Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
www.phytojournal.com
JPP 2020; 9(5): 2022-2026
Received: 18-06-2020
Accepted: 29-08-2020

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# Influence of integrated nutrient management on growth, yield and quality parameters of papaya (*Carica papaya* L.)

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**DOI:** https://doi.org/10.22271/phyto.2020.v9.i5ab.12639

**Abstract**
An experiment was carried out in the Department of Horticulture, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur (U.P.), 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 increased plant height, girth, number and length of leaves, Biomass production in plant (green weight), number of flowers and fruits set per plant, fruit yield with minimum number of days taken to first flowering were produced with the application of RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant, whereas significantly minimum plant height, girth, number and length of leaves, biomass production in plant (green weight), number of flowers and fruits set per plant, fruit yield with increased number of days taken to first flowering was recorded in unfertilized plants. As the quality parameters are concerned, it is recorded that plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant produced longest fruits with more width, weight, total soluble solids (TSS) and total sugar contents with minimum titratable acidity, whereas minimum length and width, weight, total soluble solids (TSS) and total sugar contents with maximum titratable acidity contents were recorded in fruits harvested from the plants which were kept under control (without any fertilizers application) during both years of experimentation.

**Keywords:** Papaya, integrated nutrient management, growth, yield and quality parameters

## Introduction
Papaya (*Carica papaya* L.), a member of family Caricaceae, is a fast growing, typically single-hollow stemmed, herbaceous, evergreen, dicotyledonous, perennial plant. It is basically a tropical fruit plant which is commercially grown in tropical and sub-tropical areas. In Uttar Pradesh it is being cultivated in an area of 2010 ha with a total production of 96830 MT and average productivity is 48.17 MT per hectare (Anonymous, 2018) [2]. Fruits are rich in carotene, vitamin A, thiamine, riboflavin, minerals and a number of proteolytic enzymes, and consumed as fresh when ripen as well as vegetable, when green. Because of its quick growth, continuous fruiting habit and heavy fruit yield, it is graded as a highly nutrient exhaustive fruit crop. Use of different chemical fertilizers results in decline of productivity due to its deteriorating effect on physical, chemical and biological properties of soil. An INM (Integrated Nutrient Management) is one of the most effective alternatives which involve combined use of chemical fertilizers, organic manures and bio-fertilizers for the maintenance of long-term soil fertility and productivity of crops along with sustainable crop production. Organic manures mostly enhance the nutrient availability in order 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, 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 growth, flowering and higher yield of quality fruits in papaya.

## 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.*, $T_0$ (No amount of fertilizers), $T_1$ (recommended dose of fertilizers (RDF)-200:200:300 g/plant),$T_2$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_3$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1 kg/plant), $T_4$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), $T_5$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_6$ (RDF 75%+ *Azotobacter* 100 g+ PSB 100 g/plant), $T_7$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_8$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_9$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant), $T_{10}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_{11}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1 kg/plant), $T_{12}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1.5 kg/plant), $T_{13}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_{14}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g/plant), $T_{15}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_{16}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_{17}$ (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 plant height, girth, number of leaves per plant and length of leaf, biomass production of plants were recorded at the end of fruiting season, whereas days taken to produce first flower, number of flowers and fruits set per plant were recorded by counting at ten days interval during entire fruiting season. During harvesting, data on fruit weight and yield per plant were recorded. The length and width of four randomly selected fruits were measured with measuring tape. 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 A.O.A.C. (1980).

## Results and Discussion

### Plant height and girth

Data presented in Table-1, clearly revealed that the plant height and girth were increased significantly during both years of experimentation over control when *Azotobacter,* PSB and vermicompost were used in combinations with different doses of RDF. The tallest plants (2.10 and 2.00 m, respectively) with maximum plant girth (39.60 and 35.24 cm, respectively) were produced with the application of 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 ($T_8$) fertilized plants which produced plants height of 2.01 and 1.90 m, respectively with 39.47 and 34.99 cm, respectively plant girth during both years of experimentation. The significantly minimum plant height (1.38 and 1.32 m, respectively) and girth (17.02 and 16.04 cm, respectively) was recorded under unfertilized plants during both years of experimentation. This increase in plant height and girth might be due to the fact that proper combination of chemical fertilizers, organic manure and bio-fertilizers provides nutrients in proper proportion and amount at right time which hastens the height and girth of plants. In vermicompost, earthworms changes many of the nutrients present in various organic waste into available forms such as nitrate or ammonium nitrate, exchangeable phosphorus and soluble potassium, calcium and magnesium during its processing and when it is applied to the plants with bio-fertilizers, the nutrients are rapidly taken up by the plants which help to encourage early vegetative growth. This increase in height and girth of plant with the application of integrated doses of nutrients and bio-fertilizers during the entire course of investigation are in accordance with the findings of Nayyer *et al.* (2014) [12] in banana, Srinu *et al.* (2017) [14] and Srivastava *et al.* (2014) in papaya, Tripathi *et al.* (2013) [17] in Isabgol, Mishra and Tripathi (2011) [11] and Tripathi *et al.* (2015b) [20] in strawberry.

