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INFLUENCE OF ORGANIC AND INORGANIC FERTILIZERS ON GROWTH, YIELD AND PHYSIO-CHEMICAL PROPERTIES OF PAPAYA

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ABSTRACT

A field experiment was conducted to investigate the effect of organic and inorganic fertilizers on growth, yield and physio-chemical properties of papaya (*Carica papaya*) from February to December 2019. The experiment was designed into twelve treatments [T_1 = Control, T_2 = 100% RDF (Recommended Dose of Fertilizers), T_3 = 50% RDF+ 50% MOC (Mustard Oil Cake), T_4 = 50% RDF+ 50% VER (Vermicompost), T_5 = 50% RDF + 50% PM (Poultry Manure), T_6 = 25% RDF+ 75% MOC, T_7 = 25% RDF + 75% VER, T_8 = 25% RDF+ 75% PM, T_9 = 100% MOC, T_{10} = 100% VER, T_{11} = 100% PM and T_{12} = MOC + VER + PM] at the experimental field of Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur. The experiment was laid out in randomized complete block design with three replications. The effect of treatments varied significantly for most of the characters studied. Results showed that the plant growth, yield contributing traits, fruit yield and quality of papaya significantly increased in T_{10} treatment compared to other treatments. The maximum amount of dry matter of fruit (4.37%), TSS (18.17 %), total sugar (9.43 g/ 100g), reducing sugar (6.34 g/ 100g), β- carotene (0.24 mg/ 100g), mineral as Ca (0.39%), Mg (0.33%) and K (2.08%) were found in T_{10} treatment and the minimum amount were found in the control T_1. The maximum amount of non-reducing sugar was obtained from T_{12} (3.93 g/ 100g) and the minimum from T_3 (2.23 g/ 100g). Ascorbic acid was found maximum in T_7 (24.99 mg/100g) and minimum from T_{11} (22.00 mg/100g). A significant influence of T_{10} treatment on growth, yield and physio-chemical characters was observed. The application of 100% vermicompost which influenced growth, yield and physio-chemical properties of papaya in Salna series of Red Brown-terrace soil is suggested.

Keywords: Mustard oil cake, vermicompost, yield traits, β- carotene, ascorbic acid, sugar content, *Carica papaya* L.

INTRODUCTION

Papaya (*Carica papaya* L.) is one of the most nutritious and delicious fruits in the world. It is essentially a tropical fruit and commercially grown in tropical and sub-tropical areas (Yadava *et al*., 1990*)*. It is believed to be originated in Mexico and spread to almost all the corners of the tropical world. It is a good source of protein, carbohydrate, fiber, vitamin A and C, carotene and mineral like iron, phosphorous and potassium (Mamta *et al*., 2017). Papaya is primarily a fresh-market fruit, and is used in drinks, jams, pectin, candies and as crystalized fruit. Green fruit may be cooked

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as a vegetable. Traditionally leaves have been used for treatment of a wide range of ailments, like in the treatment of malaria, dengue, jaundice, immune modulatory and antiviral activity (Singh *et al*., 2020). It has several well-known industrial uses, notably for the enzyme pepsin (EI Moussaoui *et al*., 2001) which has properties similar to gastric pepsin. In Bangladesh, it is one of the leading fruits and the yield of papaya is far below compared to other countries of the world (Chowdhury *et al*., 2008). Singh *et al*. (2012) noted that productivity of papaya is low because of the lack of appropriate nutrient management. Papaya bears flowers and fruits round the year, all the area papaya are increasing and limited information is available on organic production system in this crop (Reddy *et al*., 2010). It is nutrient exhaustive and fertilizer responsive crop. Both organic and inorganic fertilizers have potential role on the growth yield of papaya. But indiscriminate use of inorganic fertilizers changes physical, chemical and biological properties of soil and creates problem to the environment and health hazard due to toxic residual effects. Some of them included increased outbreak of pests and diseases including weeds; affecting the productivity. On the other hand organic fertilizers such as cow dung, vermicompost, poultry manure, FYM and mustard oil cake help in improving soil texture, structure, water holding capacity, aeration and microbial activities of soil (El-Shakweer *et al.*, 1998). A number of studies pointed out to the fact that organic farming approaches offered the most sustainable way of crop production besides contributing to environmental protection through minimizing degradation (Ojeniyi, 2000; Maritus and Vleic, 2001). Further, the organically raised crops besides being nutritious and also eliminated the risk of pesticide residues to the consumers, thus ensuring food safety. Moreover, organically produce product demand is increasing day by day. In view of this, there is needed to be increase production of papaya by organic way. Therefore, the present study was aimed to find out the organic and inorganic fertilizer effects on growth, yield and physio-chemical properties of papaya and also standardize the doses for maximizing yield of papaya.

