International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 12, Issue 18, 2020, pp.-10195-10198.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON FLOWERING, FRUITING, YIELD AND QUALITY PARAMETERS OF PAPAYA (*Carica papaya* L.)

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Received: September 02, 2020; Revised: September 23, 2020; Accepted: September 24, 2020; Published: September 30, 2020

Abstract: An experiment was carried out in the Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India, during 2015-16 and 2016-17 to study the influence of integrated nutrient management on growth, yield and quality parameters of papaya (*Carica papaya* L.). For this plant of Sapna cultivar was planted on 20th March during both years of experimentation at a spacing of 2.0 x 2.0 m. There were eighteen treatments comprising Azotobacter, PSB and vermicompost with graded dose of RDF including one control, replicated thrice in randomized block design. All treatments were applied at the time of planting in the field. The data of both the years of experiment were analyzed which clearly shows that during both years of experimentation significantly lesser number of nodes and days taken to first flowering, fruit developmental period with reduced fruit drop and maximum fruit retention with higher fruit yield, fruit weight and volume were recorded in the plants which were fertilized with RDF 75% + Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant, whereas uninoculated plants results in higher number of nodes to first flowering along with more days taken for the appearance of first flower, took maximum fruit developmental period, results maximum fruit drop percent and minimum fruit retention percent along with minimum yield of fruits which are lighter in weight and volume during both years of experimentation. As quality characters of fruits are concerned fruits having maximum pulp percent, total soluble solids (TSS) and total sugar contents and minimum peel percent, titratable acidity contents were recorded in fruits which were produced from the plants fertilized with RDF 75% + Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant, whereas uninoculated plants results in minimum pulp percent, total soluble solids (TSS) and total sugar contents and maximum peel percent, higher titratable acidity contents during both years of experimentation.

Keywords: *Papaya, Integrated Nutrient Management, Flowering, Fruiting, Yield and Quality parameters*

Citation: Singh A. and Tripathi V.K. (2020) Influence of Integrated Nutrient Management on Flowering, Fruiting, Yield and Quality Parameters of Papaya (*Carica papaya* L.). International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 12, Issue 18, pp.- 10195-10198.

Academic Editor / Reviewer: Kannan C. S. Warrier

Introduction

Papaya (*Carica papaya* L.), a member of family Caricaceae, is a fast growing, typically single-hollow stemmed, herbaceous, evergreen, dicotyledonous, perennial plant. The optimum temperature for papaya is reported to be 21° to 33°C. In India, it is being cultivated in an area of 1.38 Lakh ha with a total production of 5.99 Lakh MT and average productivity is 43.27 MT per hectare [1]. It is a cheap and rich source of vitamins and minerals in the daily diet of millions of people. The ripe papaya fruits are also used in the preparation of different value-added products such as syrup, jam, jelly, nectar, soft drinks, candy, ice-cream, flavouring crystallized fruit, dehydrated flakes, and baby foods *etc*. Papaya has a wide range of adaptability and high economic returns per unit area.

INM or integrated nutrient supply system in papaya refers to the maintenance of soil fertility and plant nutrient supply chain to an optimum level for sustaining the desired crop productivity and fruit quality through optimization of benefits from all possible sources in an integrated manner. Organic manures mostly enhance the nutrient availability to improve the soil structure, texture, tilth and better environment for root development and aeration. Bio-fertilizers like *Azotobacter* and Phosphate Solubilising Bacteria (PSB) results an increased availability of nitrogen and phosphorus nutrients in the soil. Contrary to various chemical fertilizers, organic manures and bio-fertilizers are available indigenously at lower cost which also improve soil health and enhanced crop yield per unit of applied nutrient and there by save energy, keeping in all above facts in view, the present investigation was carried out to standardized most suitable combination of *Azotobacter*, PSB and vermicompost with a dose of chemical fertilizers in an integrated way to get increased flowering, fruiting and higher yield of quality fruits in *Carica papaya* L.

