuscular Mycorrihizal Fungi, Diazotrophic Bacteria and Phosphate Fertilization on Papaya seedlings were studied by Lima *et al*. (2011). At 105days after sowing , the plants were collected and evaluated for plant height, leaf area, stem diameter, dry matter of shoot, root and total dry matter, percentage of root colonization and enumeration of diazotrophs in roots. Inoculation with AMF provides significant increases in the growth of papaya seedlings, even under low phosphorous availability, regardless of the presence of diazotrophic bacteria . The fungus Gigaspora. margarita and the mixed inoculums Gigaspora. margarita +Glomus. Clarum stand out as the most promising to the cultivation of papaya. The inoculation with diazotrophic bacteria in the absence or presence of AMF did not provide suppressive or stimulatory effect on papaya growth.

Sukhada *et al.* (2011) observed that plants pre-inoculated with *Glomusmosseae* + *Trichoderma harzianum*, provided the best results when challenged with phytophthora, with increased plant height, girth and yield also reduced disease severity over plants not inoculated with BCA_s. Studies with phytophthora antibodies conjugated with fluorescein isothiocyanate (FITC) and enzyme –linked immunosorbent assay (ELISA) further substantiated the reduction in infection and population of Phytophthora in BCA pre-treated plants.

Yadav *et al.* (2011) investigated the effect of various organic, inorganic and biofertilizer combination on the growth and physico-chemical attributes of papaya. Organic inputs such as biopressmud (10 kg ha^{1}), vermicompost (10 kg ha^{-1}), FYM (30 kg ha^{-1}), 100 and 75 % dose of NPK ha^{-1} (inorganic fertilizers) and biofertilizer (*Azotobacter* and PSB 25 g/plant each) were applied as basal dose. The results of the experiment revealed that combination of 10 kg Vermicompost + 100% NPK +25 g *Azotobacter* enhanced the growth characters like plant height, girth, fruiting depth and physico-chemical characters like fruit length, width, ascorbic acid, total soluble solids, total sugar content compared to other treatments.

B) Effect of Integrated nutrient management on yield of papaya

Awada and Long (1980) studied the effects of Nitrogen and potassium fertilization on fruiting and petiole composition of 24 to 48-month old papaya plants and revealed that increase in N or K rate increased the total number and total weight of marketable fruit and average weight of marketable fruit. N fertilization increased petiole concentrations of N, Fe, Mn, Cu and Zn and decreased those of P and B. K fertilization increased petiole concentrations of K and Mn, and decreased those of N, P, Ca, Mg, Na and B. The maximum yield of marketable fruit was associated with petiole concentrations of 1.44% N and 2.52% K.

Fernandes *et al*. (1990) conducted a field trial to assess the effect of rates of N (0, 115.5, 231, 462 and 924 kg/ha), P_2O_5(0, 165, 330, 660 and 1320 kg/ha) and k_2o (231 kg/ha) on the development, yield and quality of irrigated papaya cv. Solo grown on a dark red latosol. It was shown that N and P significantly affected yield and the average number of fruits/plant, but they neither not significantly influence the relative rate of plant growth nor the percentage of acidity, consistency of the pulp, and diameter and average weight of the fruit. Only N treatment significantly influenced the percentage of soluble solids. The highest yields were obtained with 668.47 kg/ha of N and 847.64 kg/ha P_2O_5, giving 28662 kg and 29393 kg fruit/ha, respectively.

Perez *et al.* (1993) fruit set and yield of papaya (*carica papaya* l.) under integrated management to reduce ring spot viruses effects reveals that when plants were tested under integrated management practices (IMP), intensive management (IM) and control (C).). Papaya plants responded best to IMP with the greatest: fruit set (19 fruits/plant); plant height (2.15 m) and stem diameter (8.02 cm). Plants in such treatment showed a delay on the onset of papaya ring spot viruses during the first five months of plant growth.

The effect of spacing, nutrition and intercrops on yield and quality of papaya (*Carica papaya* L.) in papaya cv. 9-1(D) studied by Kumar *et al*.(2000).Experiments were conducted for three years with several combinations of spacings, nutrients and intercrops 5 g each of NPK/plant dose in the widest spacing of 2.1×2.1 m recorded the highest yield of papaya (170.36 and 99.77 kg of fruit/tree). These treatments had little or no significant effects.

Rajbhar *et al*. (2000) studied the effect of N, P, K and spacing on growth and yield of papaya (*Carica papaya* l.) *Cv*. Pant papaya 1 with three doses of nitrogen i.e. 200, 250 and 300 g and two doses of phosphorus and potash i.e. 200 and 250 g/plant in different combinations. The highest average number of fruits (44.66) was recorded in N2 P2 K2 treatment which was followed by N3 P2 K2 and N1 P2 K2 treatments. The maximum average fruit weight 1298.88 g was recorded under N3 P2 K2 treatment which was followed by N2 P2 K2 treatment but it was significantly at par with each other. On the other hand, the minimum average fruit weight (682.22 g) was noted under N1 P1 K1 treatment.

Effect of integrated nutrient management of yield and quality of aonla (*Emblica officinalis* Gaertn.) cv. NA-10 studied by Singh *et al.*(2008). The results revealed that maximum fruit yield, size (length and breadth), weight, volume, pulp stone ratio, total soluble solids, ascorbic acid, total sugars, minimum acidity and total phenol were recorded with the application of (T_7) 50% NPK+50 kg FYM+5 kg bio-pressmud..

Sadarunnisa *et al.* (2008) effect of fertigation on growth and yield of papaya cv. red lady an experiment was conducted at HRS , Anantharajupet, in a randomized block design with 4 replications. . Results indicated that 75% N and K when applied through drip recorded a yield of 100.42 kg/plant which was on par with the yield of plants supplied with 100% RDF (102.60 kg/plant). The yield components like number of fruits/plant, fruit weight were superior in the treatments where fertilizers were applied through drip compared to the treatments in which soil application of fertilizers was done. Further the results also indicated that the quality characters of fruits like fruit length, circumference, volume and TSS, in fertigated treatments were superior to other treatments.

Singh and Singh (2009) studied the effect of biofertilizers and bioregulators on growth, yield and nutrient status of strawberry cv. Sweet Charlie. The results revealed that highest fruit set, yield, and optimum fruit quality was recorded in plants inoculated with *Azotobacter* and *Azospirillum* along with 60 kg N ha^{-1} (50% N of the standard dose) and 100 ppm GA_3.

Mahendra *et al.* (2009) studied the Effect of integrated nutrient management on yield and quality of ber (*Zizypjus mauritiana* Lank.) cv Banarasi karaka. and reported that the maximum fruit yield, length, width, weight and quality parameters *viz.*, TSS, ascorbic acid, reducing sugar, non-reducing sugar, total sugar and minimum acidity content was recorded with the soil application of FYM+100% NPK+ *Azotobacter* +PSB closely followed by FYM+75% NPK + *Azotobacter* + PSB.

Bisht *et al.* (2010) conducted an experiment to evaluate the effect of N:P:K and farmyard manure (FYM) application on the fruit quality and leaf nutrient status of papaya The treatments comprised four levels of FYM, i.e. 0, 10, 20 and 30 kg/plant, and four levels of N:P:K (0:100:150 g/plant), i.e. 0:0:0, 100:80:50, 200:160:100 and 300:240:150. The maximum fruit volume (2702.07 ml) was obtained with FYM at 30 kg + N:P:K at 300:240:150 g/plant. Pulp thickness showed no definite pattern with the applied levels of FYM and N:P:K. However, pulp thickness was higher with the application of fertilizers than the control. Similar trend was observed with respect to Total soluble solids (TSS) of the fruit. Total carotene contents of fruit were also not influenced by the different levels of applied fertilizers. However, carotene content was higher with the applied N:P:K and FYM than the control.

Yadav *et al*. (2011) investigated the effect of different integrated nutrient nourishment levels on yield and economics of papaya cv. Pusa Dwarf. Yield attributes such as days taken to first flowering, days taken to maturity, fruit weight, number of fruit per plant, yield kg/plant and yeild q/ha were recorded significantly with the application of 10 kg vermicompost+100% NPK+25 kg *Azotobacter* while maximum net profit and benefit:cost ratio were noted under treatment with 30 kg FYM+100% NPK+25 g *Azotobacter*.

Leaf nutrient composition, its correlation with yield and quality of sweet orange and soil microbial population as influenced by INM in vertisol of central India studied by Marathe *et al*. (2012). The results showed highest concentration of N (2.19%), P(0.111%), k(1.38%), Mg (0.302%), Zn (26.3ppm) and Cu(16.2ppm) in the leaves with the combined application of FYM along with 50% dose of inorganic fertilizers and Ca(2.51%) with green manuring with sunhemp along with 50% dose of inorganic fertilizers. Significant positive correlation was observed between leaf macronutrients content and fruit yield while leaf Zn content with both yield and quality of fruits.

Shivakumar*et al*. (2012) studied the influence of organic manures on fruit yield and their effect on nutrient status of the soil after crop harvest in papaya cv. Surya. The results revealed that application of FYM equivalent to 100% recommended dose of nitrogen (RDN) (154.3 t/ha) gave significantly higher fruit yield of 173.9 t/ha as compared to control and other organic manure treatments except agrigold equivalent to 100% RDN (33.32 t/ha) and vermicompost, sheep manure and bhumilabha in combination with FYM treatments each equivalent to 50% RDN. Analysis of the soil after harvest of papaya crop did not show any significant difference on organic carbon, dtpa-extractable Cu and Mn content among the treatments. Available major nutrients (NPK) were significantly higher with the application of FYM equivalent to100% RDN and dtpa extractable Zn and Fe in combination with FYM and vermicompost each equivalent to 50% RDN as compared to control comprising chemical fertilizer as RDF.

c) Effect of Integrated nutrient management on fruit quality of papaya

With the aim of evaluating the effect of sources as well as rates of nitrogen fertilizer on the quality of papaya (cv. Improved Sunrise Solo Line 72/12′) fruits, an experiment was carried out in field. Three rates of N (10, 20 and 30 g $plant^{-1}$ $month^{-1}$) with two sources of N (ammonium sulphate and ammonium nitrate), were applied to a total of 18 plants. Fruit number, weight, pH, acidity, ascorbic acid and total soluble solids were determined. Increasing N rates caused an increase in fruit yield. Weight, pH and acidity were not affected by the treatments. Total soluble solids contents decreased when ammonium sulphate application increased. The treatment with ammonium nitrate resulted in higher fruit production, as well as increased ascorbic acid concentration. (Marinho *et al* ., 2001.)

Effect of integrated nutrient management on physico-chemical attribute of phalsa (*Grewia subinaequalis* D.C.) studied by Yadav *et al*. (2008) and reported that maximum fruit size, average fruit weight, juice percentage, total soluble solids and ascorbic acid were recorded with the use of T_3 (110 g urea+125 g SSP+26 g MOP+10 kg FYM + *Azotobacter* + PSB). Maximum sugars and pulp/stone ratio were recorded with the use of T_4 (55 g urea+63 g SSP+13 g MOP+15 kg FYM+ *Azotobacter* + PSB).

Shukla *et al.*(2009) studied the evaluation of substrate dynamics for integrated nutrient management under high density planting of guava cv. Sardar and revealed that the application of 50 percent dose of recommended NPK+50 kg FYM+250 g *Azotobacter* (T_7) significantly increased the canopy volume (201.42 m^3), fruit weight (153.30 g), TSS (14%), ascorbic acid (198.30 mg/100 g pulp), reducing sugar (4.77%), total sugars

(8.10%), leaf nitrogen (1.40%), phosphorus (0.46%), potassium (1.17%) contents and fruit yield (28.95 kg per plant).

The effect of bio-fertilizers on homestead fruit production of papaya Cv. Ranchi revealed that different treatments of bio-fertilizers significantly increased the physico-chemical qualities of fruits and also growth characters of plant. Among different treatments under study, *Azotobacter* + *Azospirillium* + VAM + 2 kg FYM showed maximum plant height (173.75 cm), plant girth (37.44 cm) and number of fruits per plant (19.72 no's) followed by *Azotobacter* + VAM + 2 kg FYM while control recorded minimum growth characters. This treatment also recorded maximum fruit weight, bio-chemical constituents were also influenced by the applications of bio-fertilizers .maximum total soluble solids (6.20°brix), total sugar (5.18%) and carotene (2320 μg/100 g pulp) content were recorded from *Azotobacter* + *Azospirillum* + VAM + 2 kg FYM with minimum acidity along with maximum microbial (bacteria) population. (Dutta *et al.*, 2010.)

A field experiment was conducted during 2005-07 at Indian Institute of Horticultural Research, Bangalore, on papaya cv. Surya with six organic treatments along with recommended dose of fertilizers and no manure/fertilizer application. Results indicated that crop growth and fruit yield were higher in inorganic fertilizer treatment (55 t /ha) compared to organic treatments (26.9 to 38 t /ha). There was no significant variation in average fruit weight and TSS, but shelf life of the fruit was significantly higher in organic treatments (6.2 to 7.9 days) as compared to inorganic fertilizer treatment (5.1 days). Among the treatments, application of 7 kg urban compost plant^{-1} or 10 kg FYM plant^{-1} was found to be ideal for improving soil health in terms of microbial population, and biochemical reaction compared to other treatments (Reddy *et al*.2010.)