### Leaves parameters

During both years of investigation, the number and length of leaves were significantly increased over control when *Azotobacter,* PSB and vermicompost were used in combinations with different doses of RDF (Table 1). Plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant produced significantly maximum number of leaves (35.54 and 36.52, respectively) and maximum length of leaf (41.00 and 39.57 cm, respectively) followed by RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/ plant ($T_8$) fertilized plants which produced 33.44 and 33.49, respectively number of leaves having 40.00 and 38.61 cm, length of leaves respectively, whereas the minimum number (26.00 and 25.65, respectively) and length (24.27 and 24.96 cm, respectively) of leaves were recorded under untreated control plants during both years of experimentation. This increase in leaf parameters during entire experimental period are in complete agreement with that of Tripathi (2017) [16] and Nayyer *et al.* (2014) [12] in banana, who narrated that integrated application of bio-fertilizers along with graded dose of inorganic fertilizers and organic manures have considerably increased the leaf production with increased leaf area at fruiting stage. It can be attributed to the fact that the increase in nutrient levels especially nitrogen resulted in an enhanced vegetative growth and simultaneously increased in number and length of leaves. This increase in leaves parameters might also be due to the production of more chlorophyll content with the inoculation of nitrogen fixers. The similar result was reported by Srinu *et al.* (2017) [14] and Srivastava *et al.* (2014) [15] in papaya, Tripathi *et al.* (2015b) [19] and Tripathi *et al.* (2016) [20] in strawberry cv. Chandler.

### Biomass production of plant (green weight)

Biomass production in plant (green weight) was significantly more over control when *Azotobacter,* PSB and vermicompost were used in combinations with different doses of RDF during both years of experimentation (Table 1). When the plants were fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant produced maximum biomass (29.00 and 28.34 kg, respectively) per plant on green weight followed by the application of RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant, which produced 28.00 and 27.37 kg, respectively biomass during both years of experimentation. On the contrary, minimum biomass (12.00 and 11.65 kg, respectively) per plant (green weight) was produced under untreated (control) plants during both years of experimentation. Seedlings inoculated with *Azotobacter* and PSB showed significantly higher shoot biomass accumulation over control and uninoculated ones might be due to the induction of growth hormones, which stimulated cell division, cell elongation, activate the photosynthesis process. These results are corroborated with the findings of Mamta *et al.* (2017) [10], who also reported that fresh biomass accumulation in shoot of papaya plant ranged from 13.82 to 32.42 g/seedling and 2.67 to 3.53 g/seedling at 120 DAT, respectively under different INM treatments. The similar findings were reported by Kiran Kumar *et al.* (2017) [9] in guava.

**Number of days taken to first flowering**

Number of days taken to first flowering during both years of experimentation was significantly minimum over control, when *Azotobacter*, PSB and vermicompost were used in combinations with different doses of RDF (Table 1). Plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant plants took minimum number of days (85.33 and 87.78 days, respectively) as compared to all other treatments, whereas uninoculated plants took more days for the appearance of first flower (122.67 and 124.35 days, respectively) during both years of experimentation.

The reason for the 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 of the findings of Hazarika and Ansari (2010) [13], Nayyer *et al.* (2014) [12], in banana, who reported that the minimum numbers of days taken from flowering to harvesting in the plants which were treated with 100% RDF of NPK + 50g *Azospirillum* + 50g PSB + 50g *Trichoderma harzianum* per plant. The similar result was reported by Srinu *et al.* (2017) [14] in papaya, Gupta and Tripathi (2012) [4] in strawberry cv. Chandler.

