Integrated Nutrient Management of Papaya (*Carica papaya* L.) : Application of Microbial Consortium Enriched Organic Manures for Yield and Fruit Quality Enhancement

ABSTRACT

An experiment was undertaken to study the effect of integrated nutrient management on growth, yield and quality of papaya under Kerala conditions. The trial was conducted in RBD. Papaya variety used for the study was Surya with ten treatments. The results revealed that the applications of microbial consortium enriched organic manures in papaya plants (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers fertilizers (240 N: 240 P_2O_5: 480 K_2O (g $plant^{-1}$) + 10 kg FYM) resulted in the highest number of fruit production, enhanced fruit weight , total fruit yield per plant. It also resulted in the production of fruits with highest fruit length, girth, pulp percentage and flesh thickness. Fruit quality characters like high TSS, less acidity, higher carotenoid content, ascorbic acid content, highest total sugar content and reducing sugar content were enhanced in papaya. Organoleptic characters of fruit were also enhanced by adopting integrated nutrient management in papaya . Papaya being an important fruit crop of Kerala gaining importance nowadays. Integrated nutrient management (INM) involves efficient and judicious supply of all major and micro components of plant nutrients including local available resources on sustainable basis. Papaya is known to be a heavy feeder of nutrients (NPK) and information regarding the effect of INM is more important

Key words: Papaya, microbial consortium, yield, fruit quality, nutrient management

1. INTRODUCTION

Papaya (*Carica papaya* Linn.) is an important fruit belong to the family Caricacae. It is grown widely throughout the state. Papaya is the highly nutrient exhaustive fruit

crop because of its quick growth, continuous fruit habit throughout year and heavy fruit yield [1]. As such judicious application of fertilizers are needed to meet out the nutritional requirement of the plants. However, continuous application of huge amount of chemical fertilizers hamper the soil health and biological environment [3].

The use of organic products to improve the growth and production of horticultural plants has garnered significant attention and has become the new paradigm in agricultural production in recent times, after it was established that chemical fertilizers have a detrimental effect on the physical, chemical, and biological properties of the soil. Integrated Nutrient management relates to maintaining soil fertility and crop nutrient supply at an optimal rate of production by optimizing the advantages of all available organic, inorganic and biological component sources.Nutritional balance is highly essential for plant development, fruit productivity, and quality. It is a useful strategy for increasing fruit production. Papaya fruit is a crop that responds very well to nutrients. The interactive benefits of mixing organic and inorganic sources of nutrients as part of integrated nutrient management strategy was shown to be superior to the usage of each component separately under high intensive cropping systems. The integrated nutrient nourishes papaya, which involves conjunctive use of chemical fertilizers and organic manures to sustain crop productionand maintenance of soil health. However, biofertilizers offer an alternative to chemical inputs, which have an ability of mobilizing the nutrionally important elements from nonuseable to useable form through chemical processes and known to increase yield [7] and [6]).

The integrated nutrient supply system iconsisted of using biofertilizers and organic manures, which has the potential to increase crop output by using more ecologically friendly nutrient sources. Scientific crop management is needed to enhance papaya fruit's output potential. To meet the increasing demand of this fruit , it is most essential to increase both fruit productivity and quality.

Beneficial microbes increase nutrient availability, reduce disease, reduce nutrient losses, and help to degrade toxic compounds [2] and [8]. Integrated nutrient management is a sucessfull strategy method which helps in accelerated and

enhanced use of fertilisers with corresponding adoption of organic manures and biofertilizers to maintain productivity [5].

In this context, the present investigation was under taken with an objective of finding out the effect of integrated nutrient management in papaya, involving the use of microbial consortium for enhancing the fruit yield and quality of papaya.

2. MATERIALS AND METHODS

2.1 Experimental site

The experiment on Integtated Nutrient Management of papaya was conducted at Farming Systems Research Station, Sadanandapurram(Picture1) of Kerala Agricultural University. The experimental site was located in latitude 8.98'47" N and longitude 76.80'47" E. The soil in the experiment site was laterite. The pH of the soil was acidic with a value of 4.92. The available nitrogen, phosphorus and potassium contents of the soil were 275kg ha^{-1}, 15kg ha^{-1} and 165kg ha^{-1} respectively.

