

**EFFECT OF DIFFERENT PROPORTION OF ORGANIC
MANURES ON YIELD AND QUALITY OF ORGANICALLY
GROWN PAPAYA**

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BY

ASHOK PARSHOTTAMBHAI ITALIYA

M. Sc. (Agri.)

DEPARTMENT SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

N. M. COLLEGE OF AGRICULTURE

NAVSARI AGRICULTURAL UNIVERSITY

NAVSARI-396 450

GUJARAT STATE

JULY-2012

Registration No. : 04-0476-2008

**Dr. A. M. Bafna,
Professor and Head,
Soil Science and Agricultural Chemistry,
N. M. College of Agriculture
Navsari Agricultural University,
Navsari 396 450**

CERTIFICATE

This is to certify that the thesis entitled “**EFFECT OF DIFFERENT PROPORTION OF ORGANIC MANURES ON YIELD AND QUALITY OF ORGANICALLY GROWN PAPAYA**” submitted by **Shri Ashok Parshottambhai Italiya** in partial fulfillment of the requirements for the award of the Degree of **Doctor of Philosophy** in the subject of **Agricultural Chemistry and Soil Science** of the Navsari Agricultural University is a record of bonafide research work carried out by him under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place: Navsari

Date: 13/07/2012

(A. M. Bafna)

Major Advisor

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This is to declare that the whole of the research work reported here in the thesis for the partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY** in **Agricultural Chemistry and Soil Science** by the undersigned is the result of investigation done by me under the direct guidance and supervision of **Dr. A. M. Bafna**, Professor and Head, Department of Agricultural Chemistry and Soil Science, Navsari Agricultural University, Navsari and no part of the work has been submitted for any other degree so far.

Place: Navsari

Date: 13/07/2012

(A. P. Italiya)

Countersigned by

(A. M. Bafna)

Professor and Head,
Agricultural Chemistry and Soil Science,
N. M. College of Agriculture,
Navsari Agricultural University,
Navsari- 396 450

ABSTRACT

EFFECT OF DIFFERENT PROPORTION OF ORGANIC MANURES ON YIELD AND QUALITY OF ORGANICALLY GROWN PAPAYA

Name of student:
Shri. A. P. Italiya

Major advisor:
Dr. A. M. Bafna

**DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,
N. M. COLLEGE OF AGRICULTURE
NAVSARI AGRICULTURAL UNIVERSITY
NAVSARI- 396 450**

ABSTRACT

A field experiment on papaya consisting of eight treatment combinations involving different proportion of three organics on N equivalent basis [O₁: 50 % RDN through bio compost (BC) + 50 % RDN through castor cake (CC), O₂: 50 % RDN through bio compost + 50 % RDN through vermi compost (VC), O₃: 50 % RDN through bio compost + 25 % RDN through vermi compost + 25 % through castor cake and O₄: 33.3 % RDN through bio compost + 33.3 % RDN through vermi compost + 33.4 % RDN through castor cake] and two levels of banana pseudostem sap application (S₀: without sap and S₁: with sap @ 8 l/plant) along with one INM controls outside the organic farm were tested in FRBD with three replications at Organic Farm, F-block, NAU, Navsari during 2009-10 and 2010-11.

The results of present study revealed that among the organics treatments, application of BC: VC: CC in the proportion of 33.3: 33.3: 33.4 (O₄) showed superiority with respect to growth and yield parameters of papaya over O₁ and O₂ but it was closely followed by O₃ treatment (BC 50: VC 25: CC 25). The values recorded with O₄ treatment of plant height at harvest (123.06 cm), stem girth at harvest (35.64 cm), petiole length (46.33 cm), number of leaves/plant (33), number of fruits/plant (22.33), average fruit weight (0.956 kg), fruit yield/plant (21.68 kg) and fruit yield

(68.83 t/ha) were significantly higher as compared to rest of the organic treatments.

On pooled basis the application of sap @ 8 l/plant in 8 equal splits (S₁) increased the plant height, girth, number of fruits/plant and fruit yield (t/ha) by 12.3, 17.0, 6.8 and 11.2 per cent, respectively over no application of sap.

Similarly, the yield attributes *viz.*, average fruit weight, number of fruits per plant and fruit yield (t/ha) were also differed significantly between the mean of organics treatments and INM control. In all the parameters INM control recorded significantly higher values as compared to mean of organics treatments. The magnitude of increase in parameters *viz.*, plant height, girth, petiole length, number of leaves per plant, average fruit weight, number of fruit per plant, fruit yield per plant and fruit yield (t/ha) at the harvest with INM control was 16.7, 16.5, 37.4, 21.9, 21.2, 9.1, 31.5 and 31.4 per cent, respectively, over the mean of organics treatments.

Among the organics treatments, O₄ treatment recorded significantly higher values of total uptake (petiole + leaves + fruit) of all the nutrients as compared to O₂ and O₁, but it was at par with O₃ in some of the cases. The total uptake (leaves + petiole + fruit) of nutrients *viz.*, N, P, K, Fe, Mn, Zn and Cu by papaya crop did not differ significantly between organic mean and INM control. Despite significant difference in dry matter yield of individual parts of papaya and nutrient content and uptake by respective part, the differences of total uptake of nutrient between organic mean and INM mean were turned out to be not significant.

The per cent distribution values of uptake clearly revealed that under O₄ treatment, the accumulation of all the nutrients was more in fruit than O₁ treatment. For instance, the accumulation of N, P and K in fruit with O₄ treatment was 37.69, 24.08 and 33.09 per cent as against the respective values recorded with O₁ were 33.21, 19.31 and 25.53 per

cent. The results further revealed that application of sap (S_1) also increased the translocation of N, P, K, Fe, Mn, Zn and Cu from vegetative to reproductive parts as compared to no application of sap. The magnitude of increase in accumulation of N, P, K, Fe, Mn, Zn and Cu in fruit with S_1 treatment was 37.8, 24.3, 30.9, 1.1, 0.6, 2.3 and 3.4 per cent, respectively over S_0 .

Among the organics treatments, O_4 *i.e.*, application of BC: VC: CC in equal proportion recorded significantly higher values of shelf life, ascorbic acid, total sugar and reduce sugar content in papaya fruit as compared to O_2 and O_1 , but O_3 was next in ranking. The values of shelf life, ascorbic acid, total sugar and reducing sugar recorded with O_4 treatment were 9, 7, 8 and 8 per cent more than O_1 treatment. Similarly, application of pseudostem sap also exerted significant beneficial effect on quality parameters in comparison to its no application. Contrarily to this, titratable acidity was higher with INM as compared to organics mean.

The organics treatment did not exert any significant effect on soil pH, salinity, organic C, available N, P, Zn and Cu content in both the depth of soil. There was no significant difference between the means of organic treatments and INM mean with respect to EC and pH of soil. The content of available K, Fe and Mn only in surface layer of soil was affected significantly due to organics treatment during both the years. In all the case, O_4 recorded significantly higher values of available K, Fe and Mn as compared to O_2 and O_1 but it was closely followed by O_3 treatment. An application of sap could significantly increase the content of organic C, available N and K mostly in surface soil during both the years. The application of sap significantly improved the availability of Mn during both the years and Zn during second year only in subsurface soil.

However, the soil fertility parameters *viz.*, organic carbon, available N, P and K content were significantly higher with organic treatment mean in comparison to INM. The results further revealed that this effect was

more pronounced in surface layer than subsurface strata. With respect to available micronutrients cations in soil, all the cations were significantly more with organic treatment mean than INM control.

Like soil fertility, physical properties *viz.*, BD, HC and WAS of soil were also favorably improved under organic nutrient management system in comparison to INM system. Similarly, there was tremendous increase in both the fractions of aggregation under organic nutrient management system over INM.

In order to know the economic viability of both the system, the economics was computed in two way *i.e.* selling price same for organic as well as INM fruit and premium price for fruits of organic nutrient management system. At same price of fruit, the net profit realized with INM was Rs. 3,07,520/ha with BCR of 3.3 as against the net profit of Rs. 1,32,224/ha with BCR of 0.77 with organic treatment mean. The best organic treatment O₄ the net profit (1, 61, 787 Rs/ha) was almost half of the INM. Alternative scenario generated by considering premium price for organic product (Rs 10/kg), the net income realized was raised to Rs. 4,32,674/ha with BC of 2.53. This was also true for S₀ and S₁, where S₁ recorded net profit of Rs. 4,47,914/ha with premium price as against Rs. 4, 08,506/ha with S₀.

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(A. P. Italiya)

LIST OF ABBREVIATION

Sr. No.	Abbreviation	Full name
1	@	At the rate of
2	BC	Bio-compost
3	BD	Bulk density
4	CC	Castor cake
5	CEC	Cation Exchange Capacity
6	cm	Centimeter (s)
7	cm ²	Centimeter Square
8	cv.	Cultivar
9	DAP	Days after Planting
10	DM	Dry matter
11	dSm ⁻¹	Desi Siemens per meter
12	EC	Electrical conductivity
13	ESP	Exchangeable Sodium Percentage
14	et al.	And others
15	etc.	Et cetera
16	Fig.	Figure
17	FYM	Farm Yard Manures
18	HC	Hydraulic Conductivity
19	i.e.	That is
20	INM	Integrated Nutrient Management
21	O	Organic System of Nutrient Management
22	OC	Organic Carbon
23	ppm	Parts per million
24	PSB	Phosphorus solubilizing bacteria
25	RDF	Recommended Dose of Fertilizer
26	RDN	Recommended dose of nitrogen
27	RSC	Residual Sodium Carbonate
28	S	Banana pseudostem sap
29	SAR	Sodium Absorption Ratio
30	TSS	Total soluble solids
31	VC	Vermicompost
32	viz.,	Namely
33	WSA	Water Stable Aggregate

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I. INTRODUCTION

The history of agriculture is very old. In the earlier years, Indian farming was practiced in a very simple way on natural resources (manures) with less energy. In last 30 to 35 years steps were initiated towards the 'Green revolution' technology which is known as 'Exploit Agriculture' characterized by the use of high yielding varieties, chemical and bio fertilizers and pesticides, ultimately resulted in self sufficient in food grains and powered the country for export of surplus food grains. Intensive agriculture and excessive use of inorganic fertilizers after the green revolution have resulted in deterioration of soil health which ultimately resulted in lower response to applied fertilizers. Unfortunately, in present day agriculture, due to continuous use of inorganic fertilizers with minimum or no use of organic manures, the cultivable lands are rapidly depleted in organic carbon content and becoming unfertile and exerting multiple nutrient deficiencies (Katyal, 2000).

Sustainable farming depends upon the successful management of resources (inputs) for agricultural production and to satisfy the human need. No system of farming will be sustainable unless the soil which plays a pivotal role in production, however, the most important natural resources are to be managed scientifically to meet the challenges of present and future needs. The productivity and quality are to be maintained continuously and there should not be any reduction in output over the inputs. The addition of organic manures influences the availability of many plant nutrients, at the same time breakdown of organic matter in the soil releases number of growth promoters and enzymes. The released plant nutrients may or may not be readily available to plant roots because of the temporary immobilization by soil micro-organisms and fixation on soil colloids.

Reduction in subsidy is inevitable and when the farmer has to pay for the actual cost of fertilizers at the same time there is a keen

awareness worldwide in recent years on the excess use of inorganic fertilizer and other chemicals leading to environmental pollution, residual effects and higher pest infestation. Sustainable production strategies often involve in application of organic inputs. Sustainable farming depends upon the successful management of available resources in agricultural production. By maintaining or enhancing the quality of environment and conserving the natural resources one can satisfy the human demands and needs for quality food. Though, a small section of farmers are expected to take up organic farming. The consumer demand for organically produced food and fiber products provide new market opportunities to those farmers who adopt the organic farming as a farm-business.

In this context, organic farming is recognized as the best known alternative to the conventional agriculture. The number of studies conducted on organic farming indicated that the quality of agriculture produce is better than inorganically grown produce. Due to the organic farming not only the quality of agriculture produce is improved but the health of soil is also sustained rather improved in comparison to conventional farming. Simultaneously, there is steady increase in the consumers demand for organic products and they are ready to pay even premium price.

It is interesting to note that Food and Agricultural Organization (FAO, 1999) Committee on Agriculture, during the 15th Session, has discussed the topic, "Organic Agriculture" and concluded that FAO has the responsibility to give organic agriculture a legitimate place within the sustainable agriculture programmes. However, organic agriculture cannot be adopted uniformly under all farming situations looking to the ever growing population. The technology has a role to play in the cultivation of high value crops, fruits, vegetables, spices and condiments, medicinal and aromatic plants. The organically cultivated food crops have a vast

untapped export potential growing at 10-15 per cent per year. The sustainable agricultural practice can effectively prevent the entry of pesticides and toxicants in the food chain and prevent soil and water pollution *vis-à-vis* health hazards. If adopted with a blend of ecologically safe modern technologies, organic agriculture, though not in its orthodox version, has the potential to be accepted by the farmers.

Based on the global survey on organic farming carried out in 2007/2008 (Willer, 2008) by the Research Institute of Organic Agriculture (FiBL, BioFach, Germany), the International Federation of Organic Agriculture Movements (IFOAM) and Foundation Ecology and Agriculture (SOEL), organic agriculture is now followed in more than 130 countries with a total area of 30.4 million hectares in 0.7 million number of organic farms. This constitutes about 0.65 per cent of total agricultural land of the world. Global demand for organic products remains robust, with sales increasing by over US\$ 5 billion a year. Organic Monitor estimates international sales to have reached US\$ 38.6 billion in 2006, double that of 2000, when sales was at US\$ 18 billion. Consumer demand for organic products is concentrated in North America and Europe; these two regions comprise 97 per cent of global revenues. Asia, Latin America and Australasia are important producers and exporters of organic foods (Sahota, 2008).

In India, about 528,171 hectare area is under organic farming (this includes certified and area under organic conversion) with 44,926 number of certified organic farms. This accounts for about 0.3 per cent of total agricultural land. Indian organic farming industry is estimated at US\$ 78 million and is almost entirely export oriented. According to Agricultural and Processed Food Products Export Development Authority (APEDA), a nodal agency involved in promoting Indian organic agriculture, about 585,970 tonnes of organic products worth of Rs. 301 million are being exported from India. Growing awareness, increasing market demand,

increasing inclination of farmers to go organic and growing institutional support have resulted in more than 200 per cent growth in certified area during the last two years (Ramesh *et al.*, 2010).

Papaya is native to tropical America and is believed to have originated in Southern Mexico. It belongs to the family Caricaceae, and according to Purseglove (1968), it is probably originated in Southern Mexico and Costa Rica. Papaya (*Carica papaya* Linn.) is an important fruit crop of tropical world and has long been known as wonderful fruit of the tropics. Papaya is the fifth important fruit crop of India. It gives higher production of fruits per hectare and an income next to banana (Singh, 1990).

In India, it is successfully grown all over country and is available round the year. It occupies 98,000 hectares of cultivated area with 3629 thousand tonnes of production. The country's average productivity of papaya is 37.1 t/ha (Anon., 2009). In India, the important papaya growing states are Andhra Pradesh, Kerala, Tamil Nadu, Orissa, Assam, West Bengal, Gujarat and Maharashtra. These states are having ideal climatic conditions for its growth and production. However, in Gujarat its average productivity is 51.18 t/ha. It is cultivated on an estimated area of 14,100 hectares with production of 721.7 thousand tonnes (Anon., 2009).

Papaya is known as poor man's fruit due to its nutritional value and price. Papaya's sweet fruits are majorly used for table purpose. It is the storehouse of vitamins and nutrients. It contains vitamin A and C, protein, minerals, fibers, carbohydrates and small amount of fat. Papaya is also cooked and eaten like squash. Papaya contains digestive acid so; it is good fruit for dieting and to reduce fat. Green fruits are used in the treatment of blood pressure and used as an aphrodisiac. Papaya contains enzyme papain which is meat tenderizing, bear clarifier. Papain is also used in treatments of cuts, stings, burns and ointment production. For production of jam, jelly, *tutty frutty*, papaya is used as a raw material.

Papaya fruit contain pectin and beta carotene and is used in inflammatory, analgesic, stomach ache and fungal infection. Roots are used as nerve tonic. Papaya was named 'the most nutritious fruit' by the Centre for Science, USA and Christopher Columbus called it 'the fruit of the angle' owing to these multifaceted uses, it is referred as '11nd Kalpatharu'.

The major problem of organic agriculture in India is the adequate availability of organic manures which is restricting the area expansion under organic agriculture. If at all the organic manures are available, their cost is a limiting factor owing to their bulky nature *i.e.*, very less content of plant nutrient. Because of this reason huge quantity of organic manures are to be added for meeting the nutrient demand of the crop as a results of this increase the cost of inputs to be used in organic farming *vis-à-vis* fertilizer. The work done in India is predominately related to INM and very scanty literature is available on nutrient management in pure organic farming. Scrutinizing literature available on organic farming showed that in general people are using single bulky source of organic manure (Reddy *et al.*, 2010).

Hence, it was thought to use bulky and concentrate organic manures in different proportion so to curtail the cost of manuring in papaya grown under South Gujarat condition. The papaya was used as test crop because of its multifarious uses and high nutritive values. For this purpose, three organics were selected, (I) Bio compost: it is available in ample quantity in South Gujarat as a by-product of sugar industry which is concentrated in South Gujarat. Further, it is the rich source of C, Mn, S, N along with some bioinoculants, (II) Banana pseudostem based vermi compost (VC): this is a byproduct obtained during the process of fibre extraction from banana pseudostem. This is rich source of Fe and K along with some growth promoting substance (Anon., 2011) and (III) castor cake(CC): it is also liberally available in Gujarat as it is one of the

major crops of Gujarat. It was taken as concentrate organic manure. Apart from these organic, banana pseudostem sap which is also rich source of Fe and K along with *cytokinin* and GA₃ was also included in the organic nutrient management package.

Papaya crop being heavy feeder and the fruit are harvested fresh, the nutrient requirement of this crop is also very high. Growing papaya crop under organic farming can be possible only if integration of different sources of organics is done in such way that the nutrient release pattern matches with the nutrients demands of the crop. Information regarding these aspect is very scanty under South Gujarat and more so under organic farming situation. Hence, present study was planned to assess the effect of different proportion of organics with and without sap on yield and quality of papaya grown on organic farm with the following objectives:

- I. To study the effect of different proportion of organic manures on growth, yield and quality of papaya,
- II. To study the effect of different organic manures on physical and chemical properties of soil and
- III. To work out the economics.

II. REVIEW OF LITERATURE

Brief resume of research work carried out in India and abroad

The organic farming in fruit crops are getting memento now a days, however, sufficient research literature is not available. Therefore, the scarcely available literatures on these aspects related to fruit crops have been briefly presented here under following subtitles:

2.1 Effect of different organics on growth and yield attributes of papaya

2.2 Effect of different organics on content and uptake

2.3 Effect of organics on fruit quality of papaya

2.4 Effect of different organics on soil physical and chemical properties of soil

2.5 Economics

2.1 Effect of different organics on growth and yield attributes of papaya

Prabhuram and Sathiamoorthy (1993) studied the effect of organic manures on the productivity of banana. They applied 200 g RDN/plant through different combinations of organics. They found that application of RDN in the proportion of 25, 50 and 25 per cent through FYM, neem cake and urea, respectively, required less number of days to mature the banana crop from shooting and produced highest banana fruit yield.

Ray and Yadav (1996) conducted a field experiment for three years, banana plants were grown in calcareous soils (with 32.4% free CaCO_3) and low NPK content receiving 200 g N, 50 g P_2O_5 and 200 g K_2O per plant each year in different combinations of organic manures and straight fertilizers. The highest banana yield of 74.6, 83.3 and 73.7 t ha^{-1} for plant crop, first ratoon and second ratoon were obtained, respectively when cow pea was grown as a green manure crop and the

required NPK was applied in combination of 25 per cent through FYM and remaining 75 per cent through straight fertilizers. The increase in the banana yield might be due to application of FYM which has improved the physical properties of soil and served the food for microorganisms which ultimately secreted certain growth hormones and enzymes resulting in better physiological activities in the plants. These findings were also supported by Cooke (1967). Apart from this, the application of FYM has increased the availability of insoluble phosphate in to the soil and the phenolic compounds formed with organic matter resulted in favorable effect on plant growth.

Ushakumari *et al.* (1997) conducted field trial on banana; application of 10 kg vermi compost per plant was applied to full fill the requirement of RDN. The results indicated that application of vermi compost in-situ gave 36.8 per cent more bunch weight than the control (inorganic fertilizers); however, the size of fruits produced through vermi compost was smaller as compared to inorganic fertilizers.

Ramkrishnan and Rajendran (1998) reported that application of neem cake @ 5 kg per plant gave maximum number of leaves (8.1), higher shoot length (19.9 cm) and root length (14.0 cm) of papaya.

Jeyabaskaran *et al.* (2001) reported that application of pressmud or poultry manure or rice husk ash @ 15 kg per plant to banana crop can save 40 per cent NPK to produce statistically same yield at 100 per cent NPK through inorganic only at Trichy.

Soorianathasundaram *et al.* (2001) studied at the Horticultural College and Research Institute, Coimbatore during 1999-2000 to find out the possibility of reducing the usage of inorganic N fertilizer by partial substitution with organic sources and the effect of such substitution on growth and yield of banana cv. Nendran. Higher and earlier yields were recorded when nitrogen is supplied entirely through inorganic form as urea. Significant reduction of the pseudostem height was observed with

the addition of organic N sources and corresponding decreased inorganic levels. The pseudostem height was maximum when the nitrogen sources were urea alone (340 cm). The pseudostem heights were generally higher when the plants received 75 % N source as urea than when only 50 % of the N source was provided as urea. The pseudostem girth was maximum with N being supplied entirely in form of urea (62.8 cm). The number of leaves were also more (14-15) in inorganic N substitution with organic sources. The plants that received 100 % N as urea were the earliest to shoot (265 days), while reduction in supply of inorganic N form delayed the shooting markedly.

Borah *et al.* (2001) conducted a field trial during 1997 to 2000 in a seven years old *Khasi* mandarin orchard Bargaon village of Tinsukia, Assam. They found that maximum yield with appreciable tree vigour and fruit quality of mandarin could be obtained from balance nutrition of the plants through combinations of organic @ 7.5 kg neem cake per plant along with inorganic fertilizers (600 : 300 : 600 g NPK/plant/annum). The sole application of neem cake or inorganic fertilizers (NPK) was proved insufficient to achieve these objectives.

Seshadri and Madhavi (2001) carried out a field experiment from 1992 to 1997 on the twenty year old sweet orange cv. Sathgudi at Citrus Improvement Project, Tirupati. The results of experiment indicated NPK at 50 per cent RDF levels were very effective when applied with castor cake @ 15 kg/plant/year increased the yield of fruits in citrus. Beneficial effect of organic and inorganic fertilizers in improving the yield in sweet orange was also observed earlier. Though the cost benefit ratio was lesser than RDF *i.e.* that obtained with pure application of NPK alone, the beneficial effect of combining organic sources to improve the physical, chemical and biological properties cannot be ignored.

Sundararaju *et al.* (2002) conducted field trials with 6 commercial banana varieties along with 6 fertilizer treatments at the National

Research Centre of Banana, Pouavuron. The result indicated that maximum growth was found when 50, 25 and 25 per cent N was applied through neem cake, FYM and urea, respectively.

Ganeshamurthy *et al.* (2004) observed that plants receiving 50 per cent inorganic N and P + 25 per cent N as FYM and remaining 25 per cent N from Neem cake while remaining 50 per cent P as sterameal gave comparable fruit yields as compared to plants receiving through inorganic nutrients only.

Gogoi *et al.* (2004) conducted the field experiment at experimental farm, Department of Horticulture, A.A.U, Jorhat during 2001-2002. They found that significantly highest number of hands per bunch (9.00), fingers per hand (22.48), bunch weight (24.28 kg) and yield (74.91 t/ha) of banana were obtained under the treatment 50 per cent RDN + 100 per cent RDP and RDK along with *Azospirillum* + PSB.

Sabarad *et al.* (2004) studied the influence of VAM, vermi compost and *Trichoderma harzianum* on the vegetative growth of banana cv. Rajapuri. The VAM fungus (*Glomus fasciculatum*) along with *in situ* vermiculture (un inoculated control) and vermi compost were tried with different inorganic fertilizer doses, *i.e.*, 50, 75 and 100 per cent of the recommended dose of fertilizer (180:108:225 g NPK/plant). They observed that VAM inoculated banana plants showed higher plant height, plant girth, number of leaves and suckers.

Tirkey *et al.* (2001) conducted a field experiment at Horticultural Research Farm, IGAU, Raipur during 1996-97. They found that better growth and yield including early cropping of banana cv. Dwarf Cavendish were obtained when inorganic fertilizers (100: 100: 150 g NPK/plant) along with organic manures (10 kg poultry manure/plant) were applied as against application of inorganic fertilizer alone (300: 200: 300 g NPK/plant).

Sareedha *et al.* (2007) conducted a field experiment at Department of Horticulture, Tamil Nadu to study the effect of organic and inorganic nutrient on yield of gherkin. Combined application of FYM @ 25 t/ha along with inorganic fertilizer (120:90:50 kg NPK/ha) and foliar application of vermiwash (1:5 dilution) was observed to be the best treatment when compared to other treatments. The favourable effect of integrated nutrient management on fruit yield may be attributed to its involvement in the synthesis of tryptophan, the pre-cursor of the growth promoting substance. Vermiwash application in 1:5 dilutions has prompted to yield statistics due to presence of phosphates, sulphates and chlorides as potassium, sodium, magnesium, sulphur, iron and ammonia. All the salts being in soluble form would have diffused into the plant through the stomata opening and might have influenced the partitioning capacity of crop plant. Similar reports were registered by Morselli *et al.* (1999).

A field trial was conducted by Rajamani *et al.* (2007) on turmeric variety BSR-2 at Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. They found that organic inputs *viz.*, FYM 12 t/acre as basal dose + vermi compost 1 t/acre, applied in 5 split at monthly interval from second month after sowing recorded the maximum yield of 48.8 t/ha against 19.53 t/ha in control. The same treatment showed the excellent performance in the growth parameters such as plant height (131.3 cm), number of tiller (3.6), number of leaves (8.13), leaf length (64.12 cm), leaf breadth (10.67 cm) and stem girth (10.5 cm) when compared to the other treatments. This might be due to the availability of the nutrients in readily available form. During vermi composting, the C:N ratio was narrowed down substantially over normal compost. At initial stage of composting, there was no significant effect of earthworm on C:N ratio but at later stage found significant than normal composting. The lower C:N ratio ensures immediate release of N to plant when applied to soil (Chaudhary *et al.*, 2004).

Mansour and Shaaban (2007) revealed that fertilizing Washington Navel orange trees with N at 1000 g / tree in the form of ammonium sulphate at 2.43 kg/ tree, Compost EI- Neel at 11.63 kg/ tree and Biogen at 250 g/tree gave a striking effect on yield and leaf area over other mineral source of N in the form of ammonium nitrate and urea in combination with Compost EI- Neel and Biogen.

Patel (2008) studied the effect of different combinations of vermi compost and castor cake on growth of banana plants, the results indicated that maximum plant height (174.25 cm), pseudostem girth (63.0 cm), number of functional leaves (21.27) and maximum total leaf area (23.43 m²) were obtained with the application of 3 kg each of vermi compost and castor cake per plant of banana at NAU, Navsari..

Ray *et al.* (2008) studied the performance of papaya under organic farming, the results indicated that the inorganic fertilizers mixture out rightly increased the yield of papaya over organic manures.

Iqbal *et al.* (2009) carried out an experiment at the Research Orchard of Division of Fruit Science, Faculty of Agriculture, SKUAST-J, Udheywalla, Jammu during 2005-06 and 2006-07 to study the effect of organics FYM integrated with urea and *Azotobacter* on growth and yield of strawberry cv. Chandler. They found that plants attained height of 21.24 cm with 28.16 cm plant spread, 74.95cm² leaf area and fruit size (37.62 x 28.01mm) and fruit weight (15.87g) with the application of 25 per cent nitrogen through FYM augmented with *Azotobacter* and was at par with the plants supplied with cent per cent nitrogen in the form of urea in combination with *Azotobacter*. However, maximum yield of 372.89g per plant was obtained with the application of cent per cent nitrogen in the form of urea along with *Azotobacter*, whereas 358.43g fruits per plant were recorded with the application of 25 per cent nitrogen in the form of FYM + 75 per cent through urea + *Azotobacter* and were at par with each other.

Abdelaal *et al.* (2010) studied the effect of microbial bio-fertilization on yield and quality of Washington Navel Orange. They found that application of microbial strains *Pseudomonas fluorescence* strain 843 were applied one time monthly during the period of experiment to trees at two levels 300 ml and 500 ml per tree with 10^8 cells ml^{-1} significantly improve fruit yield, fruit weight and fruit length over uninoculated trees.

Reddy *et al.* (2010) conducted a field trial on papaya (cv. Surya) during 2005-2007 at the experimental farm of Indian Institute of Horticultural Research, Bangalore. The soil of experimental site was red loam with pH 6.12, organic carbon 0.73 per cent, available nitrogen 158 kg/ha, phosphorus 13 kg/ha and potash 196 kg/ha. They found that application the application of RDF (250:250:500 g NPK / plant) recorded significantly higher fruit yield (55 t/ha) as compared to rest of the organic treatments. Fruit yield reduction was 30 to 51 per cent in organic treatments as compared to inorganic treatment at two years of experimentation.

Singh *et al.* (2010) conducted a field experiment at Department of Horticulture, Allahabad Agricultural Institute, Allahabad during 2005-06 and 2006-07 to study the response of integrated nutrient management on growth, yield and quality of papaya cv. Surya. They have tried different treatments of recommended dose of fertilizer i.e. 200: 250: 250 g NPK/ plant, FYM @ 50kg/plant, vermi compost @ 20 kg/plant, poultry manure 20 kg/plant, rhizosphere bacteria culture 50 g/plant alone and in combination with reduced levels of RDF viz., 75 and 50 per cent. The yield of papaya was statistically at par with 75 per cent RDF + 25 per cent vermi compost + rhizosphere bacteria culture in comparison to control. Maximum number of leaves (18.73), trunk girth (0.26 m), number of fruits per plant (46), average fruit weight (0.85 kg) were recorded with 75 per cent RDF + 25 per cent vermi compost, while maximum plant

height (185.35 cm) and petiole length (8.42 cm) were associated with 100 per cent RDF alone.

Vo Thi *et al.* (2010) studied the effects of 10 t ha⁻¹ sugarcane filter cake compost + *Trichoderma* spp. and 20 t ha⁻¹ of fresh *Tithonia diversifolia* in combination with recommended inorganic fertilizer (250g N - 200g P₂O₅ - 120g K₂O plant⁻¹) in orange orchards where the raised beds had been constructed for more than 26 years and compared with usual farmer practice (628g N-327g P₂O₅ - 64g K₂O plant⁻¹) on fruit yield of orange. They recorded higher fruit yield in both treatments than usual farmer practice; however, the application of 10 t ha⁻¹ of sugarcane filter cake was more effective than the application of 20 t ha⁻¹ of fresh *Tithonia diversifolia*.

Rubee *et al.* (2011) conducted an experiment on 4-year old guava trees during 2007-08 to study the effect of bio-fertilizer and organic manures on yield of guava cv. Red Fleshed. They found that average maximum fruit yield with application of 250g *Azotobacter* + 20 kg FYM per tree during rainy and winter season crop was 38.23 and 19.03 kg per tree respectively. However, highest fruit weight (198.2 and 299.2 g), fruit length (5.9 and 7.19 cm) and fruit breadth (7.00 and 7.41 cm) for rainy and winter season crop, respectively, were obtained with the application of phosphobacterin (50 ml per tree), which was, remained at par with that obtained with *Vesicular Arbuscular Mycorrhizae* (VAM) (10 kg per tree).

Yadav *et al.* (2011a) conducted a field experiment to study the effect of various organic, inorganic and bio fertilizer combination on the growth and yield attributes of papaya. The results of the experiment revealed that combination of 10 kg vermi compost along with 100 per cent RDF and 25 g *Azotobacter* enhanced the growth characters like plant height, girth, fruiting depth. The notable improvement with respect to growth parameters with the use of bio fertilizers, organic manures and inorganic fertilizers may be attributed due to the sufficient availability of

NPK and other essential nutrients. Besides, *Azotobacter* is associated with the production of growth promoting substances, antifungal compounds and *cytokinins* which in turn might have lead to better root development, better transport and uptake of nutrients which resulted in increasing growth parameters. The results are in close conformity with findings of Arancon *et al.* (2004), Yadav (2006) and Srivastava (2008).

Yadav *et al.* (2011b) conducted field experiments during 2008-09 and 2009-10 to investigate nutrient nourishment levels on yield of papaya cv. Pusa Dwarf. The results indicate that the yield attributes such as days taken to first flowering, days taken to maturity, fruit weight, number of fruit per plant, yield kg/plant and q/ha were recorded significantly higher with the application of treatment 10kg vermi compost along with 100 per cent NPK and 25 g *Azotobacter* per plant. They gave the reason for early flowering and maturity of fruits might be due to the facts that bio fertilizers might have enhanced the productivity by biological nitrogen fixation or solubilization of insoluble phosphate or secreting hormones, vitamins such as thiamine, riboflavin, pyridoxine, necotinic *etc.* These results were partially support the findings of Subba (2006). The results further indicated that number of fruits per plant, fruit weight and fruit yield was higher during both the year of experimentation, this may be due to the efficiency of bio agent which can be well exploited with the use of organic manures with inorganic fertilizers (Suther, 2009) which might have improved the yield parameters by better availability and uptake of nutrients by plant and enhancing the source sink relationship by increasing the movement of carbohydrates from leaves to the fruits. Similar findings have been observed by Yadav (2006), Srivastava (2008) and Sha and Karuppaiah (2010).

2.2 Effect of different organics on content and uptake

Shafeek and El-Habbasha (2000) noted that all organic manures improve the behavior of several elements in soil through their active

groups (Fulvic and Humic acids) which have ability to retain the elements in a complex or chelated forms and consequently improve the plant growth as well as quantity and quality of yield.

Jeyabaskaran *et al.* (2001) reported that application of poultry manure @ 15 kg per plant to banana crop recorded the maximum content of N (2.90 %), K (3.51 %), Ca (1.26 %), Fe (472.6 ppm), Cu (21.9 ppm), Mn (312.0 ppm) and Zn (128 ppm) in the leaf tissues of ratoon banana compared to pressmud and or rice husk ash.

Akinyemi and Akande (2002) reported that application organic fertilizer improves the morphological parameters like stem girth, leaf area and days to 50 % flowering over inorganic fertilizers. The result further revealed that while some soil properties like potassium remained unchanged, elements like N and organic matter slightly increased with an increase in organic manure, but not with inorganic fertilizer. The use of organic fertilizer has the potential of being a good material for production of papaya and improvement in soil properties.

Ganeshamurthy *et al.* (2004) observed that plants receiving 100 per cent N and P through inorganic fertilizers recorded maximum N and P content in flesh of papaya fruit which was followed by plants receiving 50 per cent inorganic N and P + 25 per cent N as FYM and remaining 25 per cent N from Neem cake while remaining 50 per cent P as sterameal.