**Number of flowers and fruits set per plant**

During both years of experimentation number of flowers and fruits set per plant were significantly more over control when *Azotobacter*, PSB and vermicompost were used in combinations with different doses of RDF (Table 1). Higher number of flowers (104.69 and 104.80, respectively) with maximum number of fruits set (43.00 and 40.85, respectively) per plant was recorded in plants which were fertilized with RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant, whereas the minimum number of flowers (73.86 and 72.24, respectively) and fruits set (24.00 and 22.80, respectively) were recorded under control during both years of experimentation. This increase in number of flowers and fruits set in this treatment might be due to the fact that the application *Azotobacter* and PSB alongwith vermicompost and NPK fertilizers as a balanced dose accelerated the development of inflorescence, leaf number in autumn which results in increased levels of nutrients in assimilating area of crop due to which the rate of dry matter production was enhanced, which is positively correlated with the number of flowers and fruits in the following spring. Proper supply of nutrients and induction of growth hormones stimulated cell division, cell elongation, which results an increase in number of flowers and fruits. Similar findings have been reported by Srinu *et al.* (2017) [14] in papaya, Gupta and Tripathi (2012) [4] in strawberry cv. Chandler, Tripathi *et al.* (2015a) [18] in aonla and Katiyar *et al.* (2012) [7] in ber.

**Fruit yield**

Data sown in Table 2 clearly reveals 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 treated with the combination of RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant ($T_9$) and this yield was significantly higher as compared to all other treatments. Plants under control produced the minimum yield of fruits (22.34 and 23.49 kg, respectively) during both years of experimentation.

The increase in yield parameters with the application of vermicompost, *Azotobacter* and PSB with graded dose of NPK might be due to increased fruits set per plant, increased fruits size, weight and may also be due to the fact that nitrogen fixers and phosphorous solubulizers not only increased the availability of nitrogen and phosphorous to the plants but also increased their translocation from root to flower via plant foliage. Relatively higher amount of carbohydrates could have promoted the growth rate and increased fruit weight. These findings are in line with the findings of Nayyer *et al.* (2014) [12] in banana, Gupta and Tripathi (2012) [4] in strawberry, Katiyar *et al.* (2012) [7] in ber, Kumar *et al.* (2015) [8] in Guava, Ravishankar *et al.* (2010) [13], and Kanwar *et al.* (2020) [6] in papaya.

**Length, width and weight of fruits**

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 length, width and weight and they were significantly superior over control when *Azotobacter*, PSB and vermicompost were used in combinations with different graded doses of RDF. Longest fruits (26.66 and 25.81 cm, respectively) with more width (19.33 and 18.60 cm, respectively) and weight (1460.00 and 1379.66 g, respectively) were produced from the plants fertilized with RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant. The untreated plants (control) produced fruits of significantly minimum length (18.60 and 19.36 cm, respectively), width (12.67 and 12.11 cm, respectively) and weight (700.26 and 795.36 g) as compared to treated plants during both years of experimentation. This increase in length, width and weight of fruits 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 the 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 and weight of fruit (Atiyeh, 2002). Results are in accordance with the findings of Mishra and Tripathi (2011) [11], who also reported maximum increase in size and weight of strawberry fruits with the application of *Azotobacter*, PSB and vermicompost. The results also in close conformity with the findings of Kumar *et al.* (2015) [8] in Guava, Tripathi *et al.* (2016) [20] in strawberry, Katiyar *et al.* (2012) [7] in ber, Ravishankar *et al.* (2010) [13] and Kanwar *et al.* (2020) [6] in papaya

**Total Soluble Solids (TSS), total sugar and titratable acidity content**

Data presented in Table 2 clearly reveals 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. Maximum TSS (13.95 and 14.00

$^0$Brix, respectively) and total sugar (11.56 and 11.32%, respectively) was recorded in fruits which were produced from RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant ($T_9$) fertilized plants and was significantly higher than all other treatments under investigation except $T_8$, which produced fruits having TSS 12.98 and 13.11 $^0$Brix, respectively and total sugar 11.31 and 11.09%, respectively content, whereas the fruits with minimum TSS (8.98 and 9.01 $^0$Brix, respectively) and total sugar (7.85 and 7.86%, respectively) contents were recorded in fruits 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 with the application of RDF 75% + *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant during 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 in the form of starch and carbohydrates, which latter transferred to the developing fruits as a source-sink relationship. These findings are in agreement with the results of Mishra and Tripathi (2011) [11] in strawberry, Katiyar *et al.* (2012) [7] in ber, Tripathi *et al.* (2015a) [18] in aonla, Tripathi (2017) [16] in banana, Srivastava *et al.* (2014) [15] and Kanwar *et al.* (2020) [6] in papaya. Yadav (2006) [22] also reported that the application of vermicompost with 100% NPK resulted maximum TSS, total sugar and reduction in acidity of papaya 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 in 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 views were corroborated with the observations of Gupta and Tripathi (2012) [4], Tripathi *et al.* (2015b) [19] in strawberry, Srinu *et al.* (2017) [14] in papaya.