Materials and Methods

The experiment was conducted at research field and Laboratory of the Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur, during the period from February to December 2019. The site was about 24.09^0 N latitude and 90.26^0 E longitude and at an elevation of 8.40 m from the sea level.

Experimental materials and land preparation

Papaya seedlings (Red lady) were collected from BRAC nursery, Gazipur. The experiment was carried out twelve treatments in a Randomized Complete Block Design (RCBD) with four replications. In each treatment consisted of 8 plants and one replication had 24 plants. The experimental field was 2-3 plough with fine tilth. Pits of 30×30×30 cm were prepared and planting two seedlings of papaya in each pit with the spacing of row to row 2 m and plant to plant 2 m. After at a flowering stage one tree has been cut down from each treatment. Intercultural operation such as weeding, gap filling, staking

and irrigation was done when needed. Dried leaves of plants were removed to keep field disease free.

Treatments of the experiment

T_1: Control

T_2: 100% Recommended dose of fertilizer (225: 100: 225 g N- P_2O_5- K_2O per plant) follow the Fertilizer Recommendation Guide (BARC, 2012)

T_3: 50% Recommended dose + 50% Mustard Oil Cake (2.25 kg/ plant)

T_4: 50% Recommended dose + 50% Vermicompost (6.25 kg/ plant)

T_5: 50% Recommended dose + 50% Poultry Manure (9.25 kg/ plant)

T_6: 25% Recommended dose + 75% Mustard Oil Cake (3.8 kg/ plant)

T_7: 25% Recommended dose + 75% Vermicompost (9.4 kg/ plant)

T_8: 25% Recommended dose + 75% Poultry Manure (13.8 kg/ plant)

T_9: 100% Mustard Oil Cake (4.5 kg/ plant) (BARC, 2012)

T_{10}: 100% Vermicompost (12.5 kg/ plant) (BARC, 2012)

T_{11}: 100% Poultry Manure (18.5 kg/ plant) (BARC, 2012)

T_{12}: Mustard Oil Cake (1.5 kg/ plant) + Vermicompost (4 kg/ plant) + Poultry Manure (6 kg/plant)

Application of treatments

All organics were applied on N equivalent basis. Calculated quantities of inorganic fertilizers and half of total organic fertilizers were applied at the time of planting. Recommended dose of nitrogen and potassium inorganic fertilizers and remaining half of organics were applied in four splits at an interval of 30 days starting from 30 days after transplanting till flowering by ring method (30 cm away from plant on around side of plant), entire dose of phosphorus and boron was applied at the time of planting as basal dose (BARC, 2012).

Data collection

Growth, yield and physio- chemical data were collected at different growing period. Growth parameters such as the Plant height (cm) was measured with a measuring scale. The plant diameter (cm) was measured with a measuring tape. Number of leaves/plant were manually counted. Leaf area (cm^2) was measured by non-destructive method followed by Khan *el. al.* (2016). Petiole length (cm) and canopy (cm) was measured with measurement scale.

Yield parameters as days to flowering initiation, number of flowers/plant, days to fruit setting, number of fruits/plant, fruit length (cm) and fruit diameter (cm) was measured with the help of verniar calipers. The fresh fruit weight (g) was taken immediately after harvesting with the help of electronic balance. The five randomly fruits selected were cut open longitudinally and measured the pulp thickness (cm) with the help of vernier calipers. Dry matter (%) was measured by oven dried fruit weight was taken with the help of electronic balance and express in percentage. yield/plant (kg/plant), yield/ha (MT/ha) were recorded. Physio-chemical parameters such as such as TSS (%) was estimated by hand refractometer (Model: Atago N1, Japan). Total sugar (g/100g), reducing sugar (g/100g) and non-reducing sugar (g/100g) were estimated as per

the procedure by Somogyi (1952). Ascorbic acid (mg/100g) was estimated by using AOAC, 1965 method. β-carotene (mg/100g) was measured by spectrophotometer (Model no. 200-20, Hitachi, Japan) at 663 ηm, 645ηm, 505 ηm and 453 ηm (Nagata and Yamashita, 1992). Calcium (%), magnesium (%) and potassium (%) were measured by vanadomolybdate method through the Atomic Absorption Spectrophotometer (Model 170-30, Hitachi, Japan) at a wavelength of 442.8 ηm, 285.5 ηm and 766.5 ηm, respectively.