Pire and Acevedo (2005) conducted a field experiment to study the effect of vermi compost at rates 0, 5, 10, 15, 20 and 25 % on N, P and K nutrition of papaya crop. Vermicompost was applied alone or in combination with N fertilizer. Lower N fertilizer rates were used with higher vermicompost rates to keep a constant amount of this nutrient. Leaf N content decreased with increasing vermicompost rate, suggesting a dilution effect due to the significant increase in plant dry matter, P levels increased consistently with increasing vermicompost

rates. K level was significantly lowest when N fertilizer was used alone. The results showed that increasing vermi compost rates increased P levels but produced variable responses of N and K in papaya leaves.

Mansour and Shaaban (2007) conducted during 2005 and 2006 seasons on twenty – seven 20 years old Washington Navel orange trees onto sour orange rootstock in a private orchard situated at Agga, Dakahlia Governorate. The texture of the soil is clay and well drained and with a water table not less two meters deep. They found that application of N at 1000 g/tree in the form of ammonium sulphate at 2.43 kg/tree, Compost EI- Neel at 11.63 kg/ tree and Biogen at 250 g/tree significantly increased the leaf N and P content during both the years over other mineral source of N in the form of ammonium nitrate and urea in combination with Compost EI- Neel and Biogen.

Anjaneyulu (2007) conducted an experiment during 2004-05 to study the petiole nutrient norms using diagnosis and recommendation integrated system from 60 papaya (*Carica papaya*) gardens. A total of 300 samples were collected (sixth petiole from apex) to analyze for macro and micronutrients for establishment of the data bank. The whole population was divided into 2 sub-groups, namely low and high yielding by using diagnosis and recommendation integrated system and thus selected 45 nutrient expressions as diagnostic norms. These expressions had shown higher variance and lower coefficient of variation that are found to have greater diagnostic precision, viz., N/P (6.368), N/K (0.571), Mg/N (0.899), N/Zn (0.045), Ca/Mn (0.062), Ca/Zn (0.115), Mg/Zn (0.039) and S/Zn (0.010) etc. The nutritional balance index indicated through diagnosis and recommendation integrated system indices indicated that the most common yield-limiting nutrient is zinc, followed by potassium. In addition, 5 nutrient ranges have been derived using mean and standard deviation as low, deficient, optimum, high and excess for each nutrient to serve as a guide for diagnostic purpose. The optimum N

ranged from 0.91 to 1.44 %, P from 0.12 to 0.28%, K from 2.22 to 3.75%, Ca from 2.65 to 4.19 %, Mg from 0.67 to 1.37 % and S from 0.18 to 0.37 %. Among the micronutrients the optimum Zn ranged from 17 to 40 ppm, Fe from 33 to 92 ppm, Mn from 34 to 60 ppm and Cu from 6 to 12 ppm for papaya.

Khade and Rodrigues (2009) revealed that total potassium and total phosphorus content in leaf petiole of *mychorrhizal* inoculated plant was higher as compared to control. Increased in P and K content may be attributed to the fact that AM fungi may have explored the soil volume in a manner analogous to increasing root density with extra radical hyphae bridging gaps between soil and roots as well as building soil particles to each other and to the roots which is beneficial for the nutrient uptake.

Bhattacharai and Tomar (2009) conducted a field experiment on 10 – years- old walnut orchard at Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni-Solan (H.P.) to find out the effect of integrated nutrient management on leaf nutrient status of walnut (*Juglans regia* L.) with 13 different treatment combinations of organic and inorganic fertilizers. Among the treatments recommended dose of NPK (750g: 375 g: 750g per tree) + 50 kg vermi compost per tree and three fourth recommended dose of NPK+ 68.75 kg vermi compost per plant were found to be effective for improving N, P, K, Ca, Mg and micronutrient content of walnut leaf.

Ravishankar *et al.* (2010a) conducted a trial at Central Horticultural Experimentation Station during 2004-07 in order to organize modules for sustainable production of organic papaya cv., Coorg Honey Dew under Coorg region of Karnataka. They found that soil organic carbon significantly influenced by treatments FYM @ 20 kg/plant and urban compost @ 13.5 kg/plant. Soil under different organic modules had significantly higher microbial population (bacteria, fungi and *actinomyces*) and activities of urease, phosphatase, dehydrogenase

and cellulose as compared to that under recommended dose of fertilizers.

An experiment was conducted at Horticulture Research Station, West Bengal to study the efficacy of PSM (*Bacillus megatherium* + *Aspergillus awamori*) and VAM (*Glomus mosseae* + *G fasciculatum*) biofertilizers with graded levels of phosphorus (P_2O_5 at 50, 100, 150 and 200 g per plant) on growth and uptake of papaya. Maximum plant height (192.67 cm), girth (24.0 cm) and total number of leaves (25.17) were observed in VAM + 200 g P_2O_5 . Highest yield (64.85 t/ha) was resulted due to the inoculation effect of PSM and 200 g P_2O_5 treatment combination. P and K content of leaves increased with increasing phosphorus level and bio fertilizer application (Suresh *et al.*, 2010).

Sivakumar and Ponnusami (2011) carried out an experiment at the Horticultural College and Research Institute to study the effect of spacing and bio-stimulants on the plant nutrient uptake of medicinal crop nightshade (*Solanum nigrum*). They found that significantly lower uptake of N (112.98 kg/ha), P (10.22 kg/ha) and K (117.89 kg/ha) with organic treatment (FYM + Vermi compost 2.5 t/ha as basal) as compared inorganic fertilizer at the rate 139.68, 13.57 and 150.32 kg/ha N, P and K, respectively.

Yadav *et al.* (2011b) conducted field experiments during 2008-09 and 2009-10 to investigate nutrient levels on yield of papaya cv. Pusa Dwarf. The results indicate that fruit yield was higher during both the year of experimentation, this may be due to the efficiency of bio agent which can be well exploited with the use of organic manures with inorganic fertilizers (Suther, 2009) which might have improved the yield parameters by better availability and uptake of nutrients by plant roots and enhancing the source sink relationship by increasing the movement of carbohydrates from leaves to the fruits. Similar findings have been

observed by Yadav (2006), Srivastava (2008) and Sha and Karuppaiah (2010).

2.3 Effect of organics on fruit quality of papaya

Hossain *et al.* (1990) conducted an experiment at the University of Rajshahi, Bangladesh Using urea, cow dung and oil cake as sources of nitrogen. They have reported higher amount of reducing and total sugar in the ripped fruits of papaya with treatment of application of cow dung and oil cake while higher protein content was recorded in treatments oil cake followed by urea along with oil cake and cow dung with oil cake. Being organic fertilizers, cow dung and oil cake might created better environment for microbial activities and slow and gradual decomposition of oil cake also have facilitated a regular supply of nitrogen to the crop ultimately resulted in to better quality of fruits.

Ushakumari *et al.* (1997) studied the efficiency of vermi compost on yield and quality of banana. Application of additional 200 g N through vermi compost recorded higher reducing sugar (18.3 %), total sugar (22.6 %) and low acidity (0.43 %) over the treatment receiving cow dung along with inorganic fertilizers.

Suresh and Hasan (2001) conducted a field experiment at west Bengal during 1996 to 1998 to evaluate the response of *Azospirillum* and *Phosphobacterium* on fruit quality of banana. The results revealed that inoculation of *Azospirillum* alone had more pronounced effect in improving the total soluble solids, while application of half of the recommended dose of nitrogen had more pronounced effect on reducing sugar content in fruits.

Patel (2008) conducted an experiment to study the effect of organic manures on quality of banana at Organic Farm, Navsari Agricultural University, Navsari with 16 organics treatments including inorganic control. He concluded that 3 kg vermi compost along with 3 kg of castor cake per plant gave maximum TSS (25.95 %), total sugar

(14.20 %), reducing sugar (5.51 %) and non-reducing sugar (8.69 %), while minimum acidity (0.33 %) was observed with the treatment receiving 3 kg vermi compost along with 7.5 kg poultry manure per plant.

The fresh berries quality *viz.*, total soluble solids (6.81 °Brix), total sugars (4.73 per cent), ascorbic acid (73.71mg/100g) and anthocyanin (0.191 OD) content in fruits was recorded highest from treatment receiving 25 per cent nitrogen through FYM + 75 per cent nitrogen in the form of urea + *Azotobacter* respectively over rest of the combinations of inorganic and organic manures (Iqbal et al., 2009).

Bio-fertilizer inoculation with strain *Pseudomonas fluorescence* strain 843 at one time monthly during the period of experiment to trees at two levels 300 ml and 500 ml per tree with 10^{-8} cells ml⁻¹ was significantly improves fruit quality, TSS and juice volumes of Washington navel orange over uninoculated trees. Abdelaal *et al.* (2010).

Rao *et al.* (2010) conducted a field experiment at S. V. Agricultural College Farm, Tirupati on organic farming in maize-sunflower-green gram cropping system for two consecutive years (2003-04 and 2004-05). They reported that quality parameters of maize grain like protein content, starch content and amino acid content were at their best with recommended dose of fertilizer either with or without panchagavya spray. However, all the above mentioned parameters were significantly higher with the application of farm yard manure or pig manure or vermi compost in combination with foliar application of panchagavya than any other organic manurial practice yield.

Nikas *et al.* (2010) tried to study the soil characterization leaf nutrient status, fruit quality and yield of papaya at Nagpur and Wardha districts. The soils of papaya orchard were shallow to deep, calcareous, clayey to sandy clay loam in texture having fairly good physical and chemical properties suitable for papaya. The soil is slight to moderately

alkaline and calcareous with CaCO_3 increasing with depth. They found that reducing sugar and non reducing sugar were positively correlated with leaf nutrient N ($r = 0.946, 0.935$), P ($0.974, 0.965$). The K, Mn and Cu did not show significant positive correlation with leaf nutrients. The total soluble solids in fruit juice of papaya showed positive and significant correlation with leaf N, P, K, Fe and Zn, whereas non-significant positive correlation was established with manganese and copper.

Ravishankar *et al.* (2010b) tried to study the effect of organic manures on growth, yield and quality of Coorg Honey Dew papaya and revealed that application of FYM @ 20 kg/plant recorded maximum total soluble solids, ascorbic acid, total sugar and the least value of titratable acidity as compared to intensive farming and other organic treatments.

Singh *et al.* (2010) conducted a field experiment at Department of Horticulture, Allahabad Agricultural Institute, Allahabad during 2005-06 and 2006-07 to study the response of integrated nutrient management on growth, yield and quality of papaya cv. Surya. They have tried different treatments of recommended dose of fertilizer *i.e.*, 200: 250: 250 g NPK/plant, FYM @ 50kg/plant, vermi compost @ 20 kg/plant, poultry manure 20 kg/plant, rhizosphere bacteria culture 50 g/plant alone and in combination with reduced levels of RDF *viz.*, 75 and 50% and found that quality parameters of the fruit like pulp thickness (3.5 cm), shelf life of fruit (12 days), vitamin A (2280 IU/100g) and TSS (15.8 ° Brix) were to be increase with decreasing level of chemical fertilizers.

Highest TSS (16.07 °B and 17.9 °B) and vitamin C (189.57 mg/100g) content of guava cv. Red Fleshed for rainy and winter season crop, respectively, was recorded by Rubee *et al.* (2011) with the application of *Vesicular Arbuscular Mycorrhizae* (VAM) (10 kg per tree).

Yadav *et al.* (2011a) conducted a field experiment to study the effect of various organic, inorganic and bio fertilizer combination on

ascorbic acid, total soluble solids and total sugar content of papaya fruit. The results of the experiment revealed that highest TSS, total sugar, ascorbic acid content and minimum fruit acidity was recorded with the soil application of vermi compost along with 100 per cent RDF and *Azotobacter*. Improvement in fruit quality might be due to the continue supply of nutrients, higher concentration of soil enzymes, rapid mineralization and transportation of plant nutrients along with growth promoting substances produced by the microorganisms in soils. The results are in accordance with the findings of Kumar and Shanmugavelu (1986) and Athani *et al.* (2009).

2.4 Effect of different organics on soil physical and chemical properties of soil

Bhadrapur *et al.* (1970) conducted an experiment to study the effect of soil organic manures on aggregation and other physical properties in four types of soil *viz.*, dry land soil, red soil, black soil, and black alkali soil. They reported that application of FYM and groundnut cake increased the soil aggregation in all types of soil as compared to control, while physical properties like water holding capacity and per cent pore space was better in all type of soils receiving FYM alone.

Jagannath *et al.* (1972) conducted trial with organic manures, they observed that the soil properties like hydraulic conductivity, dispersion and saturation percentage was significantly improved with application of FYM as compared to other manures.

Ghoshal and Singh (1994) at BHU, Varanasi studied the influence of soil amendment (organic manure) on organic carbon and N content in dry land ecosystem. They reported that application of FYM either alone or in combination with urea significantly increased the organic carbon content (0.77 to 1.12 %) or total N from 0.074 to 0.101 mg/kg of soil.

Carmen *et al.* (1994) conducted a field experiment at Florida Agricultural Research Station on very gravelly loam soil using municipal

solid waste (MSW) compost as organic manure at 0, 75 and 151 t/ha. Addition of MSW increased water and nutrient holding capacity. MSW amended soil tended to produce higher fruit number and weight of papaya than no amended plots.

Aneesa Rani and Sathiamoorthy (1997) at Tamil Nadu Agricultural University, Coimbatore studied the effect of organics and bio fertilizers on root enzyme activity and growth of papaya. They reported that the highest phosphate activity like acid and alkaline phosphatase and dehydrogenase and peroxidase were recorded in the treatment receiving 25 per cent each of FYM and Neem cake along with 50 per cent inorganic N.

Reddy *et al.* (2001) conducted the experiment to test the combined application of urban compost and sewage sludge on *bhendi cv. Arka Anamika* during 2000-01 at Itgalpura, Bangalore. They found that organic carbon content of the soil is the key factor to maintain sustainability of *bhendi* production. Application of organics to *bhendi* crop raised the residual organic carbon of soil from 0.59 to 1.98 per cent. This was reflected in higher status of available soil nitrogen.

Gogoi *et al.* (2004) studied the effect of inorganic and bio fertilizers to banana crop. They found that the availability of N was at highest when recommended dose of NPK (RDF) applied with *Azotobacter* and PSB, this treatment was followed by RDF, *Azospirillum* and PSB at the harvest of banana. However, significantly the highest available P_2O_5 (30.30 kg/ha) and K_2O (242.42 kg/ha) was found with RDF with *Azospirillum* and PSB. More availability of P under PSB treatment can be attributed to the production of organic acids which dissolved the insoluble phosphate and also release of K from the exchange front.

Abdelaty *et al.*, (2009) conducted a field experiment during two successive seasons of 2005 and 2006 to determine the effect of different

irrigation regimes (70%, 50% and 30% of available soil water) and organic (cattle and chicken) manures on some soil physical properties. They found that application of organic manures alone or in combination with mineral fertilizer resulted significantly decrease in soil bulk density, volume drainable pores and hydraulic conductivity (cm/hr.), however, the lowest values were detected when applied 100 per cent chicken manure or 100% cattle manure and significantly increased total porosity, void ratio and available water content values in the upper surface layer of the soil compared to fertilization with mineral fertilizer alone.

Shashidhar *et al.* (2009) studied to evaluate the effect of different kinds of organic manures and microbial inoculants on leaf yield, native soil micro flora and fertility status of S36 mulberry garden was assessed during 2007-08. The pooled data of four crops revealed that mulberry raised with 100 per cent RDN (225 kg/tree/year) through 20 per cent each of Compost + *Glyricidia maculate* + Castorcake + Vermi compost and Urea + 10 kg each of *Azospirillum brasilense* + *Aspergillus awamori* Bio-fertilizer + remaining P, K (150 and 150 kg/tree/year, respectively) through chemical fertilizers + Recommended FYM (T8) recorded maximum bacterial population (64.16×10^6 cfu/g soil), fungal (37.66×10^3 cfu/g soil), actinomycetes (26.16×10^4 cfu/g soil) and increased population of introduced beneficial microflora *i.e.*, *Azospirillum brasilense* (15.66×10^6 cfu/g soil) and *Aspergillus awamori* (17.33×10^3 cfu/g soil) were recorded in the same treatment over rest of the treatments. However, increased availability of nitrogen (283.72 kg/ha), phosphorus (79.75 kg/ha), potassium (259.49 kg/ha), exchangeable calcium (5.53 C. mol/kg), exchangeable magnesium (4.26 C. mol/kg) and available sulphur (37.85 kg/ha) were also noticed in the same treatment compared to other treatments.

Vo Thi *et al.* (2010) studied the effect of fresh and composted organic amendment on soil compaction and soil biochemical properties

of Citrus Orchards in the Mekong Delta, Vietnam. The effects of 10 t ha⁻¹ sugarcane filter cake compost plus *Trichoderma* spp. and 20 t ha⁻¹ of fresh *Tithonia diversifolia* were studied in combination with recommended inorganic fertilizer (250g N - 200g P₂O₅ - 120g K₂O.plant⁻¹) in orange orchards where the raised beds had been constructed for more than 26 years. They found that amendment with sugarcane filter cake compost (plus *Trichoderma* spp.) and fresh *Tithonia diversifolia* in combination with recommended inorganic fertilizer led to an increase soil organic matter content, available nitrogen and phosphorus, CEC, percentage base saturation, soil respiration, soil aggregate stability and to reduced soil compaction as compared to usual farmer practice (628g N-327g P₂O₅ - 64g K₂O plant⁻¹).

Bhanuvally *et al.* (2010) tried to study the effect of farmer's practices in organic farming on soil properties and soil health in cotton based cropping system in Northern Dry Zone of Karnataka during summer season of 2006. The result revealed that a reduction in bulk density and an increase in aggregate stability were noticed in all the soil under organic farming as compared to conventional farming. A wide variation in increase of organic carbon content and CEC of soils of organic farming over conventional farms was also observed. The soil under organic farming recorded higher amount of available N, P, K and S than the soils under conventional farming.

Reddy *et al.* (2010) conducted a field trial on papaya (cv. Surya) during 2005-2007 at the experimental farm of Indian Institute of Horticultural Research, Bangalore. The soil of experimental site was red loam with pH 6.12, organic carbon 0.73%, available nitrogen 158 kg/ha, phosphorus 13 kg/ha and potash 196 kg/ha. They found that application of 7 kg urban compost/plant or 10 kg FYM/plant was found to be ideal for improving soil health in terms of microbial population, and biochemical reaction compared to other treatments.

Selvamani *et al.* (2011) conducted a field experiment on farmer's field, Thanjavur district, Tamil Nadu during 2006 to 2008 with Bananan (Musa AAB) cv. Poovan and revealed that significantly highest N, P and K content in soil during vegetative stage, flowering stage and harvesting stage was recorded with 50 per cent RDF through inorganic fertilizers + 25 kg FYM + 3 kg vermi compost + 1 kg neem cake + bio fertilizer as compared to 100 per cent RDF through inorganic fertilizers. Increase in content of N, P, K and micronutrient cations was due to the mechanism involved in solubilizing phosphours through acid production and enzyme activity *viz.*, dehydrogenase activity, phosphate activity and urenase activity. Increase in potassium content in the soil was due to the fact that increased levels of potassium which lead to higher content of soil potassium and attributed to the decomposition and liberation of potassium as a organic matter in to soil leading to better potassium uptake and soil potassium content (Randhawa *et al.*, 1972; Twyford and Coulter, 1964).

2.5 Economics

A survey was made on certified organic farms in the country to ascertain the real benefit and feasibility of organic farming in terms of the production potential, economics and soil health in comparison to the conventional farms. The study revealed that organic farming, in spite of the reduction in crop productivity by 9.2 per cent, provided higher net profit to farmers by 20 per cent compared to conventional farming. This was mainly due to the availability of premium price (20 – 40%) for the certified organic produced and reduction the cost of cultivation by 11.7 per cent. In cases, where such premium prices were not available and the cost of cultivation was higher primarily due to purchased off-farm inputs, organic farming was not found economically feasible. However, there was an overall improvement in soil quality in terms of various parameters *viz.*, physical, chemical, biological properties, availability of

macro and micro nutrients, indicating an enhanced soil health and sustainability of crop production in organic farming system (Ramesh *et al.*, 2010).

Yadav *et al.* (2011b) conducted a field experiment for two consecutive year of 2008-09 and 2009-10 at Main Experiment Station, N. D. University of Agriculture & Technology, Kumarganj, Faizabad to study the effect of different of different integrated nutrient nourishment levels on yield and economics of papaya cv. Pusa Dwarf. They found maximum net profit (Rs. 538224/ha and Rs. 561774.99/ha) and benefit: cost ratio (1:3.89 and 1:4.06) under 100 % recommended dose of fertilizer along with 30 kg FYM and 25 g *Azotobacter* as compared to the rest of the treatment combinations during 2008-09 and 2009-10, respectively.

A field experiment on effect of bio-regulants on growth and yield of turmeric variety BSR-2 was conducted by Rajamani *et al.* (2007) at Horticultural College and Research Institute, TNAU, Coimbatore. They have tried twelve foliar treatments of different bio-regulants and reported that highest benefit cost ratio (2.25) was observed with foliar spray of 0.05 per cent humic acid over the control and rest of the bio-regulants spray.

III. MATERIAL AND METHODS

An experiment was conducted to study the, "**Effect of different proportion of organic manures on yield and quality of organically grown papaya**" The investigation was carried out during the year 2009-10 and 2010-11 at Organic Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari. The details of material used and methods adopted during the present investigation are described in this chapter.

3.1 Material

3.1.1 Experimental site

The present study was conducted at Organic Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari during the year 2009-10 and 2010-11. This place is situated at 20° 57' N latitude, 72° 54' E longitude and has an altitude of about 10 m above the mean sea level and is located 12 km away in the east from the great historical place 'Dandi' on the Arabian seashore.

After selecting the site, land was prepared by ploughing and harrowing. The experiment was laid out in a Factorial Randomized Block Design (Fig.1) with eight + one (control outside the organic plot) treatments and three replications.

3.1.2 Weather conditions

According to agro-climatic situation, Navsari is placed in South Gujarat Heavy Rainfall Zone-I. The climate of this zone is typically tropical, characterized by humid and warm monsoon with heavy rainfall, moderately cold winter and fairly hot and humid summer. The average annual rainfall of the tract is about 1500 mm. Monsoon commences by the second fortnight of June and ceases by September end. The winter season starts from November and ends by the middle of February. The coldest months are December and January, whereas the hottest months are April and May (Table 1).

Table 1: Meteorological data recorded during crop season of the year 2009-10 and 2010-11

Month	Temperature (°C)		Relative Humidity (%)		Wind velocity (km/hr)	Sunshine hours per day	Rainfall mm
	Max.	Min.	Morning	Evening			
2009-10							
Dec. 09	30.8	15.2	85	42	3.4	8.7	-
Jan. 10	29.3	13.9	84	44	3.7	8.9	-
Feb. 10	32.1	15.7	84	35	3.8	9.6	-
Mar. 10	33.0	15.8	77	28	4.3	8.8	-
April.10	34.5	25.5	81	50	7.1	9.5	-
May.10	35.3	28.0	78	53	8.0	8.8	-
June.10	32.1	27.8	84	68	9.0	6.5	258.9
July.10	30.2	26.5	90	80	7.4	4.7	1062.7
Aug. 10	28.2	26.0	87	82	4.4	3.4	779.8
Sep. 10	31.5	25.7	91	65	4.7	6.3	161.4
Oct. 10	33.0	23.4	78	40	3.9	8.3	11.2
Nov. 10	33.4	20.7	75	35	2.9	8.4	-
Dec. 10	31.5	16.7	76	36	3.3	8.8	-
Min.	28.2	13.9	75	28	2.9	3.4	
Max.	35.3	28	91	82	9	9.6	
Mean	31.9	21.6	82.3	50.6	5.1	7.7	

Table 1 conti.....

Table 1 conti.....

Month	Temperature (°C)		Relative Humidity (%)		Wind velocity (km/hr)	Sunshine hours per day	Rainfall
	Max.	Min.	Morning	Evening			mm
2010-11							
Jan. 11	28.4	12.9	81	39	3.9	8.7	-
Feb. 11	30.1	15.2	86	49	4.4	9.7	-
Mar. 11	33.2	20.4	89	40	4.8	9.0	-
April. 11	35.0	23.6	87	44	7.3	9.6	-
May .11	34.1	27.1	86	51	7.5	9.8	-
June.11	32.7	28.6	83	66	8.0	7.4	143.8
July.11	30.2	27.4	89	78	8.3	3.5	966.5
Aug. 11	29.4	25.8	86	77	7.8	3.8	699.2
Sept. 11	29.8	25.5	92	80	6.0	4.1	388.2
Oct. 11	34.3	22.7	84	48	3.6	6.3	78.5
Nov.11	33.7	18.2	70	31	2.9	8.5	7.3
Dec. 11	30.2	14.4	74	34	3.0	8.4	-
Jan. 12	30.0	14.1	72	32	3.8	7.3	-
Min.	28.2	12.9	70	31	2.9	3.4	7.3
Max.	35.3	28.6	92	82	9.0	9.8	1062.7
Mean	31.8	21.4	82.7	51.0	5.3	7.6	-

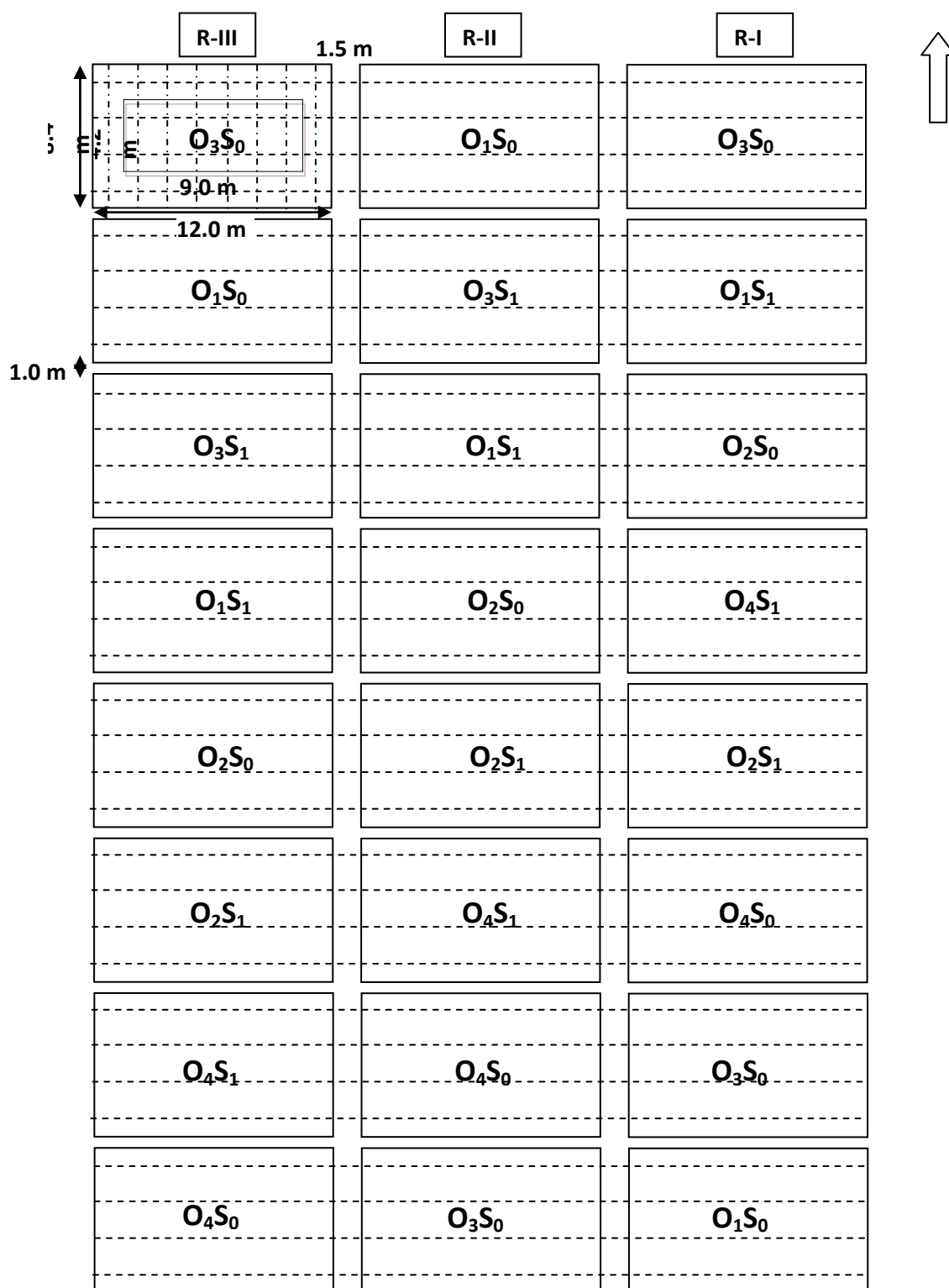


Fig 1: Layout plan of experiment (INM control was taken outside the organic farm)

3.1.3 Soil

According to seventh approximation, the soils of experimental field is classified under the order '*Inceptisols*' comprising members of fine, *montmorillonitic, isohyperthermic* family of *Vertic Ustrochrepts* and soil series Jalalpur. These soils are mainly derived from basalt, augite, granite, gneiss and lime stone. The soil develops deep cracks and becomes extremely hard when dry, while plastic and sticky when wet. The average thickness of solum ranged from 2.5 to 3.0 m. The rooting depth is extended up to 1.0 m. The color of dry soil is dark brown and texture is clay. The soil of the experimental plot was neutral to slightly alkaline in reaction.

Representative soil samples from the experimental plots were drawn from 0-22.5 cm and 22.5-45 cm depth before planting of papaya crop to determine the physical and chemical properties of the soil. The values of physical and chemical properties of experimental soil are given in table 2.

3.1.4 Water

Source of irrigation

The crop was irrigated with tube well water. The chemical analysis of irrigation water is presented in table 3. The analysis indicated that it was fairly safe for the purpose of irrigation.

3.1.5 Manures and fertilizers

The NPK and micro nutrient content in bio compost, vermi compost, castor cake and banana pseudostem sap used as a source of plant nutrients is given in table 4. The quantity of organic manures was determined for application on N equivalent basis.

Table 2: Physical and chemical properties of the experimental soil during the year 2009-10 and 2010-11

Parameters	2009-10 (INM Plot) at fixed site		2009-10 (Organic Farm)		2010-11 (Organic Farm)	
	0 – 22.5	22.5 – 45	0 – 22.5	22.5 – 45	0 – 22.5	22.5 – 45
Physical						
Coarse sand (%)	1.20	1.17	1.05	2.08	1.45	1.76
Fine Sand (%)	12.82	14.25	12.8	16.75	13.25	16.85
Silt (%)	24.08	26.35	19.9	18.92	18.55	21.45
Clay (%)	61.33	58.23	66.25	62.25	66.75	59.74
Textural class	Clay	Clay	Clay	Clay	Clay	Clay
BD (g/cc)	1.48	1.57	1.46	1.52	1.47	1.54
WSA (%) 0.5-1.0mm	30.82	38.60	20.98	16.95	21.65	14.25
>1.0mm	26.96	19.48	55.85	39.65	56.25	40.20
HC (cm/hr)	1.87	2.62	4.15	5.63	4.32	6.48
Chemical						
pH (1:2.5)	8.10	8.30	8.02	8.22	8.05	8.15
EC (1:2.5) (dS/m)	0.36	0.41	0.36	0.33	0.39	0.36
Organic carbon (%)	0.43	0.35	0.75	0.42	0.72	0.40
Available N (kg/ha)	235	220	254	190	246	185
Available P ₂ O ₅ (kg/ha)	39	23	45	26	50	18
Available K ₂ O (kg/ha)	459	430	515	402	485	385
DTPA extractable (mg/kg)						
Fe	15.3	10.3	14.2	10.35	13.2	8.21
Mn	18.6	13.2	19.6	14.68	17.65	13.50
Zn	0.48	0.36	0.58	0.42	0.52	0.40
Cu	2.5	1.9	3.45	2.05	2.45	1.65

Table 3: Quality of irrigation water used in the experiment

Sr. No.	Constituents	Value
1.	pH	7.64
2.	EC (dS/m at 25°C)	1.07
3.	Calcium + Magnesium (me/l)	6.56
4.	Sodium (me/l)	3.39
5.	Sodium Adsorption Ratio (SAR)	1.87
6.	Carbonate (me/l)	Nil
7.	Bicarbonate (me/l)	4.98
8.	Chloride (me/l)	3.84
9.	Residual Sodium Carbonate (RSC) (me/l)	1.58

Table 4: Chemical analysis of different organics used in the experiment

Nutrients	Content			
	Bio compost	Vermi compost	Castor cake	Sap
N (%)	1.50	1.30	4.40	0.007
P (%)	1.19	0.95	0.72	0.003
K (%)	1.65	1.90	1.10	0.170
Fe (mg/kg)	1834	2050	877	7.44
Mn (mg/kg)	303	96	42	2.66
Zn (mg/kg)	69	48	69	0.40
Cu (mg/kg)	36	20	27	ND
C:N	21.33	10.77	7.95	-

3.1.6 Crop and variety

The papaya seeds of variety Taiwan-786 were sown in plastic bags at university farm and one month old plants were used for planting.

3.1.7 Irrigation system

Drip system of irrigation with head unit, mains, sub-mains and lateral was installed for the experiment plot. Necessary filtration and other safety units were fitted to the smoother and efficient operation of the system.

3.1.8 Cropping history of the experimental field

The details of crops/cropping sequences followed during last three years are given in table 5.

Table 5: Cropping history of the experimental field

Year	2009-10			2010-11		
	<i>Kharif</i>	<i>Rabi</i>	Summer	<i>Kharif</i>	<i>Rabi</i>	Summer
2006-07	Ratoon Banana	Ratoon Banana	Ratoon Banana	Ratoon sugarcane	Ratoon sugarcane	Ratoon sugarcane
2007-08	Sugarcane	Sugarcane	Sugarcane	Banana	Banana	Banana
2008-09	Ratoon sugarcane	Ratoon sugarcane	Ratoon sugarcane	Ratoon banana	Ratoon banana	Ratoon banana

3.2 Methods

The investigation was carried out with four levels of different organic sources, two levels of Sap and one control outside organic farm.