Ravishankar *et al.* (2010) studied the performance of Coorg Honey Dew papaya under Organic Farming regimes in the Hill Zone of Karnataka through seven treatments with three replications. The results indicated that growth and yield characters as influenced by organic manures were on particular with the intensive farming of chemical fertilizers. Further, application of FYM 20kg/plant recorded maximum total soluble solids ascorbic acid, total sugar and the least value of titrable acidity as compared to intensive farming and other organic treatments.

Fontes *et al*. (2012) evaluated the effect of some aspects of the management of the crop as spacing and level of NPK fertilizer application on some quality attributes of fruits of the papaya hybrid of 'Formosa' group UENF/CALIMAN-01(UC01).with three planting spacings among plants (E1 = 1,80 m; E2 = 2,25 m; E3 = 2,70 m), five levels of conventional NPK (A1 = 80% of the company's standard; A2 = 100% of the standard; A3 = 120% of the standard; A4 = 140% of the standard; and A5 = 160% of the standard) and three evaluation periods (June, August and October 2007). The standard NPK fertilizer company consists of 350, 105 and 660 kg/ha/year of ammonium sulphate (20% of N), superphosphate (18% of P) and potassium chloride (60% of K), respectively to evaluate the firmness of the fruit and pulp, the concentration of soluble solids (SS), p^H, acidity (TA) and the ratio SS /TA of the pulp. Data were subjected to analysis of variance and mean test. The results show that among the conditions of spacing and NPK fertilizer levels tested, the best performance was obtained by combinations E_1A_1 or E_2A_1, which should be adopted to manage the hybrid UC01. These treatments resulted in fruits with superior quality attributes, in addition to these management practices provide a reduction in spending on NPK fertilizer and a smaller environmental impact according to excessive application of fertilizer in the soil.

Integrated nutrient management in pomegranate grown in laterite soil studied by Gosh *et al.* (2012). Highest yield (8.1 kg / plant) was recorded in plant where FYM 20kg along with N-400 P-100 and K-300 g/year was applied that was associated with the foliar N/K ratio of 1:3. The treatment also resulted in maximum fruit weight (200g) with the highest TSS (14.8^0 B), reducing sugar (12.0%) and vit. C (12.5 mg/100ml) content.

A field experiment was conducted during 2009-10 at Indian Institute of Horticulture Research, Bangalore using papaya cv.' Surya'. Ten organic nutrient treatments along with recommended dose of fertilizers and control (no manure/ fertilizer) were used totalling twelve treatment combinations of FYM, biofertilizers and vermicompost. Fruit quality parameters such as total carotenoids, lycopene, TSS, average fruit weight and ascorbic acid content were analyzed. Among the treatments, application of 50% recommended dose of fertilizers in the form of farm yard manure (FYM) applied as *Azospirillum*+ phosphate solubilising bacteria+ Mycorrhiza+ vermicompost showed high level of carotenoids, lycopene and low levels of ascorbic acid. TSS and average fruit weight were not affected by various organic treatments.(Reddy *et al*. 2012).

MATERIALS AND METHODS

This chapter deals with the details of materials and technique employed for conducting the experiment.

3.1 EXPERIMENTAL SITE

The present experiment "Integrated nutrient management for Papaya (*Carica papaya* L.) variety: Ranchi dwarf" was conducted at Horticultural Research Station(HRS), college of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha during the year 2012-2013.

3.2 LOCATION OF EXPERIMENTAL SITE

The Horticulture Research Station (HRS) of Orissa University of Agriculture and Technology is situated about 7 km away from the University and located of 20^0 $15^{'}$ North latitude and longitude of 85^0 $52^{'}$ East. It is about 60 km away from Bay of Bengal having an altitude of 25.5m above mean sea level(MSL). The site was previously fallow and during the kharif , 2012 papaya was planted.

3.3 METEOROLOGICAL OBSERVATION

3.3.1 Climate and weather

The place is characterised by warm and moist climate with hot and humid summer and mild winter. The meteorological data for the year 2012-2013 recorded at meteorological observatory, Agriculture college farm, Bhubaneswar are given in Table 3.1 and Fig. 3.1.

Table 3.1 Weather data of HRS, Bhubaneswar from July, 2012 to May, 2013

Month/Year	Temperature (^{0}C)		Relative Humidity %		Rainfall (mm)	No of rainy days	BSH (Hours)
	Max	Min	AM	PM			
July, 2012	32.3	25.3	94.0	80.8	390.9	19.0	2.4
August, 2012	32.1	25.6	93.6	81.4	257.4	21.0	4.0
September,2012	32.6	25.2	94.6	80.9	111.5	11.0	4.0
October, 2012	32.1	22.7	91.3	67.3	48.1	4.0	6.6
November, 2012	29.7	19.1	93.2	61.7	134.9	5.0	5.8
December, 2012	29.9	15.4	93.0	43.2	0.0	0.0	7.5
January, 2013	29.7	15.0	91.2	42.7	0.0	0.0	6.1
Febrauary,2013	32.3	16.7	89.9	37.0	0.1	1.0	7.5
March, 2013	37.8	21.6	89.4	31.6	0.0	0.0	7.5
April,2013	38.8	24.5	89.7	43.7	1.4	2.0	7.4
May, 2013	38.6	26.9	88.2	54.0	2.5	4.0	8.0
Total	365.9	238	1008.1	624.3	946.8	66	66.8
Average	33.2	21.6	91.6	56.7	86.07	6	6.07

3.4 SOIL PROPERTIES

The composite soil sample was collected (0 to 15 cm depth of soil) from the experimental site prior to land preparation and was chemically and physically analyzed. The data on physical analysis of soil of the experimental site are presented in Table3.2 (a and b).

Table 3.2 (a). Physical Composition of Soil (0 to 15 cm)

Constituent	Percentage composition (Air dry basis)	Methods employed
Sand	81.4%	Bouyoucos hydrometer (Piper, 1950)
Silt	3.4%	
Clay	15.2%	
Soil texture- Sandy loam		
Soil type- Red laterite		

Fig. 3.1. Weather parameters during the cropping season

Table 3. 2 (b). Chemical composition of soil (0 -15 cm)

Chemical constituents	Composition	Methods used
Available Nitrogen (kg/ha)	91	Modified Kjeldhal method (Jackson, 1973)
Available P(kg ha^{-1})	176.4	Brays p-1 method (Page *et al.*, 1982)
Available K(kg ha^{-1})	93	Neutral Ammonium acetate flame photometry (Jackson, 1973)
pH	4.76	Beckman's pH meter (Jackson, 1973)
EC (d Sm^{-1})	0.08	Jackson, 1973
OC (gkg^{-1} soil)	2.9	Walkley and Black Wet oxidation method(Page *et al* ., 1982)
CEC (cmol (p^{+}) kg soil	15.24	Jackson ,1973

3.5 EXPERIMENTAL DETAILS

3.5.1 Land preparation

The experimental field was thoroughly ploughed with tractor drawn mouldboard plough to a depth of 30 cm and harrowed twice to a fine tilth. The field was levelled and divided into plots as per the layout of the respective experiment. Pits of30 cm^3 were dug out for planting the small one month old seedlings of papaya with the spacing of row to row 2m and plant to plant 1.8 m.

3.5.2 Experimental designs and Lay out

The design for the experiment was Randomised Block Design (RBD) having 3 replications and 7 treatments. Treatments were allocated randomly to each replication. Each treatment consisted of 6 plants, one replication had 42 plants. Total 3 replications had 126 plants. The total area under this experiment was 907.2sqm.

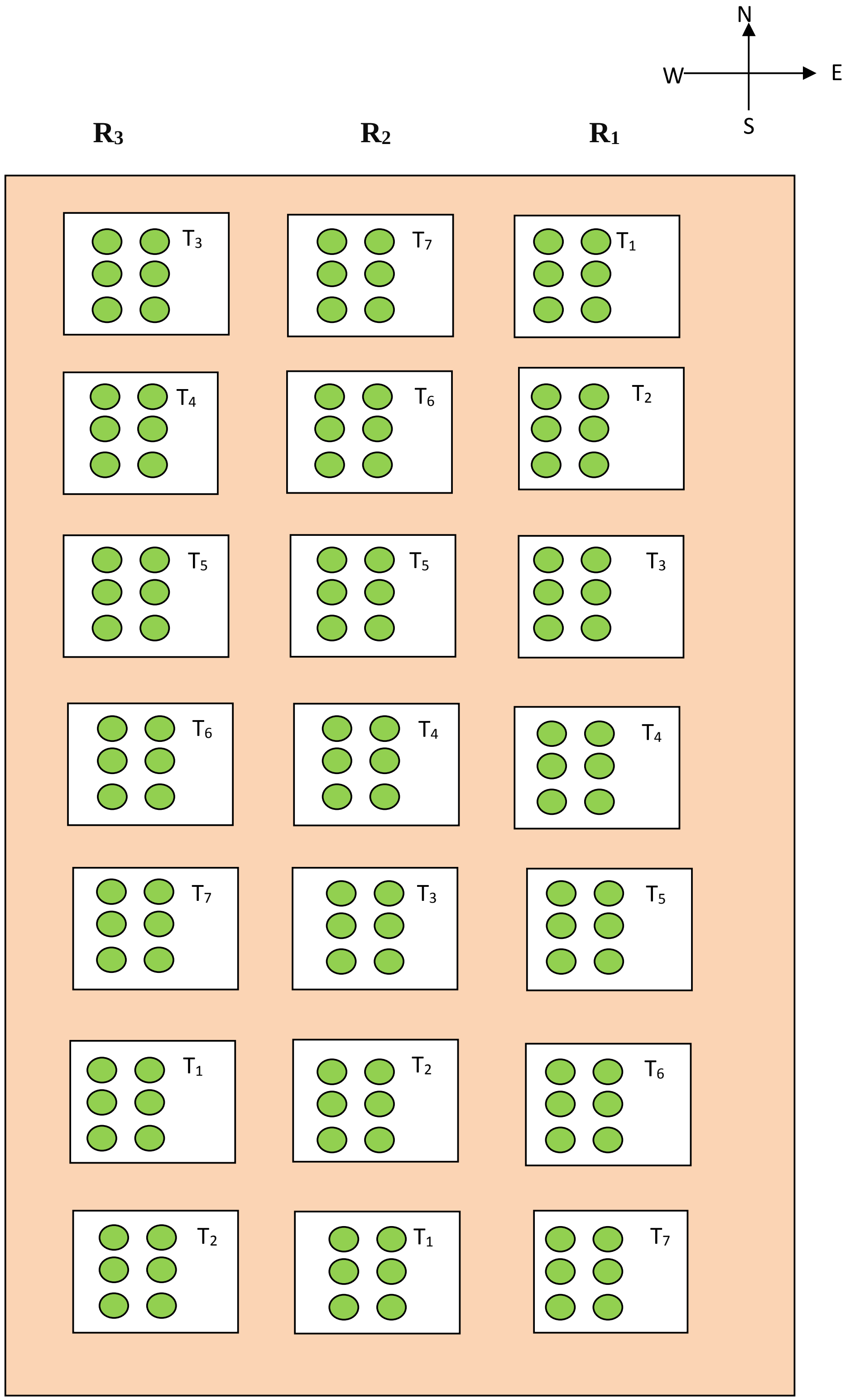

Fig. 3.2 Lay out plan of the experimental field

Plate 1. Full View of experimental Field of papaya

Plate2. Drip irrigation in papaya field

3.5.2.1 Planting material and description of the variety under taken

The "Ranchi dwarf " variety of papaya was taken for planting. It performs well under north Indian conditions and is highly valuable in respect of yield and quality. It bears large fruits on plants of a medium height. The variety "Ranchi dwarf" recorded maximum individual fruit weight (2.04 kg), yield (34.92 kg/plant) and total sugars(Jana *et al*., 2008).One month old Ranchi dwarf papaya seedlings were collected from nursery of Horticulture Research Station (HRS) of Orissa University of Agriculture and Technology.

3.5.2.2 Sources of organic manures and inorganic fertilizers

Vermicompost was obtained by culturing *Eisenia foetida* earthworms on leaf wastes in HRS nursery. In inorganic treatments (Recommended dose of Fertilizers (RDF) nitrogen, phosphorous and potassium nutrient requirements were met from the application of urea, single super phosphate and muriate of potash respectively.

3.5.2.3 Quantities of organic manures and inorganic fertilizers

The recommended dose of major nutrients for papaya is 200:200:250 g N-P_2O_5-K_2O plant^{-1}under Bhubaneswar conditions .It was proposed to conduct the present investigation with 50% of the recommended dose of Fertilizers(100 g N, 100g P_2O_5, 125g K_2O, per plant), 50% of the recommended dose of Fertilizers (100N, 100 P_2O_5, 125K_2O, per plant) along with biofertilizers,75% of the recommended dose of Fertilizers(150g N, 150g P_2O_5, 187.5g K_2Oper plant), 75% of the recommended dose of Fertilizers (150g N, 150 P_2O_5, 187.5g K_2O, per plant) along with biofertilizers, 100% recommended dose of nutrients(200g N, 200g P_2O_5, 250g K_2O, g per plant), 100% recommended dose of nutrients (200g N, 200g P_2O_5, 250g K_2O per plant) along with Biofertilizers according to treatments.

3.5.2.4 Biofertilizers

For this study, biofertilizers, viz., *Azospirillum*, phosphate solubilizing bacteria (PSB), *Azotobacter,* were procured from soil Biodiversity Biofertilizer lab (Orissa University of Agriculture and Technology) Bhubaneswar Odisha. These three organisms were inoculated (1:1:1) to pre-limed (5 %) vermicompost in 1:25 ratio each source applied @ 3 kg ha^{-1}, incubated for 7 days at 30 % moisture. Then applied @ 100 g/ pit and basal.