Initial and after harvest soil analysis

Soil nutrient status was estimated before planting and after harvesting. Total nitrogen of soil was determined by micro-kjeldahl method. Total P and K content of soil sample was determined by using Vanadomolybdate method.

Table 1. Physio-chemical properties of the soil at the experimental plot before planting

Soil properties	Analytical data
Soil pH	5.8
Available N (%)	0.06
Available P (%)	6.13
Available P_K (%)	0.61

Statistical analysis

The mean was estimated using the statistix-10 computer program. Analysis of variance was performed for all the characters to test the differences between the means of the effect of effect of the treatments. Treatment means were analyzed by Duncan's Multiple Range Test (DMRT). Mean and Co-efficient of variation (CV %) were also estimated using the statistix-10 computer program.

Table 2. Physio-chemical properties of the soil at the experimental plot after harvesting

Treatments	Nitrogen (%)	Phosphorous (%)	Potassium (%)
T_1= Control	0.02	3.39	0.12
T_2= 100% RDF	0.06	5.51	0.64
T_3= 50% RDF+ 50% MOC	0.05	5.68	0.60
T_4= 50% RDF+ 50% VER	0.03	6.13	0.59
T_5= 50% RDF + 50% PM	0.08	6.20	0.67
T_6= 25% RDF+ 75% MOC	0.09	6.69	0.73
T_7= 25% RDF + 75% VER	0.06	6.36	0.69
T_8= 25% RDF+ 75% PM	0.07	4.16	0.60
T_9= 100% MOC	0.08	6.67	0.63
T_{10}= 100% VER	0.06	6.10	0.62
T_{11}= 100% PM	0.07	6.00	0.60
T_{12}= MOC + VER + PM	0.05	6.23	0.61

RDF=Recommended dose of fertilizer; VER= Vermicompost; MOL= Mustard oil cake; PM= Poultry manure.

Results and Discussion

Plant height

The plant height was recorded at the time of first harvesting (Table 1). The tallest plant height was recorded from T_{10} (143.67 cm) treatment which was statistically identical to T_{12} (141.67 cm) treatment. The lowest plant height was recorded in the control treatment T_1 (101.67 cm) which was significantly different from all other treatments. Vermicompost treated plant generated the maximum height of the papaya plant through better uptake of minerals and microelements. It has high microbial activity due to presence of fungi, bacteria and actinomycetes which can produce plant growth regulators (PGRs) (Tomati *et al.*, 1988). Similar findings was found from Sindoni *et al.* (2009) in papaya and Joshi and Vig (2010) in tomato.

Plant diameter

The study revealed that there was a highly significant effect of organic and inorganic sources of nutrients on plant diameter of papaya (Table 1). The maximum plant diameter was observed from T_{10} (53.67 cm) and the minimum was obtained from T_1 (40.67 cm) treatment which was statistically similar to T_3 (42.33 cm) and T_5 (42.33 cm) treatment. According to Reddy *et al.* (2013) reported that the diameter of the stem was found maximum due to getting optimum nutrients at an early growing stage. This finding was well supported with the finding of Akinyemi and Akande (2008) who observed maximum stem diameter of papaya plant due to the application of vermicompost with or without any combination of other fertilizers.

Number of leaves per plant

Leaves number was influenced by different levels of organic and inorganic fertilizers (Table 1). There was a gradual rising trend of leaf number at different days after planting. The maximum number of leaves was observed from T_{10} (27.67) which was statistically similar to T_{12} (26.33) treatment. The minimum number of leaves was observed in the control treatment T_1 (15.33). This finding was well supported with the finding of Krishna *et al*. (2018) who observed the application of vermicompost or vermicompost in combination with other organic fertilizers increased the number of leaves of the papaya plant.

Leaf area

Leaf area showed significant variation in response to different organic and inorganic fertilizers at a variation time point after planting (Table 1). The maximum leaf area was also measured in T_{10} (1334.70 cm^2) treatment which was statistically alike with T_{12} (1333.30 cm^2) treatment. The minimum leaf area was measured in the control T_1 (1319.30 cm^2) which was statistically dissimilar from all other treatment. Singh *et al*. (2008) reported that the leaf area of strawberry plant increase due to the application of Vermicompost combination with other fertilizers and improve soil characteristics. These results are in conformity with the findings reported by Yadav *et al.* (2011a) in papaya.