3.2.1 Treatments details

a) Organic manures :

Treatments	Sources			Total N (%)
	BC	VC	CC	
O₁	50	-	50	100
O₂	50	50	-	100
O₃	50	25	25	100
O₄	33.3	33.3	33.4	100

b) Sap: Banana pseudostem sap

S₀: Without Sap

S₁: With Sap @ 8 l/plant

3.2.2 Location and technical programme of research work

The details of materials and techniques to be used and adopted during the course of study are as under:

- a. **Location** : Organic Farm (F-block), Navsari
Agricultural University, Navsari 396 450

- b. Experimental design** : Factorial concept of Randomized Block Design
- c. Crop and variety** : Papaya cv., Taiwan 786
- d. Year and season** : *Rabi*, 2009-10 and 2010-11
- e. No. of replications** : Three
- f. Treatments** : Eight + One (Control outside the organic plot)
- g. Spacing** : 2.1 x 1.5 m
- h. Plot size**
- i. Gross plot** : 8.4 x 12 m
- j. Net plot** : 4.2 x 9.0 m
- k. RDN** : 200 g N/plant through different organics as detailed below

3.2.3 Application of organic manures

- 1) All organics were applied on N equivalent basis
- 2) 50 per cent of N equivalent quantity of organics were applied as basal dose and remaining quantity in two equal splits first at 2 months after planting and second at four month after planting.
- 3) Uniform dose of bio-fertilizer *Azotobacter* and PSB culture *Trichodarma viridi*, *Pseudomonas* culture were applied at the rate of 5 kg/ha at the time of planting and *Trichodarma viridi*, *Pseudomonas* culture at 5 kg/ha applied after two months of planting in all the treatments.
- 4) Banana pseudostem sap was applied at the rate of 8 l/plant in eight equal splits starting from two months after planting at an interval one month.
- 5) INM control plot kept outside the organic farm was fertilized at the rate of 200 g N : 200 g P and 250 g K per plant in the form of inorganic fertilizers

3.2.4 Cultural operations

Land preparation

The land was tilled with tractor drawn cultivator followed by harrowing and cross planking to break the clods to achieve proper tillth. Subsequently, experimental layout was done manually (Fig. 1). FYM at the rate of 10 t /ha was applied to all plots. The general view of field experiment is depicted in plate 1.

The required cultural operations were carried out as and when required.

Field operations	Year	
	2009-10	2010-11
Cultivation with tractor	30/07/2009	01/09/2010
Harrowing and planking	02/08/2009	04/09/2010
Field layout	05/08/2009	06/09/2010
Application of manures	06/08/2009	06/09/2010
Planting	07/08/2009	08/09/2010
Gap filling	22/08/2009	21/09/2010
Hand weeding	20/09/2009	01/10/2010
Spray	16/12/2009	18/01/2011
First harvesting	25/05/2010	09/06/2011
Number of picking	10	12

Weed management

Weed management was done by hand weeding or by rotary power tiller at regular intervals.

Irrigation

Papaya crop was irrigated through drip system having 2.1 m lateral spacing and two drippers per plant 50 cm away from the stem with 4 lph discharge capacity. The system was operated at 1.2 kg/cm² pressure for

getting better uniformity of application. The system was operated at 0.6 PEF which comes around 2.0 hrs for winter season and 3 hours for summer season.

After care

Earthing up was carried out as and when required during the growing period.

3.2.5 Crop protection

Organic plant protection was carried out as and when required. A mixture of 3 liter cow urine, 3 liter whey, 1 kg jaggery and 1 liter green coconut water was prepared in 200 liter of water and spraying was done using knapsack sprayer.

3.2.6 Trap crop

Maize as trap crop (two rows) was grown after 4 rows of papaya and on the boarder of the field.

3.3 Bio-metric and other observations

The growth and yield attributes studied during the course of investigation are given in table 6. The observations were recorded by selecting five plants randomly from the net plot area which were tagged earlier. The details of the technique employed for different parameters are given in following sub-sections

Plant height

The height of plant was measured in centimeter from ground to base of the newly emerged leaf with the help of measuring tape then the average value of plant height was worked out.

Stem girth

The girth of stem was measured in centimeter at 10 cm above from ground level. The mean girth of five plants was work out.

Number of leaves per plant

Number of leaves per plant was recorded at the time of first picking

of tagged plants.

Length of petiole

Length of petiole was measured using steel rule. The length of petiole of lower, middle and upper portion leaves were measured and mean length was worked out from tagged plants.

3.4 Yield and yield attributes

The details of techniques employed for recording the yield attributing characters are mentioned below:

Table 6: Bio-metric observations recorded during the field investigation

Characters	Sample size	Time of recording
Plant height	5 plants	90, 120 and 150 DAS
Plant girth (cm)	5 plants	90, 120 and 150 DAS
Number of leaves/plant	5 plants	At harvest
Length of petiole (cm)	5 plants	At harvest
Number of fruits/plant	5 plants	At harvest
Average fruit weight (g)	5 plants	At harvest
Fruit yield (kg/plant)	5 plants	
Average fruit yield (t/ha)	Net plot	

Number of fruits/plant

On the basis of maturity indices, the mature fruits per plant were harvested and mean number of fruits per plant were calculated after all picking.

Fruit yield (kg/plant)

Mature fruits having yellow colored strips were harvested from each plant of net plot and weighed separately. Total weight of fruits of all pickings was considered as fruit yield and was divided by number of tagged plants.

Fruit yield (t/ha)

The data of yield per net plot was recorded and multiplied by multiple factor computed on area basis to give the final data for total yield in tonnes per hectare.

3.5 Shelf-life of fruit (days)

The shelf-life of fruit was noted by keeping two fruits from each treatment at room temperature from third and fourth picking. The shelf-life of fruits was recorded as the day taken from harvesting to optimum rippening stage.

3.6 Quality parameters

The quality parameters were determined at ripe stage of papaya fruits.

Total Soluble Solids (%)

The total soluble solids (TSS) of the ripped fruit pulp extract were determined using a handheld refractometer (Erma Japan). Having a scale in the range of 0 -32.

Reducing sugar (%)

The titrimetric method of Lane and Eynon described by Ranganna (1979) was adopted for estimation of reducing sugar. The percentage of reducing sugar was calculated according to following formula.

$$\text{Reducing sugar (\%)} = \frac{\text{Glucose Eq. (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of the pulp}} \times 100$$

Total sugars (%)

For estimation of total sugars, the filtrate obtained in the above estimation was used. An aliquot from the filtrate was taken and to one-fifth of its volume, HCl (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 per cent NaOH using phenolphthalein as an indicator and the final volume was made. The solution was filtered through Whatman No. 1 filter paper and titration was carried out using filtrate as per reducing sugars. The total sugars content was expressed as percentage in terms of invert sugars according to the formula.

$$\text{Total sugar (\%)} = \frac{\text{Glucose Eq. of Fehling's solutions (0.05)}}{\text{Titre}} \times \frac{\text{Total volume made up}}{\text{Weight of pulp taken}} \times \frac{\text{Volume made up after inversion}}{\text{Aliquot taken for inversion}} \times 100$$

Titrateable acidity (%)

The method described by Ranganna (1979) was adopted for estimation of titrateable acidity. The titrateable acidity percentage was calculated by adopting the following formula.

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali}}{\text{Volme of sample taken for estimation}} \times \frac{\text{Volume made up}}{\text{Weight of sample}} \times \frac{\text{Eq. Wt. of Malic acid}}{1000} \times 100$$

Ascorbic acid (Vitamin-C) content (mg/100g pulp)

Titrimetric method described by Ranganna (1979) was adopted for estimation of the ascorbic acid.

Procedure

Ten gram of homogenized pulp was taken and transferred to 100 ml volumetric flask. The volume was made up with 4 per cent oxalic acid solution. After 30 minutes, the suspension was filtered through Whatman No.1 filter paper. Before actual titration the 2, 6-Dichlorophenol

indophenols (Dye solution) was standardized by titrating against standard ascorbic acid solution and the dye factor was calculated. 5 ml of the aliquot was taken from the filtrate and titrated against standardized dye solution through a burette. The titration was continued till the light pink colour persisted for 15 seconds. The ascorbic acid content was calculated adopting the following formula.

$$\text{mg/100g} = \frac{\text{Titer -R x Dye Factor (0.1) x Volume made up x 100}}{\text{Volume of sample taken (Ali) x Wt. of sample taken}}$$

3.7 Analysis of plant samples

Plants sample collected at the time of harvest were first air-dried and then oven dried at 65° C till reaches the constant weight and powdered with the help of stainless steel mixture grinder. The powdered samples were stored in plastic bags and were used for analyzing N, P, K, Fe, Mn, Zn and Cu content using the prescribed methods (Table 7). The dried and powdered plant samples were digested by (H₂SO₄: H₂O₂ (30%) @ 1:1) for N and diacid using HNO₃: HClO₄ @ 10:4 for P, K, Fe, Mn, Zn and Cu determination.

Table 7: Methods employed for determination of chemical composition of different plant parts

Determination	Method employed	Reference
Acid extract	Wet digestion (diacid)	Parkinson and Allen (1975)
N	Micro Kjeldahl	Warnke and Barber (1974)
P	Vanadomolybdo phosphoric acid	Jackson (1979)
K	Flame photometric	Jackson (1979)
Fe, Mn, Zn and Cu	Atomic absorption spectrophotometric	Elwell and Gridley (1967)

3.8 Soil analysis

The soil samples were also collected at 0 – 22.5 and 22.5 - 45 cm depth from each plot at initial and after final harvest of the crop. The samples so obtained air dried and were used for the determination of available N, P, K, Fe, Mn, Zn and Cu content by methods as mentioned in table 8.

3.9 Nutrient uptake

The uptake of N, P and K by petioles, leaves and fruits was calculated by using the following formula:

$$\text{Uptake of NPK (kg/ha)} = \frac{\text{Content (\%)} \times \text{Yield (kg/ha)}}{100}$$

The uptake of Fe, Mn, Zn and Cu by petioles, leaves and fruits was calculated by using the following formula:

$$\text{Uptake of micronutrient (g/ha)} = \frac{\text{Content (mg/kg)} \times \text{Yield (kg/ha)}}{1000}$$

3.10 Statistical analysis

The data pertaining to the yield, growth attributing characters, quality, chemical constituents of plant as well as soil analysis values were subjected to statistical analysis. The analysis was carried out as per the methods described by Panse and Sukhatme (1967).

Table 8: Methods used for the determination of physical and chemical properties of soil and quality of irrigation water

Properties	Method/Extractant adopted	Reference
A. Physical properties		
Sand, Silt and Clay	International Pipette Method	Piper (1966)
Bulk density	Core Method	Black (1965)
B. Chemical properties		
pH	Potentiometric	Jackson (1979)
Electrical Conductivity	Conductometric	Jackson (1979)
Organic carbon	Walkley and Black rapid titration method	Jackson (1979)
Available N	0.32% Alkaline KMnO_4	Subbiah and Asija (1956)
Available P_2O_5	0.5 M NaHCO_3 (pH 8.5)	Olsen <i>et al.</i> (1954)
Available K_2O	Neut. N NH_4OAc	Jackson (1979)
DTPA Extractable Fe, Mn, Zn and Cu	0.05 M DTPA	Lindsay and Norvell (1978)
C. Irrigation Water Analysis		
Ca and Mg	Versenate method	Jackson (1979)
Na and K	Flame photometry	Jackson (1979)
CO_3 and HCO_3	Neutralization	Jackson (1979)
Cl	Argentometry	Jackson (1979)



Plate 1: Over view of experimental plot (Organic farm)

IV. EXPERIMENTAL RESULTS

For achieving the objectives envisaged in present study, a field experiment with papaya as test crop was conducted consecutively for two years *i.e.*, 2009-10 and 2010-11 at Organic Farm, F - Block, NAU, Navsari. In all, eight treatment combinations involving different proportion of three organics on N equivalent basis (O₁: 50 % RDN through bio compost + 50 % RDN through castor cake, O₂: 50 % RDN through bio compost + 50 % RDN through vermi compost, O₃: 50 % RDN through bio compost + 25 % RDN through vermi compost + 25 % through castor cake and O₄: 33.3 % RDN through bio compost + 33.3 % RDN through vermi compost + 33.4 % RDN through castor cake) and two levels of banana pseudostem sap application (S₀: without sap and S₁: with sap @ 8 l/plant along with one INM controls outside the organic farm were tested in FRBD with three replications. The results pertaining to growth parameters, yield attributes, yield, nutrient content, nutrient uptake, quality parameters and soil fertility obtained during the course of present study are interpreted here with the help of statistical yard stick under the following sub heads.

4.1 Biometric parameters

4.1.1 Plant height

The results regarding plant height were recorded at 90 day after planting (DAP), 120 DAP and at 150 DAP in tables 9, 10 and 11.

Plant height at 90 DAP: During the first year, plant height at 90 DAP was affected significantly due to individual effect of organic sources and sap application only (Table 9). The results revealed that among the organics treatments O₄ recorded significantly higher plant height (88.98 cm) as compared to rest of the treatments but was at par with O₃ (80.79 cm). Similarly, application of sap @ 8 l/plant (S₁) recorded 85.93 cm plant

height of papaya which was significantly higher as compared to S_0 . The control v/s rest analysis indicated INM (control) showed its superiority as compared to organic treatments mean (81.17 cm).

The plant height of papaya recorded during second year was also affected significantly due to organics and sap treatments. The treatment O_4 recorded significantly higher plant height (88.72 cm) as compared to O_1 (76.03 cm) and O_2 (77.79 cm) but was at par with O_3 (81.10 cm). Similarly, significant effect of sap on plant height was also observed. Sap application (S_1) recorded significantly higher plant height of 85.80 cm as compared to S_0 (76.02 cm). In control v/s rest analysis, INM control recorded significantly higher plant height (96.77 cm) as compared to organic treatments mean (80.91 cm).

In pooled analysis, the plant height of papaya was affected significantly due to application of organics in different proportion and sap. Significantly taller plant was recorded in O_4 treatments (88.85 cm) as compared to rest of the treatments but was at par with O_3 (80.95 cm). Sap application (S_1) recorded significantly higher plant height (85.86 cm) as compared to no sap application (S_0). The significantly higher plant height was observed in INM control (96.79 cm) as compared to the mean of organic treatments (81.04 cm).

Plant height at 120 DAP: During the first year, plant height recorded at 120 DAP was affected significantly due to individual effect of sap application only (Table 10). The results revealed that application of organics did not show any significant influence on plant height of papaya. However, soil application of sap (S_1) recorded significantly higher plant height of 104.63 cm as compared to S_0 (92.74 cm). In control v/s rest analysis, INM control recorded significantly higher plant height (114.38 cm) as compared to organic treatments (98.68 cm).

During second year, plant height of papaya was not affected significantly due to organics treatments. However, sap application (S_1) recorded significantly higher plant height (105.65 cm) as compared to S_0 (93.93 cm). In control v/s rest analysis, INM control recorded significantly higher plant height (116.25 cm) as compared to organic treatments (99.79 cm).

Table 9: Effect of different treatments on plant height (cm) of papaya at 90 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	73.10	79.33	76.22	71.72	80.33	76.03	72.41	79.83	76.12
O2	75.25	82.13	78.69	74.92	80.67	77.79	75.08	81.40	78.24
O3	75.38	86.20	80.79	75.38	86.82	81.10	75.38	86.51	80.95
O4	81.92	96.05	88.98	82.05	95.38	88.72	81.99	95.72	88.85
Mean	76.41	85.93	81.17	76.02	85.80	80.91	76.22	85.86	81.04
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	2.08	2.94	4.15	2.05	2.90	4.10	1.46	2.06	2.92
CD at 5%	6.30	8.91	NS	6.22	8.79	NS	4.23	5.98	NS
CV %	8.87			8.77			8.82		
Control			96.82			96.77			96.79
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	4.06		12.2	3.75		11.2	2.76		8.0

In pooled analysis, the plant height of papaya was affected significantly due to application of organics, sap as well as their interaction. Significantly higher plant height was recorded with O_4 treatments (104.15 cm) in comparison to rest of the treatments but was at par with O_3 (102.68 cm). Similar effect was also observed in case of sap application. Sap application (S_1) recorded significantly higher plant height (105.14 cm) as compared to without sap application (S_0). Among all the possible combinations, O_4S_1 (114.15 cm) and O_3S_1 (111.25 cm) showed superiority over rest of the combinations. In control v/s rest

analysis, significantly higher plant height was observed in INM control (115.32 cm) as compared to organic treatments (99.24 cm).

Table 10: Effect of different treatments on plant height (cm) of papaya at 120 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	91.72	95.77	93.74	93.25	96.05	94.65	92.48	95.91	94.20
O2	91.58	100.45	96.02	93.58	98.05	95.82	92.58	99.25	95.92
O3	93.72	109.25	101.48	94.52	113.25	103.88	94.12	111.25	102.68
O4	93.93	113.05	103.49	94.35	115.25	104.80	94.14	114.15	104.15
Mean	92.74	104.63	98.68	93.93	105.65	99.79	93.33	105.14	99.24
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	2.37	3.35	4.73	2.26	3.20	4.53	1.64	2.32	3.27
CD at 5%	7.18	NS	NS	6.86	NS	NS	4.74	6.71	9.48
CV %	8			8			8		
Control			114.38			116.25			115.32
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	3.40		10.21	3.75		11.23	2.53		7.29

Plant height at 150 DAP: During the first year, plant height at 150 DAP was affected significantly due to sap application only (Table 11). Application of different organic sources did not show any significant effect on plant height. However, numerically higher plant height was recorded with the treatment O₄ (121.23 cm). The results also revealed that application of sap @ 8 l/plant (S₁) recorded 120.74 cm plant height which was significantly higher as compared to S₀ (106.45 cm). INM control recorded significantly higher plant height at 150 DAP (133.13 cm) as compared to organic treatments (113.60 cm).

The plant height measured at 150 DAP during second year was also affected significantly only due to sap. Here also, significantly higher plant height (121.38 cm) was recorded with treatment (S₁) as compared to S₀ (109.13 cm). The control v/s rest analysis indicated superiority of INM control over organics mean.

In pooled analysis also, the plant height was significantly affected due to individual effect of organics and sap. Significantly higher plant height was recorded with O₄ treatment (123.06 cm) as compared to rest of the treatments with an exception of O₃ (117.03 cm). Similarly, treatments receiving sap @ 8l/plant recorded significantly higher plant height (121.06 cm) as compared to without sap application (S₀). While in comparison to INM control, with mean of organics treatments was significantly less than INM control.

Table 11: Effect of different treatments on plant height (cm) of papaya at 150 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	102.08	112.25	107.17	103.08	113.25	108.17	102.58	112.75	107.67
O2	104.08	114.82	109.45	105.08	115.82	110.45	104.58	115.32	109.95
O3	109.32	123.75	116.53	110.32	124.75	117.53	109.82	124.25	117.03
O4	110.32	132.15	121.23	118.05	131.72	124.88	114.18	131.93	123.06
Mean	106.45	120.74	113.60	109.13	121.38	115.26	107.79	121.06	114.43
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	3.40	4.81	6.80	3.21	4.53	6.41	2.34	3.30	4.67
CD at 5%	10.31	NS	NS	9.72	NS	NS	6.77	9.57	NS
CV %	10			10			10		
Control			133.13			134.13			133.63
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	4.63		13.88	4.42		13.25	3.20		9.22

4.1.2 Stem girth

The results regarding stem girth recorded at 90, 120 and 150 *days after planting* are reported in tables 12, 13 and 14.

Stem girth at 90 DAP: During the first year, stem girth at 90 DAP was affected significantly due to individual effect of sap application only (Table 12). Soil application of sap @ 8 l/plant recorded 22.30 cm stem girth which was significantly higher as compared to S₀ (19.59 cm). There was no significant difference in stem girth at 90 DAP between INM control recorded and mean of organic treatments.

Stem girth during second year did not show significant variations due to applications of organic sources. However, application of sap recorded significantly higher stem girth (22.70 cm) as compared to S₀ (19.71 cm). In control v/s rest analysis, INM control recorded significantly higher stem girth (25.35 cm) as compared to mean of organic treatments (21.21 cm).

Table 12: Effect of different treatments on stem girth (cm) of papaya at 90 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	18.38	20.72	19.55	18.85	21.23	20.04	18.62	20.98	19.80
O2	19.36	22.09	20.73	19.51	22.62	21.06	19.43	22.36	20.89
O3	19.27	22.97	21.12	20.10	22.58	21.34	19.68	22.78	21.23
O4	21.35	23.44	22.40	20.38	24.38	22.38	20.87	23.91	22.39
Mean	19.59	22.30	20.95	19.71	22.70	21.21	19.65	22.50	21.08
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.74	1.05	1.49	0.55	0.78	1.11	0.46	0.66	0.93
CD at 5%	2.25	NS	NS	1.68	NS	NS	1.34	NS	NS
CV %	12			9			11		
Control			23.87			25.35			24.61
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	1.087		NS	0.835		2.504	0.685		1.974

In pooled analysis, the stem girth of papaya was affected significantly due to application sap only. Sap application recorded

significantly higher stem girth (22.50 cm) as compared to S_0 (19.65 cm). While comparison between INM control and mean of organic treatments showed significant difference in stem girth and INM control (24.61 cm) recorded higher values as compared to mean of organic treatments (21.08 cm).

Stem girth at 120 DAP: During the first year, stem girth at 120 DAP was affected significantly due to individual effect of organic sources and sap application only (Table 13). The results revealed that application of organic sources treatment O_4 recorded significantly higher stem girth (28.14 cm) but remained at par with O_2 (25.68 cm) and O_3 (27.10 cm). Similarly, application of sap @ 8 l/plant recorded 28.33 cm stem girth which was significantly higher as compared to S_0 (24.03 cm). INM control recorded significantly higher stem girth (32.97 cm) as compared to mean of organic treatments (26.18 cm).

Stem girth during second year did not vary significantly due to application of organics treatment. But application of sap (S_1) could affect the stem girth significantly. Here also S_1 (27.41 cm) showed superiority over S_0 (23.75 cm). In control v/s rest analysis, INM control recorded significantly higher stem girth (31.65 cm) as compared to mean of organic treatments (25.68 cm).

In pooled analysis, the stem girth of papaya was affected significantly only due to individual effect of organic sources and sap application. Significantly higher stem girth (27.81 cm) was registered with organics treatment O_4 as compared to rest of the treatments. Sap application (S_1) recorded significantly higher stem girth of 27.87 cm as compared to S_0 (23.89). While comparison between INM control and mean of organic treatments, significantly higher stem girth was recorded with INM control (32.31 cm) than mean of organic treatments (25.88 cm).

Table 13: Effect of different treatments on stem girth (cm) of papaya at 120 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	22.43	25.19	23.81	23.29	24.88	24.08	22.86	25.04	23.95
O2	24.18	27.17	25.68	23.52	25.12	24.32	23.85	26.14	25.00
O3	24.45	29.75	27.10	23.78	29.08	26.43	24.12	29.42	26.77
O4	25.07	31.22	28.14	24.40	30.55	27.48	24.73	30.88	27.81
Mean	24.03	28.33	26.18	23.75	27.41	25.58	23.89	27.87	25.88
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.70	0.99	1.40	0.66	0.94	1.33	0.48	0.68	0.97
CD at 5%	2.12	3.00	NS	2.01	NS	NS	1.40	1.98	NS
CV %	9.27			8.99			9.13		
Control			32.97			31.65			32.31
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.95		2.84	0.88		2.64	0.65		1.86

Stem girth at 150 DAP: During first year, stem girth at 150 DAP was affected significantly due to individual effect of organics and sap application only (Table 14). Significantly higher stem girth (36.07 cm) was recorded with treatment O₄ as compared to rest of the treatments but was at par with O₃ (34.47 cm). Similarly, significantly higher stem girth (35.74 cm) was recorded with the application of sap @ 8 l/plant in comparison to S₀ (31.02 cm). INM control recorded significantly higher stem girth (39.18 cm) than mean of organic treatments (33.38 cm).

Stem girth during second year did not recorded significant differences due to application of organics treatment. But application of sap recorded significantly higher stem girth (35.37 cm) than S₀ (30.44 cm). In control v/s rest analysis, INM control recorded significantly higher stem girth (38.05 cm) as compared to organic treatments (32.91 cm).

In pooled analysis, the stem girth of papaya was affected significantly due to individual effect of organics and sap application only.

Significantly higher stem girth (35.64 cm) was measured with organics treatment O₄ as compared to rest of the treatments but was at par with O₃ (33.98 cm). Sap application recorded significantly higher stem girth (35.55 cm) than S₀ (30.73 cm). Between INM control and organics treatments mean, later recorded significantly lower values of stem girth than former.

Table 14: Effect of different treatments on stem girth (cm) of papaya at 150 DAP

Treatments	2009-10			2010-11			Pooled		
	S0	S1	Mean	S0	S1	Mean	S0	S1	Mean
O1	29.05	32.36	30.70	29.28	32.05	30.67	29.16	32.20	30.68
O2	29.72	34.83	32.27	29.72	34.83	32.27	29.72	34.83	32.27
O3	31.97	36.97	34.47	30.25	36.72	33.48	31.11	36.84	33.98
O4	33.34	38.80	36.07	32.53	37.89	35.21	32.94	38.35	35.64
Mean	31.02	35.74	33.38	30.44	35.37	32.91	30.73	35.55	33.14
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.88	1.24	1.76	0.94	1.32	1.87	0.64	0.91	1.28
CD at 5%	2.67	3.78	NS	2.84	NS	NS	1.86	2.63	NS
CV %	9.14			9.84			9.49		
Control			39.18			38.05			38.62
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	1.20		3.59	1.26		3.77	0.87		2.50

4.1.3 Number of leaves per plant

The number of leaves per plant of papaya recorded at harvest did not differ significantly due to individual as well as interactive effect of organics and sap application during individual year and in pooled analysis (Table 15). In contrast, the difference between organics mean and INM control were significant during both the years as well as in pooled analysis. Here, in all the cases, INM control showed superiority over mean of organics by recorded 38, 40 and 39 number of leaves/plant during 2009-10, 2010-11 and pooled analysis, respectively.

Table 15: Effect of different treatments on number of leaves per plant at harvest

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	31	30	30	31	31	31	31	30	31
O ₂	31	32	32	32	33	32	31	33	32
O ₃	31	31	31	32	32	32	31	31	31
O ₄	32	33	33	33	33	33	33	33	33
Mean	31	32	31	32	32	32	32	32	32
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.82	1.16	1.64	1.01	1.42	2.01	0.65	0.92	1.30
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9			11			10		
Control			38			40			39
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	1.16	3.47		1.36	4.07		0.89	2.57	

4.1.4 Petiole length

The pattern of treatment effect on petiole length recorded at harvest was similar to that observed on number of leaves/plant (Table 16). As like number of leaves, the petiole length was significantly longer with INM control than the mean of organics treatments during individual year and in pooled results as well.

Table 16: Effect of different treatments on petiole length (cm) at harvest

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	44.67	44.33	44.50	46.67	46.33	46.50	45.67	45.33	45.50
O ₂	45.33	45.67	45.50	47.33	47.67	47.50	46.33	46.67	46.50
O ₃	43.83	46.33	45.08	45.83	48.33	47.08	44.83	47.33	46.08
O ₄	44.00	46.33	45.17	46.00	49.00	47.50	45.00	47.67	46.33
Mean	44.46	45.67	45.06	46.46	47.83	47.15	45.46	46.75	46.10
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.69	0.98	1.38	0.67	0.95	1.34	0.48	0.68	0.96
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	5			5			5		
Control			62.33			64.33			63.33
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	1.05		3.15	1.03		3.10	0.74		2.12

4.2 Yield attributes and Yield

4.2.1 Average fruit weight

The average fruit weight was recorded at harvest and the results are reported in table 17. The results indicated that only the effect of organics treatment was significant on average fruit weight of papaya during individual year and in pooled analysis also. Among the organics treatments, treatment O₄ and O₃ were at par with each other during both the years as well as in pooled analysis, but were significantly superior to rest of the treatments. The control v/s rest analysis indicated that INM control recorded the average fruit weight values of 1.007, 1.073 and 1.080 kg during first year, second year and pooled results, respectively which was significantly more than means of organics treatments.

Table 17: Effect of different treatments on average fruit weight (kg) of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.787	0.817	0.802	0.823	0.827	0.825	0.805	0.822	0.813
O ₂	0.823	0.870	0.847	0.850	0.897	0.873	0.837	0.883	0.860
O ₃	0.897	0.927	0.912	0.937	0.970	0.953	0.917	0.948	0.933
O ₄	0.927	0.947	0.937	0.957	0.993	0.975	0.942	0.970	0.956
Mean	0.858	0.890	0.874	0.892	0.922	0.907	0.875	0.906	0.890
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.017	0.024	0.033	0.016	0.022	0.031	0.011	0.016	0.023
CD at 5%	NS	0.072	NS	NS	0.067	NS	NS	0.047	NS
CV %	7			6			6		
Control			1.087			1.073			1.080
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.022	0.066		0.022	0.065		0.015	0.045	

4.2.2 Number of fruits per plant

The total numbers of fruits per plant were obtained by summing up the number of fruits harvested at each picking. The results reported in table 18 indicated that during first year, only the effect of sap application was significant on number of fruits per plant. Between S₀ and S₁, significantly more number of fruits/plant (22.56) was recorded with S₁ than S₀ (20.90). While during second year, individual effect of organics and sap application was significant on number of fruits/plant. Among the organics treatments, O₄ and O₃ were at par with each other, but were significantly superior to O₂ and O₁. In the case of pooled analysis, only the individual effects of organics and sap were significant on number of fruits/plant. Here also, O₄ (22.33) and O₃ (21.96) were at par with each other but were significantly higher as compared to O₁. Further, O₂ and O₃ were at par with each other. In all the cases, control v/s rest analysis was turned out to be significant more number of fruits/plant than the means of organics treatments.

Table 18: Effect of different treatments on number of fruits per plant of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	20.42	21.52	20.97	19.07	20.05	19.56	19.74	20.78	20.26
O ₂	20.93	22.23	21.58	20.02	20.96	20.49	20.48	21.60	21.04
O ₃	21.02	23.14	22.08	21.22	22.45	21.84	21.12	22.80	21.96
O ₄	21.23	23.33	22.28	21.62	23.13	22.38	21.43	23.23	22.33
Mean	20.90	22.56	21.73	20.48	21.65	21.06	20.69	22.10	21.40
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.41	0.58	0.82	0.31	0.45	0.63	0.26	0.37	0.52
CD at 5%	1.25	NS	NS	0.95	1.35	NS	0.75	1.06	NS
CV %	7			5			6		
Control			23.00			23.70			23.35
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.56	NS		0.42	1.27		0.35	1.01	

4.2.3 Fruit yield per plant

The fruit yield per plant was affected significantly due to individual effect of O and S during both the years and in pooled analysis also (Table 19). During both the years as well as in pooled results, treatment O₄ recorded significantly higher fruit yield/plant as compared to O₂ and O₁. However, O₄ and O₃ were at par with each during first year of experimentation. Similarly, treatment S₁ recorded significantly higher fruit yield/plant during both the years and in pooled analysis as compared to S₀. With respect to control v/s rest analysis, it was found to be significant on fruit yield/plant of papaya during both the years and in pooled analysis. Between the two, INM control maintained its superiority over means of organics treatments during both the year as well as in pooled analysis. In none of the case, the interaction effect was significant on fruit yield per plant.

Table 19: Effect of different treatments on fruit yield per plant (kg) of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	16.08	17.56	16.82	15.68	16.54	16.11	15.88	17.05	16.47
O ₂	17.29	19.23	18.26	17.16	18.78	17.97	17.23	19.01	18.12
O ₃	18.86	21.41	20.14	19.89	21.71	20.80	19.37	21.56	20.47
O ₄	19.67	22.66	21.17	20.67	23.74	22.20	20.17	23.20	21.68
Mean	17.97	20.22	19.10	18.35	20.19	19.27	18.16	20.21	19.18
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.33	0.46	0.65	0.29	0.42	0.59	0.22	0.31	0.44
CD at 5%	0.99	1.40	NS	0.89	1.26	NS	0.64	0.90	NS
CV %	6			5			6		
Control			25.00			25.45			25.23
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.46	1.38		0.41	1.23		0.31	0.89	

4.2.4 Fruit yield

The year wise fruit yield of papaya along with pooled results are presented in table 20. The perusal of results revealed that only individual effects of O and S were turned out to be significant on fruit yield of papaya during both the years and ultimately reflected in pooled analysis. Among the organics treatments, O₄ recorded fruit yield of 67.15 t/ha during first year, 70.47 t/ha during second year and 68.83 t/ha in pooled analysis which significantly more than O₁ and O₂ during both the years and in pooled analysis. While during first year O₃ and O₄ were at par with each other. Between the two treatments of sap, sap application (S₁) showed consistent superiority over S₀ treatment during individual year as well as in pooled result. Though, individual effect of O and S were significant on fruit yield of papaya, their interactive effect failed to exert any significant effect on fruit yield during both the years as well as in pooled analysis. As regards the control v/s rest analysis, it was turned out to be significant in the case of fruit yield of papaya. Between the two, INM control recorded significantly higher fruit yield during first year (79.35 t/ha), second year (80.78 t/ha) and in pooled results (80.07 t/ha) as

compared to mean of organics treatments. The corresponding means of organics treatments are 60.61, 61.17 and 60.89 t/ha.

Table 20: Effect of different treatments on fruit yield (t/ha) of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	51.03	55.74	53.39	49.78	52.50	51.14	50.40	54.12	52.26
O ₂	54.87	61.04	57.96	54.48	59.62	57.05	54.68	60.33	57.50
O ₃	59.86	67.97	63.91	63.13	68.92	66.03	61.50	68.44	64.97
O ₄	62.43	71.93	67.18	65.60	75.34	70.47	64.02	73.64	68.83
Mean	57.05	64.17	60.61	58.25	64.09	61.17	57.65	64.13	60.89
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	1.04	1.47	2.08	0.93	1.32	1.87	0.70	0.99	1.40
CD at 5%	3.15	4.45	NS	2.83	4.00	NS	2.02	2.86	NS
CV %	6			5			6		
Control			79.36			80.78			80.07
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	1.46	4.39		1.30	3.89		0.98	2.82	

4.3 Dry matter yield

For assessing the extent of nutrient removal by leaves, petiole and fruit of papaya, the dry matter yield of all these components of papaya were recorded separately and reported under this subtitle.

4.3.1 Leaves dry matter yield

The year wise as well as pooled results pertaining to dry matter yield of leaves of papaya under different treatments are reported in table 21. The perusal of results indicated that neither individual nor interactive effect of O and S could influence the dry matter yield of leaves significantly during both the years and in pooled results as well. However, the control v/s rest analysis was turned out to be significant on leaves dry matter yield of papaya during both the years and in pooled analysis as well. In all the cases, the leaves dry matter yield of papaya was significantly higher with INM control as compared to the means of organics treatments.

Table 21: Effect of different treatments on leaves dry matter yield of papaya (q/ha)

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	4.00	3.92	3.96	4.09	4.00	4.05	4.05	3.96	4.00
O ₂	4.05	4.22	4.13	4.13	4.26	4.20	4.09	4.24	4.17
O ₃	4.05	4.05	4.05	4.13	4.13	4.13	4.09	4.09	4.09
O ₄	4.22	4.26	4.24	4.31	4.35	4.33	4.26	4.31	4.29
Mean	4.08	4.11	4.10	4.17	4.19	4.18	4.12	4.15	4.14
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.11	0.15	0.21	0.13	0.19	0.26	0.08	0.12	0.17
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9			11			10		
Control			4.92			5.18			5.05
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.15	0.45		0.18	0.53		0.12	0.34	

4.3.2 Petiole dry matter yield

Irrespective treatments, dry matter yield of petiole of papaya was more by three times than leaves dry matter yield. With respect to treatment effect on petiole dry matter yield, it was identical to that observed on leaves dry matter yield of papaya (Table 22). Here also all treatments failed to produce any significant effect on petiole dry matter yield of papaya during individual year as well as in pooled analysis. The INM control maintained its superiority over organics means in all the cases.