2.2 Experimental material

The experiment was conducted using IIHR- gynodioecious papaya variety, Surya. With characteristics such as high fruit quality, excellent taste, good keeping quality and medium sized fruits with reddish orange coloured flesh which gives higher acceptability of this variety among consumers

2.3Experimental details : The design selected for the experiment was Randomized Block Design (RBD) with ten treatments and three replications and number of plants per plot was 6. Spacing followed was 2m x 2m.

2.4 Treatment details

Treatments imposed during the experiment were T_1: 240 N: 240 P_2O_5: 480 K_2O (g $plant^{-1}$) + 10 kg FYM (Package of Practice Recommendation), T_2: N (25 %) as poultry manure enriched vermicompost + N (75%), P and K of T_1, T_3: N (25 %) as neem cake enriched vermicompost + N (75%), P and K of T_1 ,T_4: NPK (25 %) as PGPR mix-1 enriched vermicompost + N, P and K 75% of T_1 ,T_5: N (25 %) as *Azospirillum* enriched vermicompost + N (75%), P and K of T_1,T_6: N (50 %) as poultry manure enriched vermicompost + N (50%), P and K of T_1, T_7: N (50 %) as

neem cake enriched vermicompost + N (50%), P and K of T_1,T_8: NPK (50 %) as PGPR mix-1 enriched vermicompost + N, P and K 50% of T_1, T_9: N (50 %) as *Azospirillum* enriched vermicompost + N (50%), P and K of T_1 and T_{10}- Absolute control.

Soil application of treatments

Urea, Rajphos and Muriate of Potash will be used as chemical fertilizer sources.Manures and fertilizers were applied in six equal splits at 2 months interval.Fertilizer application started 1 month after transplanting of the seedlings to the main field.

Observations noted:

during the study period observations noted were yield characters like number of fruits per plant,total yield per plant, flesh thickness, fruit volume, pulp percentage and fruit quality characters like TSS, acidity, ascorbic acid, carotenoids,

2.5 Data collection:

Yield characters

Fruit weight (g)

Random selection of 5 fruits from each plant was done and its weight was taken using a weighing balance and average of fruit weight was calculated.

Fruit length (cm)

Fruit length was measured after cutting the fruits longitudinally and measuring from the stalk end to the floral end of selected fruits of each observational plant using scale or thread.

Fruit girth (cm)

Fruit girth was measured at the centre of longitudinally cut fruit, where maximum width is there and then average was found.

Fruit volume (cc)

Volume of fruits in each treatment was calculated using water displacement method. Fruits were immersed into a container fully filled with water and was placed in another container. The volume of the fruit is equal to the volume of displaced water and can be measured using a measuring cylinder.

Total yield per plant (kg)

For getting total yield per plant, the total number of fruits harvested from individual plant was counted and multiplied it with average fruit weight. It is expressed in kilogram plant^{-1}.

Quality characters

Total soluble solids (°Brix)

Hand refractometer was used to measure TSS of the selected ripened fruits and expressed in degree brix. One drop of the fruit juice was put on the refractometer's prism and percent TSS were recorded directly [6].

Acidity (%)

A known weight of fruit sample was ground with distilled water. After filtration through muslin cloth volume was made upto 100 ml in a standard flask using distilled water and an 10 ml aliquot from this sample was titrated against standard 0.1 N sodium hydroxide (NaOH). Usually Phenolphthalein is used as indicator and appearance of pink color was the end point. Titrable acidity usually expressed as per cent of citric acid [6].

Total carotenoids (mg 100g^{-1})

Carotenoid content in a fruit sample was estimated using petroleum ether-acetone extraction method. A known weight of sample with acetone was ground in a pestle and mortar. Then extract was transferred into a conical flask and extraction was continued till the it became colorless. Then the extract has taken into a separating funnel. Later to this extract added 10-15 ml of petroleum ether, distilled water and anhydrous sodium sulphate and the separating funnel was thoroughly shaken. Then after collecting upper layer formed, reextracted the lower layer. The colour was measured at 452 nm in spectrophotometer [6].

Ascorbic acid content (mg 100g-1)

Estimation of ascorbic acid was done using 2,6-dichloro phenol indophenol titration method. Five grams of fruit sample was taken and extracted with four percent oxalic acid solution. Then estimation of ascorbic acid was done using standard indicator dye 2,6- dichlorophenol indophenol and expressed as mg 100g^{-1} of fruit [6].

Total sugar (%)

Total sugar was determined using Fehling's solution and expressed as gram of glucose per 100 grams of pulp.

Reducing sugar (%)

Estimation of reducing sugar was done using Fehling's solution and expressed as gram of glucose per 100 grams of pulp.