Petiole length

The length of leaf petiole under the influence of differential treatments varied between 30.67 cm and 46.67 cm (Table 1). The highest length was measured in T_{10} (46.67 cm) which was statistically similar to T_{12} (45.33 cm). The lowest length was measured in the

Table 1. Influence of organic and inorganic fertilizers on morphological characters of papaya plant

Treatments	Plant height (cm)	Plant diameter (cm)	Number of leaves/plant	Leaf area (cm^2)	Petiole length (cm)	Canopy (cm)
T_1 = Control	101.67 g	40.67 f	15.33 g	1319.3 h	30.67 g	92.67 h
T_2 = 100% RDF	138.67 c	50.00 b	24.33 c	1329.3 c	39.67 d	111.00 b
T_3 = 50%RDF+ 50% MOC	131.00 f	42.33 ef	19.67 f	1325.3 e	38.67 de	102.67 g
T_4 = 50% RDF+ 50% VER	138.00 c	44.00 de	21.33 de	1328.7 cd	40.00 d	108.00 cd
T_5 = 50% RDF + 50% PM	138.00 c	42.33 ef	22.00 de	1323.3 f	32.33 fg	103.33 g
T_6 = 25% RDF+ 75% MOC	134.67 e	44.00 de	20.00 ef	1324.0 ef	33.67 f	104.00 fg
T_7 = 25% RDF + 75% VER	137.67 cd	47.33 c	25.67 bc	1331.3 b	43.67 bc	109.33 bc
T_8 = 25% RDF+ 75% PM	135.33 de	46.67 c	24.33 c	1321.7 g	42.00 c	106.67 de
T_9 = 100% MOC	139.33 bc	44.33 d	19.33 f	1327.7 d	39.33 de	105.67 ef
T_{10} = 100% VER	143.67 a	53.67 a	27.67 a	1334.7 a	46.67 a	113.33 a
T_{11} = 100% PM	140.33 b	47.67 c	25.33 bc	1324.7 ef	37.67 e	107.33 de
T_{12} = MOC + VER + PM	141.67 ab	51.33 b	26.33 ab	1333.3 ab	45.33 ab	110.33 b
CV (%)	1.03	2.34	3.96	0.06	2.79	1.00

Means bearing same letter (s) in a column do not differ significantly at 5 % level of probability.
RDP = Recommended dose of fertilizer; MOC = Mustard oil cake; VER= Vermicompost; PM = Poultry manure.

control T_1 (30.67 cm) which was statistically similar to T_5 (32.33 cm). These results are in harmony with the findings of Rajamanickam *et al.* (2008) who stated that the plant treated with vermicompost significantly increase the height, petiole length and other growth parameters of papaya. These present findings also support the findings Sindoni *et al.* (2009).

Canopy

Photosynthetic activities largely depend on canopy area which improve the yield and quality of fruit. The maximum canopy was recorded in T_{10} (113.33 cm) treatment and the minimum canopy was recorded in the control T_1 (92.67 cm). These results are in conformity with the findings reported by Krishna *et al.* (2018) who stated that the maximum canopy of papaya plants due to the combined application of Vermicompost and biofertilizers along with chemical fertilizers.

Days to flower initiation

The data presented in Table 2 indicate significant variations in days taken for flowering as influenced by the different doses of organic and inorganic fertilizers. The number of days taken for flowering in papaya plant ranged from 77.67 to 92.33 DAP. In the longest time for flower initiation was recorded in the plant under control T_1 (92.33 days) and the earliest time for flower initiation was recorded in T_{10} (77.67 days) treatment. Earliness in flowering due to the higher net assimilation rate on account of slow and horizontal vegetative growth in papaya (Yadav *et al.*, 2011a). These findings are in agreement with the observation of Krishna *et al.* (2018).

Number of flowers per plant

Influence of different level of organic and inorganic fertilizers on the number of flowers

per plant was found significant (Table 2). The maximum number of flowers were observed in T_{10} (41.67) treatment which was statistically alike with T_{12} (40.00) treatment. The fewest number of flowers was observed in the control T_1 (33.33) treatment which was statistically similar to T_{11} (35.00) treatment. These findings are well supported by the findings of Taleshi *et al*. (2011) who reported that a higher level of vermicompost with nitrogen fertilizers as a potential nutrient source and result in vigorous growth, increase the no. of flower per plant in safflower as compared other nutrient combination.