Table 22: Effect of different treatments on petiole dry matter yield of papaya (q/ha)

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	14.02	13.71	13.87	14.32	14.02	14.17	14.17	13.87	14.02
O ₂	14.17	14.78	14.48	14.48	14.93	14.70	14.32	14.86	14.59
O ₃	14.17	14.17	14.17	14.48	14.48	14.48	14.32	14.32	14.32
O ₄	14.78	14.93	14.86	15.09	15.24	15.16	14.93	15.09	15.01
Mean	14.29	14.40	14.34	14.59	14.67	14.63	14.44	14.53	14.49
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.37	0.53	0.75	0.46	0.65	0.92	0.30	0.42	0.59
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9			11			10		
Control			17.22			18.13			17.68
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.53	1.59		0.62	1.86		0.41	1.18	

4.3.3 Fruit dry matter yield

The scrutiny of results presented in table 23 revealed that individual effect of O and S were significant on fruit dry matter yield of papaya during both the years as well as in pooled analysis. Among the different organics treatments, application of organics as per O₄ treatment recorded significantly higher fruit dry matter yield of papaya as compared to O₁, O₂ and O₃ during both the years as well as in pooled analysis except O₃ during first year. Like organics, sap effect was also significant and treatment S₁ recorded significantly higher fruit dry matter yield during first year (96.26 q/ha), second year (96.14 q/ha) and pooled mean (96.20 q/ha) in comparison to no application of sap (S₀). In all the cases, the interaction effect between O and S was absent. But, between the two *i.e.*, INM control and means of organics treatments, the differences were significant during individual year and in pooled results. In all the case, INM control recorded significantly higher values of fruit dry matter yield as compared to means of organics treatments.

Table 23: Effect of different treatments on fruit dry matter yield of papaya (q/ha)

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	76.54	83.61	80.08	74.67	78.75	76.71	75.61	81.18	78.39
O ₂	82.31	91.56	86.94	81.72	89.43	85.58	82.01	90.50	86.26
O ₃	89.78	101.96	95.87	94.70	103.37	99.04	92.24	102.66	97.45
O ₄	93.65	107.89	100.77	98.40	113.01	105.70	96.02	110.45	103.24
Mean	85.57	96.26	90.91	87.37	96.14	91.76	86.47	96.20	91.34
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	1.56	2.20	3.11	1.40	1.98	2.80	1.05	1.48	2.09
CD at 5%	4.72	6.68	NS	4.25	6.01	NS	3.03	4.29	NS
CV %	6			5			6		
Control			119.03			121.17			120.10
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	2.20	6.59		1.95	5.83		1.47	4.23	

4.4 Nutrient content

The content of nutrients *viz.*, N, P, K, Fe, Mn, Zn and Cu in leaves petiole and fruits of papaya was determined separately and the results are described here element wise.

4.4.1 Nitrogen content

In general, the N content in leaves of papaya was considerably more than in petiole and it was minimum in fruits. The N content in papaya petiole was affected significantly only due to individual effect of O and S during first year and in pooled analysis only. In both the cases, O₄ and O₃ were at par with each other, but superior with respect to N content in petiole of papaya over the remaining two treatments. Similarly, in both the cases, S₁ showed superiority over S₀ (Table 24). However, invariably interaction effect between O and S was absent. In the case of N content in petiole, it was significantly higher with treatment mean as compared to INM control during both the years as well as in pooled analysis.

In the case of N content in leaves, it was influenced significantly only due to sap application during first year and by individual as well as interaction effect of O and S during second year and in pooled analysis as well (Table 25). Significantly higher values of N content in leaves of papaya were reported with O₄ which was closely followed by O₃ and minimum with O₂ and O₁ treatment. Similarly, in all the cases, S₁ showed superiority with respect to N content in leaves over S₀ treatment. The interaction effect of O and S on N content in leaves failed to reach the level of significance. With respect to control v/s rest analysis, in all the cases, treatment mean had significantly higher N content in leaves as compared to IMN control.

As regards the N content in papaya fruit, it was affected significantly due to S effect during both the years as well as pooled analysis, O effect in pooled analysis and O x S effect during second years (Table 26). Among the O treatments in pooled results, O₄ recorded significantly higher N content in fruit (0.171 %) in comparison to O₁, O₂

Table 24: Effect of different treatments on N content (%) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.840	0.870	0.855	0.897	0.930	0.913	0.868	0.900	0.884
O ₂	0.834	0.922	0.878	0.924	0.961	0.943	0.879	0.941	0.910
O ₃	0.910	0.952	0.931	0.951	0.967	0.959	0.930	0.960	0.945
O ₄	0.932	0.972	0.952	0.942	0.999	0.971	0.937	0.986	0.961
Mean	0.879	0.929	0.904	0.928	0.964	0.946	0.904	0.947	0.925
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.014	0.019	0.027	0.017	0.023	0.033	0.011	0.015	0.021
CD at 5%	0.041	0.058	NS	NS	NS	NS	0.031	0.044	NS
CV %	5			6			6		
Control			0.810			0.845			0.828
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.018	0.054		0.022	0.066		0.014	0.041	

Table 25: Effect of different treatments on N content (%) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	3.142	3.333	3.238	3.287	3.258	3.272	3.215	3.295	3.255
O ₂	3.207	3.462	3.334	3.196	3.520	3.358	3.202	3.491	3.346
O ₃	3.378	3.479	3.428	3.418	3.428	3.423	3.398	3.454	3.426
O ₄	3.277	3.680	3.479	3.316	3.725	3.520	3.297	3.702	3.500
Mean	3.251	3.489	3.370	3.304	3.483	3.394	3.278	3.486	3.382
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.047	0.066	0.093	0.040	0.056	0.080	0.031	0.043	0.061
CD at 5%	0.141	NS	NS	0.121	0.171	0.24	0.089	0.126	0.178
CV %	5			4			4		
Control			2.975			2.932			2.953
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.063	0.188		0.056	0.168		0.042	0.121	

Table 26: Effect of different treatments on N content (%) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.147	0.170	0.158	0.159	0.169	0.164	0.153	0.170	0.161
O ₂	0.150	0.180	0.165	0.134	0.173	0.153	0.142	0.177	0.159
O ₃	0.150	0.180	0.165	0.144	0.176	0.160	0.147	0.178	0.162
O ₄	0.160	0.190	0.175	0.149	0.186	0.167	0.154	0.188	0.171
Mean	0.152	0.180	0.166	0.146	0.176	0.161	0.149	0.178	0.164
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.003	0.004	0.006	0.002	0.003	0.005	0.002	0.003	0.004
CD at 5%	0.009	NS	NS	0.007	NS	0.015	0.006	0.008	NS
CV %	6			5			6		
Control			0.137			0.134			0.135
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.004	0.012		0.003	0.010		0.003	0.007	

and O₃ treatments. Between the two levels of sap, S₁ recorded significantly higher N content in fruit as compared to S₀ during first year, second year and in pooled results. As far as interaction effect of O x S is

concerned, during second year the combinations O_4S_1 (0.186 %), O_3S_1 (0.176 %) and O_2S_1 (0.173 %) were at par with each other with respect to N content in fruit but were significantly better than rest of the combinations. The content in fruit was significantly higher with the treatment mean as compared to INM control during both the year as well as in pooled result also.

4.4.2 Phosphorus content

The results pertaining to the P content in petiole, leaves and fruit of papaya are reported in tables 27, 28 and 29, respectively. The results showed the P content in petiole was not affected significantly due to individual and interaction effects of O and S during both the year and in pooled analysis as well (Table 27). However, treatment mean recovered significantly higher value of P content in petiole as compared to INM control. While in case of P content in leaves of papaya (Table 28), the sap application (S_1) could increase P content in leaves significantly as compared to no application of sap during first year and in pooled analysis. In rest of the cases, the effects were not significant. But, here also P content in leaves was significantly higher with treatment means as compared to INM control.

As compared to P content leaves and petiole, its content in fruit was very less. However, the individual effect of S and O was significant on P content in fruit. Here, among O levels, O_4 and O_3 showed superiority over the remaining two levels during both the years and in pooled results (Table 29). Similarly, application of sap significantly enhanced the P content in fruit during both the years and in pooled analysis as compared to no sap treatment. In all the cases, interaction effect was turned out to be not significant on P content in fruit. The control v/s rest analysis revealed that P content in fruit was significantly higher with treatment means as compared to INM control.

Table 27: Effect of different treatments on P content (%) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.310	0.313	0.312	0.329	0.333	0.331	0.320	0.323	0.321
O ₂	0.325	0.341	0.333	0.349	0.353	0.351	0.337	0.347	0.342
O ₃	0.326	0.378	0.352	0.342	0.357	0.349	0.334	0.367	0.351
O ₄	0.365	0.381	0.373	0.348	0.376	0.362	0.356	0.379	0.367
Mean	0.331	0.353	0.342	0.342	0.355	0.348	0.337	0.354	0.345
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.012	0.017	0.024	0.012	0.016	0.023	0.008	0.012	0.017
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	12			12			12		
Control			0.290			0.293			0.292
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.017	NS		0.016	0.049		0.012	0.034	

Table 28: Effect of different treatments on P content (%) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.479	0.521	0.500	0.522	0.539	0.530	0.501	0.530	0.515
O ₂	0.516	0.537	0.526	0.523	0.549	0.536	0.520	0.543	0.531
O ₃	0.515	0.553	0.534	0.555	0.554	0.555	0.535	0.554	0.544
O ₄	0.502	0.607	0.554	0.514	0.593	0.554	0.508	0.600	0.554
Mean	0.503	0.554	0.529	0.529	0.559	0.544	0.516	0.557	0.536
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.016	0.023	0.032	0.016	0.023	0.033	0.011	0.016	0.023
CD at 5%	0.049	NS	NS	NS	NS	NS	0.033	NS	NS
CV %	11			10			10		
Control			0.430			0.470			0.450
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.024	0.073		0.024	NS		0.017	0.049	

Table 29: Effect of different treatments on P content (%) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.017	0.022	0.020	0.018	0.022	0.020	0.018	0.022	0.020
O ₂	0.019	0.025	0.022	0.019	0.025	0.022	0.019	0.025	0.022
O ₃	0.020	0.026	0.023	0.019	0.025	0.022	0.020	0.025	0.022
O ₄	0.023	0.027	0.025	0.020	0.027	0.024	0.022	0.027	0.024
Mean	0.020	0.025	0.022	0.019	0.025	0.022	0.019	0.025	0.022
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.001	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.001
CD at 5%	0.002	0.003	NS	0.001	0.0020	NS	0.001	0.002	NS
CV %	10			8			9		
Control			0.016			0.015			0.016
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.001	0.003		0.001	0.002		0.001	0.002	

4.4.3 Potassium content

In general, the K content was maximum in petiole followed by leaves and least in fruit of papaya. The K content in petiole was influenced significantly only due to effect of S during first year and in pooled analysis (Table 30). In both the cases, S₁ showed superiority over S₀. With respect to control v/s rest, it was significant on K content in petiole. Here, the treatment mean recorded significantly higher K content in petiole as compared to INM control. On pooled basis, the K content in petiole of INM control was 2.44 per cent as against 3.134 per cent with treatment mean. The K content in leaves also followed the similar pattern of treatment as was observed in the case of K content in petiole (Table 31).

With respect to K content in fruit of papaya, it was differed significantly due to application of organics (O) and sap (S) individually, but their interaction effect failed to reach the level of significance during both the year and in pooled analysis (Table 32). Among the organics treatments, K content in fruit was significantly higher with O₄ as compared to rest of the treatment during both the years and in pooled analysis. Between two sap treatments, the K content considerably higher with S₁ as compared to S₀ treatments during the individual year and in pooled analysis. In all the cases, O x S interaction effect failed to reach the level of significance. But control v/s rest analysis turned out to be significant and in all the cases, treatment mean showed superiority over INM control.

Table 30: Effect of different treatments on K content (%) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	2.900	3.109	3.004	2.971	3.199	3.085	2.936	3.154	3.045
O ₂	2.967	3.167	3.067	3.040	3.303	3.171	3.004	3.235	3.119
O ₃	3.003	3.275	3.139	3.031	3.321	3.176	3.017	3.298	3.158
O ₄	2.974	3.317	3.145	3.182	3.383	3.282	3.078	3.350	3.214
Mean	2.961	3.217	3.089	3.056	3.302	3.179	3.009	3.259	3.134
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.066	0.093	0.131	0.101	0.143	0.202	0.060	0.085	0.120
CD at 5%	0.199	NS	NS	NS	NS	NS	0.174	NS	NS
CV %	7			11			9		
Control			2.470			2.410			2.440
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.087	0.261		0.133	0.400		0.080	0.229	

Table 31: Effect of different treatments on K content (%) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	2.348	2.416	2.382	2.282	2.342	2.312	2.315	2.379	2.347
O ₂	2.226	2.483	2.355	2.003	2.483	2.243	2.115	2.483	2.299
O ₃	2.337	2.544	2.441	2.211	2.479	2.345	2.274	2.511	2.393
O ₄	2.371	2.656	2.514	2.173	2.563	2.368	2.272	2.610	2.441
Mean	2.321	2.525	2.423	2.167	2.467	2.317	2.244	2.496	2.370
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.061	0.086	0.122	0.044	0.062	0.088	0.038	0.053	0.075
CD at 5%	0.184	NS	NS	0.134	NS	NS	0.109	NS	NS
CV %	9			7			8		
Control			2.117			2.093			2.105
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.081	0.242		0.061	0.182		0.050	0.145	

Table 32: Effect of different treatments on K content (%) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.220	0.240	0.230	0.220	0.230	0.225	0.220	0.235	0.228
O ₂	0.227	0.267	0.247	0.230	0.243	0.237	0.228	0.255	0.242
O ₃	0.240	0.280	0.260	0.217	0.270	0.243	0.228	0.275	0.252
O ₄	0.263	0.307	0.285	0.253	0.297	0.275	0.258	0.302	0.280
Mean	0.238	0.273	0.255	0.230	0.260	0.245	0.234	0.267	0.250
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.006	0.008	0.012	0.007	0.009	0.013	0.004	0.006	0.009
CD at 5%	0.018	0.026	NS	0.020	0.028	NS	0.013	0.018	NS
CV %	8			9			9		
Control			0.200			0.190			0.195
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.008	0.024		0.009	0.026		0.006	0.017	

4.4.4 Iron content

The Fe content in petiole of papaya was affected significantly due to individual effect of S during both the year and in pooled analysis (Table 33). An application of sap @ 8 l/plant (S₁) showed superiority with respect to Fe content in petiole over S₀ in all the cases. The effect of O

was found to not significant on Fe content in petiole in all the cases. However, its interaction with S was turned out to be significant during first year and in pooled results. Among all the combinations, O_4S_1 recorded Fe content of 36.60 and 35.20 ppm in first year and pooled results, respectively, which were significantly higher as compared to rest of the combinations. Of course, it was closely followed by the treatment O_3S_1 in both the cases. The control *v/s* rest analysis revealed that treatment mean was significantly better with respect to Fe content in petiole than INM control. During first year and pooled analysis, individual effect of S, O and their interaction effect and individual effect of S during second year were significant on Fe content in leaves (Table 34). In first year as well as in pooled analysis, S_1 showed superiority over S_0 . Similarly, among O levels, O_4 recorded significantly higher values of Fe content in leaves as compared to O_2 and O_1 , but it was at par with O_3 during first year and in pooled analysis. With respect to combinations arising out of O and S levels, O_4S_1 treatment recorded significantly more Fe content in leaves than O_2S_1 and O_3S_1 treatments. The treatment mean recorded Fe content in leaves *i.e.*, 223.48 ppm during first year, 217.97 ppm during second year and 220.91 ppm in pooled analysis.

With respect to Fe content in fruit, it was affected significantly only due to S treatments during both the years and in pooled results. Between the two S levels, S_1 recorded significantly higher values of Fe content in fruit in comparison to S_0 (Table 35). The control *v/s* rest analysis revealed that the treatment means of Fe content in fruit were superior over INM control during both the years and in pooled results also.

Table 33: Effect of different treatments on Fe content (ppm) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	30.850	32.278	31.564	30.050	32.651	31.350	30.450	32.465	31.457
O ₂	31.196	32.257	31.726	29.855	32.351	31.103	30.525	32.304	31.415
O ₃	30.717	33.691	32.204	26.882	33.200	30.041	28.799	33.445	31.122
O ₄	28.431	36.296	32.363	29.263	34.099	31.681	28.847	35.197	32.022
Mean	30.298	33.630	31.964	29.013	33.075	31.044	29.655	33.353	31.504
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.512	0.724	1.024	0.569	0.805	1.138	0.383	0.541	0.766
CD at 5%	1.554	NS	3.11	1.726	NS	NS	1.109	NS	2.218
CV %	6			6			6		
Control			28.083			28.217			28.150
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.934	2.801		0.792	2.373		0.612	1.764	

Table 34: Effect of different treatments on Fe content (ppm) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	204.32	217.34	210.83	193.44	227.59	210.51	198.88	222.47	210.67
O ₂	188.13	252.33	220.23	195.78	233.29	214.54	191.95	242.81	217.38
O ₃	211.93	242.18	227.05	201.42	237.44	219.43	206.67	239.81	223.24
O ₄	219.08	255.42	237.25	211.00	243.82	227.41	215.04	249.62	232.33
Mean	205.86	241.82	223.84	200.41	235.54	217.97	203.14	238.68	220.91
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	3.62	5.11	7.23	2.86	4.04	5.72	2.30	3.26	4.61
CD at 5%	10.97	15.51	21.94	8.669	NS	NS	6.68	9.44	13.35
CV %	6			5			5		
Control			193.95			197.86			195.91
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	4.99	14.97		3.93	11.79		3.18	9.15	

Table 35: Effect of different treatments on Fe content (ppm) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.137	0.157	0.147	0.143	0.163	0.153	0.140	0.160	0.150
O ₂	0.127	0.143	0.135	0.133	0.150	0.142	0.130	0.147	0.138
O ₃	0.133	0.163	0.148	0.140	0.170	0.155	0.137	0.167	0.152
O ₄	0.140	0.183	0.162	0.147	0.177	0.162	0.143	0.180	0.162
Mean	0.134	0.162	0.148	0.141	0.165	0.153	0.138	0.163	0.150
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.006	0.008	0.012	0.006	0.008	0.012	0.004	0.006	0.008
CD at 5%	0.018	NS	NS	0.018	NS	NS	0.012	NS	NS
CV %	14			13			14		
Control			0.103			0.110			0.107
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.009	0.026		0.008	0.025		0.006	0.017	

4.4.5 Manganese content

With an exception O x S effect on Mn content in petiole of papaya, individual as well as interaction (O x S) effect were significant on it during both the years and in pooled analysis as well (Table 36). As like Fe content, Mn content was significantly higher with S₁ and O₄ treatment as compared to their respective remaining treatments. With respect to interaction effect, the combination involving O₄ and S₁ showed superiority over rest of the combinations. Of course, O₄S₁ was closely followed the treatment O₃S₁. As compared to treatment mean, INM control mean values of Mn content in petiole were significantly low. As regards the Mn content in leaves of papaya, it was affected significantly due to O and S application during both the years and in pooled analysis (Table 37). Between the two treatments of S, S₁ recorded significantly higher values of Mn content in leaves as compared to S₀. Among O treatments, O₄ maintained its superiority over its remaining treatments during first year and in pooled analysis only. However, it was at par with O₃ treatment in both the cases. Interaction effect between O and S was not significant on

Mn content in leaves in any of the case. Here also, the Mn content in leaves was significantly higher with treatment mean as compared to INM control.

The Mn content in fruit of papaya was affected significantly due to S and O in first year and pooled analysis and S during second year (Table 38). Between two S levels, S₁ recorded significantly more Mn content in fruit as compared to S₀ in all the cases. Similarly, during first year and pooled results, O₄ showed superiority over rest of the O levels. In none of the case, interaction effect (O x S) was significant on Mn content in fruit. The Mn content in fruit of papaya was significantly higher with treatment mean as compared to INM control.

Table 36: Effect of different treatments on Mn content (ppm) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	9.936	10.389	10.162	9.497	10.609	10.053	9.716	10.499	10.107
O ₂	10.381	11.421	10.901	10.690	10.792	10.741	10.536	11.106	10.821
O ₃	10.173	13.483	11.828	10.359	13.152	11.755	10.266	13.318	11.792
O ₄	11.065	14.270	12.667	14.387	15.033	14.710	12.726	14.652	13.689
Mean	10.389	12.391	11.390	11.233	12.397	11.815	10.811	12.394	11.602
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.389	0.550	0.777	0.223	0.316	0.447	0.224	0.317	0.448
CD at 5%	1.179	1.668	NS	0.678	0.958	1.36	0.649	0.918	1.299
CV %	12			7			9		
Control			8.547			10.143			9.345
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.543		1.628	0.443		1.329	0.350		1.010

Table 37: Effect of different treatments on Mn content (ppm) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	30.42	31.38	30.90	32.71	34.05	33.38	31.56	32.72	32.14
O ₂	34.76	37.63	36.20	31.99	34.07	33.03	33.37	35.85	34.61
O ₃	33.81	37.02	35.41	34.62	35.71	35.17	34.21	36.37	35.29
O ₄	34.89	38.18	36.53	32.95	37.51	35.23	33.92	37.85	35.88
Mean	33.47	36.05	34.76	33.06	35.34	34.20	33.27	35.70	34.48
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.80	1.13	1.60	0.56	0.79	1.12	0.49	0.69	0.98
CD at 5%	2.43	3.44	NS	1.69	NS	NS	1.42	2.00	NS
CV %	8			6			7		
Control			31.18			30.20			30.69
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	1.12		3.37	0.82		2.47	0.70		2.01

Table 38: Effect of different treatments on Mn content (ppm) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.014	0.019	0.017	0.015	0.019	0.017	0.015	0.019	0.017
O ₂	0.016	0.022	0.019	0.016	0.022	0.019	0.016	0.022	0.019
O ₃	0.017	0.023	0.020	0.016	0.021	0.019	0.017	0.022	0.019
O ₄	0.020	0.024	0.022	0.019	0.021	0.020	0.019	0.023	0.021
Mean	0.017	0.022	0.019	0.017	0.021	0.019	0.017	0.021	0.019
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.001
CD at 5%	0.002	0.003	NS	0.002	NS	NS	0.001	0.002	NS
CV %	12			14			13		
Control			0.013			0.012			0.013
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.001		0.003	0.001		0.003	0.001		0.002

4.4.6 Zinc content

The Zn content in petiole of papaya was influenced significantly due to O treatment during both the years and in pooled analysis (Table 39). Among the O treatment, O₄ showed superiority over its remaining levels in all the cases. But in case of Zn content in petiole, it was affected significantly due to S effect only in second year and pooled analysis. In both the cases, Zn content in petiole was significantly higher with S₁ as compared to S₀. In all the cases, O x S effect failed to reach level of significance. In all the cases, Zn content in petiole was significantly more with treatment mean than INM control. With respect Zn content in leaves of papaya, it was significantly only due to individual effect of O during both the years and in pooled analysis also (Table 40). Among the O treatments, O₄ maintained its superiority over the remaining treatments of O in all the cases. While S effect was significant on Zn content in leaves only in pooled analysis and S₁ showed superiority over S₀ treatments. The interaction (O X S) failed to exert significant effect on Zn content in leaves during both the years and in pooled analysis as well. The comparison between treatment mean v/s INM control revealed that former maintained its superiority over later during first years and in pooled analysis only.

With an exception of O effect in pooled analysis, rest of the effect could not reach to the level of significance (Table 41) in case of Zn content in fruit. Here, O₄ (0.07 ppm) and O₃ (0.069 ppm) showed superiority over O₂ and O₁ treatments. During both the years and in pooled results, treatment mean recorded significantly higher values of Zn content in fruit of papaya as compared to INM control.

Table 39: Effect of different treatments on Zn content (ppm) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	10.917	11.700	11.308	10.407	11.108	10.758	10.662	11.404	11.033
O ₂	11.979	12.256	12.118	10.630	11.874	11.252	11.304	12.065	11.685
O ₃	11.601	12.821	12.211	11.042	12.421	11.732	11.322	12.621	11.971
O ₄	13.415	13.712	13.563	12.997	13.284	13.141	13.206	13.498	13.352
Mean	11.978	12.622	12.300	11.269	12.172	11.720	11.623	12.397	12.010
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.310	0.438	0.619	0.290	0.409	0.579	0.212	0.300	0.424
CD at 5%	NS	1.328	NS	0.878	1.242	NS	0.614	0.868	NS
CV %	9			9			9		
Control			9.903			10.060			9.982
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.418	1.254		0.411	1.231		0.293	0.844	

Table 40: Effect of different treatments on Zn content (ppm) in leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	21.787	22.387	22.087	21.589	22.134	21.862	21.688	22.260	21.974
O ₂	22.711	24.706	23.708	21.641	23.250	22.445	22.176	23.978	23.077
O ₃	23.397	25.259	24.328	23.574	23.112	23.343	23.485	24.186	23.835
O ₄	24.896	26.657	25.776	24.752	25.086	24.919	24.824	25.872	25.348
Mean	23.197	24.752	23.975	22.889	23.395	23.142	23.043	24.074	23.559
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.550	0.778	1.101	0.402	0.568	0.803	0.341	0.482	0.681
CD at 5%	NS	2.360	NS	NS	1.723	NS	0.987	1.396	NS
CV %	8			6			7		
Control			21.487			20.770			21.128
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.762	2.286		0.828	NS		0.563	1.622	

Table 41: Effect of different treatments on Zn content (ppm) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.066	0.068	0.067	0.065	0.067	0.066	0.066	0.067	0.066
O ₂	0.066	0.069	0.068	0.065	0.068	0.067	0.066	0.069	0.067
O ₃	0.070	0.071	0.071	0.067	0.069	0.068	0.068	0.070	0.069
O ₄	0.071	0.071	0.071	0.067	0.070	0.069	0.069	0.071	0.070
Mean	0.068	0.070	0.069	0.066	0.068	0.067	0.067	0.069	0.068
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001
CD at 5%	NS	NS	NS	NS	NS	NS	NS	0.003	NS
CV %	4.25			5.25			4.76		
Control			0.062			0.061			0.062
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.001	0.004		0.001	0.004		0.001	0.003	

4.4.7 Copper content

The Cu content in petiole of papaya was influenced significantly only due to S effect during both the years and in pooled analysis also (Table 42). Between the two treatments, S₁ recorded conspicuously more value of Cu content in petiole as compared to S₀ in all the cases. With respect to O effect, it was found to be significant on Cu content in petiole in pooled analysis only. In pooled results, O₄ recorded significantly higher value of Cu content (2.394 ppm) in petiole as compared to O₁, but was at par with O₂ and O₃ treatments. The control v/s rest analysis indicated that treatment means of Cu content in petiole were significantly more than INM mean values during both the years and in pooled results also.

In the case of Cu content in papaya leaves, it was affected only due to O treatments during both the years and in pooled analysis also (Table 43). Here, O₄ treatment showed out might superiority over the remaining levels of O during both the years and in pooled analysis. Between two means of treatment and control, treatment mean recorded significantly higher value of Cu content in leaves as compared to INM

control during both the years and in pooled results. The Cu content in fruits of papaya was not affected significantly due to any of the factor or their interaction during both the years and pooled analysis (Table 44) with an exception of O effect in pooled analysis. Here, O₄ and O₃ recorded identical values (0.02 ppm), but both these treatment were significantly higher Cu content in papaya fruit. The treatment mean recorded significantly higher values of Cu content in fruit as compared to INM means during both the years and in pooled analysis also.

Table 42: Effect of different treatments on Cu content (ppm) in petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	2.198	2.299	2.249	2.238	2.344	2.291	2.218	2.321	2.270
O ₂	2.148	2.409	2.278	2.324	2.416	2.370	2.236	2.413	2.324
O ₃	2.303	2.429	2.366	2.314	2.436	2.375	2.308	2.433	2.371
O ₄	2.323	2.437	2.380	2.320	2.495	2.408	2.322	2.466	2.394
Mean	2.243	2.393	2.318	2.299	2.423	2.361	2.271	2.408	2.340
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.032	0.045	0.064	0.030	0.043	0.060	0.022	0.031	0.044
CD at 5%	0.097	NS	NS	0.091	NS	NS	0.064	0.090	NS
CV %	5			4			5		
Control			2.067			2.050			2.058
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.047	0.141		0.046	0.138		0.033	0.095	

4.5 Nutrient uptake

Considering the dry matter yield of and nutrient content in petiole, leaves and fruit of papaya, uptake of N, P, K, Fe, Mn, Zn, and Cu was computed separately and reported under this subtitle.

Table 43: Effect of different treatments on Cu content (ppm) in leaves of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	4.223	4.222	4.223	4.137	4.210	4.174	4.180	4.216	4.198
O ₂	4.196	4.345	4.270	4.183	4.300	4.242	4.190	4.322	4.256
O ₃	4.663	4.864	4.763	4.267	4.822	4.544	4.465	4.843	4.654
O ₄	5.017	5.246	5.132	5.054	5.171	5.113	5.035	5.209	5.122
Mean	4.525	4.669	4.597	4.410	4.626	4.518	4.468	4.648	4.558
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.097	0.137	0.193	0.082	0.116	0.164	0.063	0.090	0.127
CD at 5%	NS	0.415	NS	NS	0.351	NS	NS	0.259	NS
CV %	7			6			7		
Control			3.877			4.023			3.950
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.144		0.430	0.116		0.348	0.092		0.266

Table 44: Effect of different treatments on Cu content (ppm) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.016	0.018	0.017	0.015	0.017	0.016	0.016	0.017	0.016
O ₂	0.016	0.019	0.018	0.015	0.018	0.017	0.016	0.019	0.017
O ₃	0.020	0.021	0.021	0.019	0.020	0.020	0.019	0.021	0.020
O ₄	0.021	0.021	0.021	0.020	0.020	0.020	0.020	0.021	0.020
Mean	0.018	0.020	0.019	0.017	0.019	0.018	0.018	0.019	0.018
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001
CD at 5%	NS	NS	NS	NS	NS	NS	NS	0.002	NS
CV %	15			16			16		
Control			0.012			0.011			0.012
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.001		0.004	0.001		0.004	0.001		0.002

4.5.1 Nitrogen uptake

The uptake of N through petiole of papaya was not affected significantly due to S, O and O x S during both the years and in pooled analysis also (Table 45). Only exception for this was O effect in pooled analysis where O₄ and O₃ were at par with each other but significantly

better than O₂ and O₁. Similarly, O₂ and O₃ were at par with each other. The control v/s rest analysis was also turned out to be not significant in all the cases. The uptake of N by leaves of papaya also showed similar pattern as was observed with N uptake by petiole (Table 46). In the case N uptake by fruit, it was affected significantly due to individual and interaction effect of S and O during both the years as well as in pooled analysis, with an exception of O x S interaction during first year (Table 47). Among the O treatments, O₄ recorded significantly higher uptake of N by fruit as compared to O₃, O₂ and O₁ during both the years and in pooled analysis. Similarly, S₁ level of sap application registered significantly more uptake of N by fruit than S₀ in all the cases. Among the different combinations, O₄S₁ recorded N uptake 21.02 kg/ha during first year and 20.75 kg/ha on pooled basis which conspicuously higher than rest of the combinations. The control v/s rest analysis suggested that control mean was significantly higher as compared to treatment mean during second year only.

Table 45: Effect of different treatments on N uptake (kg/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	11.83	11.92	11.87	12.84	13.05	12.95	12.34	12.48	12.41
O ₂	11.79	13.60	12.69	13.37	14.34	13.85	12.58	13.97	13.27
O ₃	12.90	13.55	13.22	13.76	14.06	13.91	13.33	13.80	13.57
O ₄	13.78	14.50	14.14	14.24	15.02	14.63	14.01	14.76	14.39
Mean	12.57	13.39	12.98	13.55	14.12	13.84	13.06	13.75	13.41
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.40	0.56	0.79	0.47	0.66	0.93	0.31	0.43	0.61
CD at 5%	NS	NS	NS	NS	NS	NS	NS	1.25	NS
CV %	11			12			11		
Control			13.93			15.32			14.63
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.55	NS		0.63	NS		0.42	NS	

Table 46: Effect of different treatments on N uptake (kg/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	12.63	13.09	12.86	13.44	13.04	13.24	13.04	13.07	13.05
O ₂	12.99	14.60	13.79	13.20	15.01	14.11	13.09	14.81	13.95
O ₃	13.68	14.08	13.88	14.13	14.22	14.17	13.90	14.15	14.03
O ₄	13.83	15.69	14.76	14.28	16.20	15.24	14.05	15.95	15.00
Mean	13.28	14.37	13.82	13.76	14.62	14.19	13.52	14.49	14.01
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.44	0.62	0.88	0.50	0.70	0.99	0.33	0.47	0.66
CD at 5%	NS	NS	NS	NS	NS	NS	0.959	NS	NS
CV %	11			12			12		
Control			14.62			15.14			14.88
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.61		NS	0.66		NS	0.45		NS

Table 47: Effect of different treatments on N uptake (kg/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	11.23	14.22	12.72	11.85	13.34	12.60	11.54	13.78	12.66
O ₂	12.37	16.46	14.42	10.90	15.46	13.18	11.63	15.96	13.80
O ₃	13.54	18.29	15.91	13.61	18.05	15.83	13.57	18.17	15.87
O ₄	14.99	20.49	17.74	14.62	21.02	17.82	14.81	20.75	17.78
Mean	13.03	17.36	15.20	12.74	16.97	14.86	12.89	17.17	15.03
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.39	0.55	0.77	0.26	0.37	0.52	0.23	0.33	0.47
CD at 5%	1.17	1.66	NS	0.79	1.12	1.59	0.68	0.96	1.35
CV %	9			6			8		
Control			16.32			16.14			16.23
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.54		NS	0.37		1.10	0.33		NS

4.5.2 Phosphorus uptake

The P uptake by petiole of papaya did not show significant variation due to O, S and O x S effect during both the years and in pooled analysis (Table 48). Based on pooled mean, O₄ recorded P

uptake of 5.51 kg/ha by petiole which at par with O₂ (5.02 kg/ha) and (5.0 kg/ha), but significantly more than O₁. The control v/s rest analysis also did not show any significant difference between control and treatment mean. With respect to P removal by leaves of papaya, the pattern of treatment effect almost identical to that observed with P uptake by petiole (Table 49). Only exception for this trend was, instead of O effect, here S effect was significant on P uptake by leaves in pooled analysis. An application of sap @ 8 l/plant increased the P uptake by leaves significantly as compared to its no application. However, in the case of P uptake fruit of papaya was affected significantly due to only individual effect of S and O during both the years and in pooled analysis (Table 50). In all the cases, P uptake by fruit was significantly more with S₁ and O₄ treatment than S₀ and O₁ as well as O₂ treatment. But O₃ and O₄ were at par with each other during individual years. During both the years and in pooled analysis, control v/s rest analysis was not found significant.