3.5.2.5 Time and method of manure and fertilizers application

Calculated quantities of organic manures were applied at the time of planting. Recommended dose of nitrogen and potassium inorganic fertilizers were applied in four split doses at an interval of 30 days starting from 30 days after planting till flowering by pocketing method (30 cm away from plant on either side of plant), entire dose of phosphorus was applied at the time of planting as basal dose.

3.5.2.6 Planting of seedlings

One month old seedlings of papaya were planted in the pits along with the manures like vermicompost and biofertilizers according to the treatments. The seedlings were provided with irrigation immediately after planting. The date of planting was 22/09/2012.

3.5.2.7 Cultural operations

The seedlings were applied with the fertilizers 30 days after planting. The experiment was kept weed free by manual weeding. Dried leaves of plants are removed to keep field disease free.

3.5.2.8 Source and method of irrigation

The irrigation was applied through drip system and the source is from deep well bore. Irrigation was given in two days intervals at morning hours.

3.6 TREATMENTS (PLANT^{-1} CROP CYCLE^{-1})

T_1: Absolute control

T_2: 50%NPK Recommended dose (RD)

T_3: 50%NPK Recommended dose (RD) + AZO+AZS+PSB(BFs)

T_4: 75%NPK Recommended dose (RD)

T_5: 75%NPK Recommended dose (RD) + AZO+AZS+PSB (BFs)

T_6: 100%NPK Recommended dose (RD)

T_7: 100%NPK Recommended dose (RD) + AZO+AZS+PSB (BFs)

Experimental details:

Design	:	R.B.D
Replications	:	3
Spacing	:	2.0 × 1.8m

3.7 OBSERVATIONS ON VEGETATIVE GROWTH

Each treatment consisted of six plants, they were selected to record different growth parameters during different phenological stages of the crop and reproductive, fruit characters.

3.7.1 Plant height (cm)

The plant height was measured from the base of the stem to the axil of the youngest leaf and expressed in centimeters. plant height was recorded at monthly interval from November, 2012 to May, 2013.

3.7.2 Girth of the stem

The girth of the stem was measured at the maximum circumference point of the stem by help of vernier callipers and expressed in centimetres. Stem girth was recorded at monthly interval from November, 2012 to May, 2013.

3.7.3 Number of leaves

The number of functional leaves produced after planting till the time of fruiting were counted every month from November, 2012 to May, 2013.

3.7.4 Petiole length

Length of petiole of leaf was measured in centimetres after planting till the time of fruiting at monthly interval from November, 2012 to May, 2013.

3.7.5 Petiole girth

The leaf Petiole girth was measured in centimetres after planting till the time of fruiting at every month from November, 2012 to May, 2013.

3.7.6 Leaf area

The leaf area was measured at three months after planting and four months after planting with the help of digital leaf area meter in square centimeters.

3.7.7 Spad value (chloropyhllcontent)

The leaf chlorophyll content was measured at three months after and at harvest stage with the help of spado meter.

3.7.8 Leaf nutrient concentration

For estimating leaf nitrogen, phosphorous and potassium contents, from bottom fourth or fifth leaf (including midrib) was collected at 3 MAP, 4 MAP and at harvesting of fruit

Nitrogen estimation in papaya leaf

Leaf samples were digested in H_2SO_4 with digestion mixture ($CuSO_4$: K_2SO_4: 1:10), Salicylic acid and sodium thiosulphate. The nitrogen in the aliquot was determined by kjeldahl distillation and titration method (Page *et al.*, 1982)

Phosphorus, K, Ca, Mg and S:

Leaf samples were digested with diacid mixture (HNO_3) and $HClO_4$ (3:2) for estimation of these nutrients.

Phosphorous(P):

Phosphorous was determined by spectrophotometer at 470 nm wave length by vanadomolybdo phosphoric acid yellow colour method (Jackson, 1973).

Potassium(K) :

The potassium was determined by Flame photometer after suitable dilution.

Calcium (Ca):

Calcium was estimated by complexometrictitration method using standard Ethylene Diamine Tetra Acetic acid (EDTA).

Sulphur (S):

The sulphur in the leaf sample was determined spectrophotometrically at 410 nm wave length by turbid metric method using Barium chloride as suggested by Massouri and Cornfield, 1965.

3.8 YIELD ATTRIBUTING CHARACTERS

3.8.1 Days taken for flower emergence

Days from planting of seedlings to flower emergence was recorded

3.8.2 Days taken for fruit initiation

Days from planting to fruit formation after pollination were recorded.

3.9 FRUIT CHARACTERS

3.9.1 Fruit length

Fruit length was measured from fruit initiation stage to fruit maturity stage at monthly intervals. The fruit length was measured from stalk end to flower end. It is expressed in centimetres.

3.9.2 Fruit circumference

Fruit circumference was measured from fruit initiation stage to fruit maturity stage at monthly intervals. The fruit circumference was measured at the widest point of fruit with help of vernier callipers and it is expressed in centimetres

3.9.3 Fruit width

Fruit width was measured from fruit initiation stage to fruit maturity stage by the help of measuring tape. It was expressed in centimetres.

3.9.4 Fruit weight

The fresh fruit weight was taken immediately after harvesting by the help of electronic balance.

3.9.5 Fruit yield (kg ha^{-1})

Fruit yield(kg ha^{-1}) was calculated using mean fruit weight and population density of plants is (2778 plants ha^{-1}).

Plate 3.Flowering in papaya

Plate 4.Fruits at immature stage

3.10 FRUIT QUALITY CHARACTERS

3.10.1 Total soluble solids (^{0}Brix)

Total soluble solids (TSS) content in papaya fruit was determined by hand refractometer at ripe stage of fruit.

3.10.2 Titratable acidity (%)

The amount of sample taken 5g of pulp and was ground to paste using distilled water. Samples were diluted with distilled water and titrated against 0.01N NaOH using phenolphthalein indicator. The acidity was determined using the method suggested by Ranganna (1986).

3.10.3 Reducing sugars (%)

Reducing sugars content in fruit was determined at fruit ripening stage using Lane and Eyon method (AOAC,1965).

3.10.4 Non-reducing sugars (%)

Non-reducing sugars content in fruit was determined at fruit ripening stage using Lane and Eyon method (AOAC,1965).

3.10.5 Nutrient concentration in fruit

For estimating nitrogen, phosphorous and potassium contents in fresh papaya fruit, the fresh fruit digested with sulphuric acid and digestion mixture then digester samples were distilled for the estimation of the total nitrogen (%) by micro kjeldahl method, phosphorous (%) by vanadomolybdate in acid digest method (spectrophotometer) and potassium (%) by flame photometer method (Jackson, 1973).

3.10.6 Nutrient uptake

Nutrient uptake was calculated after multiplying the concentration (%) with the respective dry matter production (q ha^{-1}).

3.10.7 Statistical analysis

The data was analyzed using computer software programmed by the method of variance outlined by Panse and Sukhatme (1985). Statistical significance was tested by F value at 5 per cent level of significance. Critical difference at 0.05 levels was worked out for the effects which were significant. The results have been depicted graphically where ever necessary.

EXPERIMENTAL FINDINGS

The Results of present investigation on "**Integrated nutrient management for papaya (*carica papaya* L.) variety: Ranchi Dwarf**" has been presented in this chapter. The results of the experiment have been explained with the help of tables, graphs and photographs as and when necessary.

4.1 INITIAL SOIL PROPERTIES

Table 4.1 Physical composition of soil (0 to 15 cm).

Constituent	Content
Sand (%)	81.4
Silt (%)	3.4
Clay (%)	15.2
pH_W (1:2.5)	4.76
EC (dSm^{-1})	0.08
OC (g kg^{-1} soil)	2.9
CEC cmol (p^+) kg^{-1}	15.24
Available Nitrogen (kg ha^{-1})	91.0
Available Phosphorus (kg ha^{-1})	178.0
Available Potassium (kg ha^{-1})	93.0
Available Sulphur (kg ha^{-1})	2.9

A field experiment was conducted in the Horticultural Research Station (HRS), college of Agriculture, Orissa University of Agriculture and Technology in the Bhubaneswar was conducted during October, 2012 to May, 2013 on papaya crop in order to study the **"Influence of integrated nutrient management in papaya**".

The soil of the experimental site was loamy sand in texture (clay 15.2 per cent and sand 81.4 per cent), strongly acidic in reaction, (pH 4.76), low soluble salts concentration (EC-0.08 dSm^{-1}), very low organic carbon (OC, 2.9 g kg^{-1} soil), cation exchange capacity of 15.24 cmol (p^+) kg^{-1} soil, low available N, K and S but high in Bray's-1 available P (Table 4.1).

The test crop papaya (cv. Ranchi Dwarf) had received seven treatments, namely (i) control, (2) 50 % RDF, (3) 50 % RDF + BF, (4) 75 % RDF, (5) 75 % RDF + BF, (6) 100 % NPK and (7) 100 % NPK + RDF + BF. The biofertilizers (BF) include, *Azotobacter*, *Azospirillum* and phosphorus solubilizing microorganisms (PSM) in 1:1:1 ratio incubated for 7 days at 30 per cent moisture for seven days (supplied by AINP on Biodiversity Biofertilizers Project) applied @ 100 g per pit as per the treatment specificity, at the time of planting of papaya seedlings.

Biometric observations

The biometric observations recorded during crop growth on different parameters have been recorded and described in this chapter.

4.2 Biometric observations

Plant height

The plant height of the crop recorded from 2nd month onward has been presented in Table 4.2 Fig.4.1. At all stages of crop growth, there was significant influence of either inorganic nutrition or its integration with BFs significantly influenced the plant height. Graded doses of inorganic nutrition also influenced the plant height considerably.

Leaf area

The leaf area of papaya crop at two stages of crop growth has been presented in Table 4.3. At 3 month stage of crop growth though there was differences in leaf area due to differential treatments, these were not statistically significant. By 4th month of crop growth the influence of integrated treatments became significant, particularly when compared over control. However, the influence of BFs was insignificant.

Table 4.2 Effect of various treatments on plant height (cm) in different months per plant

Treatments		Nov.	Dec.	Jan.	Feb.	March	April	May
T_1	Absolute control	21.86	30.63	48.73	50.30	51.6	53.93	53.93
T_2	50 % NPK	24.57	33.00	49.29	50.67	53.10	57.43	57.43
T_3	50 % NPK + BF	26.6	40.1	50.28	51.00	54.60	61.73	61.73
T_4	75 % NPK	27.8	42.57	51.22	52.6	56.77	63.57	63.57
T_5	75 % NPK + BF	28.2	43.70	55.5	56.20	59.37	63.70	63.70
T_6	100 % NPK	29.0	46.10	54.72	57.90	62.27	65.06	65.06
T_7	100 % NPK + BF	31.5	53.60	56.93	58.44	62.60	67.37	67.37
CD(P=0.05)		3.58	1.91	2.73	3.43	6.40	3.55	5.01

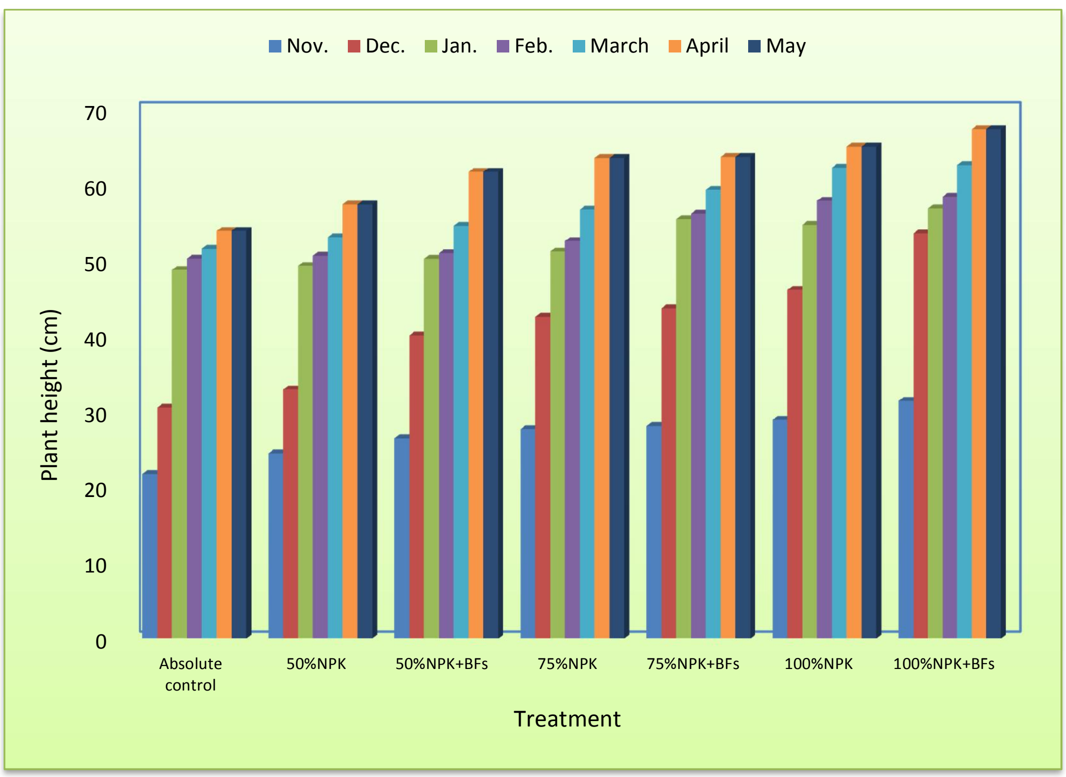

Fig. 4.1 Effect of various treatments on plant height (cm) in different months per plant

Table 4.3 Effect of various treatments on leaf area (cm^2) of papaya crop

Treatments		At 3 Month Stage	At 4 Month Stage
T_1	Absolute control	336.33	380.30
T_2	50 % NPK	431.00	451.53
T_3	50 % NPK + BF	478.4	476.50
T_4	75 % NPK	522.63	529.63
T_5	75 % NPK + BF	537.40	532.67
T_6	100 % NPK	521.60	659.30
T_7	100 % NPK + BF	570.97	708.63
SEm (±)		65.79	60.9
CD(P= 0.05%)		NS	187.8

Stem girth

The girth of papaya plant from a range of 0.9 to 4.03 cm after 2 months of crop growth increased continuously up to May (months of growth) to a range of 2.3 to 5.81cm (Table 4.4). Fertilizer application at all the three levels (T_2 , T_4,T_6) significantly increased the stem girth indicating the essentiality of crop fertilization with inorganic nutrients. Integrated use of BFs (T_3 , T_5,T_7) during early growth stages influenced the plant gaining girth particularly at higher level of fertilizers application.

