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# Synergistic Influence of Bio-Fertilizers, Growth Regulator and Micronutrients on Yield and Economics of Sapota cv. Kalipatti

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

An experiment laid down to evaluate the effect of biofertilizers, growth regulator gibbralic acid ($GA_3$) and micronutrients on yield and yield attributes of Sapota cv. Kalipatti at Fruit Research Station, Navsari Agricultural University, Gandevi, Gujarat. The treatments of recommended dose of fertilizer (RDF), *i.e.*100 kg FYM and 1000:500:500 g/plant NPK along with application of biofertilizers (*Azospirillum* + PSB), growth regulator ($GA_3$) and micronutrients. The pooled results of 75% RDF + biofertilizers- *Azospirillum* + PSB @ 40 ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutrient @ 0.5%) were exhibited significantly higher number of fruit (2815.45), yield (20.61 t/ha)along with net return (Rs. 3,03,951/ha) and Benefit Cost Ratio (2.81). The said application enhanced fruit yield up to 43.41% over control comprising RDF only. However, significantly higher fruit weight (81.34 g) was recorded in application of 100% RDF + biofertilizers- *Azospirillum* + PSB @ 40ml/tree + $GA_3$ @ 50 ppm + Grade-4 (micronutrient @ 0.5%).

*Keywords: Sapota; micronutrients; growth regulator; bio-fertilizer.*

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## 1. INTRODUCTION

Sapota (*Manilkara zapota* Mill. Fosberg.) is a hardy tropical fruit crop that prefers warm but moist weather and grows in both dry and humid areas [1]. It is low land fruit tree, and its cultivation is limited to tropical or near tropical region, becomes one of the important fruits in southern and western part of the India due to its wide range of adaptability, low production cost and reasonable economic returns with very less pest and disease susceptibility [2]. India is considered to be the largest producer of sapota in the World. In India, Navsari district of Gujarat having highest area (8,132 ha) producing the largest amount of sapota fruits (1,01,894 ton) in India [3].

In Indian fruit orchards, poor soil health and imbalance nutrient application are major cause of low orchard efficiency resulting in poor productivity. Also, proper nutrition of sapota orchards is very essential and crucial order to boost up the growth and productivity of plants which is lacking in many parts [4]. Thus, integrated nutrient management (INM) through combination of organic, inorganic, biofertilizers and growth hormones can fulfill the requirement of plant nutrients for quantitative as well as qualitative production. Organic source of nutrients are known to improve fruit quality and soil health by increasing the rhizosphere micro flora. The soil rhizosphere, micro flora and fauna plays very important role in growth and development process of plant. In integrated approach, biofertilizers are partial alternate source of chemical fertilizers. Among them, *Azospirillum* fixing the atmospheric nitrogen in soil and prevents the pollution in environment for extended sustainable agriculture. Phosphate-solubilizing bacteria are able to solubilize the insoluble phosphate from organic and inorganic phosphate sources [5]. In growth hormone, $GA_3$ induces early flowering, prolonged flower life and fruit development. In addition, micronutrients play vital role for metabolic activity in vegetative and reproductive phase of plants. They are important co-factor found in the structure of certain enzymes and hormones, due to that management of micronutrients in fruit crops for better vegetative and reproductive growth as well as physiological parameters [6]. In line, micronutrient G-4 (Micro mix) content 5 micronutrients *viz.* Zn (6%), Fe (4%), Cu (0.5%), Mn (1%) and B (0.5%). The research literature based information on symbiotic effect of bio-fertilizers, PGR's and micronutrients in combination with recommended dose of fertilizers in sapota was not tested widely and is very scanty. Considering the importance and future scope of sustainable sapota production, soil health and reduction in chemical fertilizer dose, the present experiment was framed to overview the impact of these above inputs under field condition.