Table 48: Effect of different treatments on P uptake (kg/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	4.32	4.31	4.32	4.71	4.68	4.69	4.52	4.49	4.50
O ₂	4.59	5.04	4.82	5.07	5.31	5.19	4.83	5.18	5.00
O ₃	4.65	5.36	5.00	4.92	5.14	5.03	4.78	5.25	5.02
O ₄	5.37	5.69	5.53	5.25	5.73	5.49	5.31	5.71	5.51
Mean	4.73	5.10	4.92	4.99	5.21	5.10	4.86	5.16	5.01
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.21	0.30	0.42	0.24	0.35	0.49	0.16	0.23	0.32
CD at 5%	NS	NS	NS	NS	NS	NS	NS	0.66	NS
CV %	15			17			16		
Control			5.02			5.35			5.19
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.31		NS	0.35		NS	0.23		NS

Table 49: Effect of different treatments on P uptake (kg/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	1.92	2.04	1.98	2.13	2.16	2.15	2.03	2.10	2.06
O ₂	2.08	2.25	2.17	2.18	2.33	2.25	2.13	2.29	2.21
O ₃	2.10	2.24	2.17	2.29	2.30	2.29	2.19	2.27	2.23
O ₄	2.11	2.59	2.35	2.21	2.58	2.39	2.16	2.59	2.37
Mean	2.05	2.28	2.17	2.20	2.34	2.27	2.13	2.31	2.22
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.08	0.12	0.16	0.09	0.13	0.19	0.06	0.09	0.12
CD at 5%	NS	NS	NS	NS	NS	NS	0.180	NS	NS
CV %	13			14			14		
Control			2.10			2.45			2.27
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.12	NS		0.14	NS		0.09	NS	

Table 50: Effect of different treatments on P uptake (kg/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	1.31	1.84	1.57	1.37	1.76	1.56	1.34	1.80	1.57
O ₂	1.57	2.29	1.93	1.55	2.21	1.88	1.56	2.25	1.90
O ₃	1.80	2.62	2.21	1.82	2.56	2.19	1.81	2.59	2.20
O ₄	2.13	2.87	2.50	1.99	3.02	2.50	2.06	2.94	2.50
Mean	1.70	2.41	2.05	1.68	2.38	2.03	1.69	2.40	2.04
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.08	0.12	0.16	0.05	0.07	0.10	0.05	0.07	0.10
CD at 5%	0.25	0.35	NS	0.16	0.22	NS	0.14	0.20	NS
CV %	14			9			12		
Control			1.91			1.85			1.88
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.11	NS		0.07	NS		0.07	NS	

4.5.3 Potassium uptake

The uptake of K by petiole of papaya did not vary significantly among different factors and their combinations (Table 51). This was also true for control v/s rest analysis. Almost similar effect of treatments on K uptake by leaves was also observed during both the years and in pooled

analysis. Only exception to this was S effect on K uptake by leaves during individual year, wherein S_1 showed superiority over S_0 (Table 52). As regards the K uptake by fruit of papaya, it was affected significantly due to individual effect of S and O during both the years and in pooled analysis. Among the O treatments, O_4 treatment out classed O_3 , O_2 and O_1 treatments with respect to K uptake by fruit (Table 53). Similarly, S_1 consistently recorded significantly higher uptake of K by fruit as compared to S_0 during both the years and in pooled analysis. Here, O x S effect was turned out to be significant on K uptake by fruit in pooled analysis only. Among all the combinations, O_4S_1 (33.28 kg/ha) recorded significantly higher K uptake by fruits as compared to rest of the treatments. The control v/s treatment analysis was turned out to be not significant.

Table 51: Effect of different treatments on K uptake (kg/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
O_1	40.76	42.77	41.76	42.53	45.10	43.81	41.64	43.94	42.79
O_2	42.06	46.65	44.36	44.09	49.70	46.89	43.07	48.17	45.62
O_3	42.71	46.60	44.66	43.79	48.04	45.91	43.25	47.32	45.29
O_4	43.88	49.43	46.66	47.60	51.78	49.69	45.74	50.60	48.17
Mean	42.35	46.36	44.36	44.50	48.65	46.58	43.43	47.51	45.47
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	1.57	2.22	3.14	2.37	3.35	4.73	1.42	2.01	2.84
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	12			18			15		
Control			42.50			43.63			43.06
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	2.15	NS		3.14	NS		1.90	NS	

Table 52: Effect of different treatments on K uptake (kg/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	9.41	9.45	9.43	9.31	9.43	9.37	9.36	9.44	9.40
O ₂	8.98	10.44	9.71	8.33	10.56	9.44	8.65	10.50	9.58
O ₃	9.49	10.32	9.91	9.13	10.26	9.69	9.31	10.29	9.80
O ₄	10.04	11.34	10.69	9.36	11.12	10.24	9.70	11.23	10.47
Mean	9.48	10.39	9.93	9.03	10.34	9.69	9.26	10.36	9.81
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.37	0.53	0.75	0.33	0.46	0.66	0.25	0.35	0.50
CD at 5%	NS	NS	NS	1.00	NS	NS	0.72	NS	NS
CV %	13			12			12		
Control			10.41			10.83			10.62
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.51		NS	0.44		NS	0.34		NS

Table 53: Effect of different treatments on K uptake (kg/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	16.93	20.07	18.50	16.42	18.14	17.28	16.68	19.10	17.89
O ₂	18.72	24.42	21.57	18.77	21.75	20.26	18.74	23.08	20.91
O ₃	21.56	28.48	25.02	20.52	27.95	24.24	21.04	28.22	24.63
O ₄	24.60	33.08	28.84	24.84	33.49	29.17	24.72	33.28	29.00
Mean	20.45	26.51	23.48	20.14	25.33	22.73	20.29	25.92	23.11
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.65	0.92	1.30	0.69	0.98	1.38	0.47	0.67	0.95
CD at 5%	1.97	2.78	NS	2.10	2.97	NS	1.37	1.94	2.75
CV %	10			11			10		
Control			23.88			23.01			23.44
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.93		NS	0.93		NS	0.66		NS

4.5.4 Iron uptake

With an exception of S effect during both the years and pooled analysis, all the other effects were not significant on Fe uptake by petiole (Table 54). In all the cases, uptake of Fe by petiole of papaya was significantly more with S_1 than S_0 treatment. The values recorded with S_1 were 48.54, 48.50 and 48.52 g/ha during first year, second year and in pooled results, respectively. In the case of Fe uptake by leaves of papaya, it was influenced significantly only due to main effect of S and O during both the years and in pooled analysis except O effect during second year (Table 55). An application of organics as per O_4 treatment resulted in significantly higher removal of Fe uptake by leaves of papaya as compared to remaining O treatments, during both the years and in pooled analysis also. Similarly, application of sap also enhanced Fe removal by leaves significantly as compared to its no application during both the years and in pooled analysis also. The differences between treatment and control means were not conspicuous during individual years and in pooled analysis.

With respect to Fe uptake by fruit of papaya, differences among the treatments of S and O individually were significant during individual years and in pooled results (Table 56). Among the O treatments, O_3 and O_4 were at par with each other during individual year, but the difference between two treatments was significant in pooled analysis. The results further indicated that O_4 was significantly higher as compared to O_2 and O_1 treatments. Between S_1 and S_0 levels of sap application, S_1 showed superiority over S_0 in the three cases. The effects of O x S and control v/s rest analysis were not significant on Fe uptake by fruit of papaya during both the years as well as in pooled analysis.

Table 54: Effect of different treatments on Fe uptake (g/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	43.47	44.42	43.95	43.06	45.70	44.38	43.26	45.06	44.16
O ₂	44.23	47.82	46.02	43.23	48.39	45.81	43.73	48.11	45.92
O ₃	43.59	47.82	45.71	39.04	47.98	43.51	41.31	47.90	44.61
O ₄	41.96	54.09	48.03	44.55	51.94	48.24	43.26	53.01	48.14
Mean	43.31	48.54	45.93	42.47	48.50	45.49	42.89	48.52	45.71
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	1.61	2.27	3.21	1.86	2.62	3.71	1.23	1.74	2.45
CD at 5%	4.87	NS	NS	5.63	NS	NS	3.55	NS	NS
CV %	12			14			13		
Control			48.18			51.02			49.60
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	2.39		NS	2.46		NS	1.71		NS

Table 55: Effect of different treatments on Fe uptake (g/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	81.94	85.02	83.48	78.88	91.93	85.41	80.41	88.47	84.44
O ₂	76.21	106.66	91.44	80.80	98.83	89.82	78.51	102.75	90.63
O ₃	85.87	97.26	91.57	83.15	98.50	90.83	84.51	97.88	91.20
O ₄	92.25	108.97	100.61	90.59	106.19	98.39	91.42	107.58	99.50
Mean	84.07	99.48	91.77	83.36	98.86	91.11	83.71	99.17	91.44
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	2.48	3.51	4.96	3.30	4.67	6.61	2.07	2.92	4.13
CD at 5%	7.53	10.65	NS	10.024	NS	NS	5.99	8.47	NS
CV %	9			13			11		
Control			95.17			102.55			98.86
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	3.33		NS	4.50		NS	2.80		NS

Table 56: Effect of different treatments on Fe uptake (g/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	1.04	1.31	1.17	1.07	1.29	1.18	1.05	1.30	1.18
O ₂	1.04	1.32	1.18	1.10	1.34	1.22	1.07	1.33	1.20
O ₃	1.19	1.67	1.43	1.33	1.75	1.54	1.26	1.71	1.49
O ₄	1.31	1.98	1.64	1.45	2.00	1.72	1.38	1.99	1.68
Mean	1.15	1.57	1.36	1.24	1.60	1.42	1.19	1.58	1.39
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.06	0.08	0.12	0.06	0.09	0.12	0.04	0.06	0.08
CD at 5%	0.18	0.25	NS	0.18	0.26	NS	0.12	0.17	NS
CV %	15			15			15		
Control			1.22			1.33			1.28
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.09	NS		0.09	NS		0.06	NS	

4.5.5 Manganese uptake

The Mn uptake by petiole was affected significantly only due to main effect of S during first year and in pooled analysis as well as O effect during second year and in pooled analysis (Table 57). In these cases S₁ between S levels and O₄ among O treatments showed its superiority with respect to Mn uptake by petiole over their remaining levels. The results presented in table 50 indicate that S effect in pooled analysis and O effect during first year and in pooled analysis were significant on Mn uptake by leaves of papaya (Table 58). In these, S₁ and O₄ treatment recorded significantly higher uptake of Mn by leaves as compared to their remaining levels. However, O₃ and O₄ were at par with each other in both the cases i.e. first year and in pooled results. The control v/s rest analysis was turned out to be not significant in all the cases. As far as Mn uptake by fruit of papaya is concerned, it was significantly influenced due to individual effect of S and O during both the years as well as in pooled analysis (Table 59). Here also S₁ and O₄ treatment remained their superiority over remaining treatments during

both the years and in pooled analysis as well. In contrast, O x S and treatment v/s control analysis failed to reach the level of significance during individual year and in pooled analysis.

Table 57: Effect of different treatments on Mn uptake (g/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	13.97	14.22	14.09	13.63	14.78	14.20	13.80	14.50	14.15
O ₂	14.72	16.98	15.85	15.65	16.29	15.97	15.19	16.64	15.91
O ₃	14.43	19.30	16.86	15.02	18.92	16.97	14.73	19.11	16.92
O ₄	16.19	21.26	18.73	21.78	23.04	22.41	18.98	22.15	20.57
Mean	14.83	17.94	16.38	16.52	18.26	17.39	15.67	18.10	16.89
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.76	1.08	1.53	0.70	0.99	1.40	0.52	0.73	1.03
CD at 5%	2.31	NS	NS	NS	2.99	NS	1.50	2.12	NS
CV %	16			14			15		
Control			14.77			18.57			16.67
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	1.09		NS	1.13		NS	0.79		NS

Table 58: Effect of different treatments on Mn uptake (g/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	12.14	12.37	12.25	13.36	13.68	13.52	12.75	13.02	12.89
O ₂	14.08	15.94	15.01	13.19	14.52	13.86	13.63	15.23	14.43
O ₃	13.69	14.82	14.26	14.31	14.75	14.53	14.00	14.78	14.39
O ₄	14.72	16.27	15.49	14.04	16.21	15.13	14.38	16.24	15.31
Mean	13.66	14.85	14.25	13.73	14.79	14.26	13.69	14.82	14.25
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.49	0.69	0.97	0.43	0.61	0.86	0.33	0.46	0.65
CD at 5%	NS	2.09	NS	NS	NS	NS	0.94	1.33	NS
CV %	12			10			11		
Control			15.35			15.67			15.51
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.68		NS	0.62		NS	0.46		NS

Table 59: Effect of different treatments on Mn uptake (g/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.11	0.16	0.13	0.11	0.15	0.13	0.11	0.16	0.13
O ₂	0.13	0.20	0.17	0.13	0.19	0.16	0.13	0.20	0.16
O ₃	0.15	0.23	0.19	0.15	0.21	0.18	0.15	0.22	0.19
O ₄	0.18	0.25	0.22	0.18	0.24	0.21	0.18	0.25	0.22
Mean	0.14	0.21	0.18	0.15	0.20	0.17	0.14	0.21	0.18
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01
CD at 5%	0.02	0.03	NS	0.02	0.03	NS	0.02	0.02	NS
CV %	15			16			16		
Control			0.15			0.15			0.15
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.01	NS		0.01	NS		0.01	NS	

4.5.6 Zinc uptake

As far as Zn uptake by petiole is concerned, it was influenced significantly due to O effect during both the years and in pooled analysis and S effect only in pooled analysis (Table 60). Among the organics (O) treatment, O₄ recorded significantly higher uptake of Zn by petiole in comparison to O₃, O₂ and O₁ treatment during individual year and in pooled analysis. In the case of pooled results, S₁ recorded Zn uptake of 18.01 g/ha by petiole which was conspicuously more than S₀ (16.79 g/ha). The difference among the combinations of O and S as well as between treatment and control mean were not significant in all the cases. With an exception of significant effect of organics in pooled analysis, effect of rest of the factors and their combinations as well as control v/s rest analysis were failed to reach the level of significance on Zn uptake by leaves of papaya during both the years and in pooled analysis also

(Table 61). Among the organics treatment on pooled basis O₄ recorded significantly higher uptake of Zn by leaves (10.86 g/ha) as compared to the remaining treatment of organics. With Zn uptake by fruits of papaya, it was influenced significantly due to individual effect of O and S during both the years and in pooled analysis (Table 62). Here also, O₄ and S₁ treatments maintained their superiority over rest of their respective levels during both the years and in pooled result also. In all the cases, the interaction effect (O x S) and difference between control and treatment mean were not significant in the case of Zn uptake by fruit of papaya.

Table 60: Effect of different treatments on Zn uptake (g/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	15.26	15.95	15.60	14.93	15.34	15.13	15.09	15.64	15.37
O ₂	16.98	18.15	17.56	15.34	17.78	16.56	16.16	17.96	17.06
O ₃	16.34	18.10	17.22	15.95	17.96	16.95	16.14	18.03	17.08
O ₄	19.82	20.49	20.16	19.67	20.34	20.01	19.75	20.42	20.08
Mean	17.10	18.17	17.64	16.47	17.85	17.16	16.79	18.01	17.40
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.54	0.76	1.08	0.54	0.77	1.09	0.38	0.54	0.76
CD at 5%	NS	2.31	NS	NS	2.33	NS	1.11	1.57	NS
CV %	11			11			11		
Control			17.04			18.21			17.63
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.71	NS		0.74	NS		0.51	NS	

Table 61: Effect of different treatments on Zn uptake (g/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	8.81	8.78	8.79	8.81	9.07	8.94	8.81	8.92	8.87
O ₂	9.18	10.42	9.80	8.89	9.87	9.38	9.03	10.15	9.59
O ₃	9.49	10.24	9.86	9.73	9.62	9.68	9.61	9.93	9.77
O ₄	10.54	11.36	10.95	10.66	10.88	10.77	10.60	11.12	10.86
Mean	9.50	10.20	9.85	9.52	9.86	9.69	9.51	10.03	9.77
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.38	0.54	0.76	0.42	0.59	0.83	0.28	0.40	0.56
CD at 5%	NS	NS	NS	NS	NS	NS	NS	1.15	NS
CV %	13			15			14		
Control			10.58			10.80			10.69
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.55	NS		0.64	NS		0.42	NS	

Table 62: Effect of different treatments on Zn uptake (g/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.51	0.57	0.54	0.49	0.53	0.51	0.50	0.55	0.52
O ₂	0.55	0.63	0.59	0.53	0.61	0.57	0.54	0.62	0.58
O ₃	0.63	0.73	0.68	0.63	0.71	0.67	0.63	0.72	0.67
O ₄	0.66	0.77	0.71	0.66	0.79	0.73	0.66	0.78	0.72
Mean	0.58	0.67	0.63	0.58	0.66	0.62	0.58	0.67	0.62
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.01	0.02	0.03	0.01	0.02	0.03	0.01	0.01	0.02
CD at 5%	0.05	0.06	NS	0.04	0.06	NS	0.03	0.04	NS
CV %	8			7			8		
Control			0.74			0.74			0.74
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.02	0.06		0.02	0.06		0.01	0.04	

4.5.7 Copper uptake

The results related to Cu uptake by petiole of papaya revealed that with an exception of S effect in pooled analysis, rest of the effect were not significant during individual year as well as in pooled analysis (Table 63). Between the two S treatment, on pooled basis S₁ recorded significantly higher Cu uptake by petiole (3.50 g/ha) as compared to S₀ (3.28 g/ha). Similarly, except O effect during individual year and pooled analysis, the uptake of Cu by leaves of papaya was not affected significantly due to any of the factors (Table 64). In all the cases, the Cu uptake by leaves was significantly more with O₄ than O₃, O₂ and O₁ treatments. While Cu uptake by fruits of papaya was affected significantly due to individual effect of O and S during both the years and in pooled analysis (Table 65). In all the cases, O₄ and O₃ were at par with each other, but were significant better than O₂ and O₁ treatment. Similarly, S₁ maintained better than O₂ and O₁ treatments. Similarly, S₁ maintained its superiority over S₀ during individual year and in pooled analysis. Interaction effect was absent. Similarly, control v/s rest analysis was also turned out to be not significant on Cu uptake by fruits of papaya.

Table 63: Effect of different treatments on Cu uptake (g/ha) by petiole of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	3.10	3.16	3.13	3.21	3.29	3.25	3.15	3.22	3.19
O ₂	3.04	3.56	3.30	3.33	3.60	3.47	3.19	3.58	3.39
O ₃	3.26	3.44	3.35	3.34	3.53	3.44	3.30	3.49	3.39
O ₄	3.43	3.64	3.54	3.50	3.78	3.64	3.46	3.71	3.59
Mean	3.21	3.45	3.33	3.34	3.55	3.45	3.28	3.50	3.39
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.11	0.15	0.22	0.11	0.15	0.21	0.08	0.11	0.15
CD at 5%	NS	NS	NS	NS	NS	NS	0.218	NS	NS
CV %	11			11			11		
Control			3.55			3.70			3.63
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.15	NS		0.14	NS		0.10	NS	

Table 64: Effect of different treatments on Cu uptake (g/ha) by leaf of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	1.67	1.66	1.66	1.69	1.69	1.69	1.68	1.67	1.68
O ₂	1.70	1.84	1.77	1.73	1.83	1.78	1.72	1.84	1.78
O ₃	1.89	1.96	1.92	1.77	2.00	1.88	1.83	1.98	1.90
O ₄	2.12	2.24	2.18	2.18	2.25	2.21	2.15	2.24	2.20
Mean	1.84	1.92	1.88	1.84	1.94	1.89	1.84	1.93	1.89
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.06	0.09	0.12	0.07	0.11	0.15	0.05	0.07	0.10
CD at 5%	NS	0.26	NS	NS	0.32	NS	NS	0.20	NS
CV %	11			14			13		
Control			1.91			2.08			2.00
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.09	NS		0.10	NS		0.07	NS	

Table 65: Effect of different treatments on Cu uptake (g/ha) by fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.12	0.15	0.14	0.11	0.13	0.12	0.12	0.14	0.13
O ₂	0.13	0.17	0.15	0.12	0.16	0.14	0.13	0.17	0.15
O ₃	0.18	0.22	0.20	0.18	0.21	0.19	0.18	0.21	0.20
O ₄	0.19	0.23	0.21	0.19	0.23	0.21	0.19	0.23	0.21
Mean	0.16	0.19	0.17	0.15	0.18	0.17	0.15	0.19	0.17
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.01
CD at 5%	0.03	0.04	NS	0.03	0.04	NS	0.02	0.03	NS
CV %	19			18			18		
Control			0.14			0.13			0.14
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.01	NS		0.01	NS		0.01	NS	

4.6 Quality parameters

In order to compare the quality of papaya fruits produced under two distinct set of nutrient management *viz.*, organic and INM, the quality parameters *viz.*, shelf life, TSS, acidity, ascorbic acid, total sugar and reducing sugars were determined. The results are present here.

3.6.1 Shelf life

The shelf life of papaya fruit was affected significantly due to individual effect of O and S during both the years and in pooled analysis. In all the cases, the shelf life of papaya fruit significantly higher with O₃ and O₄ treatment as compared to O₂ and O₁ consistently during both the years which was reflected in pooled analysis also (Table 66). Similarly, application of banana pseudostem sap could also enhance the shelf life of papaya fruit significantly in comparison to its no application. On an average, one to one half more shelf life was observed with organics as compared to INM treatment. This was reflected by significant differences between treatment mean and control mean during individual year and in pooled results.

Table 66: Effect of different treatments on shelf-life (days) of papaya fruit

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	6.23	6.50	6.37	6.12	6.38	6.25	6.18	6.44	6.31
O ₂	6.10	6.50	6.30	6.16	6.43	6.30	6.13	6.47	6.30
O ₃	6.49	7.05	6.77	6.33	6.63	6.48	6.41	6.84	6.63
O ₄	6.60	7.11	6.86	6.58	7.34	6.96	6.59	7.23	6.91
Mean	6.36	6.79	6.57	6.30	6.70	6.50	6.33	6.74	6.53
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.10	0.14	0.19	0.11	0.16	0.23	0.07	0.11	0.15
CD at 5%	0.29	0.41	NS	0.35	0.49	NS	0.22	0.31	NS
CV %	5			6			6		
Control			5.30			5.55			5.43
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.13		0.38	0.16		0.47	0.10		0.29

4.6.2 Total soluble solids

As such, the TSS content in papaya fruit was not influenced due to different treatments during individual year as well as in pooled analysis except S effect in pooled results (Table 67). Based on the pooled results, the TSS content of 7.23 per cent recovered with S_1 was significantly more than S_0 (6.92 %). Though treatment effect was not conspicuous on TSS content in papaya fruit, differences between means of organics and INM were significant during both the years and in pooled analysis. The values of TSS recovered with organics mean 7.06, 7.09 and 7.08 per cent during first year, second year and pooled analysis, respectively, were significantly higher as compared to INM mean. The O x S interaction effect was invariably turned out to be significant on TSS content in papaya fruit.

Table 67: Effect of different treatments on content of total soluble solids (%) in fruit

Treatments	2009-10			2010-11			Pooled		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
O_1	6.61	6.96	6.79	6.85	7.07	6.96	6.73	7.01	6.87
O_2	6.93	7.20	7.06	6.90	7.24	7.07	6.92	7.22	7.07
O_3	7.02	7.28	7.15	6.97	7.32	7.14	7.00	7.30	7.15
O_4	7.08	7.42	7.25	7.02	7.37	7.19	7.05	7.39	7.22
Mean	6.91	7.21	7.06	6.94	7.25	7.09	6.92	7.23	7.08
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.11	0.15	0.21	0.10	0.15	0.21	0.07	0.10	0.15
CD at 5%	NS	NS	NS	NS	NS	NS	0.213	NS	NS
CV %	5			5			5		
Control			6.44			6.46			6.45
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.15	0.45		0.14	0.42		0.10	0.30	

4.6.3 Acidity

The titratable acidity in papaya fruit was affected significantly due to individual effect of S during both the years and in pooled analysis and O effect during second year and pooled analysis (Table 68). Between the two treatments of S, S₀ showed superiority over S₁ with respect acidity in fruit during both the years and in pooled analysis. Similarly, among the O treatments O₂ and O₃ recorded significantly higher values of acidity in papaya fruit in comparison to O₁ and O₄ treatments during second year and in pooled analysis. The interaction effect between O x S was consistently absent in all the cases. However, the differences between organics mean and INM mean were significant during individual years as well as in pooled analysis. In all the events, acidity was conspicuously with INM system than application of nutrients only through organic sources.

Table 68: Effect of different treatments on acidity (%) of papaya fruit

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.026	0.020	0.023	0.026	0.018	0.022	0.026	0.019	0.023
O ₂	0.031	0.020	0.026	0.032	0.021	0.027	0.032	0.021	0.026
O ₃	0.032	0.021	0.026	0.033	0.022	0.027	0.033	0.021	0.027
O ₄	0.028	0.019	0.024	0.031	0.020	0.025	0.030	0.019	0.024
Mean	0.029	0.020	0.025	0.030	0.020	0.025	0.030	0.020	0.025
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.001	0.001	0.002	0.001	0.001	0.002	0.001	0.001	0.001
CD at 5%	0.003	NS	NS	0.003	0.004	NS	0.002	0.003	NS
CV %	14			13			13		
Control			0.036			0.037			0.036
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.001	0.004		0.001	0.004		0.001	0.003	

4.6.4 Ascorbic acid

With respect to ascorbic acid content in papaya fruit, it was influenced significantly due to individual effect of S during both the years and in pooled results and O effect in pooled analysis (Table 69). In all the events, treatment S₁ maintained its superiority by recording higher ascorbic acid content in papaya fruit over S₀ treatment. Similarly, in pooled results, O₄ recorded ascorbic acid content of 23.10 mg/100g which was significantly more than O₃ (21.92 mg/100g), O₂ (21.74 mg/100g) and O₁ (21.50 mg/100g). In comparison to organic system of nutrient management, INM system (control) recorded significantly lower ascorbic acid content in papaya fruit during both the years and pooled result also.

Table 69: Effect of different treatments on ascorbic acid content in (mg/100g pulp) pulp of papaya fruit

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	20.25	22.28	21.27	21.32	22.13	21.73	20.78	22.21	21.50
O ₂	20.88	22.85	21.86	20.55	22.67	21.61	20.71	22.76	21.74
O ₃	20.68	23.35	22.02	20.67	22.97	21.82	20.68	23.16	21.92
O ₄	22.03	24.72	23.38	22.29	23.36	22.83	22.16	24.04	23.10
Mean	20.96	23.30	22.13	21.21	22.78	22.00	21.08	23.04	22.06
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.37	0.52	0.73	0.42	0.60	0.85	0.28	0.40	0.56
CD at 5%	1.11	NS	NS	1.286	NS	NS	0.812	1.148	NS
CV %	6			7			6		
Control			20.37			18.93			19.65
Control v/s rest	SEm±		CD at 5%	SEm±		CD at 5%	SEm±		CD at 5%
	0.53		1.59	0.65		1.95	0.42		1.21

4.6.5 Total sugar

The total sugar content in any fruit impart sweetness, it was also affected significantly due to individual effect of S during first year and in pooled analysis and O effect during both the years and in pooled analysis

(Table 70). In these cases, S_1 and O_4/O_3 recorded significantly higher values of total sugar content in papaya fruit in comparison to their respective remaining levels. The values of total sugar content in papaya recorded with control were 6.20 per cent during first year, 6.25 per cent during second year and 6.23 per cent in pooled results were significantly lower than means of organics treatment. The corresponding values with organic mean were 6.99, 7.12 and 7.06.

Table 70: Effect of different treatments on total sugar content (%) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S_0	S_1	Mean	S_0	S_1	Mean	S_0	S_1	Mean
O_1	6.51	6.94	6.73	6.67	7.00	6.84	6.59	6.97	6.78
O_2	6.42	7.11	6.76	6.84	7.11	6.97	6.63	7.11	6.87
O_3	6.95	7.29	7.12	7.28	7.14	7.21	7.12	7.21	7.16
O_4	7.18	7.56	7.37	7.12	7.80	7.46	7.15	7.68	7.41
Mean	6.76	7.23	6.99	6.98	7.26	7.12	6.87	7.24	7.06
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.11	0.15	0.22	0.10	0.15	0.21	0.08	0.11	0.15
CD at 5%	0.33	0.47	NS	NS	0.44	NS	0.22	0.31	NS
CV %	5			5			5		
Control			6.20			6.25			6.23
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.15	0.44		0.14	0.43		0.10	0.30	

4.6.6 Reducing sugar

The reducing sugar content in papaya fruit reported in table 71 exhibited an identical pattern of treatment effect as was observed with total sugar content in papaya fruit. The values of reducing sugar determined in papaya fruit with organics means were 5.39 per cent during first year, 5.51 during second year and 5.45 per cent in pooled results were significantly more than control mean. The respective control means were 4.82, 5.08 and 4.95 per cent.

Table 71: Effect of different treatments on reducing sugar content (%) in fruit of papaya

Treatments	2009-10			2010-11			Pooled		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	5.02	5.34	5.18	5.15	5.42	5.28	5.08	5.38	5.23
O ₂	5.08	5.43	5.26	5.28	5.40	5.34	5.18	5.41	5.30
O ₃	5.32	5.63	5.47	5.54	5.81	5.68	5.43	5.72	5.58
O ₄	5.42	5.91	5.67	5.68	5.82	5.75	5.55	5.86	5.71
Mean	5.21	5.58	5.39	5.42	5.61	5.51	5.31	5.59	5.45
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.08	0.12	0.17	0.07	0.11	0.15	0.06	0.08	0.11
CD at 5%	0.26	0.36	NS	NS	0.32	NS	0.16	0.23	NS
CV %	5			5			5		
Control			4.82			5.08			4.95
Control v/s rest	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
	0.11	0.34		0.10	0.30		0.08	0.22	

4.7 Soil properties

For evaluating the effect of organics and sap application on soil chemical viz., pH, EC and soil fertility parameters viz., available N, P, K, Fe, Mn, Zn and Cu, soil samples were collected from two depth (0-22.5 and 22.5-45 cm) after harvest of crop and analyzed for these properties.

3.7.1 Soil chemical properties

Soil reaction: The results regards soil pH measurement at 0-22.5 and 22.5-45 cm depth, are reported in tables 72 and 73. The results revealed that the effect of all the treatments was not significant on soil pH of surface (0-22.5 cm) and sub surface layer (22.5-45 cm). This was also true for the control v/s rest analysis.

Soil salinity: With respect to soluble salt content in soil (EC_{2.5}), it was not affected significantly due to different organic treatment in both depths and years (Tables 74 and 75). Similarly, the difference between mean of organics and INM treatments was also not significant during both the years.

Table 72: Effect of different treatments on pH_{1:2.5} of surface soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	8.61	8.51	8.56	8.64	8.56	8.60
O ₂	8.53	8.43	8.48	8.63	8.45	8.54
O ₃	8.46	8.41	8.44	8.48	8.54	8.51
O ₄	8.46	8.45	8.45	8.47	8.45	8.46
Mean	8.52	8.45	8.48	8.55	8.50	8.53
Source	S	O	O x S	S	O	O x S
SEm±	0.04	0.05	0.07	0.04	0.06	0.08
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	1.48			1.62		
Control			8.53			8.46
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.05	NS		0.05	NS	

Table 73: Effect of different treatments on pH_{1:2.5} of subsurface soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	8.68	8.59	8.63	8.66	8.69	8.67
O ₂	8.68	8.53	8.60	8.75	8.61	8.68
O ₃	8.63	8.66	8.65	8.70	8.75	8.72
O ₄	8.62	8.65	8.63	8.67	8.58	8.62
Mean	8.65	8.60	8.63	8.70	8.66	8.68
Source	S	O	O x S	S	O	O x S
SEm±	0.10	0.13	0.19	0.05	0.08	0.11
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	4			2		
Control			8.43			8.50
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.13	NS		0.07	NS	

4.7.2 Soil fertility parameters

Organic carbon: The organic carbon content in soil was influenced significantly due to individual effects of S during both the years in surface soil and during first years in sub surface soil. In all the cases, application of sap increased the organic C content in soil significantly as compared to its no application (Tables 76 and 77). During both the years and depth,

Table 74: Effect of different treatments on EC_(1:2.5) (dS/m) of surface soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.344	0.351	0.347	0.367	0.365	0.366
O ₂	0.342	0.332	0.337	0.368	0.339	0.353
O ₃	0.370	0.377	0.374	0.374	0.357	0.365
O ₄	0.375	0.349	0.362	0.369	0.369	0.369
Mean	0.358	0.352	0.355	0.370	0.357	0.363
Source	S	O	O x S	S	O	O x S
SEm±	0.007	0.009	0.013	0.005	0.008	0.011
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	6			5		
Control			0.388			0.389
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.010	0.030		0.008	0.023	

Table 75: Effect of different treatments on EC_{1:2.5} (d/Sm) of subsurface soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.323	0.332	0.328	0.328	0.358	0.343
O ₂	0.355	0.328	0.342	0.352	0.352	0.352
O ₃	0.350	0.314	0.332	0.354	0.345	0.350
O ₄	0.333	0.331	0.332	0.332	0.340	0.336
Mean	0.340	0.326	0.333	0.342	0.349	0.345
Source	S	O	O x S	S	O	O x S
SEm±	0.007	0.010	0.014	0.011	0.015	0.022
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	7			11		
Control			0.362			0.358
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.013	NS		0.015	NS	

treatment mean recorded significantly higher organic C content in soil in comparison to INM mean. Of course, the extent of decrease of organic C in surface soil with INM was less than organics treatments.

Available N: The available N content in soil was increased considerably in surface soil only due to application of sap during both the years (Tables 78 and 79). Here, application of sap improved available N

content in surface soil significantly as compared to no application of sap. In contrast, this effect was not evident on available N content. In subsurface soil during both the years the control v/s rest analysis revealed the difference in available N content in surface soil during both the years and during second year in subsurface soil between organics mean and INM control were significant. In all the cases, organics mean maintained its superiority over INM control.

Available P: The perusal of results presented in tables 80 and 81 indicated that except the effect of sap on available P content in 22.5 to 45.0 cm depth soil during second year, all the effect were not significant. Here, S₁ recorded available P content of 39.77 kg during second year in subsurface layer was significantly higher as compared to S₀ (36.46 kg/ha). With an exception of available P content in subsurface layer during first year, in all the cases available P content of soil in both the depth was more with organic mean than INM control.