Days to fruit setting and number of fruits per plant

Fruits are the ultimate target of crop production. The fruits per plant is one of the most important yield contributing characters in all fruits and as well as papaya. The data depicted in the Table 2 indicate significant variations in the number of days taken for fruiting in the papaya plant. The number of days taken for fruit initiation range from 131.00 to 151.33. The maximum number of days was noted in the control T_1 (151.33) and the minimum was noted from T_{10} (131.00) which was statistically similar to T_{12} (131.67) treatment. The maximum number of fruits per plant was observed in treatment T_{10} (32.67) which was statistically similar to T_{12} (31.67) treatment. The minimum number of fruits per plant was found in T_1 (23.33) which was statistically similar to T_3 (26.00), T_5 (26.00), T_6 (26.33), T_8 (25.67), and T_{11} (23.67) treatments. These findings are agreement with the observation of Arancon *et al.* (2006) who reported that application of vermicompost increased fruit number of strawberry and pepper. These findings are in agreement with

Table 2. Influence of organic and inorganic fertilizers on flowering and fruiting of papaya

Treatments	Days to flower initiation	Total number of flowers/ plant	Days to fruit setting	Total number of fruits/ plant
T_1 = Control	92.33 a	33.33 f	151.33 a	23.33 d
T_2 = 100% RDF	82.33 e	37.67 c	141.67 e	28.67 bc
T_3 = 50% RDF+ 50% MOC	89.33 b	39.00 bc	146.67 c	26.00 cd
T_4 = 50% RDF+ 50% VER	83.33 de	37.33 cd	142.67 e	27.00 c
T_5 = 50% RDF + 50% PM	87.33 c	38.00 c	145.67 cd	26.00 cd
T_6 = 25% RDF+ 75% MOC	88.00 bc	35.67 de	144.33 d	26.33 cd
T_7 = 25% RDF + 75% VER	84.33 d	37.33 cd	139.33 f	27.33 c
T_8 = 25% RDF+ 75% PM	87.33 c	38.33 bc	144.33 d	25.67 cd
T_9 = 100% MOC	83.67 de	35.67 de	148.33 b	27.67 c
T_{10} = 100% VER	77.67 g	41.67 a	131.00 g	32.67 a
T_{11} = 100% PM	82.67 e	35.00 ef	143.67 de	23.67 d
T_{12} = MOC + VER + PM	79.67 f	40.00 ab	131.67 g	31.67 ab
CV (%)	1.00	2.94	0.42	7.14

Means bearing same letter (s) in a column do not differ significantly at 5 % level of probability.
RDP = Recommended dose of fertilizer; MOC = Mustard oil cake; VER= Vermicompost; PM = Poultry manure.

the observation of Reddy *et al.* (2013) in papaya.

Single fruit weight of papaya

The influence of organic and inorganic fertilizers on single fruit weight was found significant (Table 3). The highest individual fruit weight was observed in treatment T_{10} (742.00 g) which was statistically similar to T_{12} (723.67 g) and the lowest was observed in the control T_1 (289.33 g) treatment. Arancon *et al.* (2006) found that the application of vermicompost increased the fruit weight of strawberry and pepper. Vermicompost has growth promoting substances that normally increase the fruit size and shape. Yadav *et al*. (2011b) in papaya supported these findings.

Fruit length

In case of fruit length, a significant result was found in the application of different levels of organic and inorganic fertilizer treatments (Table 3). The highest fruit length was recorded in T_{10} (22.67 cm) treatment which was closely followed by T_{12} (21.33 cm) and the lowest was in the control T_1 (9.90 cm) which was statistically inferior to all other treatments. These findings are in agreement with Alidadi *et al*. (2014) who reported that the application of vermicompost leachates increased the length of tomato fruits. This findings are also agreement with the findings by Shijini (2010) in papaya.

Fruit diameter

The application of different levels of organic and inorganic fertilizers markedly influenced the fruit diameter (Table 3). The highest fruit diameter was found in T_{10} (34.50 cm) treatment which was statistically superior to all other treatments. On the other hand, the lowest fruit diameter was found in the control

Table 3. Influence of organic and inorganic fertilizers on single fruit weight, fruit length, fruit diameter, pulp thickness and yield of papaya