Table 4.4 Effect of various treatments on stem girth (cm) at different months of crop growth per plant

Months \ Treatments/		Nov.	Dec.	Jan.	Feb.	March	April	May
T_1	Absolute control	0.93	1.6	2.62	2.7	2.83	2.9	3.20
T_2	50 % NPK	1.5	1.93	2.84	2.9	2.94	2.94	3.73
T_3	50 % NPK + BF	1.71	2.00	2.91	3.2	3.6	4.2	4.51
T_4	75 % NPK	2.15	2.21	3.4	3.7	3.81	4.0	4.6
T_5	75 % NPK + BF	2.22	2.40	3.73	3.8	4.11	4.4	4.7
T_6	100 % NPK	3.0	2.8	4.53	4.7	4.9	4.0	4.95
T_7	100 % NPK + BF	4.03	4.45	5.3	5.4	5.71	5.71	5.81
CD(P=0.05)		0.030	0.52	0.40	0.40	0.44	0.48	1.41

Number of leaves

At two month old the papaya crop plant hadthe average number of leaves ranging from 8.0 to 12.9, lowest with control and highest with 100 % RDF + BF (Table 4.5). Maximum number of leaves per plant was recorded during 3rdmonth of growth which varied between 11.2 and 23.8, thereafter number of leaves, started decreasing, by 8th month it was brought down to a range of 6.3 to 12.6 (Fig. 4.2). Inorganic nutrition of crop (T_2, T_4,T_6) always encouraged higher number of leaves attaining highest with 100 % NPK added with BFs. Integration of BFs use with inorganic fertilizers had positive influence of leaf numbers (T_3, T_5,T_7).

Table 4.5 Effect of various treatments on number of functional leaves at different months of growth per plant

	Treatments/ months	November	December	January	February	March	April	May
T_1	Absolute control	8.0	11.24	13.72	11.3	8.43	4.82	6.33
T_2	50%NPK	8.2	12.5	11.93	11.70	9.17	8.03	7.10
T_3	50%NPK+BFs	8.2	14.37	13.11	13.6	9.82	9.53	9.5
T_4	75%NPK	8.9	16.03	14.32	14.1	10.57	8.97	10.6
T_5	75%NPK+BFs	9.8	16.0	14.53	14.5	11.1	10.00	10.0
T_6	100%NPK	11.4	17.42	15.30	16.5	9.2	9.07	11.0
T_7	100%NPK+BFs	12.9	23.8	13.7	17.6	13.6	11.83	12.6
CD(P=0.05)		0.97	2.30	3.17	2.22	2.11	3.32	1.37

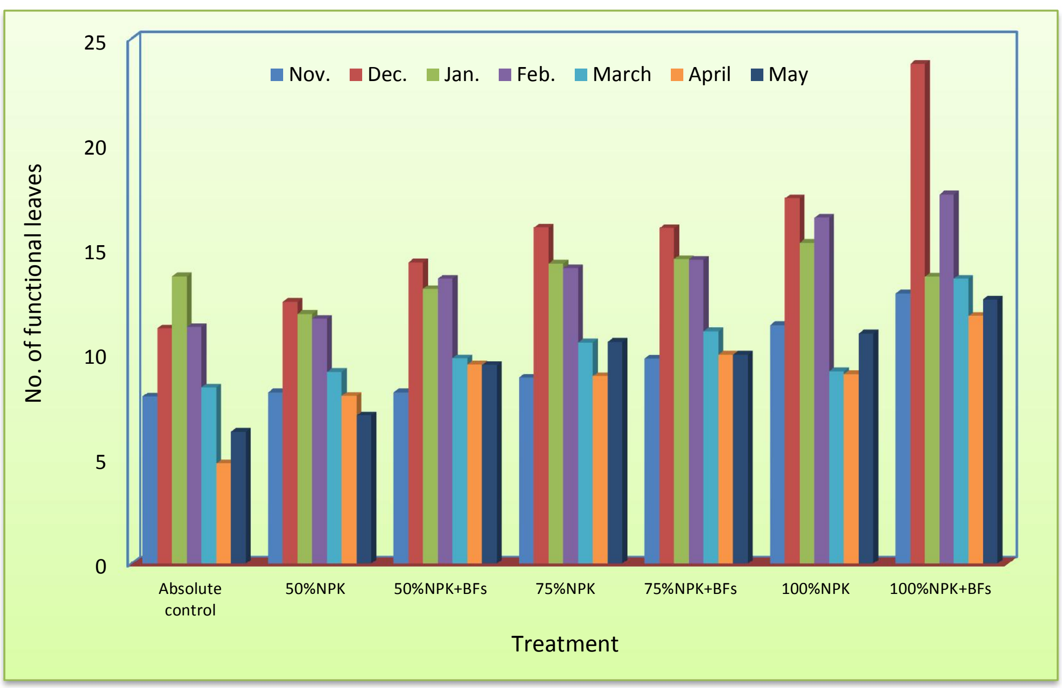

Fig.4.2 Effect of various treatments on number of functional leaves at different months of growth per plant

Petiole length

The length of leaf petiole signifies the canopy area. More the canopy area more is the photosynthetic activity, better fruiting, more benefit. By 3rd month of crop growth the length of leaf petiole under the influence of differential treatments varied between 18.3 and 32.3 cm. Its length increased gradually and attended the maximum length by May (8 month stage), which varied between 22.9 and 38.2 cm. Incremental doses of inorganic fertilizers, particularly when integrated with BFs increased the petiole length (Table 4.6) Fig 4.3 considerably.

Table 4.6 Effect of various treatments on leaf petiole length (cm) at different months of crop growth per plant

Treatments \ Months		January	February	March	April	May
T_1	Absolute control	18.32	20.2	21.22	22.35	22.87
T_2	50%NPK	20.23	23.87	25.90	25.97	26.62
T_3	50%NPK+BFs	22.13	25.23	27.30	28.73	29.12
T_4	75%NPK	24.30	26.6	29.57	33.50	33.8
T_5	75%NPK+BFs	26.83	27.9	31.23	34.67	34.90
T_6	100%NPK	29.63	30.4	34.20	35.70	36.03
T_7	100%NPK+BFs	32.37	33.63	37.4	37.77	38.23
CD(P=0.05)		3.00	1.30	3.04	3.06	2.49

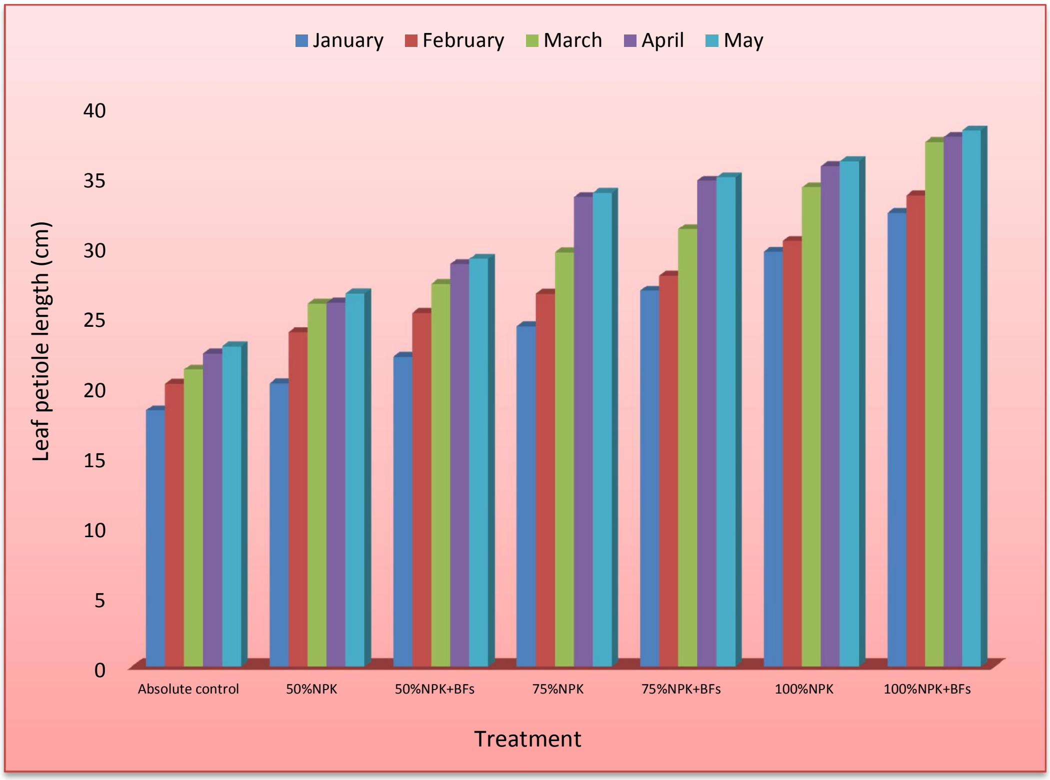

Fig. 4.3 Effect of various treatments on leaf petiole length (cm) at different months of crop growth per plant

Petiole girth

Not only the petiole length but also its girth was influenced under differential nutrition supplied through fertilizers and BFs. During last five months (January to May) the petiole girth ranging from 0.53 to 1.85 cm increased to higher girth ranging from 1.41 to 2.94 cm (Table 4.7) Fig 4.4. All along the plants in control field maintained lowest petiole girth and plants under 100 % RDF + BF treatment had highest petiole girth indicating healthy situation for healthy and profitable crop.

Table 4.7 Effect of various treatments on leaf petiole girth (cm) at different months of crop growth per plant

Months \ Treatments		January	February	March	April	May
T_1	Absolute control	0.53	0.76	0.92	1.16	1.41
T_2	50%NPK	0.63	0.82	1.11	1.32	1.55
T_3	50%NPK+BFs	0.79	0.94	1.27	1.40	1.58
T_4	75%NPK	1.32	1.52	1.73	1.82	2.00
T_5	75%NPK+BFs	1.25	1.64	1.85	2.09	2.30
T_6	100%NPK	1.62	1.78	1.90	2.16	2.54
T_7	100%NPK+BFs	1.85	1.99	2.3	2.51	2.94
SEm(±)		0.09	0.04	0.07	0.09	0.25
CD(P=0.05)		0.28	0.14	0.22	0.29	0.77
CV(%)		14.1	5.84	7.88	9.42	21.2

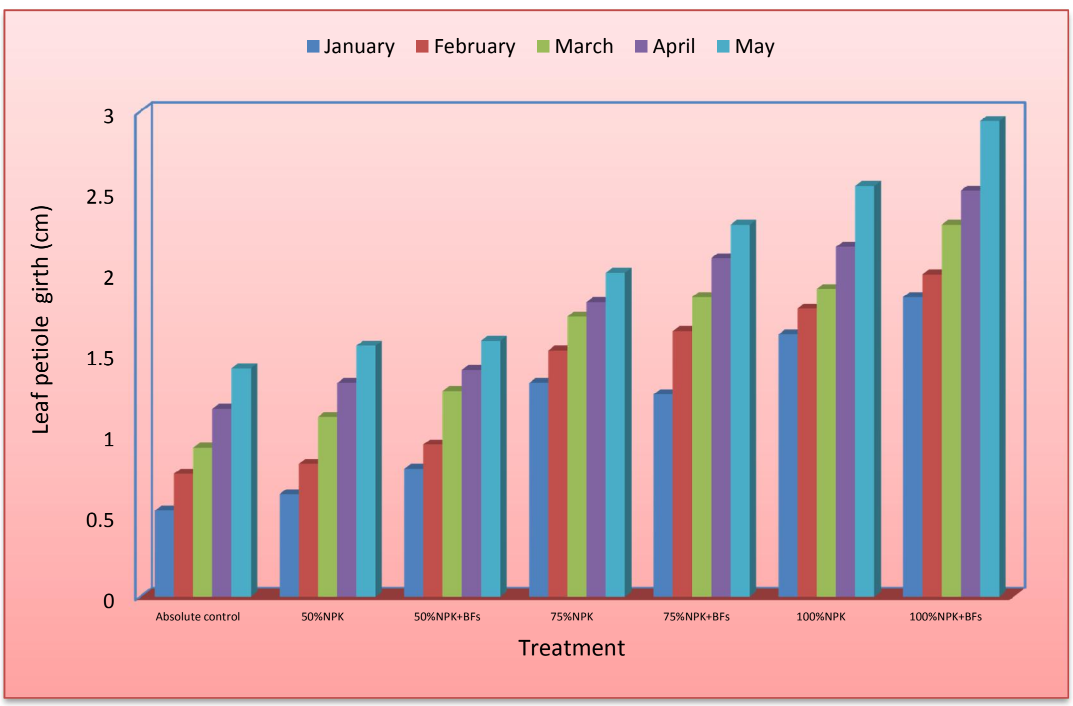

Fig. 4.4 Effect of various treatments on leaf petiole girth (cm) at different months of crop growth per plant

4.3 Photosynthetic activity

It was measured by measuring the chlorophyll content of leaves at two growth stages (4th and at harvest stage) by spadometer. At 4th month of crop growth it was higher (ranging from 40.1 to 49.7) than it harvest stage (ranging from 37.9 to 43.2). Integration of BFs (T_3, T_5& T_7) application helped the plant maintaining higher chlorophyll content than without it or lone (T_1, T_2,T_4 and T_6) fertilizers application . Application of fertilizers at higher rates maintained more chlorophyll content compared to lower doses (Table 4.8).