## 2. MATERIALS AND METHODS

A field experiment was conducted in the already established 29 year old sapota (cv. Kalipatti) plantation (1987) at Fruit Research Station (ICAR-AICRP on Fruits) Navsari Agricultural University, Gandevi, Dist. Navsari (Gujarat) during five consecutive years from 2014-15 to 2019-2020. The experimental site located at 20.807545º N 73.022260º E. The soil of the experimental site is Clay (heavy black) having soil pH of about 6.80 with electrical conductivity of 0.21 $dSm^{-1}$ and 0.71% organic carbon.

The experiment was designed in Randomized Block Design (RBD) with 3 replications and 9 treatments.The treatments were- $T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (*Azospirillum* + PSB @ 40 ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100% RDF + biofertilizers (*Azospirillum* + PSB @ 40 ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$ (75% RDF + Biofertilizers (*Azospirillum* + PSB @ 40 ml/tree), $T_7$ (75% RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + bio-fertilizers (*Azospirillum* + PSB @ 40 ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%).

The application of fertilizers was done in June and October month (Two equal splits), bio-fertilizer applied in July, $GA_3$ spray in November and Grade 4 micronutrients spray in December.

The observations on growth, yield and quality parameters were recorded. The fruits were harvested from month of November to May. Fertilizers were applied between the radial distances 150 to 200 cm away from trunk, 15-25 cm deep and then properly covered with soil. Bio fertilizers were applied by mixing in FYM two week after application of inorganic fertilizers. For recording the fruit quality parameters observation, five mature fruits were randomly selected from each observational tree. The soil of experimental site was well drained clayey soil.

Irrigation method during experiment was ridge and furrow system.

## 3. RESULTS AND DISCUSSION

The effect of different treatments on growth parameters viz., plant height, stem girth and canopy volume were found non-significant (Table 1). The yield attributes revealed the significantly higher number of fruits (3738.17, 3067.02, 2215.95, 2759.78, 2296.33 and 2815.45), yield per tree (258.9, 214.6, 170.3, 212.7, 173.9 and 206.1 kg), yield per ha (25.89, 21.46, 17.03, 21.27, 17.39 and 20.61 ton) recorded in $T_9$ (75% RDF + Biofertilizers- *Azospirillum* + PSB @ 40ml/tree + GA3 @ 50 ppm + Grade 4 micronutrient @ 0.5%) (Table 2, 3 and 4) in 2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and pooled, followed by treatment $T_5$. Moreover, number of fruits and yield per tree recorded higher over control were recorded with treatment $T_9$ (Fig.1 and 2).

Meanwhile, Yield per tree in percentage was recorded maximum in treatment $T_9$ (43.41%) followed by treatment $T_5$ (32.82%) over control (Table-3)

The improvement of yield parameters in the presence of *Azospirrilum,* might be due to its dual nature in nitrogen fixation, production of phytohormone substances and increase uptake of nutrient such as nitrogen [7]. $GA_3$ increased number flowers per shoot, fruit set and fruit retention in sapota cv. Kalipatti [8].Micronutrients helps in reduce flower drop and increase the fruit retention (Zn), chlorophyll production (Fe), flower development and pollen germination, pollen tube growth, flower fertilization, fruit set and early fruit development (B) [9], photosynthesis process (Cu and Mn) [6]. Appropriate quantity of micronutrients is necessary for better growth, flowering, higher fruit set, yield and quality of horticultural crops [10], while its deficiency leads lowering the productivity [11].

With respect to yield attributes, the significantly higher fruit weight (79.49, 77.66, 78.64, 78.04, 92.88 and 81.34 g) was recorded in 2015-16, 2016-17, 2017-18, 2018-19, 2019-20 and pooled obtained with treatment $T_5$ [100% RDF + Biofertilizers (*Azospirillum* + PSB @ 40 ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutrient @ 0.5%)], followed by treatment $T_3$ (Table 5). Fruit weight and fruit size are highly correlated with dry matter content and balance level of hormones. Superior physical fruit quality may be due to fact that, organic manures and microbial fertilizers enhances the nutrient availability by enhancing the capability of plants to better solute uptake from rhizosphere, also these nitrogen fixers are known for accumulation of dry matter and their translocation as well as synthesis of different growth regulators [12,13]. *Azospirillum* derive positive benefit in terms of enhancement in uptake of $NO_3^-$, $NH_4^+$, $H_2PO_4^-$, $K^+$ and Fe $^{2+}$ increase nitrate reductase activity in the plants [14]. *Azospirillum* and PSB increase availability