Treatments	Single fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Pulp thickness (cm)	Yield/ plant (kg)	Yield/ ha (MT)
T_1 = Control	289.33 g	9.90 g	24.83 f	1.94 e	6.84 g	17.10 h
T_2 = 100% RDF	642.33 cd	17.00 cd	27.33 de	2.73 b	18.41 c	46.03 c
T_3 = 50% RDF+ 50% MOC	562.67 ef	14.60 def	26.00 ef	2.48 c	14.41 f	36.53 fg
T_4 = 50% RDF+ 50% VER	602.67 de	13.83 ef	25.33 f	2.65 b	16.25 de	40.53 e
T_5 = 50% RDF + 50% PM	635.67 cd	14.90 def	26.33 ef	2.45 c	16.51 de	41.28 de
T_6 = 25% RDF+ 75% MOC	551.00 ef	12.90 f	28.00 cd	2.48 c	14.51 f	36.28 fg
T_7 = 25% RDF + 75% VER	678.00 bc	18.67 bc	29.00 c	2.73 ab	18.53 c	46.33 c
T_8 = 25% RDF+ 75% PM	671.33 bc	16.00 cde	26.00 ef	2.41 c	17.22 cd	43.50 d
T_9 = 100% MOC	536.00 f	13.33 ef	26.00 ef	2.10 d	14.84 ef	37.07 f
T_{10} = 100% VER	742.00 a	22.67 a	34.50 a	2.93 a	24.23 a	60.06 a
T_{11} = 100% PM	595.33 def	16.67 cd	26.33 ef	2.38 c	13.87 f	34.70 g
T_{12} = MOC + VER + PM	723.67 ab	21.33 ab	31.00 b	2.77 ab	22.91 b	57.27 b
CV (%)	5.98	9.96	3.45	3.47	6.02	3.09

Means bearing same letter (s) in a column do not differ significantly at 5 % level of probability.
RDP = Recommended dose of fertilizer; MOC = Mustard oil cake; VER= Vermicompost; PM = Poultry manure.

T_1 (24.83 cm) which was statistically similar to T_3 (26.00 cm), T_4 (25.33 cm), T_5 (26.33 cm), T_8 (26.00 cm), T_9 (26.00 cm), and T_{11} (26.33 cm). The similar result was also obtained by Nath (2001) who reported an improved fruit diameter and yield of papaya with the application of organic fertilizers. These findings are also in supported by the findings of Ram and Rajput (1998) in guava and Dutta *et al.* (2008) in papaya.

Pulp thickness

Pulp thickness is one of the important characters determining the quality of papaya (Table 3). The maximum pulp thickness was observed in T_{10} (2.93 cm) treatment which was statistically similar to T_{12} (2.77 cm) and T_7 (2.73 cm). On the other hand, the lowest pulp thickness was observed in the plant under control T_1 (1.94 cm). Singh *et al*. (2008a) reported in papaya also the same opinion and agreed with the present findings.

Yield per plant

Fruit yield varied significantly due to the treatments. Organic sources of nutrients produced markedly better yields than that of the inorganic fertilizers in the control treatment (Table 3).The maximum fruit yield per plant was recorded in treatment T_{10} (24.23 kg) which was statistically dissimilar from all other treatments. The lowest yield per plant was found in the control T_1 (6.84 kg) which was statistically inferior to other treatments. These present findings are supported by the findings of Yadav *et al*. (2011b)

Yield per hectare

Due to the influence of organic and inorganic fertilizer on yield of papaya per hectare varied significantly ranging from 17.10 MT to 60.06 MT (Table 3). In the application of vermicompost equivalent to 100% recommended dose of nitrogen (RDN) T_{10} (60.06 MT/ha) treatment gave significantly higher fruit yield/ ha which was statistically dissimilar from other treatments. The lower yield/ha was recorded in the control T_1 (17.10 MT/ha) which was statistically inferior to all other treatments. The application of Vermicompost is the effective source for growth and yield of strawberry (Rahman *et al*., 2018). These findings are in agreement with the findings of Yadav *et al.* (2011b) in papaya.

Dry matter

The dry meter is the most important parameter in papaya. There were significant differences in different levels of fertilizer treatment (Table 4). Dry matter increased with increasing the rate of leaf area and canopy which increase the photosynthesis activity. The maximum amount of dry matter content was found in T_{10} (4.37 %) treatment which was statistically similar by T_{12} (4.33 %). The minimum amount of dry weight was found in the control T_1 (2.57 %) treatment which was statistically inferior to all other treatments. Singh *et al*. (2008) reported that there was a significant increase in the plant canopy, leaf area, and dry matter in strawberry with the application of vermicompost which agree with these present findings.