Table 4.8 Effect of Various Treatments on Spad value (chlorophyll content) in Papaya Leaf.

Treatments		**Spad value at 4 month (average)**	**Spad value at harvest (average)**
T_1	Absolute control	44.60	39.60
T_2	50%NPK	40.10	37.90
T_3	50%NPK+BFs	48.33	42.44
T_4	75%NPK	42.03	38.72
T_5	75%NPK+BFs	46.60	42.70
T_6	100%NPK	44.90	38.57
T_7	100%NPK+BFs	49.70	43.23
SEm(±)		2.03	2.27

4.4 Nutrient concentration in leaves of papaya at different stages of growth

The concentration of nitrogen in papaya plant leaf at three growth stages have been depicted in Appendix-I and Fig. 4.5

Nitrogen

At three months of growth the N concentration in the leaf was higher, ranging from 6.9 to 8.7 per cent, gradually reduced to a range of 6.61 to 8.0 per cent at 6 month crop growth and at harvest maintained between 6.5 and 6.91 (Fig. 4.5). Inorganic nutrition of crop with graded doses increased N content in the leaf. Integration of BFs application further added to the concentration.

Phosphorus

The concentration of P in the papaya leaf at 3 month of crop growth was higher, ranging from 0.468 to 0.625 per cent . After one month of crop growth it decreased and was maintained between 0.425 and 0.574 per cent (Appendix-II Fig-4.6)At harvest stage its concentration decreased and maintained between 0.277 and 0.403 per cent. At all stages of crop growth the plants under control treatment maintained lowest P concentration compared to the plants receiving external addition of nutrients including P. Bioinoculated plants (T_3 , T_5 and T_7) maintained higher P concentration than uninoculated plants.

Potassium

The concentration of K in papaya leaf (Appendix III and Fig. 4.7) at 3 month state was in the higher range from 2.65 to 3.55 per cent. The concentration decreased to a range of 1.40 to 1.82 per cent at 4 month stage and increased to a level ranging from 1.35 to 3.07 per cent except control. Higher K concentration was maintained when the crop received 75 % NPK either alone or integrated with BFs application. The unfertilized and uninoculated crop maintained lower concentration of potassium in the leaf.

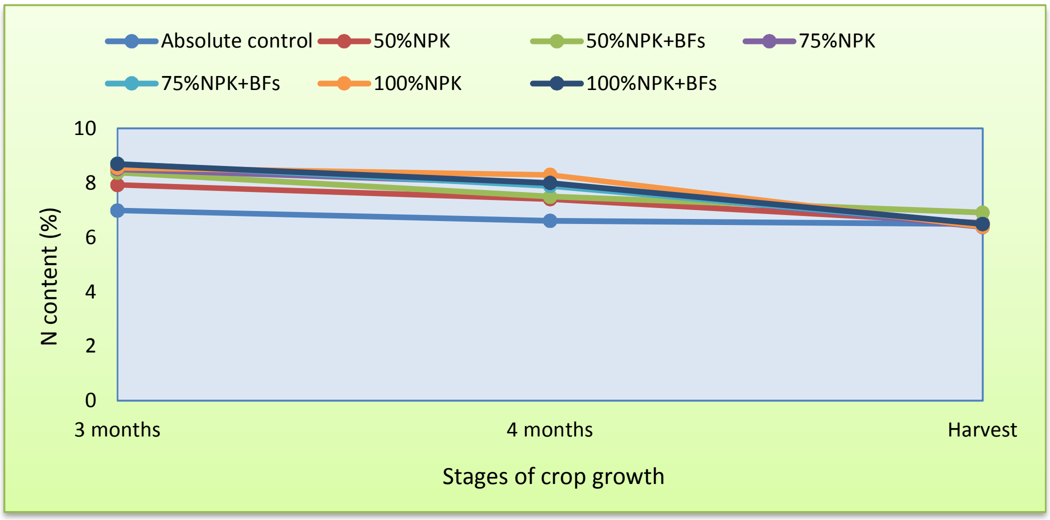

Fig 4.5 Leaf nutrient concentration in papaya during growing period-Nitrogen

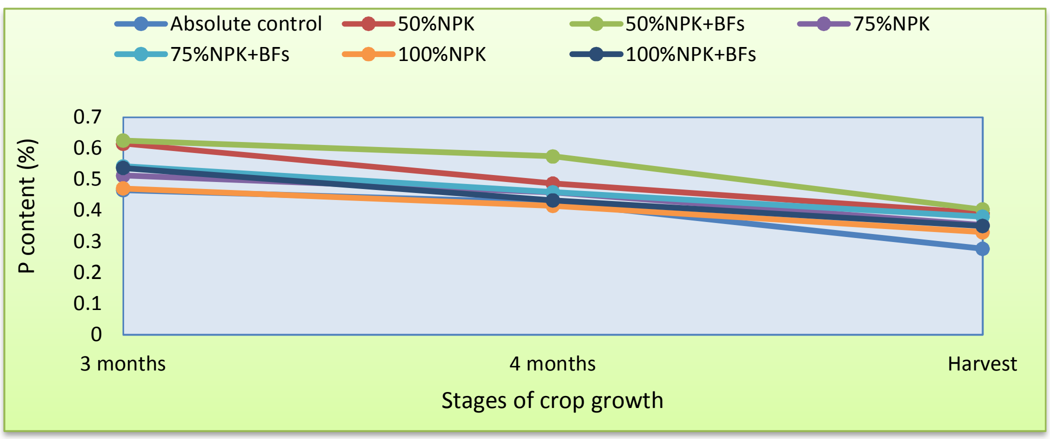

Fig 4.6 Leaf nutrient concentration in papaya during growing period-Phosphorous

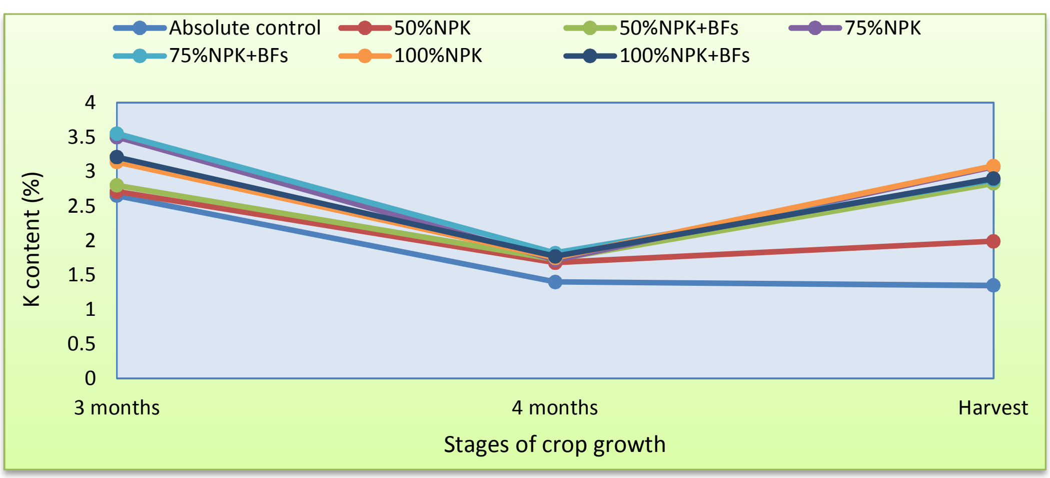

Fig 4.7 Leaf nutrient concentration in papaya during growing period -potassium

Calcium

The concentration of Ca in the papaya leaf at 3 month growth stage was lower (ranging from 0.396 to 0.589 per cent) compared to the concentration at 4 month stage (ranging from 1.15 to 1.75 per cent). At harvest stage it further increased and maintained between 1.40 and 1.82 per cent. The bioinoculated crop before harvest stage maintained higher Ca concentration, however, at harvest stage reverse trend was observed.

The concentration of Mg in papaya leaf at different growth stages has been presented in Fig. 4.8, Appendix V.

Magnesium

At the three month stage of growth the Mg concentration in the papaya leaf receiving differential input treatments ranged from 0.21 to 0.30 per cent, lowest in control and highest 100 % NPK + BF treatment, almost half the concentration of Ca. With crop growth, its concentration in the leaf increased by 4th month of growth, ranging from 0.69 to 1.04 per cent. Till the harvest stage its concentration continued to increase irrespective of the treatments and maintained between 1.04 and 1.2 per cent. Bioinoculated crops (T_3, T_5 and T_7) maintained higher Mg concentration in the leaf compared to uninoculated one except at harvest stage may be their population might have decreased.(Fig 4.9).

Sulphur

The concentration of sulphur in papaya leaf at different growth stages has been presented in Fig. 4.10 and Appendix VI. Its concentration was higher at 3 month growth stage (ranging from 0.26 to 0.375 per cent) than the concentration ranging from 0.16 to 0.22 per cent at 4th month of crop growth. Thereafter it increased and maintained between 0.2 and 0.28 per cent at harvest stage. At all stages of crop growth bioinoculated crop (T_3, T_5 and T_7) maintained higher content of S than uninoculated one.