**Table 1. Combine effect of bio fertilizers, $GA_3$ and micronutrients on growth parameters of sapota cv. Kalipatti**

| Treatment* | Plant height (m) | Stem girth (cm) | Tree canopy volume ($m^3$) |
|---|---|---|---|
| $T_1$ | 10.80 | 110.03 | 370.34 |
| $T_2$ | 10.64 | 121.67 | 330.07 |
| $T_3$ | 10.94 | 110.24 | 358.70 |
| $T_4$ | 11.24 | 118.21 | 374.94 |
| $T_5$ | 11.30 | 114.93 | 349.69 |
| $T_6$ | 10.81 | 111.54 | 319.21 |
| $T_7$ | 10.61 | 115.61 | 325.19 |
| $T_8$ | 10.87 | 111.21 | 373.82 |
| $T_9$ | 11.04 | 117.23 | 352.81 |
| CD 5% | NS | NS | NS |
| CV % | 9.36 | 13.45 | 28.25 |

**$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40 ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100% RDF + biofertilizers(Azospirillum + PSB @ 40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$ (75% RDF + Biofertilizers (Azospirillum + PSB @ 40 ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB @ 40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

**Table 2. Effect of biofertilizers, growth regulator and micronutrients on number of fruits per tree/ year of Sapota cv. Kalipatti**

| Treatment* | Fruitsper tree/year | | | | | |
|---|---|---|---|---|---|---|
| | I year | II year | III year | IV Year | V year | Pooled |
| $T_1$ | 2516.55 | 2289.21 | 2028.66 | 2228.51 | 1422.68 | 2097.12 |
| $T_2$ | 2693.16 | 2473.62 | 2145.72 | 2335.05 | 1734.51 | 2276.41 |
| $T_3$ | 2773.36 | 2710.67 | 2150.12 | 2371.09 | 1565.83 | 2314.21 |
| $T_4$ | 2679.45 | 2502.27 | 2030.98 | 2318.3 | 1210.52 | 2148.30 |
| $T_5$ | 3043.87 | 2396.86 | 2142.37 | 2625.87 | 1696.33 | 2381.06 |
| $T_6$ | 2567.38 | 2315.72 | 2013.15 | 2209.24 | 1348.5 | 2090.80 |
| $T_7$ | 2834.39 | 2574.62 | 2060.33 | 2409.58 | 1814.67 | 2338.72 |
| $T_8$ | 2540.96 | 2325.16 | 1998.09 | 2272.04 | 1402.83 | 2107.82 |
| $T_9$ | 3738.17 | 3067.02 | 2215.95 | 2759.78 | 2296.33 | 2815.45 |
| CD 5%(T) | 373.08 | 459.74 | NS | 314.79 | 479.20 | 198.49 |
| CV %(T) | 7.64 | 10.55 | 8.53 | 7.60 | 17.19 | 11.22 |
| CD@ 5%(Y) | -- | -- | -- | -- | -- | 120.59 |
| CD 5% (Y x T) | -- | -- | -- | -- | -- | NS |
| CV% (Y x T) | -- | -- | -- | -- | -- | 9.71 |

**$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40 ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100% RDF + biofertilizers (Azospirillum + PSB @ 40 ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$ (75% RDF + Biofertilizers (Azospirillum + PSB @ 40 ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB @ 40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