Material and Methods

The present investigation was carried out in the garden, Department of Horticulture, C.S. Azad University of Agriculture & Technology Kanpur during the two subsequent years i.e., 2015-16 and 2016-17. The experiments were laid out in Randomized Block Design with eighteen treatments *viz*., T0 (No amount of fertilizers), T1 (recommended dose of fertilizers (RDF)-200:200:300 g/plant),T2 (RDF 75%+ *Azotobacter* 50 g + PSB 50 g/plant), T3 (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1 kg/plant), T4 (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), T5 (RDF 75%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), T6 (RDF 75%+ *Azotobacter* 100 g+ PSB 100 g/plant), T7 (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), T8 (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T9 (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant), T10 (RDF 50%+ *Azotobacter* 50 g + PSB 50 g/plant), T11 (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1 kg/plant), T12 (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1.5 kg/plant), T13 (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), T14 (RDF 50%+ *Azotobacter* 100 g + PSB 100 g/plant), T15 (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), T16 (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T17 (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant). Planting was done at a distance of 2m × 2m on 20th March during both years of experimentation i.e., 2015-16 and 2016-17, using 'Sapna' cultivar. Two plants are used as a unit.

Observations on number of nodes and days taken to produce first flowering were recorded by counting the days from transplanting to the appearance of first flower.

Fruit developmental period was counted as the period between fruit set and fruit maturity. Fruit drop and fruit retention percent was recorded by counting number of fruits set initially and remained at the end at the time of harvesting. During harvesting, data on fruit weight and yield per plant were recorded. Peel and pulp percent content of four randomly selected fruits were measured by dividing the pulp/peel weight by total fruit weight. The TSS of fruits was recorded with the help of hand refractometer. The titratable acidity and total sugars contents of fruits were determined by the methods as suggested by [2].

Results and discussion

Number of nodes and days taken to first flowering

Data presented in [Table-1], clearly revealed that during both years of experimentation number of nodes and days taken to first flowering were significantly minimum when *Azotobacter*, PSB and vermicompost were used in different combinations using different doses of RDF. Plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant plants resulted in lesser number of nodes to first flowering (25.87 and 25.79, respectively) with minimum number of days (85.33 and 87.78 days, respectively) taken for first flowering as compared to all other treatments, whereas, uninoculated plants results in higher number of nodes to first flowering (34.89 and 34.84, respectively) along with more days taken for the appearance of first flower (122.67 and 124.35 days, respectively) during both years of experimentation.

This phenomenon may be on account of more supply of balanced nutrition to the plants in the presence of *Azotobacter*, PSB and organic manures. These results are in line with the findings of [13], who also recorded earlier flowering with NPK + PSB and NPK + *Azotobacter* treatments. The reason for earliness in flowering might be due to the higher net assimilation rate on account of better growth leading to the production of endogenous metabolites in optimum level enabling early flowering and simultaneous transport of growth substances like cytokinin to the auxiliary bud and breaks the apical dominance. These results have got the support with the findings [18] and [20], who also got advanced duration of harvesting (earliness) by approximately one month which obviously extended the period of harvesting by the application of *Azotobacter*, PSB and vermicompost in strawberry. The similar result was reported by [15] in papaya, [22] in strawberry cv. Chandler.

Fruit developmental period

Fruit developmental period was significantly minimum over control when *Azotobacter*, PSB and vermicompost were used in combinations with different doses of RDF during both years of experimentation [Table-1]. Significantly minimum fruit developmental period (140.25 and 141.37 days, respectively) was recorded when the plants were fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant, whereas the maximum fruit developmental period (164.00 and 163.26 days, respectively) was recorded in untreated control plants. Application of graded dose of chemical fertilizers in association with organic manure and bio-fertilizers, may results in enhanced activity of biological nitrogen fixation and higher net assimilation rate on account of better growth leading to the production of endogenous metabolites. These results are in conformity with the findings of [15] and [16] in papaya.