**Table 1:** Influence of Integrated Nutrient Management on growth and flowering parameters of papaya (*Carica papaya* L.)

| Treatments | Height of plant (cm) | | Plant girth (cm) | | Number of leaves per plant | | Length of leaf (cm) | | Biomass production of plant (kg) | | Days taken to first flowering | | Number of flowers per plant | | Number of fruits set per plant | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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 | 2015-16 | 2016-17 |
| $T_0$ | 1.38 | 1.32 | 17.02 | 16.04 | 26.00 | 25.65 | 24.27 | 24.96 | 12.00 | 11.65 | 122.67 | 124.35 | 73.86 | 72.24 | 24.00 | 22.80 |
| $T_1$ | 1.91 | 1.79 | 36.74 | 33.33 | 33.33 | 31.45 | 39.00 | 37.64 | 27.00 | 26.39 | 90.00 | 92.63 | 103.85 | 103.28 | 40.00 | 38.00 |
| $T_2$ | 1.53 | 1.46 | 23.83 | 21.62 | 28.76 | 27.87 | 28.46 | 27.46 | 18.46 | 18.08 | 110.00 | 113.38 | 77.00 | 75.15 | 28.00 | 27.56 |
| $T_3$ | 1.55 | 1.47 | 25.03 | 22.70 | 26.57 | 27.24 | 29.67 | 28.63 | 19.67 | 19.25 | 106.67 | 101.96 | 84.76 | 80.25 | 30.00 | 28.50 |
| $T_4$ | 1.57 | 1.51 | 25.03 | 22.70 | 33.24 | 31.67 | 30.00 | 28.95 | 20.00 | 19.58 | 99.00 | 99.92 | 89.00 | 84.55 | 32.00 | 30.40 |
| $T_5$ | 1.73 | 1.65 | 31.13 | 28.24 | 34.24 | 32.62 | 32.00 | 30.88 | 22.00 | 21.52 | 91.33 | 94.00 | 97.25 | 94.05 | 36.00 | 34.20 |
| $T_6$ | 1.58 | 1.60 | 26.03 | 23.61 | 29.97 | 29.86 | 30.00 | 28.95 | 20.00 | 19.58 | 96.67 | 99.55 | 85.10 | 83.95 | 28.50 | 27.70 |
| $T_7$ | 1.69 | 1.68 | 23.83 | 21.62 | 30.91 | 30.76 | 29.33 | 28.30 | 17.33 | 16.98 | 93.93 | 97.08 | 91.00 | 89.45 | 31.00 | 29.45 |
| $T_8$ | 2.01 | 1.90 | 39.47 | 34.99 | 33.44 | 33.49 | 40.00 | 38.61 | 28.00 | 27.37 | 87.67 | 90.21 | 104.20 | 104.75 | 41.50 | 39.43 |
| $T_9$ | 2.10 | 2.00 | 39.60 | 35.24 | 35.54 | 36.52 | 41.00 | 39.57 | 29.00 | 28.34 | 85.33 | 87.78 | 104.69 | 104.80 | 43.00 | 40.85 |
| $T_{10}$ | 1.48 | 1.42 | 25.24 | 22.89 | 28.33 | 27.45 | 29.45 | 28.42 | 17.45 | 17.09 | 108.00 | 101.30 | 79.00 | 75.05 | 25.18 | 24.97 |
| $T_{11}$ | 1.50 | 1.53 | 30.64 | 27.79 | 27.79 | 26.50 | 34.00 | 32.81 | 22.00 | 21.52 | 97.33 | 99.23 | 81.30 | 80.15 | 29.00 | 27.55 |
| $T_{12}$ | 1.52 | 1.56 | 31.54 | 28.61 | 31.33 | 30.86 | 31.00 | 29.92 | 19.00 | 18.60 | 91.67 | 94.36 | 82.00 | 83.08 | 27.00 | 25.65 |
| $T_{13}$ | 1.58 | 1.69 | 29.74 | 26.98 | 30.33 | 31.81 | 35.00 | 33.78 | 23.00 | 22.50 | 86.67 | 89.92 | 84.22 | 82.50 | 28.00 | 26.60 |
| $T_{14}$ | 1.60 | 1.75 | 26.44 | 23.98 | 27.24 | 28.97 | 27.67 | 26.70 | 15.67 | 15.36 | 96.34 | 90.38 | 81.10 | 82.05 | 27.00 | 25.65 |
| $T_{15}$ | 1.65 | 1.64 | 30.33 | 27.52 | 29.33 | 27.96 | 30.00 | 28.95 | 18.00 | 17.63 | 91.66 | 89.16 | 88.00 | 87.60 | 33.00 | 31.35 |
| $T_{16}$ | 1.71 | 1.69 | 34.33 | 31.15 | 32.33 | 30.81 | 33.00 | 31.85 | 21.00 | 20.55 | 88.00 | 87.78 | 94.00 | 89.30 | 36.00 | 34.20 |
| $T_{17}$ | 1.75 | 1.74 | 37.66 | 34.17 | 33.15 | 32.98 | 37.00 | 35.72 | 26.00 | 27.44 | 86.81 | 86.50 | 98.00 | 93.10 | 38.00 | 36.10 |
| SEm ± | 0.14 | 0.13 | 1.49 | 1.81 | 1.76 | 2.00 | 2.12 | 2.17 | 1.95 | 1.98 | 2.92 | 2.86 | 4.08 | 3.18 | 2.29 | 1.81 |
| $CD_{5\%}$ level | 0.41 | 0.38 | 4.52 | 5.50 | 5.34 | 6.08 | 6.44 | 6.58 | 5.91 | 5.99 | 8.85 | 8.67 | 12.37 | 9.66 | 6.95 | 5.50 |
| CV | 14.22 | 13.35 | 8.69 | 11.70 | 9.95 | 11.47 | 11.40 | 12.02 | 16.23 | 16.62 | 5.26 | 5.12 | 7.95 | 6.35 | 12.37 | 10.26 |