Non- reducing sugar (%)

The estimation of non-reducing sugars was done by subtracting the reducing sugars from the total sugars and expressed as grams of glucose per 100 grams of pulp .

Organoleptic evaluation of fruits

Sensory analysis at the laboratory level were done by fifteen members panel of judges selected from a group of teachers and students. Appearance, color, taste, texture, flavor and overall acceptability are the major quality characters included for evaluation of papaya fruit based on nine-point hedonic scale [9].

3. RESULTS AND DISCUSSION

3.1 Yield Characters

The results of the experiment (Table 1.) revealed that highest fruit number (54.26) was reported by the application of NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers (240 N: 240 P_2O_5: 480 K_2O (g $plant^{-1}$) + 10 kg FYM) whereas least number of fruits was reported from absolute control. Highest fruit weight (Fig. 1) of 975.52g and highest total yield per plant (52.93 kg) was noticed with T_4 (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers)**.** Highest fruit length of (22.30 cm) and width (43.68 cm) was noticed with the application of microbial consortium enriched organic manures in papaya plants (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers). This was followed by T_3 (N (25 %) as neem cake enriched vermicompost along with N (75%), P and K of recommended dose of

fertilizers. Lowest value of fruit length and girth was reported from absolute control. Highest fruit volume (975.75cc) , pulp % (90.28) and flesh thickness (3.58 cm) was also reported from the application of NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers.

Table 1. Effect of integrated nutrient management on yield characters of papaya

Treatments	Number of fruits Per Plant	Fruit weight(g)	Total yield per plant (Kg)	Fruit length(cm)	Fruit girth (cm)	Fruit volume (cc)	Pulp %	Flesh thickness(cm)
T_1	42.00	800.58	33.62	17.92	34.02	790.38	70.26	2.66
T_2	46.62	850.44	39.65	18.82	38.25	850.96	82.52	3.08
T_3	50.51	905.16	45.72	21.26	41.96	900.64	86.74	3.24
T_4	54.26	975.52	52.93	22.30	43.68	975.75	90.28	3.58
T_5	42.18	815.74	34.40	18.00	36.12	812.42	75.42	2.95
T_6	38.00	630.46	23.95	16.34	30.50	555.26	62.64	2.02
T_7	38.75	710.38	27.52	16.75	31.86	628.68	65.82	2.28
T_8	40.94	750.68	30.73	17.24	32.50	700.25	72.68	2.52
T_9	36.52	520.12	19.00	15.82	28.40	415.34	61.44	1.78
T_{10}	32.06	490.62	15.73	14.28	24.68	260.76	55.25	1.64
CD(0.05)	1.68	2.68	2.03	1.33	2.44	8.21	6.00	0.33