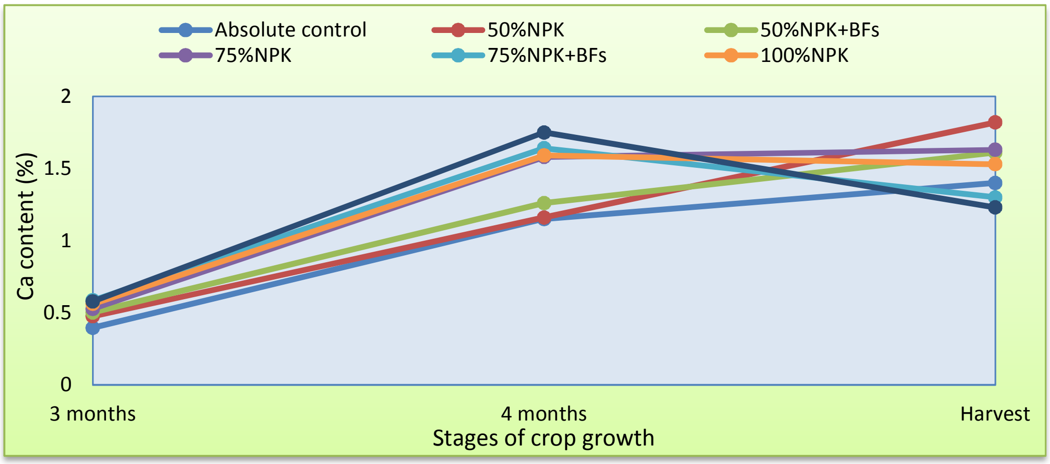

Fig 4.8 Leaf nutrient concentration in papaya during growing period –calcium

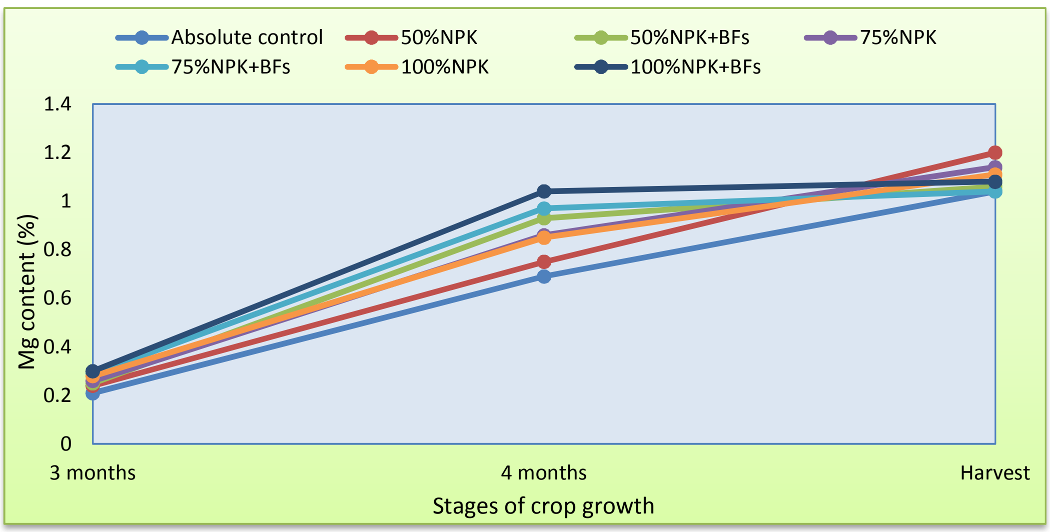

Fig 4.9Leaf nutrient concentration in papaya during growing period –magnesium

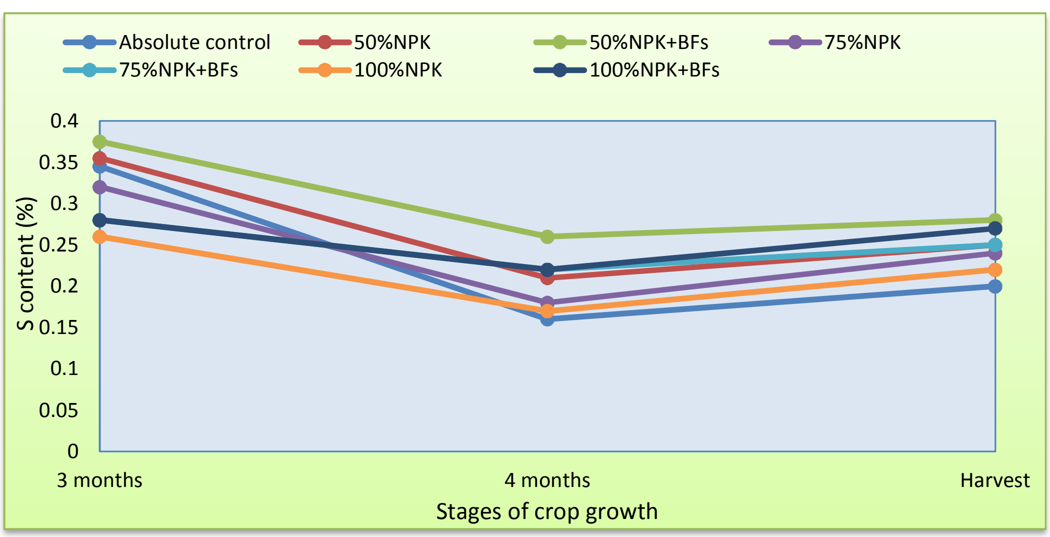

Fig 4.10Leaf nutrient concentration in papaya during growing period -sulphur

4.5 Flowering and fruiting

Days taken for flowering

The data presented in Table 4.9 indicated significant variations in days taken for flowering as influenced by recommended dose of fertilizers and biofertilizers. The number of days taken for flowering in papaya plant ranged from 72.6 to 92.33 days. Maximum days of 92.3 recorded with T_1 (Absolute control) and minimum withT_7(100%RDF+BFs).The $T_1$was statistically at par with T_2,T_4,T_5.

Days taken for fruiting initiation

The data depicted in the Table No.4.9 indicated significant variations in number of days taken for fruiting in papaya plant. The number of days taken for fruiting range from 127.3-181.3. Maximum number of days recorded with T_1 (control) and it was par with T_3(50%+BFs). Minimum number of days for fruiting was recorded with T_7 (100%RDF+BFs).

Table 4.9 Effect of Various Treatments on For Flowering and Fruit Emergence of Papaya

Treatments		Days Taken For Flower emergence	Days Taken For Fruiting
T_1	Absolute control	92.33	181.33
T_2	50%NPK	89.00	163.67
T_3	50%NPK+BFs	74.33	176.00
T_4	75%NPK	84.00	159.33
T_5	75%NPK+BFs	91.33	144.67
T_6	100%NPK	84.67	137.33
T_7	100%NPK+BFs	72.67	127.33
SEm(±)		4.68	3.11
CD(P = 0.05)		14.2	NS
CV(%)		9.64	3.4

Fruit parameters

The data relating to biometric observations of fruit of papaya [(Length of papaya, width, fruit circumference, number of fruits per plant, unripe fruit weight, fruit yield(kgha^{-1})] are influenced by different treatments with recommended dose of fertilizers and biofertilizers have been evaluated in this study (Table 4.10).

Fruit length

The data on fruit length presented in the Table 4.10indicated that the significant variations in the fruit length under the influence of recommended dose of fertilizers and biofertilizers application. The Fruit length ranged from 21.83 to 26.13 cm. The highest fruit length of papaya (26.13 cm) was recorded from the treatment T_7(100% RDF+BFs) than other treatments except the treatment T_4 (75%RDF+ BFs) and T_6(100%RDF) which were statistically at par. The data also indicated that the lower fruit length was marked under control condition.

Fruit circumference

There was great variation in Fruit diameter (27.87 to 36.03 cm) as per data presented in Table 4.10 .The maximum diameter (36.03cm) was recorded in the treatment T_7 (100% RDF+BFs) than the rest of the treatments T_6(100%RDF) which was statistically at par. The minimum diameter (27.87cm) was in control treatment, where only vermicompost applied as organic manure.

Fruit width

The data depicted in Table 4.10.Significant variations (11.58 to 16.8cm) in width of fruit under the influence of various doses of fertilizer and biofertilizers applied . The highest fruit width16.80cm was recorded inT_7(100% RDF+BFs) where as lowest (11.58cm) in control treatment. But T_6 (100%RDF) was statistically at par with the T_7.

Tale 4.10 Effect of Various Treatments on Fruit Parameters of Papaya

Treatments		Average fruit length (cm)Per Plant	Average Fruit circumference (cm) Per Plant	Average Fruit Width (cm) Per Plant
T_1	Absolute control	21.83	27.87	11.58
T_2	50%NPK	22.15	29.17	12.37
T_3	50%NPK+BFs	23.16	25.83	12.71
T_4	75%NPK	24.63	28.27	13.20
T_5	75%NPK+BFs	25.33	29.37	14.05
T_6	100%NPK	25.03	33.00	16.30
T_7	100%NPK+BFs	26.13	36.03	16.80
SEm(±)		0.51	1.66	0.67
CD(P = 0.05))		1.57	5.13	2.09
CV(%)		9.63	9.63	8.48

4.6 Productivity of papaya crop

The information on average fruit number per plant, unit fruit weight, fresh fruit and dry fruit yield has been presented in Table 4.11.

4.6.1 Fruit number

The mean fruit number per plant varied widely between 6.1 and 20.6, lowest due to no addition of inputs (control) and highest due to optimal dose of inorganic nutrients added with BFs. Fruit number per plant doubled with the application of half the recommended dose. Integrating BFs use with this dose increased the number of fruits by 9.7 per cent higher. Incremental doses of fertilizers increased the number of fruits per plant significantly. Combined use of BFs with respective inorganic doses also significantly influenced the fruit number.

4.6.2 Unit fruit weight

Not only the fruit number per plant was influenced but also the unit fruit weight by integrated treatments. The unit fruit weight varied between 0.6 and 1.35 kg ha^{-1}. Even though suboptimal dose of inorganic nutrients increased unit fruit weight compared to control, but small increment could not increase unit weight of fruits. However with higher doses it influenced the fruit weight significantly. Combining BFs use even though increased the unit fruit weight but the increase was not statistically significant (Table 4.11).

4.6.3 Fresh fruit yield

The integrated treatments brought significant difference in fruit yield, which varied between 5083 and 38955 kg ha^{-1}.With 50 % , 75 % and 100 % RDF there was 3.6, 4.6 and 4.7 times yield increase compared to control yield of 5083 kg ha^{-1}. Integration of BFs application with 50, 75 and 100 % RDF, resulted in 18, 21 and 12 per cent yield increase respectively compared to lone application of inorganic nutrients (Table 4.11 and Fig. 4.11).

Table 4.11 Crop productivity of papaya crop as influenced by integrated treatments

Treatments		No of fruits per plant	Unit Fruit Weight (kg)	Fruit yield (kg ha^{-1})	Dry fruit yield (kg ha^{-1})
T_1	Absolute control	6.1	0.6	5083	776
T_2	50%NPK	13.1	0.79	18,168	1191
T_3	50%NPK+BFs	16.7	0.93	21,707	1713
T_4	75%NPK	17.2	0.87	23,227	2031
T_5	75%NPK+BFs	19.1	1.02	28,056	2715
T_6	100%NPK	18.6	1.19	34,718	3433
T_7	100%NPK+BFs	20.6	1.35	38,943	4500
CD (P=0.05%)		1.46	0.17	1309.3	147.0

4.6.4 Dry matter production

The dry matter production of papaya crop varied between 776 and 4500 kg ha^{-1}. Incremental doses of inorganic fertilizers significantly increased the yield. The dry matter yield increased further as a result of integration of BFs application with inorganic sources of nutrients. These increase with 50,75 and 100 % RDF were 43, 33 and 31 and 31 per cent respectively (Table 4.11 and Fig. 4.11).

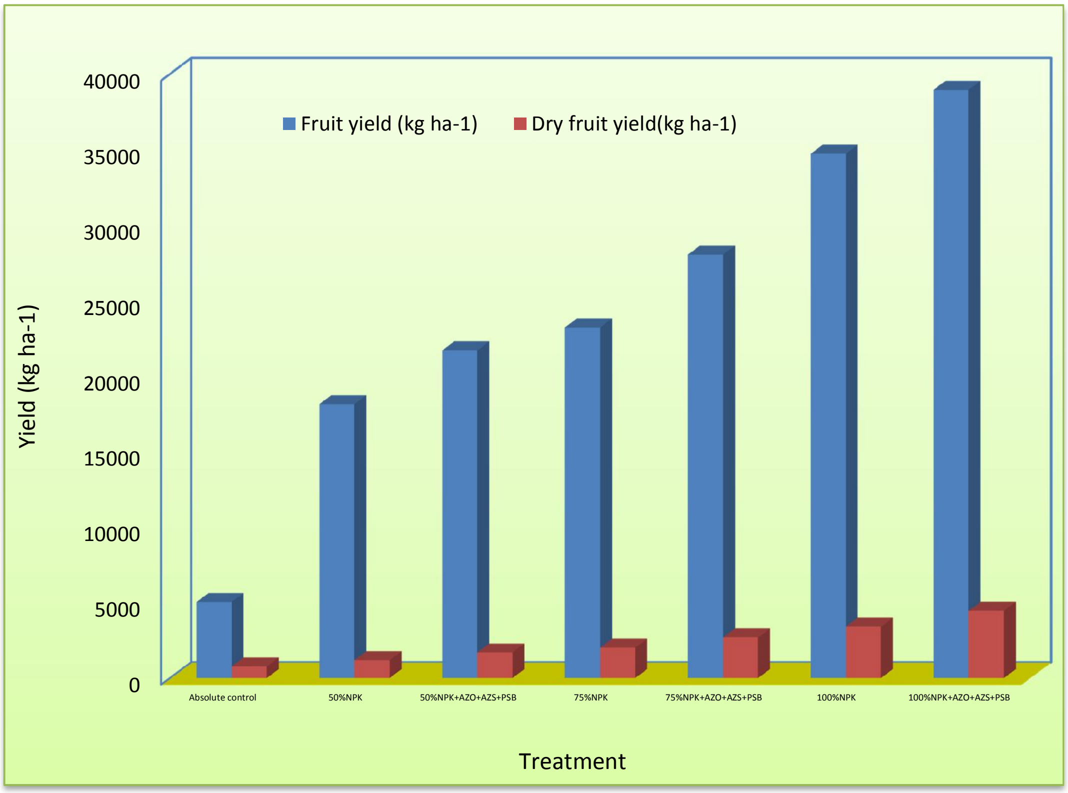

Fig. 4.11 Crop productivity of papaya crop as influenced by integrated treatments

4.7 Fruit nutrient concentration and their uptake

The concentration of N, P, K, S, Na, Ca and Mg by papaya fruit has been presented in Table 4.12, 4.13, 4.14, 4.15, 4.15, 46 and 4.16 respectively.

4.7.1 Nitrogen

The concentration of N in papaya fruit under the influence of integrated treatments varied widely between 1.23 and 2.61 per cent. Inorganic nutrition brought significant increase in N content up to 75 % NPK application dose . Beyond this dose, the N concentration decreased. Bioinoculation had a little influence of N concentration in fruit (Table 4.12).

Plate 5. Fruiting in plants treated with Absolute control

Plate 6. Fruiting in plants treated with 50%NPK

Plate 7. Fruiting in plants treated with 50%NPK+Biofertilizer

Plate 8. Fruiting in plants treated with 75%NPK

Plate 9. Fruiting in plants treated with 100%NPK

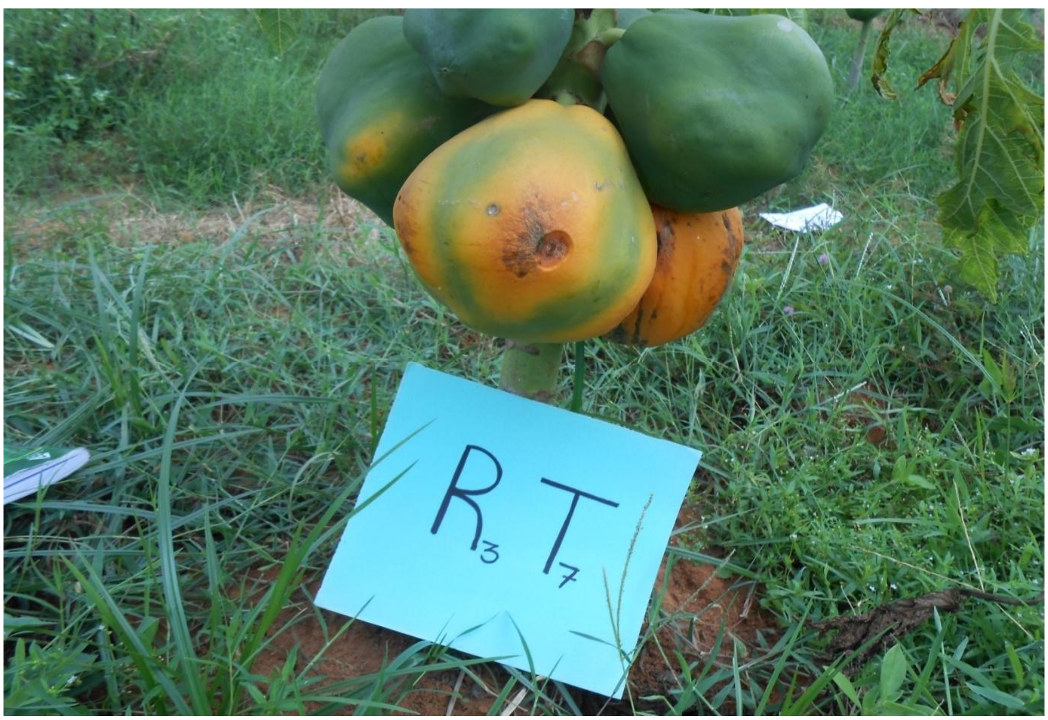

Plate 10. Fruiting in plants treated with 100%NPK+Biofertilizer

The uptake of N through fruit ranged from 9.6 in control to 91.8 kg ha^{-1} in the treatment receiving full inorganic nutrients added with BFs. Both incremental doses of fertilizers either alone or additions of BFs with respective doses increased N uptake through fruits (Table 4.12).