**Table 3. Effect of biofertilizers, growth regulator and micronutrients on fruit yield/tree/year (kg) of Sapota cv. Kalipatti**

| Treatment | Fruit yield/tree/year (kg) | | | | | |
|---|---|---|---|---|---|---|
| | I year | II year | III year | IV Year | V year | Pooled |
| $T_1$ | 155.11 | 139.2 | 136.6 | 160.08 | 112.43 | 140.68 |
| $T_2$ | 168.86 | 153.85 | 148.35 | 170.83 | 146.23 | 157.62 |
| $T_3$ | 190.6 | 178.13 | 162.43 | 181.23 | 137.15 | 169.91 |
| $T_4$ | 179.86 | 163.6 | 150.6 | 174.59 | 100.82 | 153.89 |
| $T_5$ | 239.04 | 186.42 | 168.85 | 204.91 | 156.7 | 191.18 |
| $T_6$ | 165.3 | 143.85 | 141.78 | 165.05 | 119.2 | 147.04 |
| $T_7$ | 187.63 | 164.15 | 151.72 | 182.63 | 147.38 | 166.70 |
| $T_8$ | 166.77 | 145.05 | 143.99 | 170.51 | 126.97 | 150.66 |
| $T_9$ | 258.95 | 214.6 | 170.28 | 212.68 | 173.87 | 206.08 |
| CD 5%(T) | 15.87 | 28.18 | 21.11 | 21.55 | 36.61 | 11.91 |
| CV %(T) | 4.82 | 9.84 | 7.98 | 6.91 | 15.59 | 9.33 |
| CD@ 5%(Y) | -- | -- | -- | -- | -- | 7.99 |
| CD 5% (Y x T) | -- | -- | -- | -- | -- | 23.96 |
| CV% (Y x T) | -- | -- | -- | -- | -- | 8.92 |

***$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

**Table 3. Increase yield in percentage over control (Continued)**

| Treatment* | Fruit yield/tree/year (kg) | | | | | |
|---|---|---|---|---|---|---|
| | I year | II year | III year | IV Year | V year | Pooled |
| $T_1$ | -- | -- | -- | -- | -- | -- |
| $T_2$ | 8.86 | 10.52 | 8.60 | 6.72 | 30.06 | 12.04 |
| $T_3$ | 21.02 | 25.30 | 17.41 | 12.38 | 16.90 | 18.54 |
| $T_4$ | 12.99 | 13.70 | 8.62 | 8.01 | -8.47 | 7.77 |
| $T_5$ | 46.66 | 28.86 | 21.41 | 25.68 | 43.91 | 32.82 |
| $T_6$ | 4.26 | 2.49 | 3.07 | 2.43 | 4.32 | 3.33 |
| $T_7$ | 19.67 | 17.34 | 10.66 | 13.66 | 29.32 | 17.70 |
| $T_8$ | 6.21 | 3.56 | 4.87 | 5.71 | 9.87 | 5.99 |
| $T_9$ | 62.27 | 51.98 | 23.39 | 30.85 | 48.39 | 43.41 |

**$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

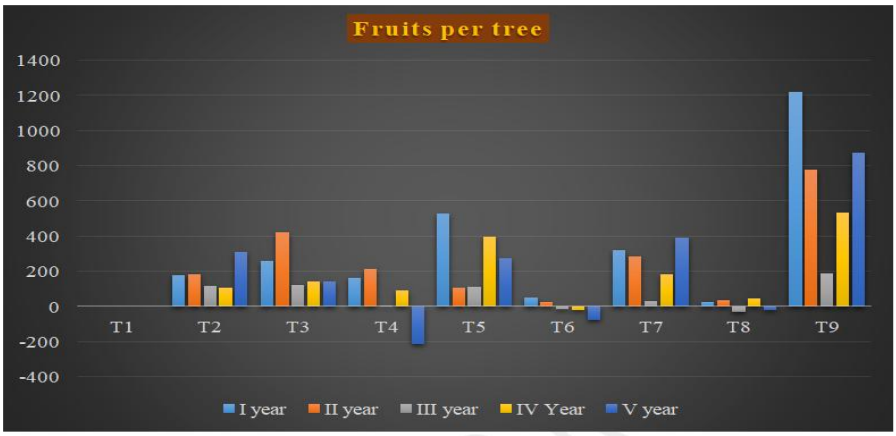


**Fig. 1. Year wise trend of effect of biofertilizers, growth regulator and micronutrients on fruit per tree over control of Sapota cv. Kalipatti**