Table 76: Effect of different treatments on organic carbon content (%) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.80	0.94	0.87	0.85	0.99	0.92
O ₂	0.85	0.96	0.90	0.90	1.01	0.95
O ₃	0.93	1.05	0.99	0.98	1.10	1.04
O ₄	0.97	1.09	1.03	1.02	1.14	1.08
Mean	0.89	1.01	0.95	0.94	1.06	1.00
Source	S	O	O x S	S	O	O x S
SEm±	0.03	0.04	0.06	0.03	0.04	0.06
CD at 5%	0.09	NS	NS	0.09	NS	NS
CV %	11			10		
Control			0.61			0.66
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.04	0.12		0.04	0.12	

Table 77: Effect of different treatments on organic carbon content (%) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.51	0.53	0.52	0.55	0.55	0.55
O ₂	0.50	0.53	0.51	0.52	0.57	0.54
O ₃	0.51	0.60	0.56	0.56	0.63	0.59
O ₄	0.53	0.61	0.57	0.56	0.63	0.59
Mean	0.51	0.57	0.54	0.54	0.59	0.57
Source	S	O	O x S	S	O	O x S
SEm±	0.02	0.02	0.03	0.02	0.03	0.04
CD at 5%	0.05	NS	NS	NS	NS	NS
CV %	11			13		
Control			0.44			0.47
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.02	0.07		0.03	0.09	

Table 78: Effect of different treatments on available N content (kg/ha) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	288	307	297	281	309	295
O ₂	292	309	300	285	294	289
O ₃	302	310	306	323	326	324
O ₄	298	322	310	279	325	302
Mean	295	312	303	292	314	303
Source	S	O	O x S	S	O	O x S
SEm±	4.59	6.49	9.18	6.25	8.84	12.50
CD at 5%	14	NS	NS	19	NS	NS
CV %	5			7		
Control			264			264
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	6	19		8	25	

Table 79: Effect of different treatments on available N content (kg/ha) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	217	237	227	222	247	235
O ₂	228	244	236	241	272	257
O ₃	239	258	249	256	273	265
O ₄	248	263	256	258	263	260
Mean	233	251	242	244	264	254
Source	S	O	O x S	S	O	O x S
SEm±	5.90	8.34	11.80	6.82	9.64	13.64
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	8			9		
Control			219			224
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	8	NS		9	28	

Table 80: Effect of different treatments on available P₂O₅ content (kg/ha) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	60.64	70.14	65.39	66.64	76.14	71.39
O ₂	62.59	72.03	67.31	68.59	76.51	72.55
O ₃	66.80	73.87	70.33	72.80	79.87	76.33
O ₄	68.38	77.15	72.77	74.38	83.15	78.77
Mean	64.60	73.30	68.95	70.60	78.92	74.76
Source	S	O	O x S	S	O	O x S
SEm±	3.05	4.32	6.11	3.19	4.51	6.38
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	15			15		
Control			42.58			47.16
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	4.34	13.01		4.29	12.86	

Table 81: Effect of different treatments on available P₂O₅ content (kg/ha) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	34.17	36.43	35.30	35.18	38.31	36.75
O ₂	35.45	37.38	36.42	36.62	39.99	38.30
O ₃	35.05	37.83	36.44	37.25	39.52	38.38
O ₄	35.05	38.98	37.02	36.79	41.26	39.03
Mean	34.93	37.66	36.29	36.46	39.77	38.12
Source	S	O	O x S	S	O	O x S
SEm±	1.11	1.56	2.21	0.98	1.39	1.97
CD at 5%	NS	NS	NS	2.985	NS	NS
CV %	11			9		
Control			31.18			32.85
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	1.67	NS		1.37	4.11	

Available K: The available status of K in surface soil was affected significantly due to S and O effect during first year and only due to S during second year (Table 82). The interaction between O x S failed to exert any significant effect on available K content in both the depth. In all the cases, S₁ showed superiority over S₀ by registering higher values of available K content in soil. Among the O levels, O₄ (469 kg/ha) and O₃ (443 kg/ha) and O₃ with O₀ (437 kg/ha) were at par with each other but superior over O₁ treatment. While only S effect could influence the available K content in subsurface soil significantly during both the years (Table 83). Here also, S₁ maintained its superiority over S₀. Except first year, available K content in surface soil, in rest of the cases the difference between treatment mean and INM control were not significant. During first year, the available K content in surface soil was significantly higher with treatment mean as compared to INM control.

Available Fe (DTPA Extractable): The availability of Fe in surface soil was influenced significantly only due to individual effect of O during both the years (Table 84). While in case of Fe availability in subsurface layer, it was affected only by individual effect of S during second year (Table 85). In surface and subsurface layers, S₁ treatment recorded significantly higher values of available Fe as compared S₀ treatment. Among the O levels in all the significant cases, O₄ and O₃ treatments were at par with each other, but were significantly higher than O₁ and O₂. With respect to control v/s rest analysis, in all the cases the treatment means were invariably more than INM control values during both the years.

Table 82: Effect of different treatments on available K₂O content (kg/ha) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	411	435	423	404	446	425
O ₂	420	454	437	418	450	434
O ₃	428	458	443	423	459	441
O ₄	469	469	469	439	478	459
Mean	432	454	443	421	458	440
Source	S	O	O x S	S	O	O x S
SEm±	6.83	9.66	13.65	11.84	16.75	23.69
CD at 5%	21	30	NS	36	NS	NS
CV %	5			9		
Control			397			400
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	9.90	30		16.06	NS	

Table 83: Effect of different treatments on available K₂O (kg/ha) of subsurface soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	296	329	312	307	340	323
O ₂	298	360	329	309	371	340
O ₃	312	329	321	323	340	332
O ₄	323	367	345	334	378	356
Mean	307	346	327	318	357	338
Source	S	O	O x S	S	O	O x S
SEm±	8.13	11.50	16.27	8.13	11.50	16.27
CD at 5%	25	NS	NS	25	NS	NS
CV %	9			8		
Control			322			333
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	11.14	NS		11.13	NS	

Table 84: Effect of different treatments on available Fe content (ppm) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	15.73	16.38	16.06	15.75	16.25	16.00
O ₂	15.44	16.26	15.85	15.31	16.13	15.72
O ₃	17.79	18.40	18.09	17.02	18.27	17.64
O ₄	17.86	18.66	18.26	17.73	19.62	18.67
Mean	16.71	17.43	17.07	16.45	17.57	17.01
Source	S	O	O x S	S	O	O x S
SEm±	0.42	0.59	0.83	0.43	0.61	0.87
CD at 5%	NS	1.79	NS	NS	1.86	NS
CV %	8			9		
Control			15.13			15.00
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.56	1.68		0.58	1.73	

Table 85: Effect of different treatments on available Fe content (ppm) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	7.71	8.43	8.07	7.96	8.68	8.32
O ₂	7.62	8.32	7.97	7.87	8.90	8.39
O ₃	8.18	8.57	8.37	8.19	8.62	8.41
O ₄	8.13	8.72	8.43	8.38	8.78	8.58
Mean	7.91	8.51	8.21	8.10	8.75	8.42
Source	S	O	O x S	S	O	O x S
SEm±	0.22	0.32	0.45	0.21	0.30	0.42
CD at 5%	NS	NS	NS	0.64	NS	NS
CV %	9			9		
Control			6.28			6.53
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.30	0.91		0.29	0.86	

Available Mn (DTPA Extractable): As regards the Mn availability in both the year, it was affected significantly due to individual effect of O in surface soil (Table 86) and by S effect in subsurface soil (Table 87). In surface layer the available Mn content was significantly higher with O₄ and O₃ in comparison to O₂ and O₁ treatment during both the years. Similarly in subsurface layer, S₁ showed superiority over S₀ during both the years. The values of available Mn content in subsurface soil recorded with S₁ treatment were 15.95 and 16.22 ppm during the year 2009-10 and 2010-11, respectively. The control v/s rest analysis revealed that treatment means for available Mn content in both the layer was significantly higher as compared to INM control mean values during the year 2009-10 and 2010-11.

Available Zn (DTPA Extractable): As far as available Zn content in both the layers of soil is concerned, it was affected significantly only by the application of sap during the year 2010-11 only (Tables 88 and 89). In

both the depth, the treatment S_1 maintained its superiority over S_0 by recording available Zn content of 0.84 and 0.66 ppm in 0-22.5 and 22.5-45 cm layers, respectively. At both the depths, the available Zn content in soil was significantly more with treatment mean than INM control during 2009-10 and 2010-11.

Available Cu (DTPA Extractable): Effect of all the factor either individually or interactively failed to produce any significant effect on available Cu content in 0-22.5 and 22.5-45 cm depth during both the years (Table 90 and 91). Of course, O_4 and S_1 had edge over their remaining levels. However, the treatment mean values of available Cu content in both the layers were significantly higher in comparison to INM mean during 2009-10 and 2010-11.

Table 86: Effect of different treatments on available Mn content (ppm) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S_0	S_1	Mean	S_0	S_1	Mean
O_1	23.08	23.82	23.45	23.72	24.45	24.08
O_2	23.33	24.28	23.81	23.97	24.92	24.44
O_3	26.53	27.05	26.79	27.16	27.68	27.42
O_4	27.32	28.74	28.03	27.96	29.05	28.50
Mean	25.07	25.97	25.52	25.70	26.52	26.11
Source	S	O	O x S	S	O	O x S
SEm±	0.58	0.82	1.16	0.67	0.94	1.33
CD at 5%	NS	2.50	NS	NS	2.85	NS
CV %	8			9		
Control			18.48			19.12
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.87	2.61		1.02	3.06	

Table 87: Effect of different treatments on available Mn content (ppm) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	13.65	15.87	14.76	14.12	16.33	15.23
O ₂	13.85	15.26	14.56	14.31	15.73	15.02
O ₃	14.00	16.12	15.06	14.47	16.25	15.36
O ₄	14.35	16.53	15.44	14.81	16.57	15.69
Mean	13.96	15.95	14.95	14.43	16.22	15.32
Source	S	O	O x S	S	O	O x S
SEm±	0.28	0.40	0.56	0.30	0.42	0.59
CD at 5%	0.85	NS	NS	0.90	NS	NS
CV %	7			7		
Control			13.25			13.73
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.39	1.18		0.46	1.39	

Table 88: Effect of different treatments on available Zn content (ppm) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.67	0.73	0.70	0.72	0.79	0.76
O ₂	0.63	0.77	0.70	0.70	0.84	0.77
O ₃	0.73	0.80	0.76	0.76	0.87	0.81
O ₄	0.78	0.81	0.80	0.77	0.87	0.82
Mean	0.70	0.78	0.74	0.74	0.84	0.79
Source	S	O	O x S	S	O	O x S
SEm±	0.03	0.04	0.06	0.03	0.05	0.07
CD at 5%	NS	NS	NS	0.10	NS	NS
CV %	14			15		
Control			0.55			0.62
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.04	0.12		0.05	0.14	

Table 89: Effect of different treatments on available Zn content (ppm) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	0.50	0.57	0.53	0.53	0.66	0.60
O ₂	0.57	0.64	0.61	0.57	0.64	0.61
O ₃	0.61	0.65	0.63	0.62	0.65	0.64
O ₄	0.63	0.68	0.66	0.65	0.68	0.67
Mean	0.58	0.63	0.61	0.59	0.66	0.63
Source	S	O	O x S	S	O	O x S
SEm±	0.02	0.03	0.05	0.02	0.02	0.03
CD at 5%	NS	NS	NS	0.05	NS	NS
CV %	13			10		
Control			0.50			0.53
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.03	0.10		0.02	0.07	

Table 90: Effect of different treatments on available Cu content (ppm) in soil (0-22.5 cm) after harvest of papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	3.78	3.98	3.88	4.05	4.25	4.15
O ₂	4.08	4.19	4.14	4.25	4.45	4.35
O ₃	4.25	4.30	4.28	4.38	4.55	4.47
O ₄	4.20	4.47	4.33	4.60	4.68	4.64
Mean	4.08	4.23	4.16	4.32	4.48	4.40
Source	S	O	O x S	S	O	O x S
SEm±	0.12	0.17	0.25	0.12	0.17	0.24
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	10			9		
Control			3.37			3.73
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.16	0.49		0.17	0.51	

Table 91: Effect of different treatments on available Cu content (ppm) in soil (22.5-45.0 cm) after harvest of the papaya

Treatments	2009-10			2010-11		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	3.37	3.50	3.44	3.29	3.27	3.28
O ₂	3.19	3.45	3.32	2.96	3.22	3.09
O ₃	3.30	3.49	3.40	3.07	3.26	3.16
O ₄	3.42	3.55	3.48	3.18	3.53	3.36
Mean	3.32	3.50	3.41	3.13	3.32	3.22
Source	S	O	O x S	S	O	O x S
SEm±	0.11	0.16	0.22	0.11	0.15	0.21
CD at 5%	NS	NS	NS	NS	NS	NS
CV %	11			11		
Control			2.82			2.68
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.16	0.47		0.14	0.43	

4.7.3 Soil physical properties

The physical properties viz., BD, HC, WSA (fine and coarse fractions) were determined in duplicate before (initial) and treatment wise after harvest of crop during both the years (Table 92). The results revealed that there is considerable improvement in all the physical properties of soil due to different nutrient management systems. Between the two nutrient management systems, organic system recorded relatively lower bulk density and higher hydraulic conductivity in both the depths than INM system. It is interesting to note that, there was considerable increase in proportion of coarser fraction of water stable aggregates (WSA) with organic treatments as compared to INM mean.

**Table 92: Effect of different treatments on physical properties of soil
(Mean Values)**

Treatments	BD (g/cc)		HC (cm/hr)		WSA (0.5-1.0 mm)		WSA (>1.0 mm)	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Depth : 0-22.5 cm								
Initial	1.46	1.47	4.15	4.32	20.98	21.65	55.85	56.25
O ₁	1.41	1.43	4.65	4.68	10.25	11.62	65.35	68.54
O ₂	1.39	1.41	4.5	4.65	9.56	10.56	74.26	70.56
O ₃	1.38	1.39	4.78	4.65	6.56	6.85	74.42	71.65
O ₄	1.37	1.38	4.65	4.58	5.47	4.26	76.38	78.68
Mean (O₁-O₄)	1.39	1.40	4.65	4.64	7.96	8.32	72.60	72.36
Initial of INM	1.48	1.47	1.87	2.23	30.82	25.65	26.96	27.85
After harvest	1.47	1.43	2.23	2.65	25.56	23.65	27.85	29.45
Depth : 22.5-45.00 cm								
Initial	1.52	1.54	5.63	6.48	16.95	14.25	39.65	40.2
O ₁	1.48	1.49	5.65	5.43	11.5	10.4	49.65	50.56
O ₂	1.48	1.51	5.68	5.65	10.2	9.54	55.65	59.64
O ₃	1.49	1.49	6.26	6.56	9.45	8.65	58.45	59.64
O ₄	1.47	1.48	6.56	6.45	6.54	7.54	60.75	62.35
Mean (O₁-O₄)	1.48	1.49	6.04	6.02	9.42	9.03	56.13	58.05
Initial of INM	1.57	1.56	2.62	2.48	38.6	29.45	19.48	20.23
After Harvest	1.56	1.45	2.48	2.75	29.45	25.45	20.23	21.23

V. DISCUSSION

A field experiment consisting of eight treatment combinations involving different proportion of three organics on N equivalent basis (O_1 : 50 % RDN through bio compost + 50 % RDN through castor cake, O_2 : 50 % RDN through bio compost + 50 % RDN through vermi compost, O_3 : 50 % RDN through bio compost + 25 % RDN through vermi compost + 25 % through castor cake and O_4 : 33.3 % RDN through bio compost + 33.3 % RDN through vermi compost + 33.4 % RDN through castor cake) and two levels of banana pseudostem sap application (S_0 : without sap and S_1 : with sap @ 8 l/plant along with one INM controls outside the organic farm were tested in FRBD with three replications. The results pertaining to the growth parameters, yield attributes, yield, nutrient content, nutrient uptake, quality parameters and soil fertility obtained during the course of present investigation are interpreted in preceding chapter using statistical significance. In this chapter, an attempt has been made to explain the important findings of the present study with logical and scientific reasoning along with discussing the same in the context of earlier reported pertinent work. For brevity, the discussion is subdivided into the following heads.

- 5.1 Growth and yield
- 5.2 Nutrient uptake
- 5.3 Quality parameter
- 5.4 Soil properties
- 5.5 Economics

5.1 Growth and yield

Under this subtitle, the important findings related to plant height, stem girth, number of leaves/plant, length of petiole, average fruit weight, number of fruit / plant, fruit yield/plant, fruit yield and dry leaves, petiole and fruit yields are discussed.

5.1.1 Comparison between organic and INM

The growth parameters *viz.*, periodical plant height as well as stem girth and petiole length, number of leaves per plant were differed significantly between mean of organics treatments and INM control. Similarly, the yield attributes *viz.*, average fruit weight, number of fruits per plant and fruit yield (t/ha) were also differed significantly between the mean of organics treatments and INM control. In all the parameters INM control recorded significantly higher values as compared to mean of organics treatments. The magnitude of increase in parameters *viz.*, plant height, girth, petiole length, number of leaves per plant, average fruit weight, number of fruit per plant, fruit yield per plant and fruit yield (t/ha) at the harvest with INM control was 17, 17, 38, 22, 21, 9, 32 and 31 per cent, respectively over the mean of organics treatments (Fig 2).

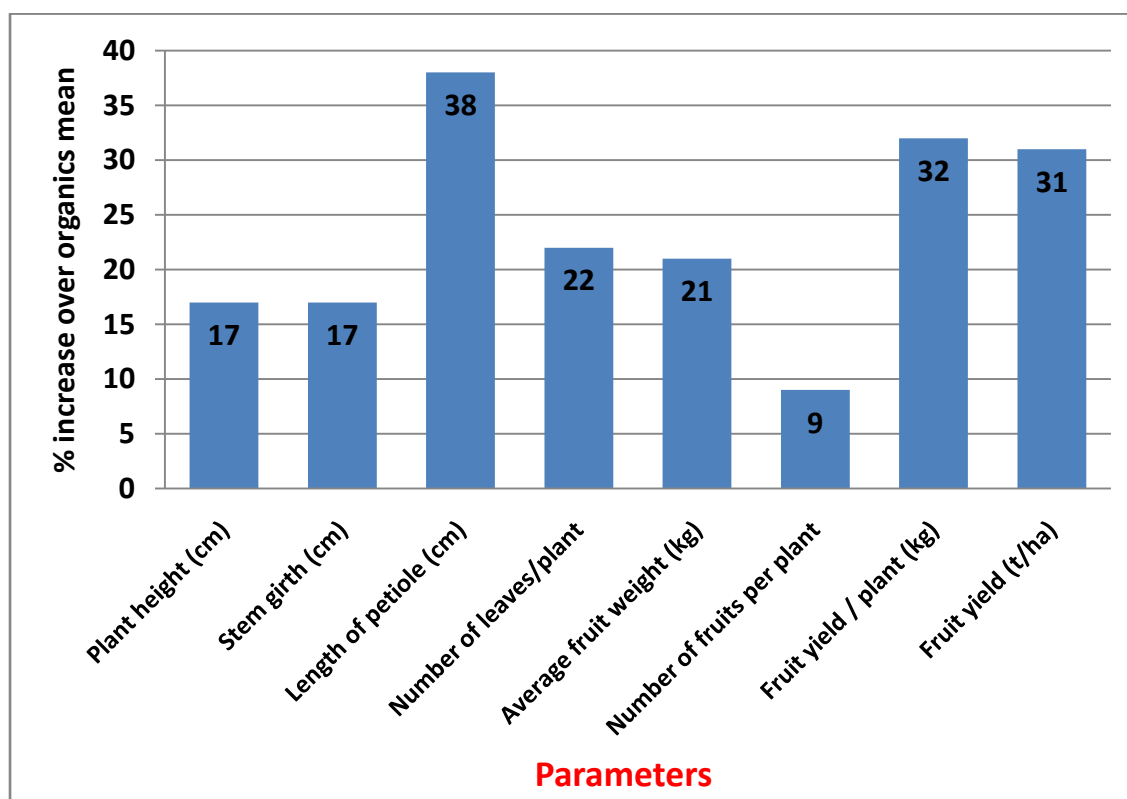


Fig. 2: Per cent increase in different parameters with INM control over mean of organics treatments

An increase observed in growth as well as yield parameters of papaya with INM control over organics treatments mean could be attributed to the fact that under INM system combination of inorganic, organic and biological sources are involved. Combined application of these sources results in improved soil physical, chemical and biological properties of soil in comparison to inorganic sources alone. However as compared to organic system of nutrient management, though it is better than INM system with respect to physical, chemical and biological properties of soil, the rate of plant available nutrients release may not be synchronized with the nutrient demand of plant. This could be the reason why yields of different crops are low in organic system of nutrient management than INM system. This phenomenon may be pronounced when the soil is under transition phase i.e. 4th year of conversion from INM/ inorganic to organic farm. There are chances of getting yield comparable with INM system by adopting organic nutrient management system, after the soil is stabilized i.e., perfectly converted to organic farm (minimum of 4 years). The work related to organic nutrient management done by Reddy *et al.* (2010) on red loam soil (pH 6.12, Organic carbon 0.73%) of IIHR, Bangalore using papaya (cv. Surya) also reported about 30 per cent reduction in fruit yield with treatments receiving nutrients only through organic sources (20 kg sun hemp + 150 g rock phosphate per plant per year) over treatment wherein recommended doses of fertilizers were applied. However, from the data base generated through survey related to status of organic farming in India, Ramesh *et al.* (2010) have also reported that on an average the crop yield is decreased by 9.2 per cent. However, this decrease was slightly higher in fruit crop and more so in case of heavy feeder crop like banana (16.0 %). In present study, crop like papaya was tested and the reduction in fruit yield was of the order of 31 per cent. The higher magnitude of reduction in yield of papaya seems to be due to initial phase of conversion of farm to organic and relatively slow release rate of available nutrient under such situation. Further, it

could be due to mean of group of fruit crop and across the organics location in India *i.e.*, it is not specifically for papaya crop.

5.1.2 Comparison with in organics treatments

In present study organic sources were used in different proportion on equivalent N basis along with and without banana pseudostem for developing suitable package of nutrient management for papaya grown on organic farm. The results described in preceding chapter revealed that among the organics treatments, application of BC: VC: CC in the proportion of 33.3: 33.3: 34.4 (O_4) showed superiority with respect to growth and yield parameters over O_1 and O_2 but it was closely followed by O_3 treatment (BC 50: VC 25: CC 25). For evaluating the superiority of O_4 over O_1 treatment, the data pertaining to per cent increase in plant height at harvest (14 %), stem girth at harvest (16 %), petiole length (2 %), number of leaves/plant (6 %), number of fruits/plant (10 %), average fruit weight (18 %), fruit weight/plant (32 %) and fruit yield (32 %) are presented in Fig 3.

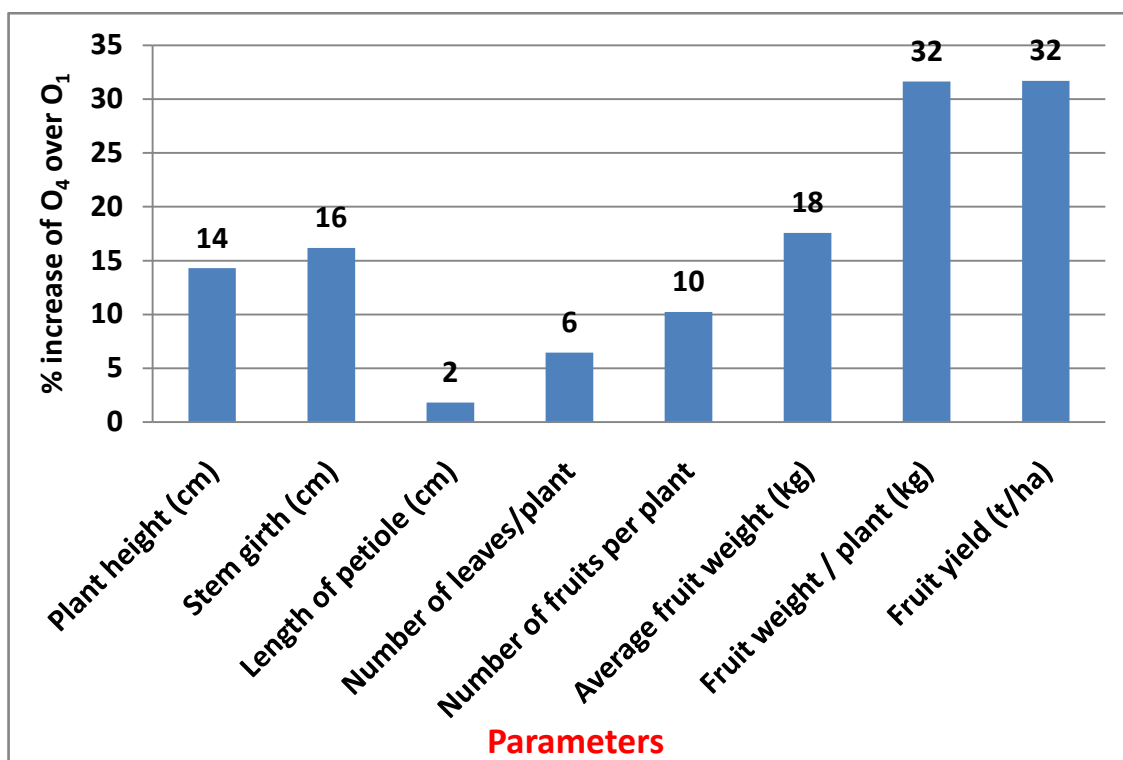


Fig. 3: Per cent increase in different parameters with O_4 over O_1

Despite application of organics on equivalent N basis, the yield differences among the treatment were significant. For explaining these results we have computed the amount of nutrient added through different organics (Table 93).

Table 93: Amount of nutrients added through different organics treatments

Source	C:N ratio	N	P	K	Fe	Mn	Zn	Cu
		g/plant						
O ₁	14.64	200	95.70	135.00	14.22	2.12	0.62	0.30
O ₂	16.05	200	152.41	256.15	28.00	2.76	0.83	0.39
O ₃	15.35	200	124.05	195.58	21.11	2.44	0.72	0.35
O ₄	13.30	200	111.72	186.06	19.83	1.89	0.65	0.30

C: N ratio of BC: 21.33, VC: 10.77 and CC: 7.95

The data given in table 93 clearly indicated that there is considerable variation with respect to amount of nutrients other than N added in different treatments. For instance, the addition of P was remaining from 95.70 g/plant with O₁ to 152.41 g/plant with O₂. The minimum and maximum values for K and Fe were also registered with O₁ and O₂, respectively. But this is not the cases with Mn, Zn and Cu. This implies that better performance of O₄ than O₁ is due to addition of higher amount of P, K and Fe inadvertently in O₄ treatment as compared to O₁. Despite addition of higher amount of all the nutrients inadvertently in O₂ treatment, fruit yield was significantly lower with O₂ than O₄. This might be due to relatively wider C: N ratio of O₂ (16.05) than O₄ (13.30). This might be the reason to the remaining O treatments. Though, the variation in C: N ratio of different treatments is between 13 and 16, yet its effect may be more pronounced in the situation of farm which was under conversion process. In other words, even with slightly narrower C: N ratio (13.3) of O₄ treatment the nutrient release pattern might have

synchronized with the nutrient demand of papaya plant. Relatively poor performance of O_2 in spite of higher inadvertent addition of plant nutrient could be presumably due to presence of phenolic compound present in banana pseudostem scutcher which was used for preparing VC (Anon.2011).

The basic difference between O_4 and O_2 is in former the proportion is BC 33.3: VC 33.3: CC 33.4 and than in later BC 50: VC 50. This implies that using pseudostem based vermi compost for supplying N up to 50 per cent is not advisable. However, BC, VC and CC used in equal proportion seems to be excellent combination from matching the release and plant demand pattern point of view. Like pseudostem based Vermicompost, castor cake also has some anti bacterial properties. Hence, treatment O_1 where BC: CC supplied equal amount of N (50: 50). The results of present experiment clearly brought the fact that under organic farming situation, use of BC: VC: CC in equal proportion is a must. In other word, use of any single organic source for supplying all the nutrient is not prudent option. Similar variation in papaya fruit yield due to different sources of organics viz., FYM, urban compost, rural compost, sun hemp green manure and Vermicompost have also been reported by Reddy *et al.* (2010).

Another factor studied in present study was application of pseudostem sap which is obtained during extraction of fibre from pseudostem. Application of sap @ 8 l/plant in 8 equal splits (S_1) on pooled basis increased the plant height, girth, number of fruits/plant and fruit yield (t/ha) by 12.3, 17.0, 6.8 and 11.2 per cent, respectively over no application of sap. An increase in growth and yield of papaya due to application of sap could be due to the following points.

- As discussed earlier, the amount of P and K through organics is less than recommended dose of papaya (200: 200: 250 g NPK/plant). Application of sap @ 8 l/plant have added 240 and 13600 mg/plant, P and K, respectively, which might have helped in

increasing the growth parameters and fruit yield of papaya. Apart from P and K, sap also supplied N, Fe, Mn, Zn and Cu over and above the organics; this might have further enhanced the fruit yield of papaya.

- Banana pseudostem sap being extract of plant, it contains the plant nutrient in available form, there by facilitating their efficient utilization. Additionally, sap was applied in split which might have further improved the nutrient utilization and more so under organic farm situation. Because under organic farming, the rate of release from organics is always less than nutrient demand by plant.
- Apart from essential plant nutrients, pseudostem sap also contains the growth promoting substances like cytokinin, GA₃ etc., which might have exerted beneficial effects on plant growth and ultimately reflected on the yield of papaya.

Similar beneficial effect of sap application on yields of banana (3 l/plant), sugarcane (5000 l/ha) and onion (1500 l/ha) have also been observed with INM system under South Gujarat conditions (Anon., 2012). The work reported here is under INM system only, as no work on use of sap as liquid fertilizer in any crop have been reported in literature.

The results pertaining to the interaction effect of O and S is not discussed here, as in all the cases it was turned out to be not significant.

5.2 Nutrient uptake

The uptake of nutrients viz., N, P, K, Fe, Mn, Zn and Cu by petiole, leaves, fruit and total was mostly affected by individual effect of organics and sap application. In almost all the cases O₄ and S₁ treatments showed superiority over O₁ and S₀, respectively. It seems that the pattern of nutrient uptake was governed by the dry matter yield of different components of papaya plant. Hence, the content of these nutrients is not discussed. Otherwise, concentration of nutrient in plant is deceptive trait which is affected by dilution effect *i.e.*, more dry matter yield leads to less concentration of nutrient and *visa versa*.

5.2.1 Comparison of organics means v/s INM control

The total uptake (leaves + petiole + fruit) of nutrients viz., N, P, K, Fe, Mn, Zn and Cu by papaya crop did not differ significantly between organic mean and INM control (Tables 94 to 96 and Figs. 4 to 10). Despite significant difference in dry matter yield of individual parts of papaya and nutrient content and uptake by respective part, the differences of total uptake of nutrient between organic mean and INM mean were turned out to be not significant. This is mainly due to higher dry matter yield and less nutrient content in INM than organics mean. Ultimately, the treatment effect was nullified on total uptake of nutrient by papaya.

5.2.2 Comparison with in organics treatments

In contrast to organics and INM means with in organics and sap treatments, the differences in total uptake (petiole + leaves + fruit) of all the nutrients were significant (Tables 94 to 96 and Figs. 4 to 10). Among the organics treatments, O₄ treatment recorded significantly higher values of total uptake (petiole + leaves + fruit) of all the nutrients as compared to O₂ and O₁, but it was at par with O₃ in some of the cases. This could be mainly due to the higher dry matter yield of different components of papaya recorded with O₄ treatment as compared to O₂ and O₁. This was also reflected in total uptake of all the elements. The probable reason given in caption 5.1 are tenable here also.

For understanding the extent of translocation of nutrients from vegetative to reproductive part, the per cent distribution of uptake of nutrients through petiole, leaves and fruit was worked out treatment wise (Table 97). The per cent distribution values clearly revealed that under O₄ treatment, the accumulation of all the nutrients was more in fruit than O₁ treatment. For instance, the accumulation of N, P and K in fruit with O₄ treatment was 37.69, 24.08 and 33.09 per cent as against the respective values recorded with O₁ were 33.21, 19.31 and 25.53 per cent. These results clearly indicated that when the bulky (BC, VC) and concentrated

(CC) organic sources are used in equal proportion, it enhances translocation of nutrients from vegetative parts to reproductive parts. This might be one of the reasons for recording significantly higher yield under O_4 treatment as compared to O_2 and O_1 . Similar results were also reported by Reddy *et al.* (2010) who used combination of FYM and Sun hemp.

The results presented in table 97 further revealed that application of sap (S_1) also increased the translocation of N, P, K, Fe, Mn, Zn and Cu from vegetative to reproductive parts as compared to no application of sap. The magnitude of increase in accumulation of N, P, K, Fe, Mn, Zn and Cu in fruit with S_1 treatment was 37.81, 24.32, 30.93, 1.06, 0.63, 2.33 and 3.38 per cent. The corresponding values for S_0 treatments were 32.66, 19.47, 27.80, 0.93, 0.47, 2.16 and 2.85 per cent. It seems that the presence of cytokinin and GA_3 apart from supplementation of nutrients in sap might have facilitated translocation of nutrient from vegetative to reproductive part. The explanations given for better performance of papaya due to sap application are equally applicable here.