The recovery of N through papaya fruit was low, ranging from 6.2 -14.8 per cent. The recovery of N increased both with the incremental doses of inorganic nutrients either alone or more with integration of BFs Table 4.12)..

Table 4.12. Concentration, uptake and recovery of N by papaya fruit

Treatments		Concentration (%)	Uptake (kg ha^{-1})	Apparent recovery (%)
T_1	Absolute control	1.23	9.6	
T_2	50%NPK	2.25	26.8	6.2
T_3	50%NPK+BFs	2.30	39.4	10.8
T_4	75%NPK	2.55	51.8	10.1
T_5	75%NPK+BFs	2.61	70.9	14.7
T_6	100%NPK	2.03	69.7	10.8
T_7	100%NPK+BFs	2.04	91.8	14.8
	CD (P=0.05%)	0.25	10.4	-

4.7.2 Phosphorus

The data relating to P concentration its uptake and recovery by papaya fruit, have been presented in Table 4.13.

The P concentration ranged from 0.35 to 0.42 per cent, lowest with the fruits produced from control plots and highest with 75 % NPK + BF treated crop. Such nutrient concentration resulted in uptake of P varying between 2.6 and 18.0, lowest with control and highest with 100 % NPK + BF. Significant influence of incremental dose of nutrients either alone or more with addition of BFs have been reflected in P uptake.

Its recovery was quiet low (lowest amongst nutrients studied) ranging from 1.5 to 6.4 per cent only, which increased with incremental doses of nutrients to favour more uptake, particularly with BFs for creating favourable condition and availability of P by the crop.

Table 4.13. Concentration, uptake and recovery of Phosphorous

Treatments		Concentration (%)	Uptake (kg ha^{-1})	Apparent recovery (%)
T_1	Absolute control	0.35	2.6	-
T_2	50%NPK	0.37	4.4	1.5
T_3	50%NPK+BFs	0.39	6.7	3.4
T_4	75%NPK	0.38	7.7	2.8
T_5	75%NPK+BFs	0.42	11.4	4.9
T_6	100%NPK	0.37	12.7	4.2
T_7	100%NPK+BFs	0.40	18.0	6.4
	CD (P=0.05%)	0.02	1.2	-

4.7.3 Potassium

The information relating K concentration, uptake and recovery through papaya fruit have been presented in Table 4.14.

Its concentration in the fruit ranged from 1.6 to 2.18 per cent, lowest with control and highest with 100 % NPK + BF treatment having some resemblance with N. Such nutrient distribution resulted in uptake of K by the crop varying between 12.4 and 98.1 kg ha^{-1}, almost at par with that of N.

Incremental doses of inorganic nutrients significantly influenced the crop growth, there by favouring more K uptake, by the crop and the apparent recovery. The recovery of K through papaya fruit varied between 3.3 and 15.5 per cent. Bioinoculation of crop maintained higher K recovery per cent than uninoculated crop.

Table 4.14 Concentration, uptake and recovery of potash by papaya

Treatments		Concentration (%)	Uptake (kg ha^{-1})	Apparent recovery (%)
T_1	Absolute control	1.60	12.4	-
T_2	50%NPK	1.80	21.5	3.3
T_3	50%NPK+BFs	1.86	31.9	7.1
T_4	75%NPK	2.07	42.1	7.2
T_5	75%NPK+BFs	2.09	56.8	10.7
T_6	100%NPK	2.12	72.8	10.9
T_7	100%NPK+BFs	2.18	98.1	15.5
	CD (P=0.05%)			

4.7.4 Sodium

Probably Na is preferred by papaya crop. Its concentration and uptake by the crop have been presented in Table 4.15. Its concentration in the fruit produced with different combination of nutrients varied between 1.05 to 1.37. Both concentration and uptake through fruit increased with incremental doses of nutrients, particularly when added with BFs. The uptake varied between 8.2 and 51.7 kg ha^{-1}. Quantity wise its uptake amount was next to N and K.

4.7.5 Sulphur

The essential secondary nutrient sulphur concentration in papaya fruit (Table 4.15) was low, ranging from 0.08 to 0.29 per cent. So also the uptake quantity ranged from 0.6 to 12.6 kg ha^{-1}. Its uptake through the crop was also influenced by inorganic nutrition as well as integration of BFs application.

Table 4.15 Concentration and uptake of Na and S by papaya fruit as influenced by INM practices

Treatments		Concentration (%)		Uptake (kg ha^{-1})	
		Na	S	Na	S
T_1	Absolute control	1.05	0.08	8.2	0.6
T_2	50%NPK	1.03	0.09	12.3	1.1
T_3	50%NPK+BFs	1.13	0.10	19.6	1.7
T_4	75%NPK	1.27	0.13	25.8	2.6
T_5	75%NPK+BFs	1.37	0.18	37.2	4.9
T_6	100%NPK	1.11	0.29	38.1	9.9
T_7	100%NPK+BFs	1.15	0.28	51.7	12.6
	CD (P=0.05%)	0.03	0.02	4.0	0.72

4.7.6 Calcium

The concentration of Ca in papaya fruit varied between 0.32 and 0.48 per cent, which resulted in the uptake of Ca ranging from 2.5 to 21.6 kg ha^{-1} next to Na. Incremental doses of inorganic sources of nutrients either alone or more particularly added with BFs influenced Ca uptake significantly (Table 4.16).

4.7.7 Magnesium

The papaya fruit produced with different integrated nutrient management practices had variable concentration of Mg which varied between 0.22 and 0.42 per cent (Table 4.16), lowest with control and highest with full dose of inorganics added with BFs. Such differential nutrient concentration in the fruit has also been reflected in uptake through fruits. Uptake through fruit varied between 1.7 and 17.1 kg ha^{-1}. Incremental doses of inorganic fertilizers significantly influenced its uptake, particularly when added with BFs.

Table 4.16 Concentration and uptake of Ca and Mg by papaya fruit as influenced by INM practices

Treatments		Concentration (%)		Uptake (kg ha^{-1})	
		Ca	Mg	Ca	Mg
T_1	Absolute control	0.32	0.22	0.5	1.7
T_2	50%NPK	0.42	0.27	5.0	3.2
T_3	50%NPK+BFs	0.37	0.38	6.4	4.8
T_4	75%NPK	0.46	0.39	9.3	7.9
T_5	75%NPK+BFs	0.48	0.42	13.0	11.4
T_6	100%NPK	0.47	0.35	16.1	12.0
T_7	100%NPK+BFs	0.48	0.38	21.6	17.1
	CD (P=0.05%)	0.022	0.02	1.04	0.82

4.8 Fruit quality parameters

There was great variation in quality parameters of the papaya fruit which were influenced by different nutrient management practices like recommended dose of fertilizers 100%, 75%, and 50% along with biofertilizers supplied to the plants (Table 4.17)

4.8.1 Total Soluble Solid content in papaya Fruit (ºBrix):-

The results presented in Table 4.17 indicated significant variations in TSS content of papaya fruits ranges from 4.13^0 to 9.2^0 Brix. There was significant higher TSS content of 9.2^0 Brix was marked in the treatment T_7(100% RDF+BFs) than all treatments except application of 100% RDF(T_6) which is statistically at par.

4.8.2 Acidity in Fruit

The results presented in the Table No 4.17 indicated non significant variations in acidity under the influence of different treatments. Acidity in papaya fruits ranges 0.15 to 3.1. However, maximum acidity 3.1 with T_1 receiving only vermicompost and lower acidity 0.15 in T_3 (50% RDF+BFs) and T_6 (100%RDF).

4.8.3 Reducing sugars

The finding presented in the Table 4.17 indicated significant variations innon-reducing sugar of papaya fruit under the influence of recommended dose of fertilizers and biofertilizers application . Reducing sugars in papaya fruit ranged from 5.91 to 9.33 . Maximum value of 9.33 was with T_7 (100%RDF+ BFs) than rest of the treatments, except T_3,T_4,T_5,T_6 which were statistically at par.

Table 4.17 Effect of Various Treatments on Fruit Quality Parameters of Papaya

Treatments	TSS content in Fruit	Acidity in Fruit	Reducing sugars	Non Reducing Sugars
T_1	4.13	0.31	5.91	3.79
T_2	5.97	0.17	6.32	4.01
T_3	6.93	0.15	7.9	4.08
T_4	5.43	0.21	8.14	3.01
T_5	6.13	0.15	8.34	2.80
T_6	7.93	0.16	8.89	1.81
T_7	9.23	0.19	9.33	0.73
SEm(±)	0.50	0.04	0.58	0.30
CD(P=0.05)	1.56	NS	1.79	0.94
CV(%)	1.34	38.3	12.8	18.4

4.8.4 Non Reducing Sugars

The result presented in the Table 4.17 indicated significant variations in non reducing sugar of papaya fruit under the influence of recommended dose of fertilizers and biofertilizers application . Non reducing sugars in papaya fruit ranges from 0.73 to 3.79( ). Maximum value of non reducing sugar recorded as 3.79 with T_1 (Absolute control) and minimum 0.73 with T_7 (100%RDF+ BFs) where as T_1 statistically at par with T_1,T_3, T_4.

DISCUSSION

The papaya is a high nutrient requiring crop. As a result, it has responded positively and significantly to the incremental doses of nutrients supplied through chemical fertilizers. There was 3.6, 4.6 and 7.7 times increase in the fruit yield of papaya due to 50 %, 75 % and 100 % of RDFcompared to the yield of 5083 kg ha^{-1} for no nutrient supply. The primary nutrients due to their impact on crop growth and role in crop nutrition have influenced the crop production.

The biofertilizers are living micro-organisms. Even though these are non nutrients, help the crop getting nutrients as well as cause certain functions which stimulate the crop growth. In the present study *Azotobacter*, *Azospirillum* and phosphorus solubilizing micro-organisms (1:1:1) were inoculated to the crop through pre limed (5 %) vermicompost in 1:25 ratio, incubated for 7 days at 30 % moisture. Such practice enhances the population of micro-organisms *Azotobacter* by 12-18 times, *Azospirillum* by 14 to 16 times and PSM by 6-8 times compared to their initial population (Pattanayak *et al*., 2008, Pattanayak, 2010, 2011, 2012, 2013) and help the micro-organisms in easy establishment in the new environment. After establishment, the inoculated microbes perform their activity. The *Azotobacter a*nd *Azospirillum* in addition to N_2 fixation (15-25 kg ha^{-1}) secrete growth promoting substrates like gibberlic acid, indol acetic acid, cytokinins etc which influence root growth. Their proliferation and enhanced cation exchange capacity (Pattanayak *et al*., 2008) for nutrient absorption. The PSM by secreting organic acids (citric, malic etc) solubilize insoluble phosphates (aluminium phosphate, iron phosphate in acid soil), make available for crop uptake. In addition to this they secreted growth hormones also influence crop quality (Pattanayak, 2010-11-12).

The integrated use of BFs with the incremental doses of inorganic nutrients had catalysed the crop growth processes and parameters and expressed in terms of increasing plant height, girth, leaf area, petiole length, petiole girth, chlorophyll content of leaf, leaf number etc. All these had also influenced number of fruits per plant, unit fruit weight ultimately crop yield and their quality. Similar influence of bioinoculants on crop quality have been reported by Pattanayak *et al*. (2008), in case of lycopene content in tomato, ascorbic acid in chilli, β-carotene in water melon grown in acid soils under Odisha condition.

The present findings revealed some significant variations in certain physical characteristics of papaya fruits. Average fruit length ranged from 21.83 to 26.13 cm. The maximum (26.13 cm) fruit length was obtained in 100 % RDF with biofertilizers over control (21.83 cm). Yadav *et al*. (2011) also reported that the great variations in the average fruit length was observed due to the combination of vermicompost with 100 % NPK + 25 g *Azotobacter* as compared to other treatments.

In present findings the average fruit circumference ranged from 25.83 to 36.03 cm and average width of fruit varies from 11.58 to 16.80 cm. The similar result also reported earlier in papaya by Fernandes *et al*. (1999). Singh *et al.* (2008) and Yadav *et al*. (2011) and Mahendra *et al.* (2009) in ber cv. Banarasi Karaka.