Treatments notations: $T_0$ (No amount of fertilizers), $T_1$ (recommended dose of fertilizers (RDF)-200:200:300 g/plant),$T_2$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_3$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1 kg/plant), $T_4$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), $T_5$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_6$ (RDF 75%+ *Azotobacter* 100 g+ PSB 100 g/plant), $T_7$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_8$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_9$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant), $T_{10}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_{11}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1 kg/plant), $T_{12}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1.5 kg/plant), $T_{13}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_{14}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g/plant), $T_{15}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_{16}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_{17}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant)

**Table 2:** Influence of Integrated Nutrient Management on yield and quality parameters of papaya (*Carica papaya* L.)

| | Fruit yield (kg/tree) | | Fruit length (cm) | | Fruit width (cm) | | Fruit weight (g) | | 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 |
| $T_0$ | 22.34 | 23.49 | 18.60 | 19.36 | 12.67 | 12.11 | 700.26 | 795.36 | 8.98 | 9.01 | 7.85 | 7.86 | 0.198 | 0.197 |
| $T_1$ | 58.80 | 52.98 | 25.00 | 24.20 | 17.67 | 17.00 | 1370.00 | 1294.30 | 12.00 | 12.21 | 11.06 | 10.85 | 0.181 | 0.182 |
| $T_2$ | 29.38 | 26.47 | 20.66 | 20.00 | 15.66 | 12.82 | 1030.00 | 971.81 | 9.86 | 9.81 | 8.89 | 8.73 | 0.162 | 0.161 |
| $T_3$ | 35.70 | 36.17 | 21.59 | 20.90 | 14.26 | 13.72 | 1090.00 | 1028.72 | 12.80 | 10.87 | 9.82 | 9.65 | 0.161 | 0.160 |
| $T_4$ | 39.81 | 35.87 | 22.36 | 21.64 | 15.03 | 14.46 | 1144.00 | 1079.93 | 10.55 | 10.65 | 10.07 | 10.01 | 0.153 | 0.158 |
| $T_5$ | 49.18 | 44.31 | 24.00 | 23.23 | 16.67 | 16.04 | 1266.00 | 1195.65 | 11.87 | 12.10 | 10.76 | 10.60 | 0.151 | 0.155 |
| $T_6$ | 31.20 | 28.11 | 21.00 | 20.33 | 13.67 | 14.15 | 1100.00 | 1038.20 | 10.65 | 10.77 | 9.23 | 9.07 | 0.150 | 0.152 |
| $T_7$ | 38.22 | 34.44 | 22.66 | 21.93 | 15.33 | 12.75 | 1133.00 | 1069.50 | 11.83 | 11.70 | 10.89 | 10.70 | 0.125 | 0.131 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $T_8$ | 62.94 | 56.71 | 24.83 | 24.01 | 18.50 | 17.80 | 1415.00 | 1336.98 | 12.98 | 13.11 | 11.31 | 11.09 | 0.110 | 0.115 |
| $T_9$ | 67.08 | 60.44 | 26.66 | 25.81 | 19.33 | 18.60 | 1460.00 | 1379.66 | 13.95 | 14.00 | 11.56 | 11.32 | 0.101 | 0.102 |