Fruit drop and retention percent

During both years of present investigation significantly minimum fruit drop and maximum fruit retention over control was recorded when plants were treated with *Azotobacter*, PSB and vermicompost in combinations with different doses of RDF [Table-1]. Reduced fruit drop percent (48.32 and 47.23 %, respectively) and maximum fruit retention percent (51.33 and 51.33 %, respectively) was recorded in the plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant. The plants under control resulted in maximum fruit drop percent (63.90 and 63.10 %, respectively) and minimum fruit retention percent (36.10 and 36.90 %, respectively) as compared to treated ones during both years of experimentation. This increase in fruit retention and reduced fruit drop with the application of graded dose of NPK in combination with bio-fertilizers and vermicompost might be due to the result of its association with auxin synthesis, supply of nutrients and their proportion right from starting of the experimentation to the harvesting of the crop, which might induced more flowering and retention of fruit as a results of production and supply of photosynthates at critical requirements. These findings agree with the findings of [14], [8] in guava cv. Sardar, [20] in aonla.

Fruit yield

Data presented in [Table-1] clearly shows that significantly maximum fruit yield was recorded when plants were fertilized with *Azotobacter*, PSB and vermicompost in combinations with different doses of RDF during both years of experimentation. The maximum yield per plant (63.76 kg, respectively) was recorded in plants fertilized with the combination of RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant (T9) and this yield was significantly higher as compared to all other treatments. Plants kept under control produced the minimum yield of fruits (22.34 and 23.49 kg, respectively) per plant during both years of experimentation.

This increase in yield parameters during present experiments with the application of vermicompost, *Azotobacter* and PSB along with graded dose of NPK might be due to increased fruits set per plant, higher contents of available nutrients, more nitrogen fixation in soil, increased availability of phosphorus with increased production of phytohormones, increased uptake of nutrient and translocation of photosynthates from source (leaves) to sink (fruit) results an increase in yield of fruits. Vermicompost have immobilized microflora, which produce useful products and having immobilized enzymes like protease, lipase, amylase, cellulase, lichanase and chitinase in the soil, which helps in biodegradation of macromolecular of agricultural residues in the soil and absorb moisture from the air [3]. These findings are in line with the findings of [10] in banana, [5], [18] in strawberry, [20] in aonla, [7] in ber, [12]and [6] in papaya.

Weight and volume of fruit

During both years of present investigation, it was observed that integrated dose of different nutrients with bio-fertilizers and vermicompost has given remarkable increase in the fruit weight and volume and they were significantly superior when *Azotobacter*, PSB and vermicompost were used in combinations with different graded doses of RDF [Table-2]. Fruits having more weight (1460.00 and 1379.66 g, respectively) and volume (1385.00 and 1310.75 cc, respectively) were produced from the plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant closely followed by RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant having fruits of weight (1415.00 and 1336.98g, respectively) and volume (1340.00 and 1268.00 cc, respectively). The untreated plants (control) produced fruits of significantly minimum weight (700.26 and 795.36 g, respectively) and volume (695.20 and 740.37 cc, respectively) as compared to treated plants during both years of experimentation.

This increase in fruit weight and volume with the use of an integrated dose of NPK along with bio-fertilizers (*Azotobacter* and PSB) and vermicompost might be due to the supply of plant nutrients and growth hormones in appropriate amount and time during entire crop period resulted an increased uptake of nutrients from soil which has produced enough carbohydrates in the leaves caused more plant height and ultimately more photosynthates for translocation to the sink resulted better filling of fruits which produced more length, width, weight and volume of fruit [4]. The maximum gain in weight and volume was also due to the greater mobility of the metabolites into the developing fruit, which acted as strong metabolic sink as compared to the treatments involving higher integrated dose of fertilizers. Results are in accordance with the findings of [8] in Guava, [10] in banana, [5], [18], [21] in strawberry, [7] in ber, [12] and [6] in papaya.

Pulp and peel percent

Data presented in [Table-2] clearly reveals that during both years of present investigation, integrated dose of different nutrients with bio-fertilizers and vermicompost has given remarkable increase in the fruit pulp content and decrease in peel content and they were significantly superior over control when *Azotobacter*, PSB and vermicompost were used in combinations with different graded doses of RDF.