The days taken to first flowering and days taken to first fruiting varies from 72.67 to 92.33 and 127.33 to 181.33 respectively. The days taken to first flowering was non-significant and days taken to first fruiting significantly variated. Perez *et al.* (1973) and Yadav *et al.* (201) also reported that the similar trend in their investigation with the application of 10 kg vermicompost + 100 % NPK + 25 kg *Azotobacter*.

The present findings revealed that content of total soluble solids, acidity, reducing sugar and non-reducing sugar variated significantly from 4.13 to 9.23, 0.15 to 0.31, 5.91 to 9.33 and 0.73 to 4.08 respectively except acidity which was non-significant in the present context. Similar findings also reported in papaya by Singh *et al.*(2008); Sadorunnisa *et al.*(2008) and Bisht *et al*., 2010). They also reported the difference in the physico-chemical composition which were recorded during present findings and observations recorded by earlier workers may probably be due to difference in cultivars, harvest, maturity, state of ripening, location, soil, nutrients and climatic conditions. Besides, Kumar *et al* (2006) found that potash fertilizer use improve major quality parameters of papaya fruits like the sweetness of papaya(TSS), latex yield and its quality.

The results of the present experiment emphasizes combined use of biofertilizers with soil test based nutrient application for enhanced yield and quality of papaya with better quality.

SUMMARY AND CONCLUSION

The integrated nutrient management in papaya was studied with the help of field experiment conducted in the orchard of Horticultural Research Station (HRS), college of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha. The soil of the experimental area was loamy sand, strongly acidic in reaction (pH 4.76), low soluble salts concentration (0.08 dSm^{-1}), very low organic carbon content (2.9 g kg^{-1} soil), CEC of 15.24 cmol (p^+) kg^{-1} soil, low available N, K. and S but high P status.

The different INM treatments for papaya cv. Ranchi Dwarf tested were, (i) control, (no nutrition from any source), except from soil source , (ii) 50 % RDF (NPK) alone (iii) 50 % RDF (NPK) + BF (iv) 75 % RDF (NPK) , (v) 75 % RDF (NPK) + BF, (vi) 100 % RDF (NPK) alone, (vii) 100 % RDF (NPK) + BF. The BF sources were, *Azotobacter* + *Azospirillum* + PSB in 1:1:1 ratio (3 kg each ha^{-1}) inoculated to 5 % limed vermicompost in 1:25 ratio, incubated for 7 days at 30 % moisture. It was applied @ 100 g per pit at the time of planting of seedlings. Another application was repeated at 2nd month of crop growth. The dose of N, P_2O_5, K_2O @ 200 g, 200g and 250 g per plant respectively during entire crop growth period.

Different biometric parameters like plant height, leaf area, stem girth, number of leaf, petiole length, its girth, chlorophyll content, fruit length, fruit width measured at different effective growing periods of the crop indicated significant influence of both incremental doses of inorganic nutrients and integration of BFs in particular. Full dose of inorganic nutrition combined with BFs expressed the performance of all parameters

The leaf nutrient concentration study, indicated the concentration of N and P where higher during early growth stage, decreased towards crop maturity, whereas the concentration of K, Ca, Mg continued to increase towards maturity except for Ca in 75% NPK + BF, 100 % NPK and 100 % NPK + BF. However, the concentration of S dropped at mid growth stage compared to early stage and increased towards maturity but less compared to early stage.

The impact of inorganic fertilization and its integration with BFs application in terms of fruit number per plant, unit fruit weight and ultimately the raw fruit yield were spectacular. The fruit number per plant varied between 6.1 and 20.6, unit fruit weight between 0.6 and 1.35 kg $plant^{-1}$, the fruit yield between 5083 and 38, 955 kg ha^{-1}, the fruit dry weight between 776 and 4500 kg ha^{-1}. Integration of BFs with 50, 75 and 100 % of RDF resulted in 18, 21 and 12 per cent yield increase compared to their respective yields of 18.522, 23,249 and 34,739 kg ha^{1} respectively. The extent of such increase with BFs application with dry matter production were 43, 33 and 31 per cent respectively.

The concentration of N, P, K, Na, S, Ca and Mg in the fruit under the influence of integrated nutrient management ranged from 1.23 to 2.61 per cent, from 0.35 to 0.42 per cent, from 1.6 to 2.18 per cent, from 1.05 to 1.27 and from 0.08 to 0.29 per cent, from 0.32 to 0.48 per cent and from 0.22 to 0.42 per centrespectively. The uptake of N varied between 9.6 and 91.8 kg ha^{-1}, P between 2.6 and 18.0 kg ha^{-1}, K between 12.4 and 98.1 kg ha^{-1}, Na between 8.2 and 51.7 kg ha^{-1} and S between 0.6 and 12.6 kg ha^{-1}, Ca between 2.5 and 21.6 kg ha^{-1} and Mg between 1.7 and 17.1 kg ha^{-1}.

The recovery of major nutrients were low for papaya fruit. For N it varied between 6.2 and 14.8 per cent, for P between 1.5 and 6.4 per cent and for K between 3.3 and 15.5 %. Incremental doses of inorganic nutrients increased the recovery. However, integration of BFs use considerably increased the recovery of major nutrients.

CONCLUSION

From the present experiment following conclusions can be drawn regarding integrated nutrient management for papaya crop.

1. The productivity of papaya crop can significantly be increased from a level of 5083 $kgha^{-1}$ without nutrients to 18,522 $kgha^{-1}$ with 50%RDF, 4.6 times with 75%RDF (23,420 Kg ha^{-1}) and 6.8 times with 100 % RDF (34,739 kg ha^{-1}).

2. Combining biofertilizers application with 50%RDF recommendation, can achieve 18 percent increased fruit yield (21,707 $kgha^{-1}$) compared to 50%RDF alone (18,168 $kgha^{-1}$) with N, P and K recoveries of 10.8, 3.4 and 7.1 percent respectively.

3. Similar biofertilizers application with 75 % RDF could achieve 21 percent increase in fruit yield with associated recoveries of 14.7, 14.9 and 10.7 percent of N, P and K, respectively.

4. Integration of 100%RDF recommendation of fertilizers and biofertilizers application achieved 12 per cent increased fruit yield (38943 $kgha^{-1}$) compared to the yield 34178 kg ha^{-1} due to 100% RDF associated with added N, P and K recoveries of 14.8, 6.4 and 15.5 kg ha^{-1}.

5. Integration of 100%RDF recommendation and biofertilizers application not only increased the fruit yield but also improved major quality parameters of papaya fruits such as the sweetness of papaya(TSS), latex yield and its quality.

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APPENDICES

Appendix I. Leaf nutrient concentration in papaya during growing period – Nitrogen

S.NO	Treatments	N concentration (%)		
		3 months	4 months	Harvest
1	Absolute control	6.99	6.61	6.50
2	50%NPK	7.93	7.41	6.53
3	50%NPK+BFs	8.38	7.50	6.91
4	75%NPK	8.51	7.97	6.38
5	75%NPK+BFs	8.71	7.89	6.50
6	100%NPK	8.56	8.30	6.39
7	100%NPK+BFs	8.70	8.00	6.49
	CD (P=0.05%)	1.3	1.7	0.5

Appendix II. Leaf nutrient concentration in papaya during growing period – Phosphorus

S.NO	Treatments	(P- concentration %)		
		3 months	**4 months**	**Harvest**
1	Absolute control	0.465	0.425	0.277
2	50%NPK	0.615	0.487	0.391
3	50%NPK+BFs	0.625	0.574	0.403
4	75%NPK	0.512	0.458	0.353
5	75%NPK+BFs	0.542	0.459	0.380
6	100%NPK	0.471	0.415	0.330
7	100%NPK+BFs	0.537	0.432	0.350
	CD (P = 0.05)	0.11	NS	NS

Appendix III. Leaf Nutrient Concentration in papaya during growth – Potassium

S.NO	Treatments	(K –concentration%)		
		3 months	4 months	Harvest
1	Absolute control	2.65	1.40	1.35
2	50%NPK	2.71	1.68	1.99
3	50%NPK+BFs	2.80	1.73	2.83
4	75%NPK	3.50	1.72	3.07
5	75%NPK+BFs	3.55	1.82	2.88
6	100%NPK	3.14	1.75	3.08
7	100%NPK+BFs	3.21	1.77	2.90
	CD (P = 0.05)	NS	NS	1.6

Appendix IV. Leaf Nutrient Concentration in papaya during growth – Calcium

S.NO	Treatments	(Ca-concentration%)		
		3 months	4 months	Harvest
1	Absolute control	0.396	1.15	1.40
2	50%NPK	0.476	1.16	1.82
3	50%NPK+BFs	0.503	1.26	1.61
4	75%NPK	0.528	1.58	1.63
5	75%NPK+BFs	0.587	1.64	1.30
6	100%NPK	0.562	1.59	1.53
7	100%NPK+BFs	0.580	1.75	1.23
	CD (P=0.05%)	NS	0.27	NS

Appendix V. Leaf nutrient Concentration in papaya crop during crop growth – Magnesium

S.NO	Treatments	(Mg –concentration%)		
		3 months	4 months	Harvest
1	Absolute control	0.21	0.69	1.04
2	50%NPK	0.24	0.75	1.20
3	50%NPK+BFs	0.25	0.93	1.06
4	75%NPK	0.26	0.86	1.14
5	75%NPK+BFs	0.29	0.97	1.04
6	100%NPK	0.28	0.85	1.11
7	100%NPK+BFs	0.30	1.04	1.08
	CD (P=0.05%)	0.01	NS	NS

Appendix VI. Leaf Nutrient Concentration in Papaya crop during growth – Sulphur

S.NO	Treatments	(S-concentration %)		
		3 months	4 months	Harvest
1	Absolute control	0.345	0.16	0.2
2	50%NPK	0.355	0.21	0.25
3	50%NPK+BFs	0.375	0.26	0.28
4	75%NPK	0.320	0.18	0.24
5	75%NPK+BFs	0.28	0.22	0.25
6	100%NPK	0.26	0.17	0.22
7	100%NPK+BFs	0.28	0.22	0.27
	CD (P=0.05%)	NS	0.05	NS

Appendix : VII

Plant Height in the month of May

Source	df	SS	MSS	Fcal
Replication	2	18.40777	9.203886	1.157806
Treatment	6	511.972	85.32867	10.73395
Error	12	95.39303	**7.949419**	

Stem girth in the month of May

source	df	SS	MSS	Fcal
Replication	2	0.880695	0.440348	0.697614
Treatment	6	12.51156	2.08526	3.303541
Error	12	7.574638	**0.63122**	

Number of leaves in the month of May

	df	SS	MSS	Fcal
Replication	2	3.686667	1.843333	3.077922
Treatment	6	92.69619	15.44937	25.79671
Error	12	7.186667	**0.598889**	

Petiole length in May

	df	SS	MSS	Fcal
Replication	2	3.034352	1.517176	0.769763
Treatment	6	575.0883	95.84806	48.63001
Error	12	23.65158	**1.970965**	

Petiole girth in the month of May

	df	SS	MSS	Fcal
Replication	2	0.149981	0.07499	0.397309
Treatment	6	5.962362	0.993727	5.264889
Error	12	2.264952	**0.188746**	

Spadvalue at 4th month

	df	SS	MSS	Fcal
Replication	2	30.20857	15.10429	1.211211
Treatment	6	191.4467	31.90778	2.558682
Error	12	149.6448	**12.4704**	

Spadvalue at harvest

	df	SS	MSS	Fcal
Replication	2	0.153724	0.076862	0.004947
Treatment	6	95.27323	15.87887	1.021976
Error	12	186.4491	**15.53743**	

Days taken for flower emergence

	df	SS	MSS	Fcal
Replication	2	56.38095	28.19048	0.428778
Treatment	6	1111.619	185.2698	2.817962
Error	12	788.9524	**65.74603**	

Days taken for fruiting

	df	SS	MSS	Fcal
Replication	2	204.0952	102.0476	3.499728
Treatment	6	7228.667	1204.778	41.31791
Error	12	349.9048	**29.15873**	

Average fruit length per plant

	df	SS	MSS	Fcal
Replication	2	2.116114	1.058057	1.348432
Treatment	6	49.7904	8.2984	10.57583
Error	12	9.415886	**0.784657**	

Average fruit circumference per plant

	df	SS	MSS	Fcal
Replication	2	22.46994	11.23497	1.350091
Treatment	6	214.0641	35.67735	4.287299
Error	12	99.85966	**8.321638**	

Average fruit width per plant

	df	SS	MSS	Fcal
Replication	2	1.877943	0.938971	0.679143
Treatment	6	71.46332	11.91055	8.614715
Error	12	16.59099	**1.382583**	

No of fruits per plant

	df	SS	MSS	Fcal
Replication	2	1.268571	0.634286	0.738155
Treatment	6	437.4857	72.91429	84.85453
Error	12	10.31143	**0.859286**	

Unit fruit weight

	df	SS	MSS	Fcal
Replication	2	0.018067	0.009033	0.926496
Treatment	6	1.345057	0.224176	22.99243
Error	12	0.117	**0.00975**	

Fruit yield

	df	SS	MSS	Fcal
Replication	2	2266612	1133306	2.091707
Treatment	6	2.24E+09	3.74E+08	689.388
Error	12	6501709	**541809.1**	

Dry fruit yield

	df	SS	MSS	Fcal
Replication	2	134719.5	67359.77	0.10054
Treatment	6	30757816	5126303	7.651452
Error	12	8039733	**669977.8**	