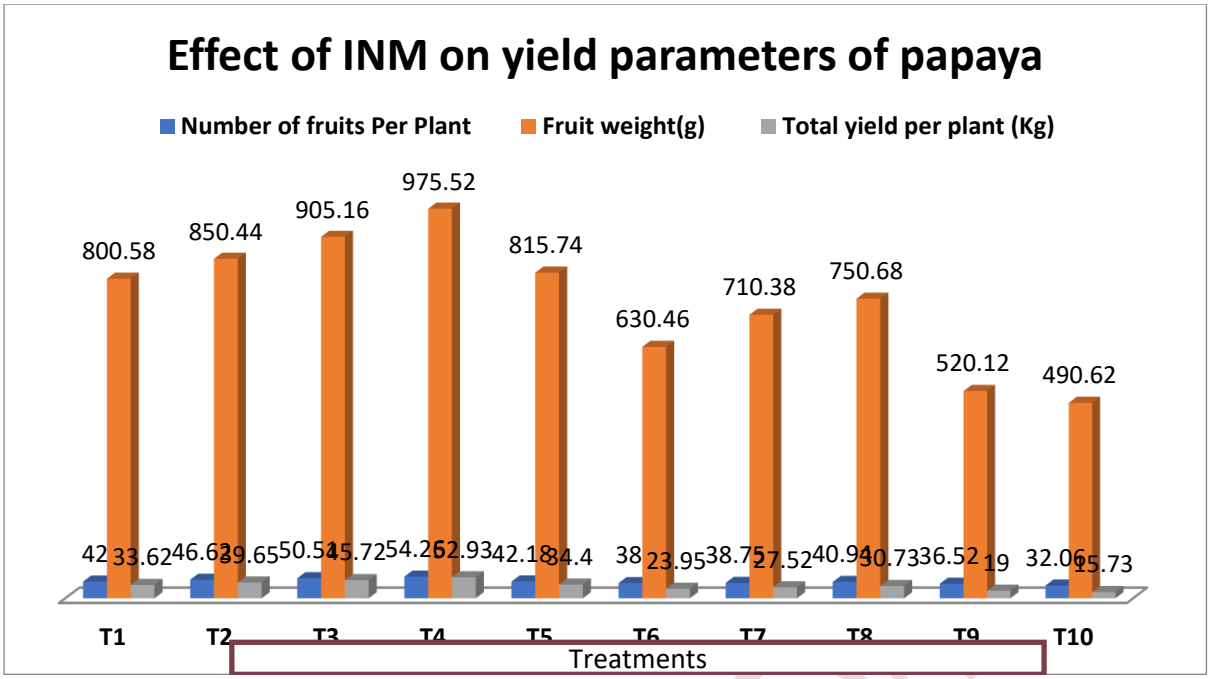

Fig.1. Effect of INM on yield parameters of papaya

3.2 Fruit quality characters

The results of the experiment (Table 2.) revealed that highest TSS (15.64◦brix)was obtained by the application of NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers (240 N: 240 P_2O_5: 480 K_2O (g $plant^{-1}$) + 10 kg FYM) whereas least number TSS was noticed with absolute control (11.00◦brix). Least fruit acidity (Fig.2.) was noticed (0.10 %) with the application of microbial consortium enriched organic manures in papaya plants (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers. This was followed by T_3 (0.13%) (N (25 %) as neem cake enriched vermicompost along with N (75%), P and K of recommended dose of fertilizers. Highest value of fruit acidity was reported from absolute control (0.28%). Highest carotenoid content (2.35 mg 100 g^{-1}), ascorbic acid content (68.67 mg 100 g^{-1}), total sugar(9.94%)andreducing sugar (8.82%) was reported

fromT_4(NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers)**.** Highest non reducing sugar content (1.32%) was seen with the application ofT_3 (N (25 %) as neem cake enriched vermicompost along with N (75%), P and K of recommended dose of fertilizers.

Table 2. Effect of integrated nutrient management on fruit quality characters of papaya

Treatments	**TSS(◦brix)**	**Acidity (%)**	**Carotenoids (mg 100 g^{-1})**	**Ascorbic acid (mg 100 g^{-1})**	**Total sugar (%)**	**Reducing sugar(%)**	**Non reducing sugar (%)**
T_1	13.02	0.18	2.00	54.76	8.62	7.54	1.08
T_2	14.28	0.15	2.12	60.82	9.08	8.02	1.06
T_3	14.90	0.13	2.18	63.22	9.76	8.44	1.32
T_4	15.64	0.10	2.35	68.67	9.94	8.82	1.12
T_5	13.50	0.15	2.05	58.84	8.80	7.80	1.00
T_6	12.0	0.25	1.42	45.44	7.28	6.20	1.08
T_7	12.82	0.23	1.59	49.82	7.62	6.35	1.30
T_8	12.46	0.20	1.86	52.65	8.08	6.84	1.24
T_9	11.90	0.25	1.40	44.36	7.06	6.18	0.88
T_{10}	11.00	0.28	1.38	40.56	6.50	5.0	0.55
CD(0.05)	0.611	0.006	0.285	4.495	0.423	0.649	0.531