Table-1 *Influence of Integrated Nutrient Management on flowering, fruiting, and yield parameters of papaya (Carica papaya L.)*

Treatments	Number of nodes to first flowering		Days taken to first flowering		Fruit developmental period		Fruit drop (%)		Fruit retention (%)		Fruit yield (kg/tree)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_0	34.89	34.84	122.67	124.35	164.00	163.26	63.90	63.10	36.10	36.90	22.34	23.49
T_1	27.57	27.58	90.00	92.63	144.23	142.20	52.38	51.20	47.62	47.62	58.80	52.98
T_2	33.99	33.97	110.00	113.38	159.37	158.33	61.76	60.38	38.24	38.24	29.38	26.47
T_3	30.93	30.89	106.67	101.96	152.19	151.34	51.30	52.14	42.70	42.70	35.70	36.17
T_4	29.33	29.34	99.00	99.92	160.00	158.08	55.06	53.82	44.94	44.94	39.81	35.87
T_5	28.32	28.30	91.33	94.00	155.67	154.68	54.55	53.32	45.45	45.45	49.18	44.31
T_6	33.10	32.16	96.67	99.55	159.93	155.86	56.29	56.84	45.71	45.71	31.20	28.11
T_7	26.31	29.39	93.93	97.08	159.33	154.96	50.00	48.88	44.00	44.00	38.22	34.44
T_8	26.36	26.31	87.67	90.21	141.32	141.65	50.35	49.22	49.64	49.64	62.94	56.71
T_9	25.87	25.79	85.33	87.78	140.25	141.37	48.32	47.23	51.33	51.33	67.08	60.44
T_{10}	34.53	34.52	108.00	101.30	155.34	151.67	62.03	60.53	37.97	37.97	26.93	26.26
T_{11}	32.36	32.47	97.33	99.23	154.35	153.42	55.92	55.73	41.08	41.08	32.66	31.83
T_{12}	32.29	32.16	91.67	94.36	152.67	153.32	56.84	54.52	42.16	42.16	35.07	33.60
T_{13}	31.96	31.89	86.67	89.92	155.00	144.35	52.16	50.99	45.84	45.84	35.17	32.69
T_{14}	34.16	34.19	96.34	90.38	149.28	147.93	57.28	55.66	42.72	42.72	28.51	25.69
T_{15}	31.85	31.82	91.66	89.16	147.59	146.20	53.13	51.93	46.88	46.88	35.54	32.03
T_{16}	31.25	31.21	88.00	87.78	162.47	157.19	50.13	50.95	47.86	47.86	46.80	42.17
T_{17}	30.59	30.28	86.81	86.50	163.24	160.23	51.53	50.37	48.47	48.47	53.58	48.28
SEm ±	1.92	2.34	2.92	2.86	4.50	4.53	1.66	1.65	1.72	1.72	2.33	1.94
$CD_{5\%}$ level	5.82	7.09	8.85	8.67	13.67	13.74	5.03	4.99	5.22	5.22	7.06	5.87
CV	10.97	13.32	5.26	5.12	5.06	5.16	5.26	5.30	6.71	6.71	9.96	8.99

Treatments notations: T0 (No amount of fertilizers), T1 (recommended dose of fertilizers (RDF)-200:200:300 g/plant),T2 (RDF 75%+ Azotobacter 50 g + PSB 50 g/plant), T3 (RDF 75%+ Azotobacter 50 g + PSB 50 g+ vermicompost 1 kg/plant), T4 (RDF 75%+ Azotobacter 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), T5 (RDF 75%+ Azotobacter 50 g + PSB 50 g + vermicompost 2 kg/plant), T6 (RDF 75%+ Azotobacter 100 g+ PSB 100 g/plant), T7 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 1 kg/plant), T8 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T9 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant), T10 (RDF 50%+ Azotobacter 50 g + PSB 50 g/plant), T11 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 1 kg/plant), T12 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 1.5 kg/plant), T13 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 2 kg/plant), T14 (RDF 50%+ Azotobacter 100 g + PSB 100 g/plant), T15 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 1 kg/plant), T16 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T17 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant)

Table-2 *Influence of Integrated Nutrient Management on physical and chemical quality parameters of papaya (Carica papaya L.)*