| $T_{10}$ | 26.93 | 26.26 | 21.55 | 20.65 | 12.94 | 12.67 | 1012.00 | 974.22 | 9.42 | 9.50 | 8.56 | 8.39 | 0.164 | 0.163 |
| $T_{11}$ | 32.66 | 31.83 | 22.67 | 22.26 | 15.67 | 15.07 | 1233.00 | 1164.35 | 10.17 | 10.12 | 9.23 | 9.03 | 0.162 | 0.161 |
| $T_{12}$ | 35.07 | 33.60 | 22.86 | 22.13 | 15.53 | 14.94 | 1199.00 | 1132.10 | 10.30 | 10.30 | 9.85 | 9.95 | 0.158 | 0.160 |
| $T_{13}$ | 35.17 | 32.69 | 23.56 | 22.81 | 16.23 | 15.61 | 1156.00 | 1091.32 | 11.43 | 11.49 | 10.24 | 10.18 | 0.154 | 0.157 |
| $T_{14}$ | 28.51 | 25.69 | 22.33 | 21.62 | 13.00 | 13.43 | 890.00 | 967.62 | 10.50 | 10.25 | 9.10 | 8.99 | 0.152 | 0.155 |
| $T_{15}$ | 35.54 | 32.03 | 21.86 | 21.16 | 14.53 | 13.98 | 977.00 | 1021.53 | 10.01 | 11.03 | 9.89 | 9.87 | 0.131 | 0.145 |
| $T_{16}$ | 46.80 | 42.17 | 20.66 | 22.90 | 16.33 | 15.71 | 1200.00 | 1133.05 | 11.83 | 11.50 | 10.25 | 10.28 | 0.122 | 0.125 |
| $T_{17}$ | 53.58 | 48.28 | 24.00 | 23.23 | 16.67 | 16.04 | 1310.00 | 1237.39 | 12.10 | 12.26 | 10.95 | 10.76 | 0.114 | 0.112 |
| SEm ± | 2.33 | 1.94 | 1.27 | 1.17 | 1.17 | 1.18 | 55.91 | 56.45 | 0.93 | 0.48 | 0.57 | 0.61 | 0.011 | 0.012 |
| $CD_{5\%}$ level | 7.06 | 5.87 | 3.86 | 3.55 | 3.54 | 3.57 | 169.60 | 171.25 | 2.83 | 1.45 | 1.72 | 1.84 | 0.034 | 0.037 |
| CV | 9.96 | 8.99 | 9.74 | 9.16 | 13.01 | 13.73 | 8.40 | 8.87 | 14.46 | 7.42 | 9.87 | 10.66 | 13.362 | 14.230 |

Treatments notations: $T_0$ (No amount of fertilizers), $T_1$ (recommended dose of fertilizers (RDF)-200:200:300 g/plant), $T_2$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_3$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1 kg/plant), $T_4$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g+ vermicompost 1.5 kg/plant), $T_5$ (RDF 75%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_6$ (RDF 75%+ *Azotobacter* 100 g+ PSB 100 g/plant), $T_7$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_8$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_9$ (RDF 75%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant), $T_{10}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g/plant), $T_{11}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1 kg/plant), $T_{12}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 1.5 kg/plant), $T_{13}$ (RDF 50%+ *Azotobacter* 50 g + PSB 50 g + vermicompost 2 kg/plant), $T_{14}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g/plant), $T_{15}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1 kg/plant), $T_{16}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 1.5 kg/plant), $T_{17}$ (RDF 50%+ *Azotobacter* 100 g + PSB 100 g + vermicompost 2 kg/plant)

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