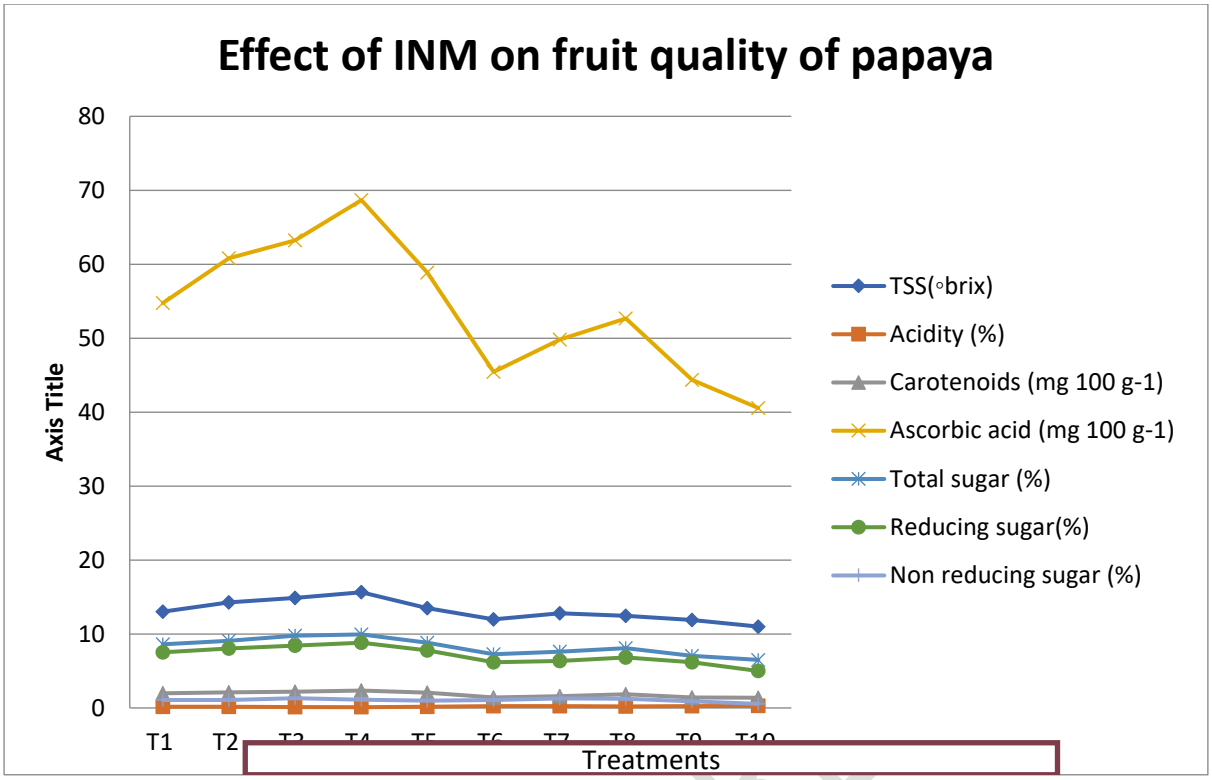

Fig.2. Effect of INM on fruit quality of papaya

Picture1. INM plot of papaya

3.3 Organoleptic quality

Highest score for organoleptic qualities of papaya was noticed in case of appearance (3.58) , colour (3.49), flavor (3.62). taste (3.75), texture (3.5) , papain odour (3.28) and overall acceptability (21.22) was noticed with the application of microbial consortium enriched organic manures in papaya plants (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers and lowest overall acceptability (12.14) was reported from absolute control.

Table 3. Effect of integrated nutrient management on organoleptic qualities of papaya

Treatments	**Appearance**	**Colour**	**Flavour**	**Taste**	**Texture**	**Papain odour**	**Overall acceptability**
T_1	2.82	2.54	2.88	3.00	2.74	2.68	16.66
T_2	3.28	3.00	3.14	3.24	3.18	2.95	18.79
T_3	3.50	3.16	3.48	3.52	3.46	3.20	20.32
T_4	3.58	3.49	3.62	3.75	3.50	3.28	21.22
T_5	3.00	2.82	3.00	3.18	2.95	2.82	17.77
T_6	2.18	2.14	2.25	2.60	2.40	2.42	13.99
T_7	2.35	2.38	2.46	2.80	2.47	2.44	14.90
T_8	2.64	2.50	2.62	2.82	2.66	2.65	15.89
T_9	2.02	2.08	2.18	2.68	2.22	2.28	13.46
T_{10}	1.45	1.95	2.08	2.54	2.00	2.12	12.14

4. CONCLUSION

It was concluded from the study that application of microbial consortium enriched organic manures in papaya plants (NPK (25 %) as PGPR mix-1 enriched vermicompost along with N, P and K 75% of recommended dose of fertilizers fertilizers (240 N: 240 P_2O_5: 480 K_2O (g $plant^{-1}$) + 10 kg FYM) resulted in the highest number of fruit production, enhanced fruit weight , total fruit yield per plant. It also resulted in the production of fruits with highest fruit length, girth , pulp percentage and flesh thickness. Fruit quality characters like high TSS, less acidity, higher carotenoid content, ascorbic acid content, highest total sugar content and reducing sugar content were enhanced in papaya. Organoleptic characters were also enhanced by the integrated nutrient management in papaya including the application of microbial consortium enriched organic manures along with chemical fertilizers under Kerala conditions

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