Treatments	Fruit weight (g)		Volume of fruit (cc)		Pulp (%)		Peel (%)		Total soluble solids (^{0}Brix)		Total Sugars (%)		Titratable acidity (%)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
T_0	700.26	795.36	695.20	740.37	75.69	74.90	21.34	20.79	8.98	9.01	7.85	7.86	0.198	0.197
T_1	1370.00	1294.30	1295.00	1225.25	85.39	83.51	11.44	13.53	12.00	12.21	11.06	10.85	0.181	0.182
T_2	1030.00	971.81	955.00	992.25	80.66	79.25	15.11	15.23	9.86	9.81	8.89	8.73	0.162	0.161
T_3	1090.00	1028.72	1058.00	1059.25	81.59	80.96	13.85	13.96	12.80	10.87	9.82	9.65	0.161	0.160
T_4	1144.00	1079.93	1069.00	1010.55	82.69	81.92	14.08	14.19	10.55	10.65	10.07	10.01	0.153	0.158
T_5	1266.00	1195.65	1191.00	1126.45	84.48	82.53	12.44	12.53	11.87	12.10	10.76	10.60	0.151	0.155
T_6	1100.00	1038.20	1025.00	1068.75	81.35	80.98	14.45	14.56	10.65	10.77	9.23	9.07	0.150	0.152
T_7	1133.00	1069.50	1058.00	1000.10	82.66	81.21	13.78	13.88	11.83	11.70	10.89	10.70	0.125	0.131
T_8	1415.00	1336.98	1340.00	1268.00	86.03	84.33	10.61	10.69	12.98	13.11	11.31	11.09	0.110	0.115
T_9	1460.00	1379.66	1385.00	1310.75	86.66	85.14	9.78	9.85	13.95	14.00	11.56	11.32	0.101	0.102
T_{10}	1012.00	974.22	947.00	994.65	81.33	80.61	15.78	15.90	9.42	9.50	8.56	8.39	0.164	0.163
T_{11}	1233.00	1164.35	1018.00	1095.10	83.00	80.55	14.44	14.54	10.17	10.12	9.23	9.03	0.162	0.161
T_{12}	1199.00	1132.10	1124.00	1062.80	82.86	81.41	14.58	14.68	10.30	10.30	9.85	9.95	0.158	0.160
T_{13}	1156.00	1091.32	1081.00	1021.95	83.56	82.10	12.88	12.98	11.43	11.49	10.24	10.18	0.154	0.157
T_{14}	890.00	967.62	981.00	931.95	82.33	80.15	14.99	15.22	10.50	10.25	9.10	8.99	0.152	0.155
T_{15}	977.00	1021.53	1002.00	1051.90	81.86	80.43	14.18	14.69	10.01	11.03	9.89	9.87	0.131	0.145
T_{16}	1200.00	1133.05	1125.00	1163.75	83.66	82.20	12.78	12.88	11.83	11.50	10.25	10.28	0.122	0.125
T_{17}	1310.00	1237.39	1235.00	1268.25	84.00	82.53	11.44	12.53	12.10	12.26	10.95	10.76	0.114	0.112
SEm ±	55.91	56.45	55.10	60.23	1.43	1.33	1.19	1.19	0.93	0.48	0.57	0.61	0.011	0.012
$CD_{5\%}$ level	169.60	171.25	167.16	182.71	4.33	4.02	3.62	3.60	2.83	1.45	1.72	1.84	0.034	0.037
CV	8.40	8.87	8.77	9.68	2.99	2.82	15.01	14.63	14.46	7.42	9.87	10.66	13.362	14.230

Treatments notations: T0 (No amount of fertilizers), T1 (recommended dose of fertilizers (RDF)-200:200:300 g/plant),T2 (RDF 75%+ Azotobacter 50 g + PSB 50 g/plant), T3 (RDF 75%+ Azotobacter 50 g + PSB 50 g+ vermicompost 1 kg/plant), T4 (RDF 75%+ Azotobacter 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), T5 (RDF 75%+ Azotobacter 50 g + PSB 50 g + vermicompost 2 kg/plant), T6 (RDF 75%+ Azotobacter 100 g+ PSB 100 g/plant), T7 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 1 kg/plant), T8 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T9 (RDF 75%+ Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant), T10 (RDF 50%+ Azotobacter 50 g + PSB 50 g/plant), T11 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 1 kg/plant), T12 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 1.5 kg/plant), T13 (RDF 50%+ Azotobacter 50 g + PSB 50 g + vermicompost 2 kg/plant), T14 (RDF 50%+ Azotobacter 100 g + PSB 100 g/plant), T15 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 1 kg/plant), T16 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 1.5 kg/plant), T17 (RDF 50%+ Azotobacter 100 g + PSB 100 g + vermicompost 2 kg/plant)