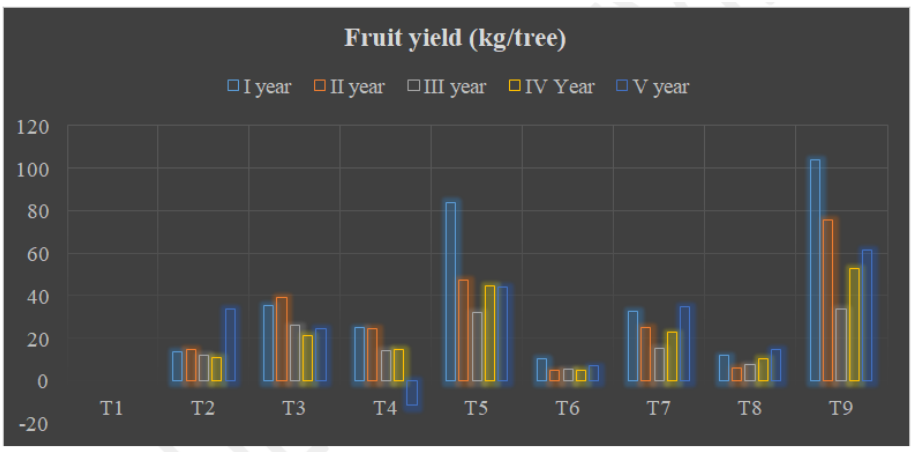


**Fig. 2. Year wise trend of effect of biofertilizers, growth regulator and micronutrients on fruit yield (kg/tree) over control of Sapota cv. Kalipatti**

**Table 4. Effect of biofertilizers, growth regulator and micronutrients on fruit yield/ha/year (t/ha) of Sapota cv. Kalipatti**

| Treatment* | Fruit yield/ha/year(t/ha) | | | | | |
|---|---|---|---|---|---|---|
| | I year | II year | III year | IV Year | V year | Pooled |
| $T_1$ | 15.51 | 13.92 | 13.66 | 16.01 | 11.24 | 14.07 |
| $T_2$ | 16.89 | 15.39 | 14.84 | 17.08 | 14.62 | 15.76 |
| $T_3$ | 19.06 | 17.81 | 16.25 | 18.13 | 13.72 | 16.99 |
| $T_4$ | 17.99 | 16.36 | 15.06 | 17.46 | 10.08 | 15.39 |
| $T_5$ | 23.9 | 18.64 | 16.89 | 20.49 | 15.67 | 19.12 |
| $T_6$ | 16.53 | 14.39 | 14.18 | 16.51 | 11.92 | 14.71 |
| $T_7$ | 18.76 | 16.42 | 15.18 | 18.26 | 14.74 | 16.67 |
| $T_8$ | 16.68 | 14.51 | 14.40 | 17.05 | 12.70 | 15.07 |
| $T_9$ | 25.9 | 21.46 | 17.03 | 21.27 | 17.39 | 20.61 |
| CD 5%(T) | 1.59 | 2.82 | 2.11 | 2.15 | 3.66 | 1.19 |
| CV %(T) | 4.83 | 9.84 | 7.99 | 6.90 | 15.59 | 9.33 |
| CD@ 5%(Y) | -- | -- | -- | -- | -- | 0.80 |
| CD 5% (Y x T) | -- | -- | -- | -- | -- | 2.40 |
| CV% (Y x T) | -- | -- | -- | -- | -- | 8.92 |

***(100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)***

**Table 5. Effect of biofertilizers, growth regulator and micronutrients on average fruit weight (g) of Sapota cv. Kalipatti**