Total soluble solids (TSS) content

Total soluble solids is an important quality determining character in papaya. There were significant differences in TSS per plant to different levels of fertilizers utilization from different treatments (Table 4). The TSS (%) showed an increased with the increased amount of different kinds of organic fertilizer along

Table 4. Influence of organic and inorganic fertilizers on dry matter, TSS and sugar content of papaya

Treatment combination	Dry matter (%)	TSS (%)	Total sugar (g/100g)	Reducing sugar (g/100g)	Non-reducing (g/100g)
T_1 = Control	2.57 h	8.43 h	5.29 h	2.92 g	2.37 d
T_2 = 100% RDF	3.70 b	15.17 d	7.13 bc	4.17 c	2.96 bc
T_3 = 50% RDF+ 50%MOC	3.36 efg	10.30 g	5.77 fgh	3.54 de	2.23 d
T_4 = 50% RDF+ 50% VER	3.56 cd	14.70 d	6.77 cd	3.78 cd	2.99 bc
T_5 = 50% RDF + 50% PM	3.33 fg	11.83 f	5.50 gh	3.13 fg	2.37 d
T_6 = 25% RDF+ 75% MOC	3.46 de	11.40 f	5.73 fgh	3.00 fg	2.73 c
T_7 = 25% RDF + 75% VER	3.63 bc	16.40 c	7.67 b	4.67 b	3.00 b
T_8 =25% RDF + 75% PM	3.60 bc	14.93 d	6.23 def	3.80 cd	2.43 d
T_9 = 100% MOC	3.26 g	13.20 e	6.10 efg	3.33 ef	2.77 bc
T_{10} = 100% VER	4.37 a	18.17 a	9.43 a	6.34 a	3.09 ab
T_{11} = 100% PM	3.43 ef	13.80 e	6.43 de	3.70 de	2.73 c
T_{12} = MOC+ VER+ PM	4.33 a	17.30 b	9.10 a	5.17 ab	3.93 a
CV (%)	2.19	3.47	5.41	5.99	4.81

Means bearing same letter (s) in a column do not differ significantly at 5 % level of probability.
RDP = Recommended dose of fertilizer; MOC = Mustard oil cake; VER= Vermicompost; PM = Poultry manure; TSS= Total Soluable sdids

with the control. The maximum amount of TSS content was found in T_{10} (18.17%) which was statistically similar to T_{12} (17.30%). The lowest amount of TSS content was found in the fruit of the plant under control T_1 (8.43%) treatment. These findings are in agreement with the observation of Kirad *et al*. (2010) who reported that the TSS level was to be increased by the application of vermicompost with decreasing level of chemical fertilizers.

Total sugar

Significant variation was found in total sugar content to different doses of organic and inorganic fertilizers treatment (Table 4). The maximum amount of total sugar was found in T_{10} (9.43 g/100g) treatment which was statistically similar to T_{12} (9.10 g/100g). The minimum amount of total sugar was found in the control T_1 (5.29 g/100g) which was statistically similar to T_3 (5.77 g/100g), T_5 (5.50 g/100g), and T_6 (5.73 g/100g). Vermicompost makes the micronutrients in readily available form for plant and due to the availability of these nutrients sweetness of papaya fruits was increased. Kirad *et al*. (2009) in strawberry and Ravishankar and Karunakaran (2008) in papaya supported these present findings.

Reducing sugar

In case of reducing sugar, significant variation was found due to the different treatments (Table 4). Organic sources of nutrients produced markedly better result than that of the control treatment. The maximum amount of reducing sugar was observed in T_{10} (6.34 g/100g) treatment which was closely followed by T_{12} (5.17 g/100g). The lowest amount of reducing sugar was found in control T_1 (2.92 g/100g) which was statistically similar to T_5 (3.13 g/100g) and T_6 (3.00 g/100g) treatment. These findings are in conformity with the

findings of Ravishankar *et al*. (2008) who stated that the application of organic fertilizers which improved the reducing sugar and other quality of papaya.

Non-reducing sugar

The non-reducing sugar content was statistically significant to different level of treatment (Table 4). The maximal amount of non-reducing sugar was found in T_{12} (3.93 g/100g) which was statistically similar to T_{10} (3.09 g/100g). The minimum amount of non-reducing sugar was found in T_3 (2.23 g/100g) treatment which was statistically similar to T_1 (2.37 g/100g), T_5 (2.37 g/100g), and T_8 (2.43 g/100g) treatment. Eda *et al.* (2018) also reported similar findings.

Ascorbic acid

The highest amount of ascorbic acid content was found in T_7 (24.99 mg/ 100g) treatment which was closely followed by T_2 (24.45 mg/ 100g), T_6 (24.22 mg/ 100g), T_{10} (24.67 mg/ 100g) and T_{12} (24.33 mg/ 100g). The lowest amount of ascorbic acid was found in T_{11} (22.00 mg/ 100g) treatment which was statistically similar to T_1 (22.67 mg/ 100g) and T_5 (22.60 mg/ 100g). Similar results was obtained by Yadav *et al.* (2011a) in papaya.