During both years of experimentations, plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant produced fruits having maximum pulp percent (86.66 and 85.14%, respectively) and minimum peel percent (9.78 and 9.85 %, respectively), which were statistically at par with T8 which produced fruits having pulp percent of 86.03 and 84.33 %, respectively and peel percent of 10.61 and 10.69 %, respectively but significantly higher than all other treatments. The untreated plants produced fruits having minimum pulp percent (75.69 and 74.90%, respectively) and maximum peel percent (21.34 and 20.79 %, respectively) during both years of experimentation.

This increase in pulp content of fruits and decrease in peel content might be on account of incorporation of chemical fertilizers, organic manures, and bio-fertilizers as a nutrition source to the plants. Organic manures and bio-fertilizers especially *Azotobacter* have direct role in nitrogen fixation, PSB helps in the increasing availability of phosphorus and vermicompost ensure availability of all other nutrients in balanced amount at appropriate time, thus production of phytohormones like substances increased and uptake of nutrients also increased, hence quality improvement reflected in fruit characters. These observations agree with the findings of [19], [17] in banana, [20] in aonla and [16] in papaya.

Total Soluble Solids (TSS) and total sugar content

From the data presented in [Table-2] it is clear that during both years of present investigation, significantly more total soluble solids (TSS) and total sugar contents in fruits have been recorded in all treatments over control when *Azotobacter*, PSB and vermicompost were used in combinations with different doses of RDF. Fruit with maximum TSS (13.95 and 14.00 °Brix, respectively) and total sugar (11.56 and 11.32 %, respectively) were produced from RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant (T9) fertilized plants, whereas the fruits with minimum TSS (8.98 and 9.01 °Brix, respectively) and total sugar (7.85 and 7.86 %, respectively) contents were harvested from the plants which were kept under control (without any fertilizers application) during both years of experimentation.

The improvement in TSS and total sugar contents with the application of RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant in the present investigation might be due to the addition of bio-fertilizers and organic manures (supplements for ample of nutrients and growth promoting substances) which enhances metabolic and hormonal activity of the plant and promotes production of more photosynthates which was stored in leaves to plants in the form of starch and carbohydrates, which latter transferred to the developing fruits as a source-sink relationship.

The increase in TSS and total sugar content in papaya fruits could also be attributed due to the conversion of reserved starch and other insoluble carbohydrates into soluble sugars. These findings are in agreement with the results of [9], [18] in strawberry, [7] in ber, [20] in aonla, [17] and [10] in banana, [15] and [6] in papaya.

Titratable acidity content of fruit

The maximum titratable acidity (0.198 and 0.197 %, respectively) was recorded in the fruits which were produced from the unfertilized plants, whereas the minimum acidity (0.101 and 0.102 %, respectively) was recorded with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant fertilized plants during both years of experimentation. The reduction in titratable acidity content of papaya fruits through application of different organic manure with inorganic fertilizers might be due to the positive influence of various micro-organisms in conversion of acids into sugar and their derivatives by the reaction involving in glycolytic pathway or be used in respiration or in both. The results are in line with the findings of [5], [21] in strawberry, [17] and [10] in banana and [15] in papaya.

Application of research: Very useful to the papaya grower to get higher yield of quality fruits in a shorter period of time than the normal one.

Research Category: Scientific way of production

Abbreviations: kg- Kilogram, g-Gram, CC-Cubic Centimetres,
RDF- Recommended Dose of Fertilizer, PSB- Phosphate Solubilizing Bacteria

Acknowledgement / Funding: Authors are thankful to Department of Horticulture, C. S. Azad University of Agriculture and Technology, Kanpur, 208 002, Uttar Pradesh, India

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Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Garden, Department of Horticulture, CSAU Kanpur

Cultivar / Variety / Breed name: 'Sapna', Papaya (*Carica papaya* L.)

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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