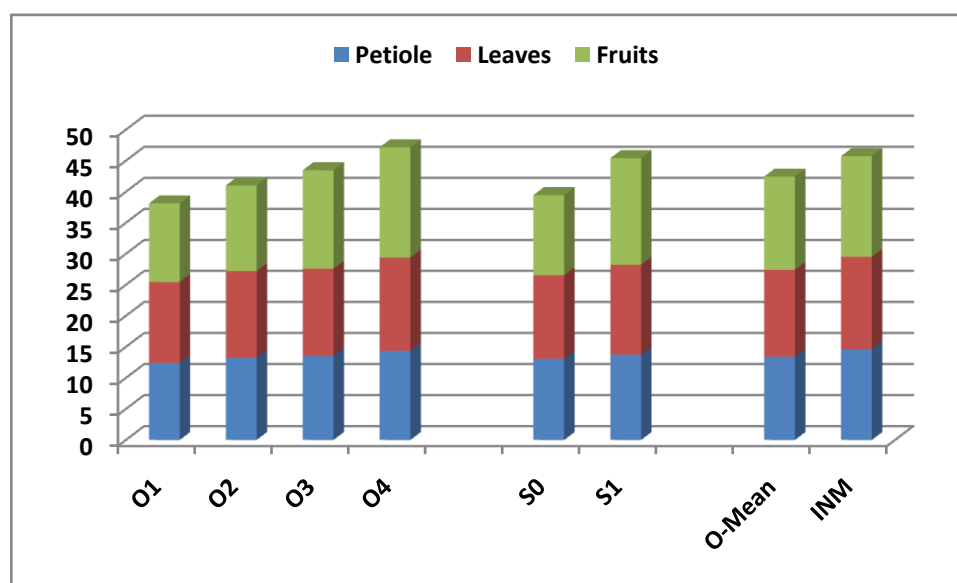


Fig.4: Effect of different treatments on N uptake (kg/ha) by petiole, leaf and fruit

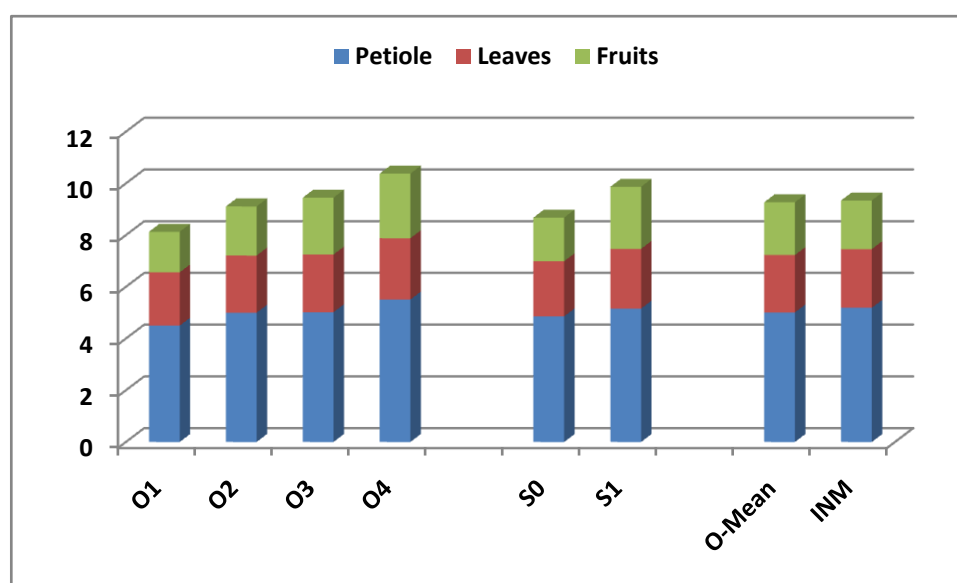


Fig.5: Effect of different treatments on P uptake (kg/ha) by petiole, leaf and fruit

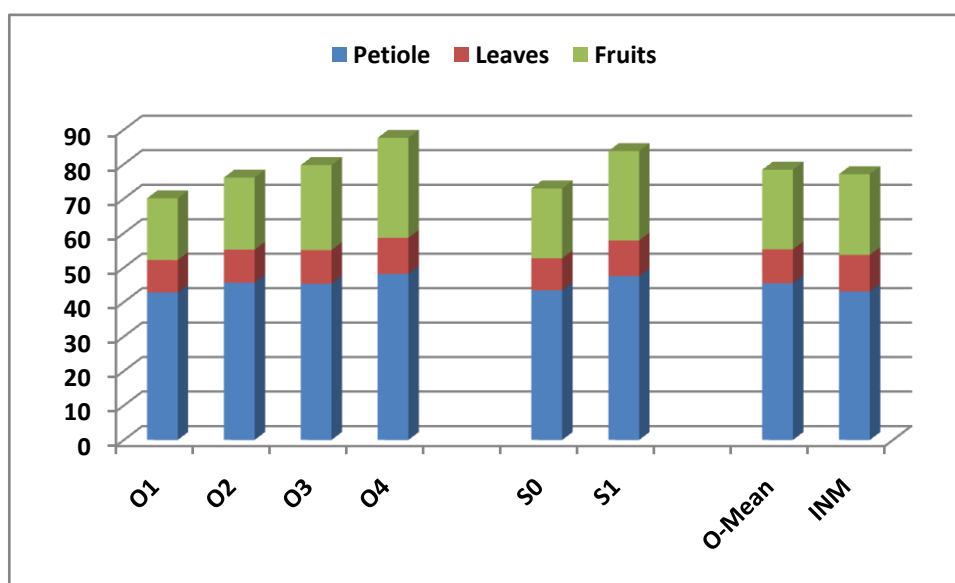


Fig.6: Effect of different treatments on K uptake (kg/ha) by petiole, leaf and fruit

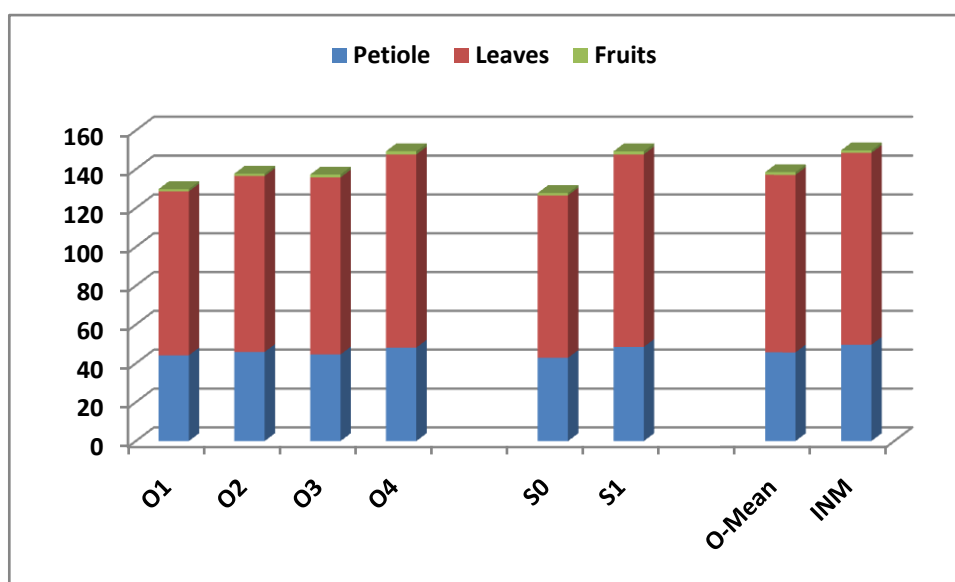


Fig.7: Effect of different treatments on Fe uptake (g/ha) by petiole, leaf and fruit

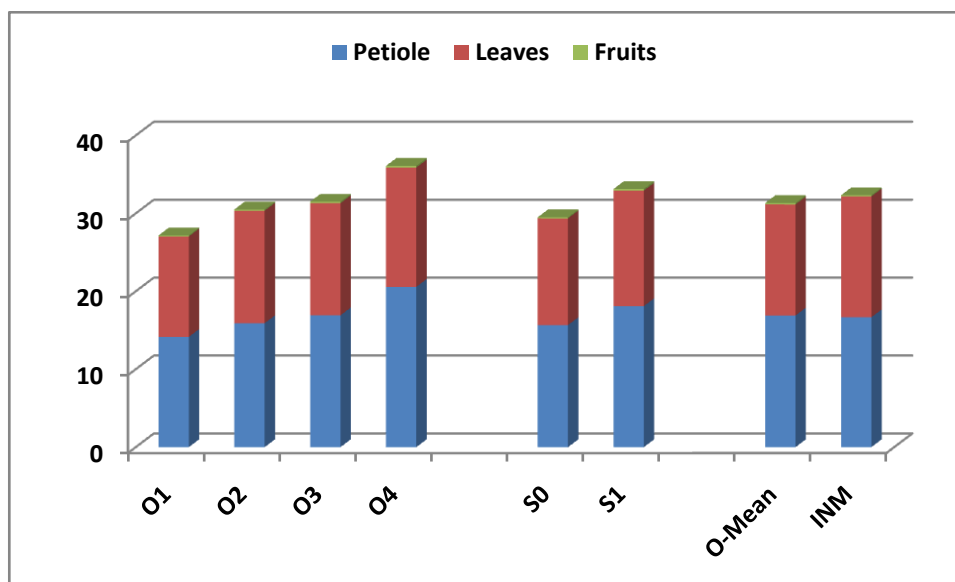


Fig.8: Effect of different treatments on Mn uptake (g/ha) by petiole, leaf and fruit

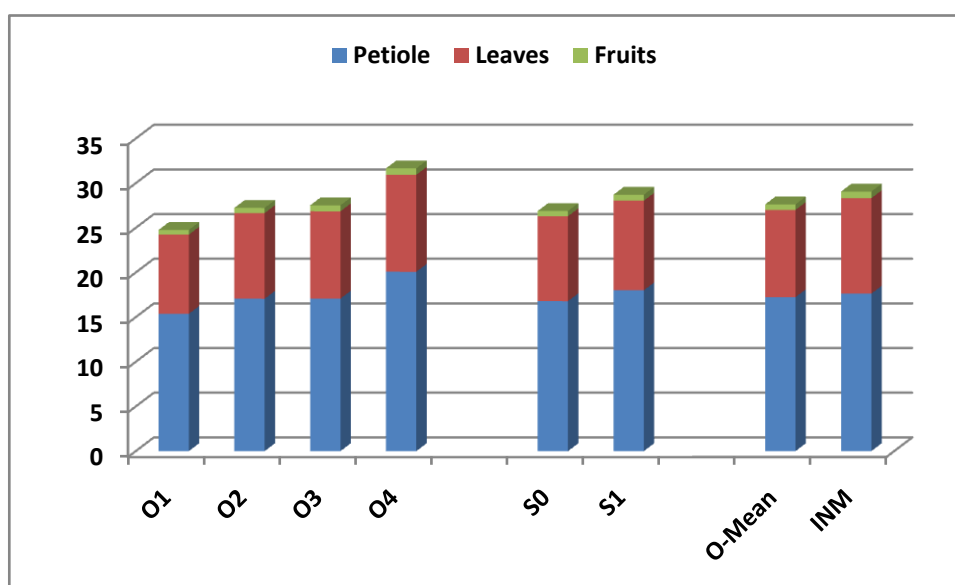


Fig.9: Effect of different treatments on Zn uptake (g/ha) by petiole, leaf and fruit

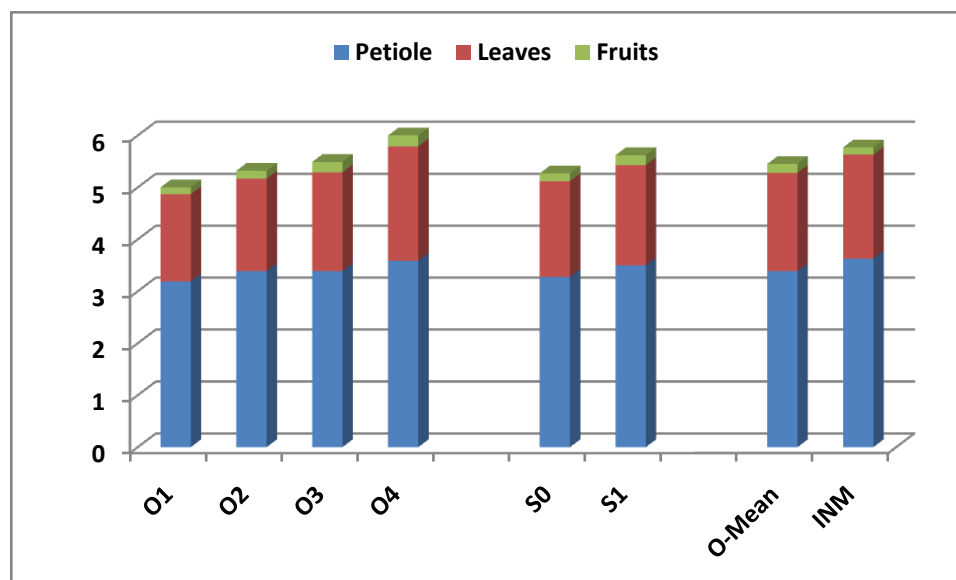


Fig.10: Effect of different treatments on Cu uptake (g/ha) by petiole, leaf and fruit

Table 94: Effect of different treatments on N, P and K uptake (kg/ha) by papaya (pooled)

Treatments	N			P			K		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	36.91	39.33	38.12	7.88	8.39	8.13	67.68	72.48	70.08
O ₂	37.31	44.73	41.02	8.52	9.71	9.11	70.47	81.76	76.11
O ₃	40.81	46.12	43.46	8.79	10.11	9.45	73.60	85.82	79.71
O ₄	42.87	51.46	47.17	9.53	11.24	10.38	80.16	95.12	87.64
Mean	39.47	45.41	42.44	8.68	9.86	9.27	72.98	83.79	78.39
Source	S	O	O x S	S	O	O x S	S	O	O x S
SEm±	0.65	0.92	1.30	0.22	0.32	0.45	1.61	2.28	3.22
CD at 5%	1.89	1.27	NS	0.65	0.91	NS	4.66	6.59	NS
CV %	8			12			10		
Control			45.74			9.34			77.13
	SEm±	CD at 5%		SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.90	NS		0.31	NS		2.19	NS	

Table 95: Effect of different treatments on Fe and Mn uptake (g/ha) by papaya (pooled)

Treatments	Fe			Mn		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	124.73	134.84	129.78	26.66	27.67	27.17
O ₂	123.31	152.18	137.75	28.95	32.07	30.51
O ₃	127.09	147.49	137.29	28.88	34.12	31.50
O ₄	136.06	162.58	149.32	33.55	38.64	36.09
Mean	127.80	149.27	138.54	29.51	33.12	31.32
Source	S	O	O x S	S	O	O x S
SEm±	3.13	4.43	6.26	0.75	1.06	1.50
CD at 5%	9.07	12.82	NS	2.17	3.07	NS
CV %	11			12		
Control			149.74			32.33
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	4.24	NS		1.11	NS	

Table 96: Effect of different treatments on Zn and Cu uptake (g/ha) by papaya (pooled)

Treatments	Zn			Cu		
	S ₀	S ₁	Mean	S ₀	S ₁	Mean
O ₁	24.40	25.11	24.75	4.95	5.03	4.99
O ₂	25.73	28.73	27.23	5.03	5.59	5.31
O ₃	26.38	28.68	27.53	5.31	5.68	5.49
O ₄	31.01	32.31	31.66	5.81	6.18	5.99
Mean	26.88	28.71	27.79	5.27	5.62	5.45
Source	S	O	O x S	S	O	O x S
SEm±	0.58	0.81	1.15	0.12	0.16	0.23
CD at 5%	1.67	2.36	NS	0.34	0.48	NS
CV %	10			10		
Control			29.05			5.76
	SEm±	CD at 5%		SEm±	CD at 5%	
Control v/s rest	0.78	NS		0.16	NS	

5.3 Quality parameters

The study being related to organic nutrient management, the quality parameters *viz.*, shelf life, TSS, acidity, ascorbic acid, total sugar and reducing sugar were also determined from papaya fruit. With an exception of TSS, all the parameters were affected conspicuously due to mean effect of O and S only. Similarly, in case of control *v/s* rest analysis also indicated that all the quality parameters were differed significantly between organics mean and INM mean.

5.3.1 Comparison of organics *v/s* INM mean

Between the two nutrient management systems, organic nutrient management showed superiority over INM by recording significantly higher values of shelf life, ascorbic acid, total sugar and reducing sugar. Contrarily to this, titratable acidity was higher with INM as compared to organics mean. On pooled basis, the magnitude of increase in shelf life, TSS, ascorbic acid, total sugar and reducing sugar with organics was 16, 9, 11, 12 and 9 per cent over INM system. It is well established fact that quality of fruit is invariably better with organics than INM or inorganic. This is responsible for fetching more prices in market of organic produce than INM or inorganic produce. This become more pertinent in the era of health consciousness among the people and more so in urban population. Similarly improvement in quality parameters of papaya with organic nutrient management has also been reported by Ravishanker *et al.*, 2010b and Singh *et al.*, 2010. Though the results of the present study corroborate with these scientists, yet no specific reason for improvement in quality of fruit has been specified by them. In short this is still debatable issue. Of course Hossain *et al.* (1990) and Yadav *et al.* (2011a) reported that the improvement in quality of fruits under INM system was due to better nutrient availability, uptake and transport to fruit from leaves of papaya.

5.3.2 Comparison with in organic treatments

Among the organics treatments, O₄ *i.e.*, application of BC: VC: CC in equal proportion recorded significantly higher values of shelf life, ascorbic acid, total sugar and reducing sugar content in papaya fruit as compared to O₂ and O₁, but O₃ was next in ranking. The values of shelf life, ascorbic acid, total sugar and reducing sugar recorded with O₄ treatment were 9, 7, 8 and 8 per cent more than O₁ treatment. The overall improvement in the quality of fruit under O₄ treatments could be attributed to the reasons given for increase in fruit yield of papaya. As like organics, application of pseudostem sap also exerted significant beneficial effect on quality parameters in comparison to its no application. Here also the reasons quoted for fruit yield in 5.2 are applicable.

In all the cases, acidity was more in INM, O₁ and S₀ than organic mean, O₄ and S₁. Actually higher acidity in papaya fruit facilitate better canning than lower acidity of fruit. Of course, the stage for canning require of excess fruit in market under organic farming has not reached in India.

5.4 Soil properties

The soil samples collected from two depth after harvest of crop were analysed for pH, EC, organic C, available N, P, K, Fe, Mn, Zn and Cu as well as for the physical properties *viz.*, BD, HC and WAS, the treatment wise results have been discussed in preceding chapter. Here more emphasis has been given to some important fertility and physical parameters with special focus on control *v/s* rest analysis.

5.4.1 Comparison between organic mean & INM

There was no significant difference between the means of organic treatments and INM mean with respect to EC and pH. However, the soil fertility parameters *viz.*, organic carbon content (Figs. 11 and 12),

available N, P and K (Figs. 13 to 18) were significantly higher with organic treatment mean in comparison to INM. The results further revealed that this effect was more pronounced in surface layer than subsurface strata. With respect to available micronutrients cations in soil (Figs. 19 to 22), all the cations was significantly more with organic treatment mean than INM control. Similarly, lower BD (Figs. 23 and 24), higher HC (Figs. 25 and 26) and WSA (Figs. 27 and 30) values

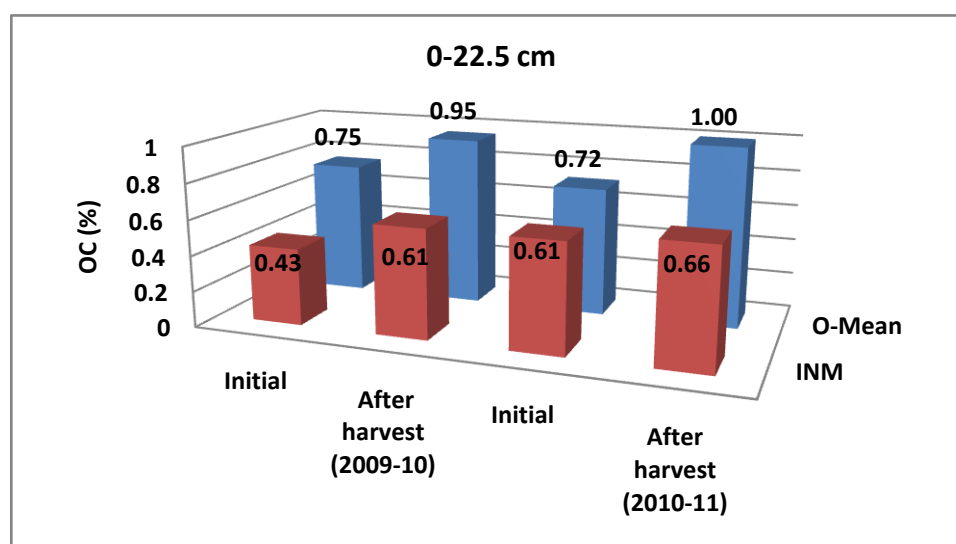


Fig.11: Mean organic carbon content (%) in surface soil under INM and organic nutrient management system

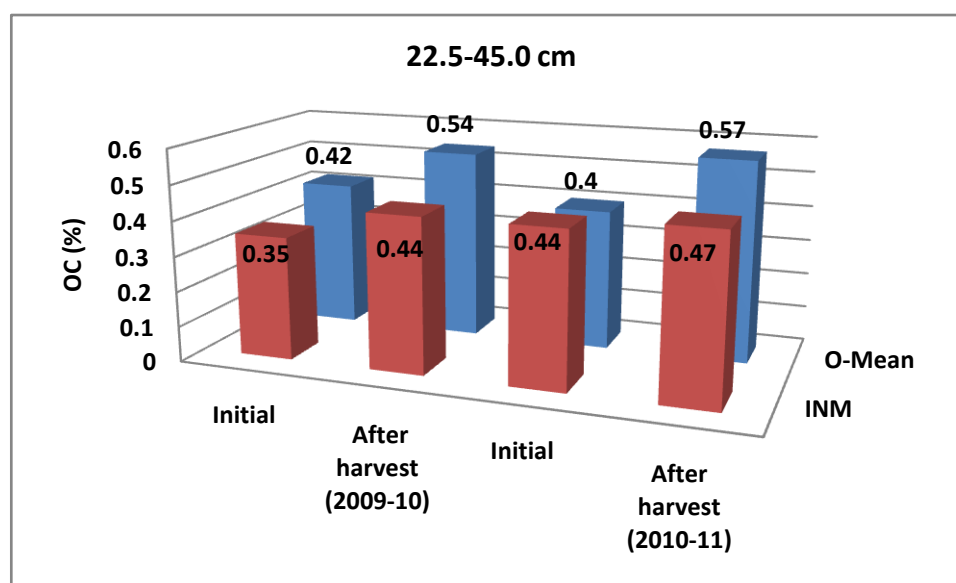


Fig.12: Mean organic carbon content (%) in sub surface soil under INM and organic nutrient management system

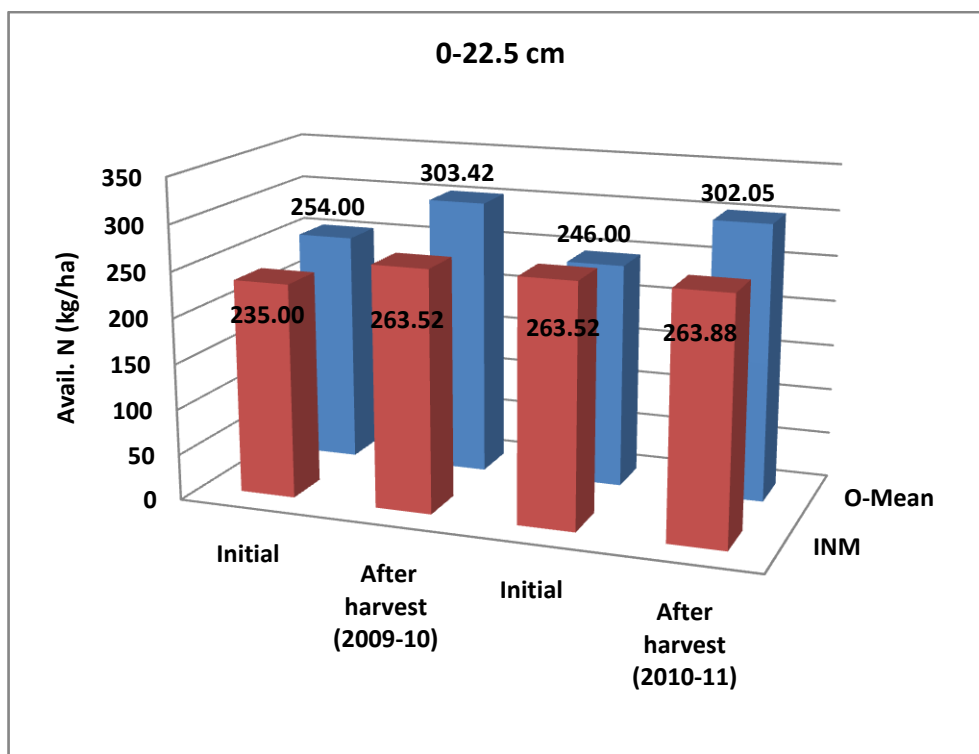


Fig.13: Mean available N content (kg/ha) in surface soil under INM and organic nutrient management system

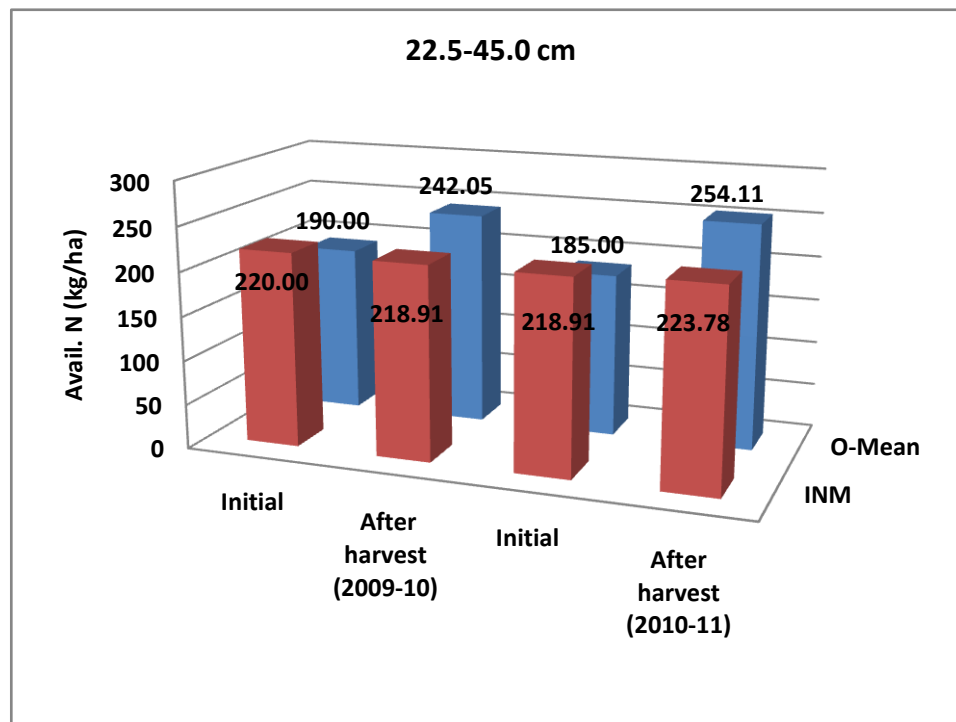


Fig.14: Mean available N content (kg/ha) in sub surface soil under INM and organic nutrient management system

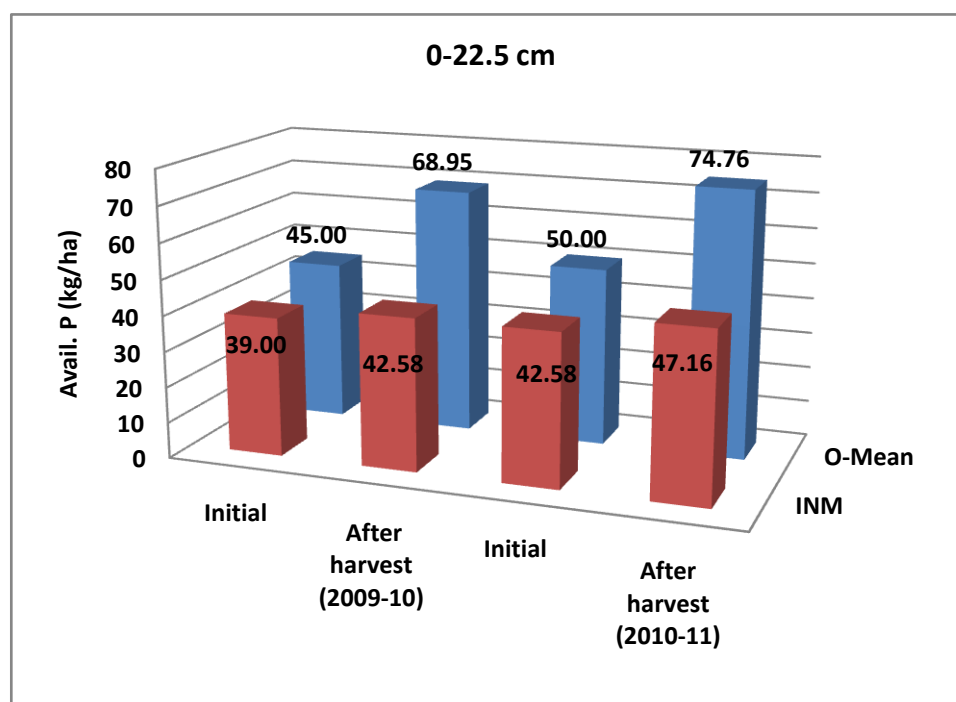


Fig.15: Mean available P content (kg/ha) in surface soil under INM and organic nutrient management system

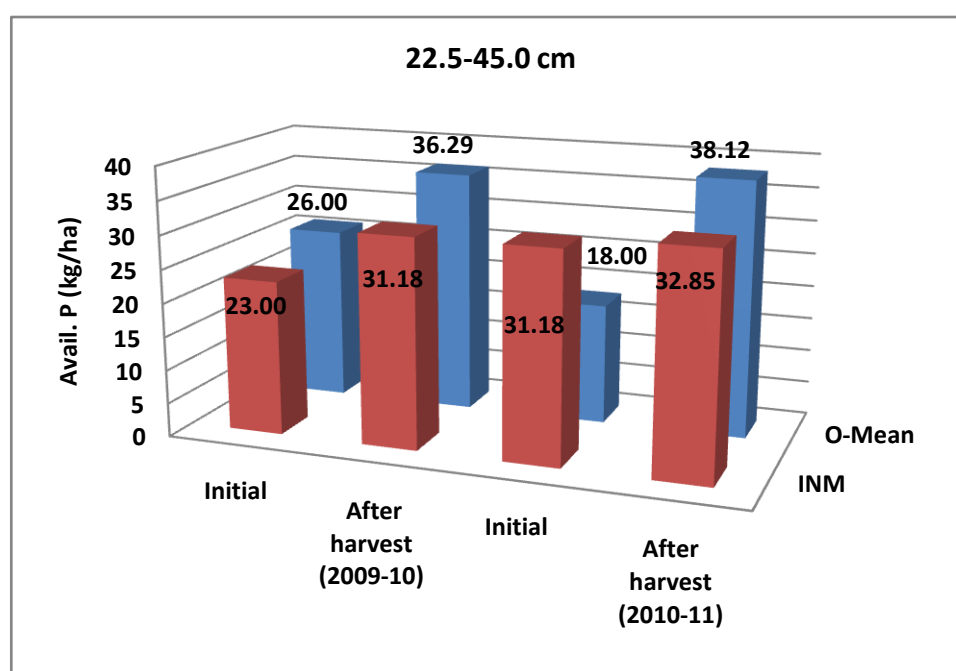


Fig.16: Mean available P content (kg/ha) in sub surface soil under INM and organic nutrient management system

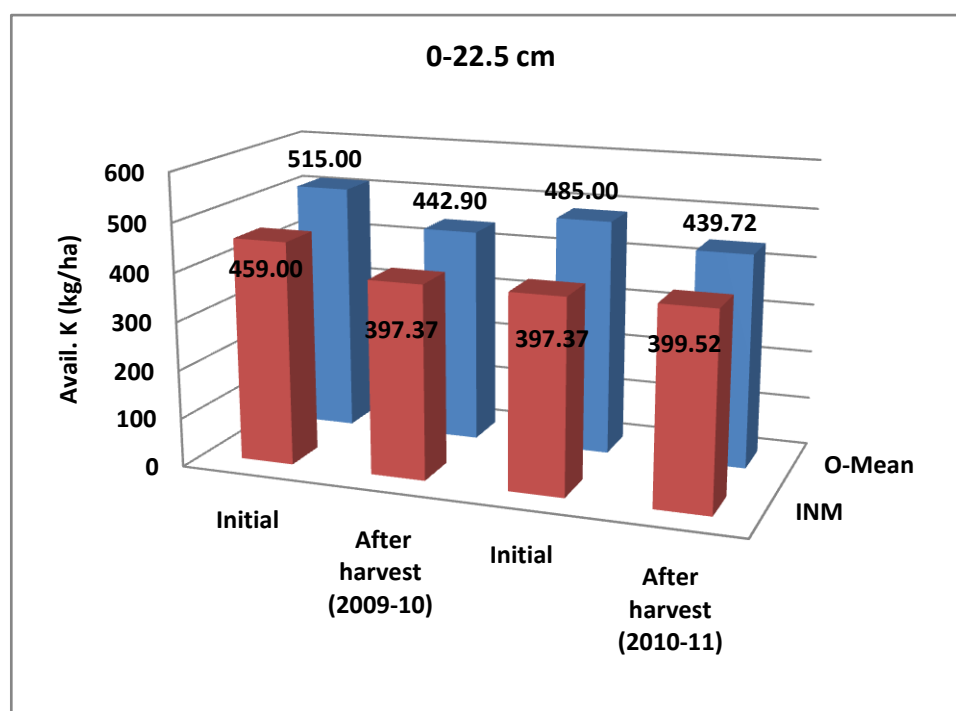


Fig.17: Mean available K content (kg/ha) in surface soil under INM and organic nutrient management system

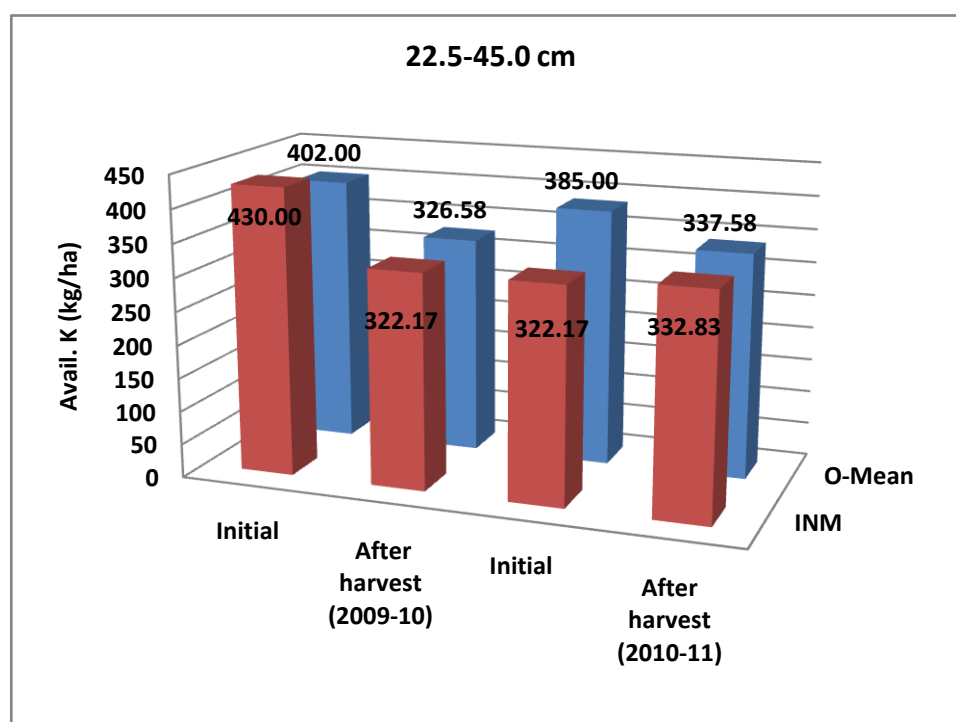


Fig.18: Mean available K content (kg/ha) in sub surface soil under INM and organic nutrient management system

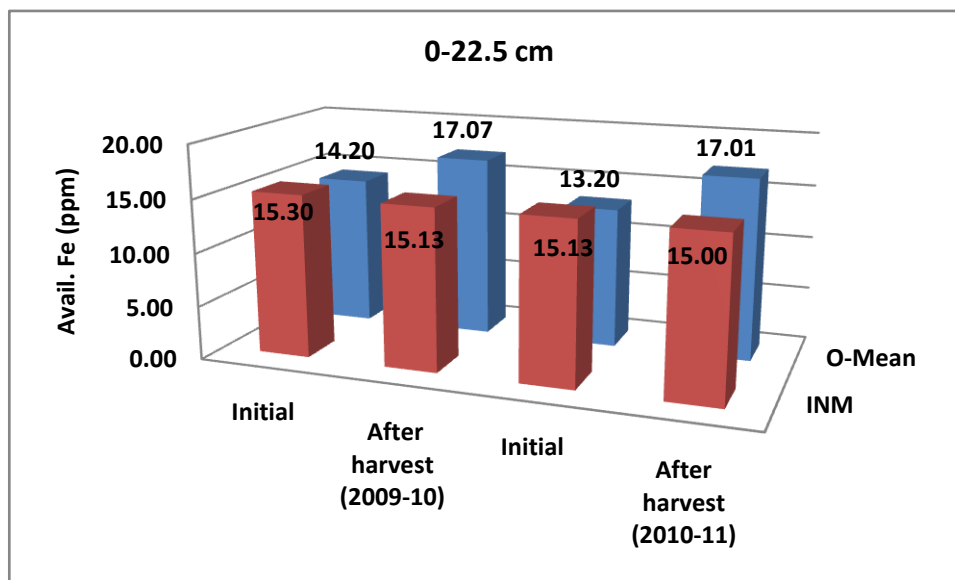


Fig.19: Mean available Fe content (ppm) in surface soil under INM and organic nutrient management system