β-Carotene

The highest β-Carotene content was observed in T_{10} (0.24 mg/ 100g) treatment which was closely related to T_{12} (0.23 mg/ 100g) and T_7 (0.23 mg/ 100g) treatments. On the other hand, the lowest amount of β-Carotene content was observed in treatment T_5 (0.16 mg/ 100g) treatment which was statistically similar with T_1 (0.17 mg/ 100g), T_3 (0.18 mg/ 100g), T_4 (0.18 mg/ 100g) and T_9 (0.18 mg/ 100g). The β-Carotene content was more in fruits of plants applied with organic fertilizer might be due to continuous supply of both macro and micro nutrients to the plants. These results were in harmony with the earlier findings of Singh *et al.* (2008a) in papaya.

Calcium (Ca)

Significant variation was found in calcium content to different doses of organic and inorganic fertilizers treatment (Table 5). The maximum amount of calcium content was found in T_{10} (0.39%) treatment which was statistically similar to T_{12} (0.37%). The lowest amount of calcium was found in the control T_1 (0.27%) which was statistically similar to T_5 (0.29%) treatment. Calcium concentration was maximum in papaya fruit treated with organic fertilizers. These results are in conformity with the findings of Ray *et al.* (2008) reported that significant increase in quality content of papaya fruits due to the application of organic fertilizers.

Magnesium (Mg)

Different variation was found in magnesium content to different treatments. It varied from 0.16 to 0.33% (Table 5). The plants obtained from T_{10} (0.33%) treatment had significantly maximum magnesium content. The minimum amount of magnesium was found in the control T_1 (0.16%) which was statistically similar to T_3 (0.19%) and T_6 (0.18%) treatments. These result are agreed with the findings of Verma and Kaushal (2014).

Potassium (K)

Potassium content was also significantly different among treatment. The maximum amount of potassium was found in T_{10} (2.08%) which was statistically similar to T_{12} (2.03%) (Table 5). The minimum amount of potassium was found in control T_1 (1.78%) which was statistically identical with T_8 (1.85%). Pant *et*

Table 5. Influence of organic and inorganic fertilizers on ascorbic acid, β-Carotene, calcium, magnesium and potassium of papaya

Treatments	Ascorbic acid (mg/100g)	β-Carotene content(mg/100g)	Calcium (%)	Magnesium (%)	Potassium (%)
T_1 = Control	22.67 de	0.17 ef	0.27 h	0.16 f	1.78 d
T_2 = 100% RDF	24.45 ab	0.21 bc	0.34 cde	0.27 b	1.96 bc
T_3 = 50% RDF+ 50% MOC	23.67 bcd	0.18 def	0.31 fg	0.19 ef	1.90 c
T_4 = 50% RDF+ 50% VER	23.51 bcd	0.18 ef	0.35 bcd	0.24 cd	1.93 bc
T_5 = 50% RDF + 50% PM	22.60 de	0.16 f	0. 29 gh	0.22 de	1.92 bc
T_6 = 25% RDF+ 75% MOC	24.22 abc	0.19 cde	0.33 cdef	0.18 f	1.92 bc
T_7 = 25% RDF + 75% VER	24.99 a	0.23 ab	0.36 bc	0.26 bc	1.92 bc
T_8 = 25% RDF+ 75% PM	23.67 bcd	0.21 bcd	0.32 efg	0.23 cd	1.85 cd
T_9 = 100% MOC	23.22 cd	0.18 def	0.33 def	0.24 cd	1.91 bc
T_{10} = 100% VER	24.67 ab	0.24 a	0.39 a	0.33 a	2.08 a
T_{11} = 100% PM	22.00 e	0.19 cde	0.34 cdef	0.25 bc	1.90 c
T_{12} = MOC + VER + PM	24.33 abc	0.23 ab	0.37 ab	0.28 b	2.03 ab
CV (%)	3.03	7.19	5.06	7.00	3.57

Means bearing same letter (s) in a column do not differ significantly at 5 % level of probability.
RDP = Recommended dose of fertilizer; MOC = Mustard oil cake; VER= Vermicompost; PM = Poultry manure.

al. (2009) reported that in pak choi, the total P and K contents per plant were also higher in vermicompost tea-treated plants compared with control.

Conclusions

In conclusion, the present study reports that the establishment of an effective application of organic fertilizers as an alternative source of fertilizers for more production of papaya. Application of vermicopmost also showed the significant results on growth, yield and physiochemical properties. The plant produced maximum growth and yield of papaya due to application of 12.5 kg vermicompost/plant (treatment T_{10}).

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