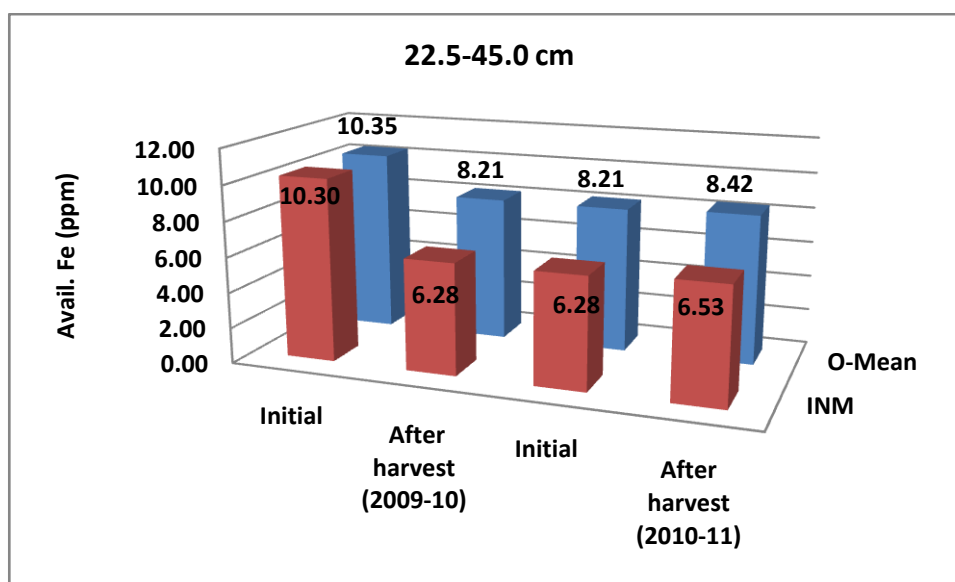


Fig.20: Mean available Fe content (ppm) in sub surface soil under INM and organic nutrient management system

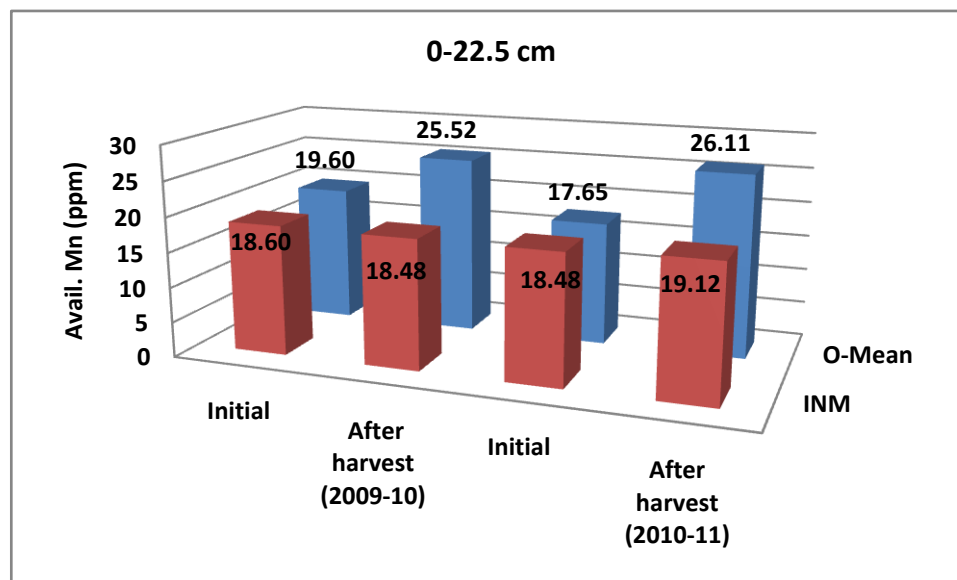


Fig.21: Mean available Mn content (ppm) in surface soil under INM and organic nutrient management system

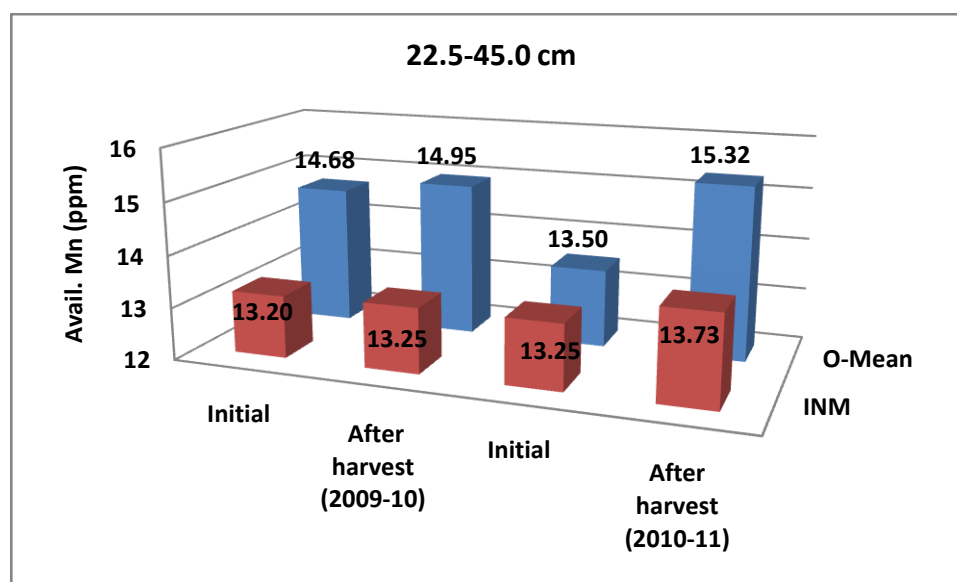


Fig.22: Mean available Mn content (ppm) in sub surface soil under INM and organic nutrient management system

were registered with organic treatment mean than INM control. The effect was more pronounced on finer and coarser fractions of aggregate in both the layers of sampling. From soil fertility point of view, as compared to initial values, after harvest of crop soil fertility was tended to improve under both the nutrient management system, but the improvement was more consistent with organic nutrient management system than INM during both the years. This was more visible in surface layer than lower layer of soil. This is because of the reason that the content of nutrient in organic manures is in organic form which mineralizes and then taken up by the crop. In other words, the organic sources have more residual effect than combined use of organic and inorganic sources for supplying plant nutrients. This implies that soil fertility is maintained rather improved under organic nutrient management system in comparison to INM system. This is particularly true for the increase of organic carbon due to addition of large quantity of organics. Similarly contribution of improvement in physical properties of soil leading to more microbial activity towards better nutrient availability in soil under organic nutrient management system also cannot be ruled out. The result of present study are in agreement with those earlier reported by Abdelaty and Gamal (2009) and Bhanuvally *et al.* (2010).

Like soil fertility, physical properties viz., BD, HC and WAS of soil were also favorably improved under organic nutrient management system in comparison to INM system. Because of application of bulky organic manures in large quantity for supplying plant nutrient, the bulk density of the soil was decreased. Similarly, tremendous increase in both the fractions of aggregation (Figs. 27 to 30) under organic nutrient management system over INM might further made the soil more porous which results in lower BD. An improvement in aggregation with the addition of organics is due to increase in microbial activity, intermediate products release during decomposition and release of some mucilage

also facilitates aggregation of soil particles. Effect of this phenomenon is more pronounced in presence of crop like papaya.

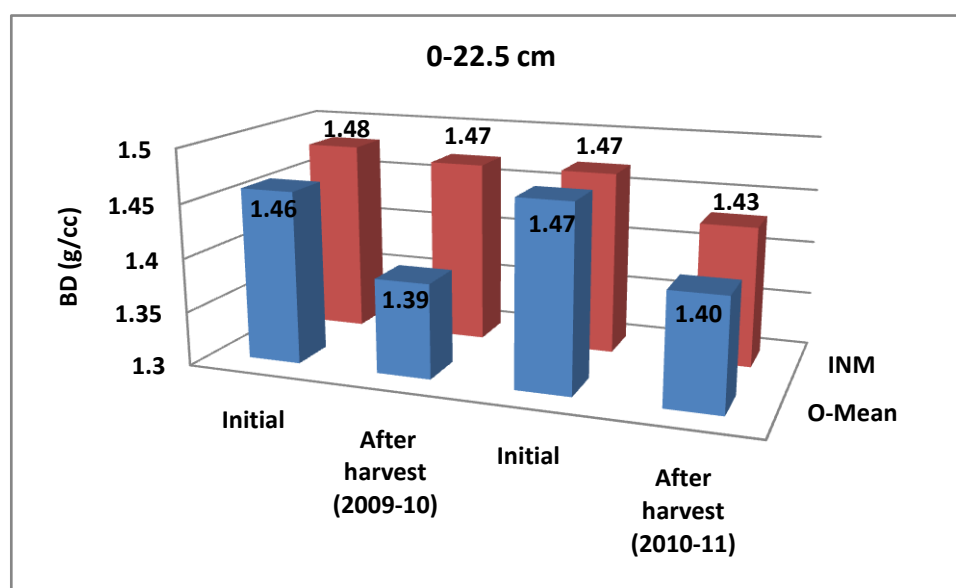


Fig.23: Mean bulk density (g/cc) of surface soil under INM and organic nutrient management system

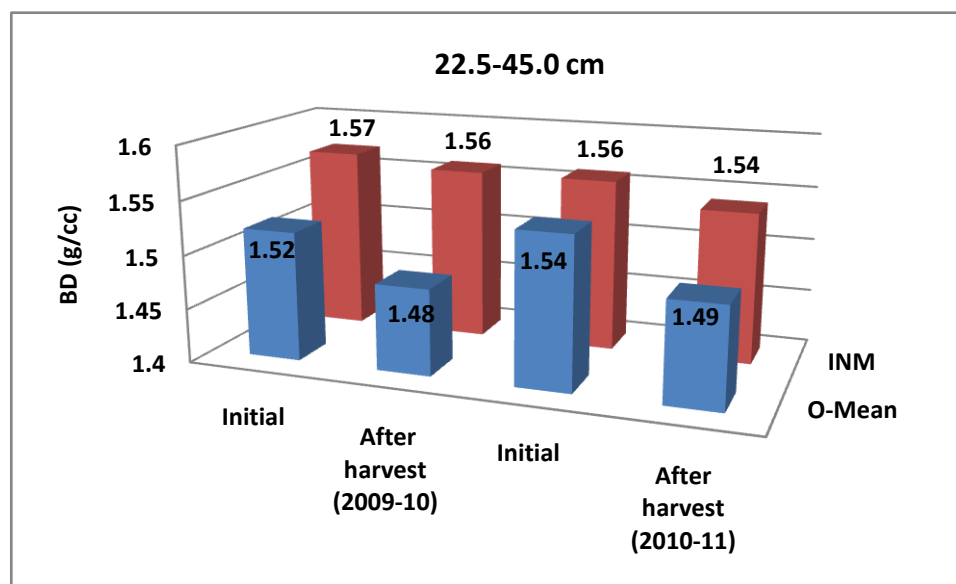


Fig.24: Mean bulk density (g/cc) of sub surface soil under INM and organic nutrient management system

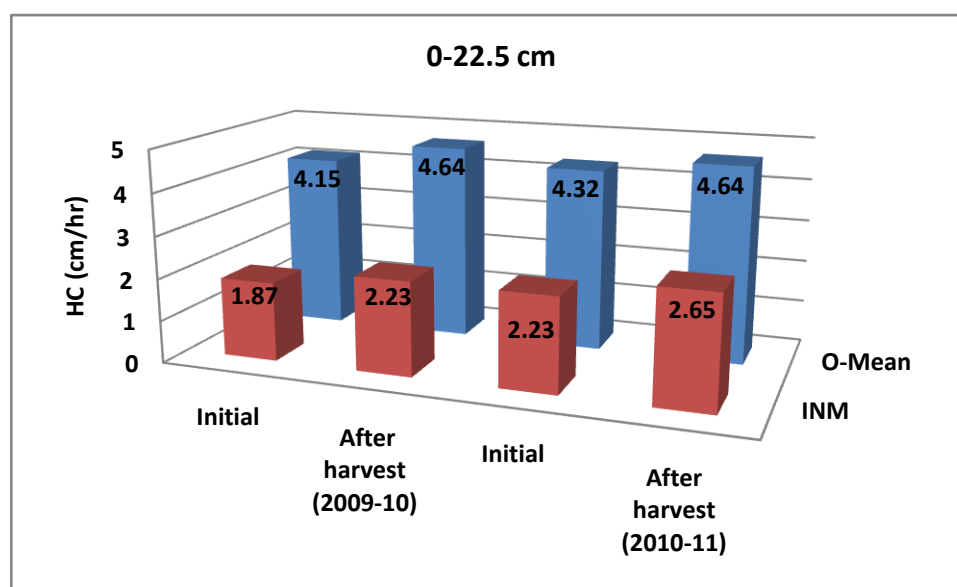


Fig.25: Mean hydraulic conductivity (cm/hr) of surface soil under INM and organic nutrient management system

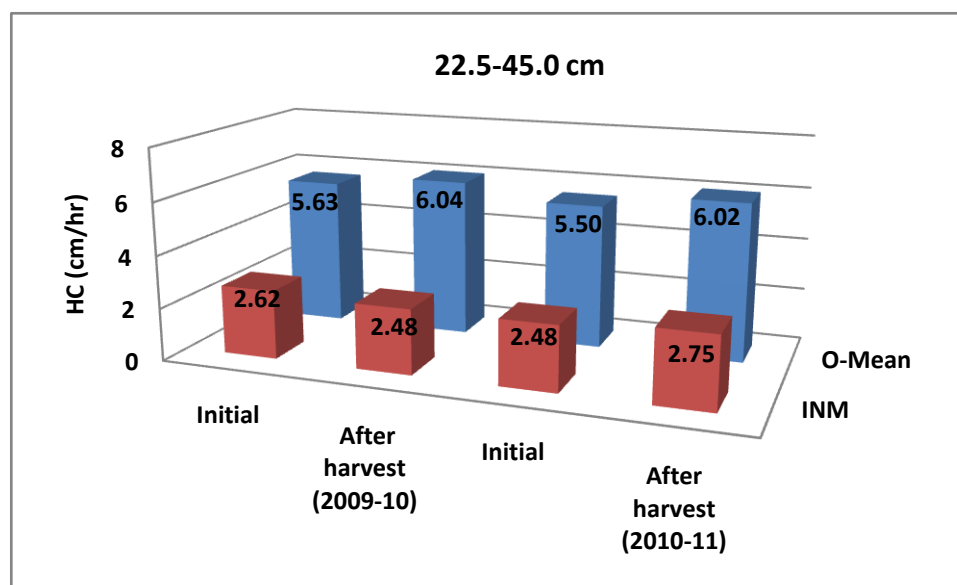


Fig.26: Mean hydraulic conductivity (cm/hr) of sub surface soil under INM and organic nutrient management system

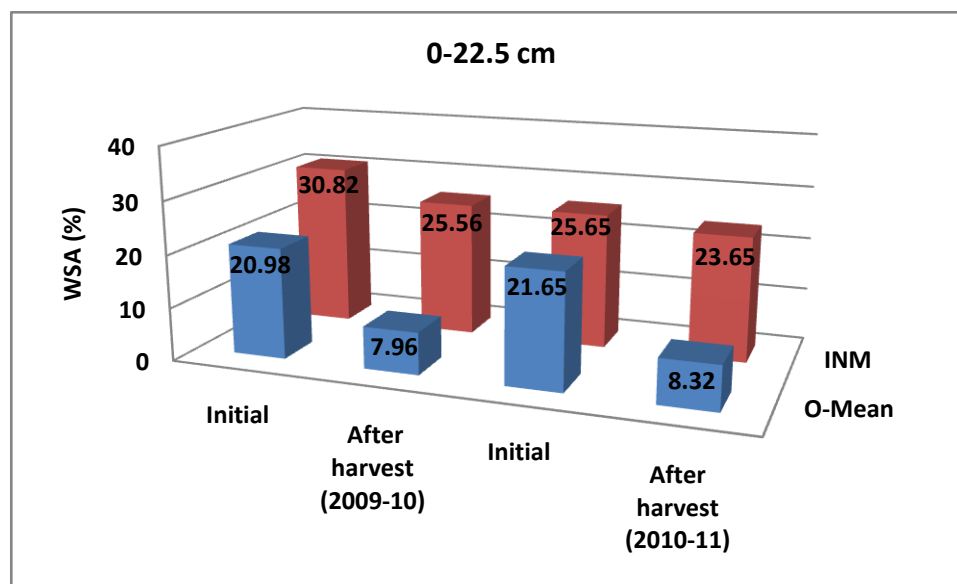


Fig.27: Mean water stable aggregates (0.5-1.0 mm) of surface soil under INM and organic nutrient management system

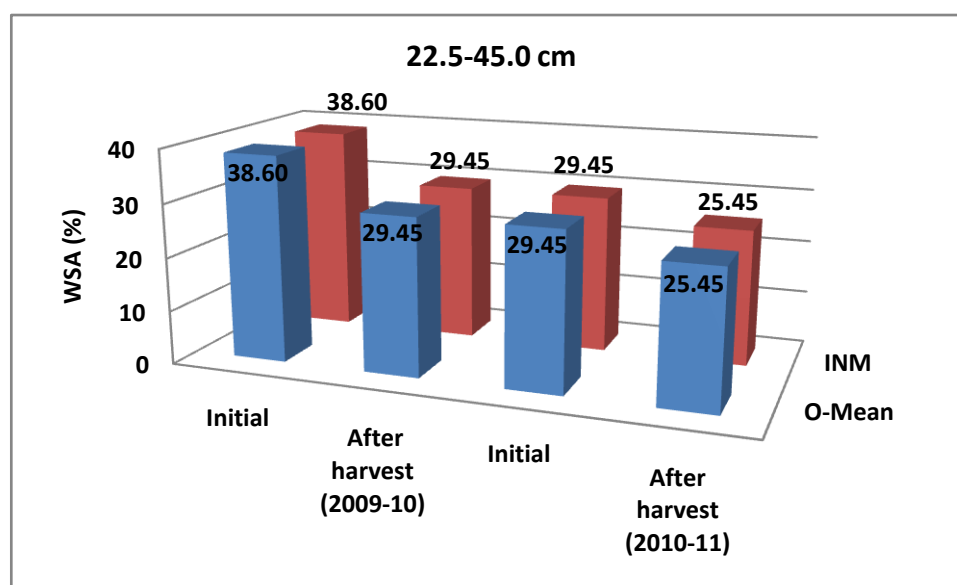


Fig.28: Mean water stable aggregates (0.5-1.0 mm) of sub surface soil under INM and organic nutrient management system

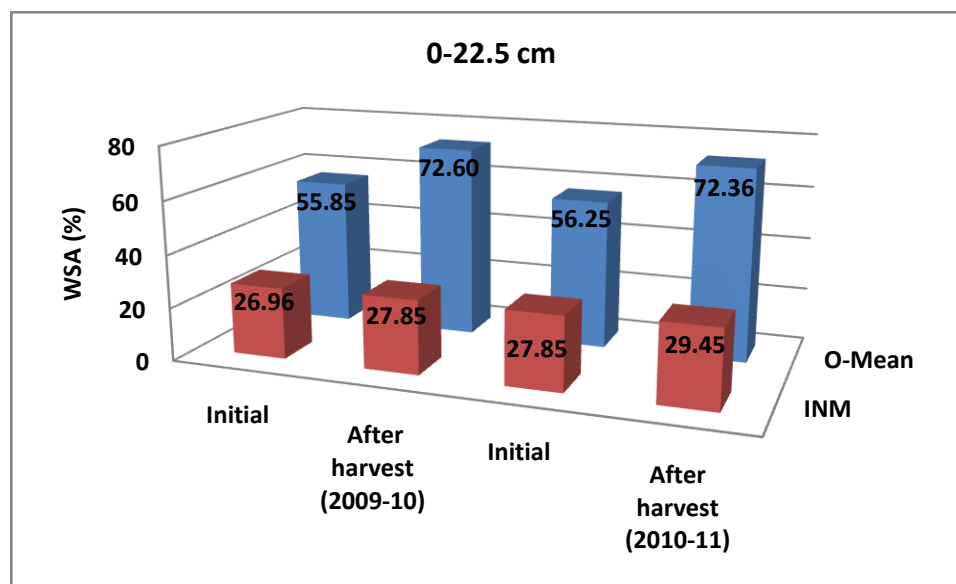


Fig.29: Mean water stable aggregates (>1.0 mm) of surface soil under INM and organic nutrient management system

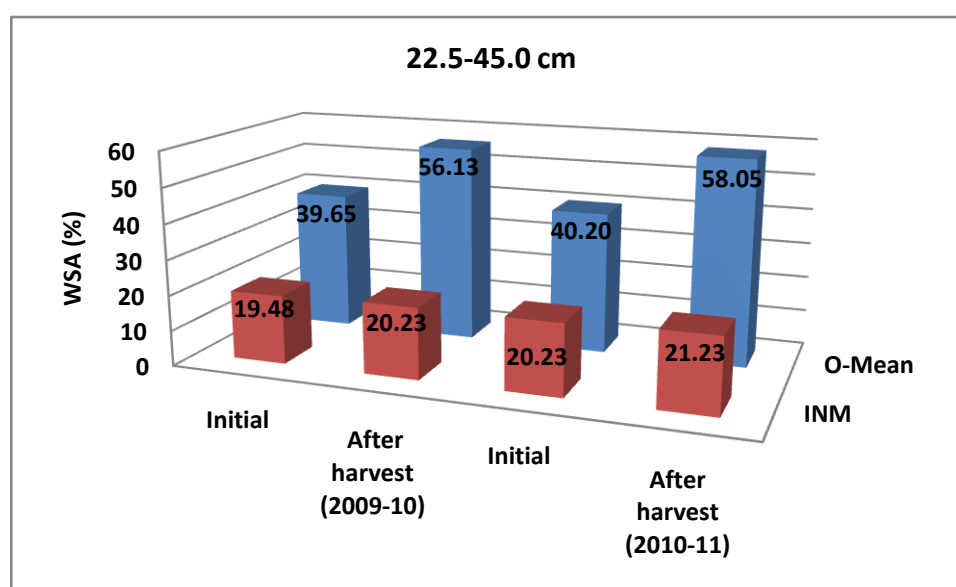


Fig.30: Mean water stable aggregates (>1.0 mm) of sub surface soil under INM and organic nutrient management system

Because of released root exudates which also helps in aggregation of soil particles. These are the reasons for lower values of BD recorded in both depth with organic nutrient management system. The combined effect of increase in WSA and decrease in BD was also ultimately reflected on higher hydraulic conductivity of soil under organic nutrient

management system as compared to INM. Similar beneficial effects of application of organics on physical properties of soil have also been reported earlier by Bhadrapur *et al.* (1970) on four types of soil viz., dry land soil, red soil, black soil, and black alkali soil and reported that application of FYM and groundnut cake increased the soil aggregation in all types of soil as compared to control, while physical properties like water holding capacity and per cent pore space was better in all type of soils receiving FYM alone.

5.4.2 Comparison among the organic treatments

The organics treatment did not exert any significant effect on soil pH, salinity, organic C, available N, P, Zn and Cu content in both the depth of soil. Contrary to this, the content of available K, Fe and Mn only in surface layer of soil was affected significantly due to organics treatment during both the years. In all the case, O₄ recorded significantly higher values of available K, Fe and Mn as compared to O₂ and O₁ but it was closely followed by O₃ treatment. The probable reason for higher availability of K, Fe and Mn with O₄ treatment as compared to O₂ and O₁ is proportion of BC: VC: CC and content of these element in them. An application of sap could significantly increase in the content of organic C, available N and K mostly in surface soil during both the years. This increase could be credited to the additional amount of these elements particularly K added through sap (Table 98). It is interesting to note that application of sap could improve the availability of Mn during both the years and Zn during second year in subsurface soil significantly only. Though, sap was applied in eight equal splits, yet the higher content of available Mn and Zn in subsurface soil is not explained as the quantity of sap applied at each split was only 1000 ml/plant. So the chances of leaching of Mn and Zn to subsurface are minimum.

Table 98: Amount of nutrients added through sap application

Source	N	P	K	Fe	Mn	Zn	Cu
	g/plant						
S ₁	0.56	0.24	13.60	0.060	0.021	0.003	-

Application of banana pseudostem sap @ 8 l/plant

5.5 Economics

Ultimate aim of conducting any research in agriculture by using either sole organic or integrated use of organic + inorganic + biological sources for nutrient management towards enhancing crop productivity is to increase the net income of the farmers. In present study, both the system of nutrient management was studied simultaneously. In order to know the economic viability of both the system, the economics has been computed in two way *i.e.* selling price same for organic as well as INM fruit and premium price for fruits of organic nutrient management system (Table 99). If we compare organics v/s INM, the net profit realized with INM is Rs. 3,07,520/ha with BCR of 3.3 as against the net profit of Rs. 1,32,224/ha with BCR of 0.77 with organic treatment mean. Even if we consider best organic treatment O₄ the net profit (1, 61, 787 Rs/ha) is almost half of the INM. This economics clearly indicate that though in comparison to INM, organic nutrient management is less remunerative yet it is economically viable.

Alternative scenario generated by considering premium price for organic product (Rs 10/kg), the net income realized is raised to 4,32,674/ha with BC of 2.53. Another important point emerged from the present study is that organic farming is costly affair. This is because of the reason that though net profit is higher with organic mean yet the BCR (2.5) is less than INM (3.3). This suggests that the input cost in organic farming is more than INM. Even the best organic treatment O₄ is also having BCR of 2.77 this is also true for S₀ and S₁, where S₁ recorded net

profit of 4,47,914 Rs/ha with premium price as against Rs. 4, 08,506/ha with S_0 . Here also, the significant increase in fruit yield could not counter balance the cost of sap *i.e.*, less BCR of 2.32 with S_1 and higher BCR of 2.43 with S_0 under organic farming situation. This may not be true for INM system in the nutrient input cost is less than organics. In view of the fruit yield and economics of organic treatment and INM, if area expansion of organic farming is to be achieved, then Government should encourage the farmers through providing incentives in the form of soft loan for establishing infrastructure for preparing on farm manures. This will improve the economics of organic farming system. Similar observations were also made by Reddy *et al.* (2010) and Yadav *et al.* (2011b).

Table 99: Comparative economics of papaya under different treatments

Treatments	Treatment cost (Rs/ha)	Common cultivation cost (Rs/ha)	System cost (Rs/ha)	Total cost (Rs/ha)	Yield (t/ha)	Market price			Premium price		
						Income (Rs/ha)	Net income (Rs/ha)	BC	Income (Rs/ha)	Net income (Rs/ha)	BC
O₁	67778	45163	15667	128608	52.26	261300	132692	1.03	522600	393992	3.06
O₂	130623	45163	15667	191453	57.50	287500	96047	0.50	575000	383547	2.00
O₃	108722	45163	15667	169552	64.97	324850	155298	0.92	649700	480148	2.83
O₄	121533	45163	15667	182362	68.83	344150	161788	0.89	688300	505938	2.77
S₀				167994	57.65	288250	120256	0.72	576500	408506	2.43
S₁				193386	64.13	320650	127264	0.66	641300	447914	2.32
O-Mean				172226	60.89	304450	132224	0.77	608900	436674	2.54
INM	32000	45163	15667	92830	80.07	400350	307520	3.31	-	-	-

Market price @ Rs. 5.0/kg for both

Premium price @ Rs. 5.0/kg for INM and Rs. 10/kg for organic

VI. SUMMARY AND CONCLUSIONS

A field experiment consisting of eight treatment combinations involving different proportion of three organics on N equivalent basis (O_1 : 50 % RDN through bio compost + 50 % RDN through castor cake, O_2 : 50 % RDN through bio compost + 50 % RDN through vermi compost, O_3 : 50 % RDN through bio compost + 25 % RDN through vermi compost + 25 % through castor cake and O_4 : 33.3 % RDN through bio compost + 33.3 % RDN through vermi compost + 33.4 % RDN through castor cake) and two levels of banana pseudostem sap application (S_0 : without sap and S_1 : with sap @ 8 l/plant) along with one INM controls outside the organic farm were tested in FRBD with three replications. The results presented and discussed in the preceding chapters, are summarised here.

6.1 Summary

6.1.1 Crop growth and yield

- I. Significantly higher plant height, stem girth, length of petiole, number of leaves per plant, average fruit weight, number of fruits per plant, fruit yield per plant and fruit yield were recorded in INM control.
- II. The magnitude of increase in parameters viz., plant height, girth, petiole length, number of leaves per plant, average fruit weight, number of fruit per plant, fruit yield per plant and fruit yield (t/ha) at the harvest with INM control was 16.7, 16.5, 37.4, 21.9, 21.2, 9.1, 31.5 and 31.4 per cent, respectively over the mean of organics treatments.
- III. Among the organics treatments, application of BC: VC: CC in the proportion of 33.3: 33.3: 34.4 (O_4) showed superiority with respect to growth and yield parameters over O_1 and O_2 but it was closely followed by O_3 treatment (BC 50: VC 25: CC 25).

- IV. The extent of increase in growth and yield parameters *viz.*, plant height, stem girth, petiole length, number of leaves/plant, number of fruits/plant, average fruit weight, fruit weight/plant and fruit yield at harvest with O₄ treatment was 14, 16, 2, 6, 10, 18, 32 and 32 per cent, respectively over O₁.
- V. The leaves, petiole and fruit dry matter yield of papaya was significantly higher with INM control as compared to the means of organics treatments, where as leaves and petiole dry matter yield was not influenced significantly due to organic treatments.
- VI. Despite addition of higher amount of all the nutrients inadvertently in O₂ treatment, fruit yield was significantly lower with O₂ than O₄.
- VII. On pooled basis, application of sap @ 8 l/plant in 8 equal splits (S₁) increased the plant height, girth, number of fruits/plant and fruit yield (t/ha) by 12.3, 17.0, 6.8 and 11.2 per cent, respectively over no application of sap.

6.1.2 Nutrient uptake

- I. The total uptake (leaves + petiole + fruit) of nutrients *viz.*, N, P, K, Fe, Mn, Zn and Cu by papaya crop did not differ significantly between organic mean and INM control.
- II. Among the organics treatments, O₄ treatment recorded significantly higher values of total uptake (petiole + leaves + fruit) of all the nutrients as compared to O₂ and O₁, but it was at par with O₃.
- III. In comparison to O₁ and O₂ in O₄ treatment, an accumulation of nutrient was more in reproductive part (fruit) than vegetative part.
- IV. Application of sap (S₁) also increased the translocation of N, P, K, Fe, Mn, Zn and Cu from vegetative to reproductive parts as compared to no application of sap. The magnitude of increase in accumulation of N, P, K, Fe, Mn, Zn and Cu in fruit with S₁

treatment was 37.81, 24.32, 30.93, 1.06, 0.63, 2.33 and 3.38 per cent, respectively over S_0 treatment.

6.1.3 Quality parameters

- I. Between the two nutrient management systems, organic nutrient management showed superiority over INM by recording significantly higher values of shelf life, ascorbic acid, total sugar and reducing sugar. On pooled basis, the magnitude of increase in shelf life, TSS, ascorbic acid, total sugar and reducing sugar with organics was 16, 9, 11, 12 and 9 per cent, respectively over INM system.
- II. Among the organics treatments, O_4 *i.e.*, application of BC: VC: CC in equal proportion recorded significantly higher values of shelf life, ascorbic acid, total sugar and reducing sugar content in papaya fruit as compared to O_2 and O_1 , but O_3 was next in ranking. The values of shelf life, ascorbic acid, total sugar and reducing sugar recorded with O_4 treatment were 9, 7, 8 and 8 per cent, respectively more than O_1 treatment.
- III. Application of pseudostem sap also exerted significant beneficial effect on quality parameters in comparison to its no application.
- IV. Acidity was more in INM, O_1 and S_0 than organic mean, O_4 and S_1 treatment.

6.1.4 Soil properties

- I. There was no significant difference between the means of organic treatments and INM mean with respect to EC and pH.
- II. The soil fertility parameters *viz.*, organic carbon, available N, P and K content were significantly higher with organic treatment mean in comparison to INM. The results further revealed that this effect was more pronounced in surface layer than subsurface strata.

- III. All the micronutrients cations were significantly more with organic treatment mean than INM control.
- IV. Similarly, lower BD, higher HC and WSA values were registered with organic treatment mean than INM control.
- V. From soil fertility point of view, as compared to initial values, after harvest of crop soil fertility was tended to improve under both the nutrient management systems, but the improvement was more consistent with organic nutrient management system than INM during both the years. This was more visible in surface layer than lower layer of soil.
- VI. The organics treatment did not exert any significant effect on soil pH, salinity, organic C, available N, P, Zn and Cu content in both the depth of soil.
- VII. The treatment O₄ recorded significantly higher values of available K, Fe and Mn as compared to O₂ and O₁ but it was closely followed by O₃ treatment.
- VIII. Application of sap could improve the availability of Mn and Zn in subsurface soil significantly.

6.1.5 Economics

- I. The input cost in organic farming is more than INM.
- II. When the economics is computed considering equal price of fruit, the net profit realized with INM is Rs. 3,07,520/ha with BCR of 3.3 as against the net profit of Rs. 1,32,224/ha with BCR of 0.77 with organic treatment mean. Even with the best organic treatment O₄ the net profit (1, 61, 787 Rs/ha) is almost half of the INM.
- III. However, by considering the premium price for organic produce (Rs 10/kg), the net income realized is raised to Rs. 4,32,674/ha with BC of 2.53. Even the best organic treatment O₄ is also having BCR of 2.77

- IV. By considering premium price of fruit, the organic treatments with S_1 recorded net profit of Rs.4,47,914/ha as against Rs.4,08,506/ha with S_0 treatment.
- V. Treatment S_1 recorded higher BCR of 2.43 with S_0 under organic farming situation.

CONCLUSIONS

Based on the results of two years field experiments following conclusions are drawn.

- i. For achieving higher fruit yield of papaya with superior quality under organic farming situation of South Gujarat, it is essential to apply bio compost: vermi compost: castor cake in equal proportion to supply N @ 200 g/plant and
- ii. Application of banana pseudostem sap @ 8 l/plant further enhanced the fruit yield and improved the quality of papaya grown under organic farming situation.
- iii. Soil fertility was tended to improve under both the nutrient management system, but the improvement was more consistent with organic nutrient management system than INM during both the years.
- iv. The input cost in organic farming is more than INM.
- v. Growing papaya under organic farming is profitable / feasible only if farmer can get the premium price of fruits.

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