| Treatment* | Fruit weight (g) | | | | | |
|---|---|---|---|---|---|---|
| | I year | II year | III year | IV Year | V year | Pooled |
| $T_1$ | 61.65 | 60.85 | 67.27 | 71.91 | 80.09 | 68.35 |
| $T_2$ | 63.1 | 62.2 | 69.27 | 73.12 | 84.61 | 70.46 |
| $T_3$ | 68.72 | 65.69 | 75.66 | 76.43 | 87.51 | 74.80 |
| $T_4$ | 67.14 | 65.31 | 74.22 | 75.35 | 83.89 | 73.18 |
| $T_5$ | 79.49 | 77.66 | 78.64 | 78.04 | 92.88 | 81.34 |
| $T_6$ | 64.42 | 62.2 | 70.47 | 74.7 | 88.59 | 72.08 |
| $T_7$ | 66.39 | 63.74 | 73.64 | 75.84 | 82.14 | 72.35 |
| $T_8$ | 65.84 | 62.53 | 72.28 | 75.25 | 90.3 | 73.24 |
| $T_9$ | 69.3 | 70.45 | 76.96 | 77.09 | 75.65 | 73.89 |
| CD 5%(T) | 8.24 | 4.86 | 6.25 | 3.37 | NS | 3.36 |
| CV %(T) | 7.07 | 4.27 | 4.93 | 2.59 | 7.87 | 5.92 |
| CD@ 5%(Y) | -- | -- | -- | -- | -- | 2.40 |
| CD 5% (Y x T) | -- | -- | -- | -- | -- | NS |
| CV% (Y x T) | -- | -- | -- | -- | -- | 6.03 |

***$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)***

**Table 6. Effect of biofertilizers, growth regulator and micronutrients on quality parameters of Sapota cv. Kalipatti**

| Treatment* | Fruit diameter (cm) | TSS ($^0$B) | Pulp peel ratio | No. of seeds/fruit | Days to ripening |
|---|---|---|---|---|---|
| $T_1$ | 5.65 | 20.43 | 9.09 | 1.59 | 6.33 |
| $T_2$ | 5.60 | 20.23 | 9.01 | 1.73 | 6.21 |
| $T_3$ | 5.54 | 20.08 | 9.15 | 1.77 | 6.34 |
| $T_4$ | 5.65 | 20.04 | 8.89 | 1.72 | 6.20 |
| $T_5$ | 5.66 | 19.98 | 9.45 | 1.90 | 6.40 |
| $T_6$ | 5.53 | 20.15 | 9.03 | 1.74 | 6.35 |
| $T_7$ | 5.55 | 20.17 | 8.74 | 1.74 | 6.27 |
| $T_8$ | 5.63 | 20.22 | 9.20 | 1.73 | 6.51 |
| $T_9$ | 5.52 | 20.29 | 8.52 | 1.82 | 6.70 |
| CD 5%(T) | NS | NS | NS | NS | NS |
| CV %(T) | 3.52 | 2.28 | 8.03 | 14.15 | 6.93 |
| CD@ 5%(Y) | 0.09 | 0.39 | 0.39 | NS | 0.35 |
| CD 5% (Y x T) | NS | NS | NS | NS | NS |
| CV% (Y x T) | 3.07 | 3.52 | 7.87 | 13.74 | 10.14 |

**$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

**Table 7. Combine effect of bio fertilizers, $GA_3$ and micronutrients on economics of sapota cv. Kalipatti**

| Treat-ment | Cost (A) (Rs.) | Cost (B) (Rs.) | Cost (C) (Rs.) | Income (Rs.) | Net profit (Rs.) | BCR |
|---|---|---|---|---|---|---|
| $T_1$ | 61477 | 80237 | 80237 | 281400 | 201163 | 2.51 |
| $T_2$ | 65217 | 86230 | 86230 | 315200 | 229248 | 2.67 |
| $T_3$ | 74188 | 96842 | 96842 | 339800 | 242958 | 2.51 |
| $T_4$ | 67608 | 88128 | 88128 | 307800 | 219672 | 2.49 |
| $T_5$ | 82647 | 108140 | 108140 | 382400 | 274538 | 2.55 |
| $T_6$ | 59540 | 79153 | 79153 | 294200 | 215325 | 2.73 |
| $T_7$ | 69684 | 91910 | 91910 | 333400 | 241490 | 2.63 |
| $T_8$ | 63103 | 83197 | 83197 | 301400 | 218203 | 2.62 |
| $T_9$ | 81047 | 108527 | 108527 | 412200 | 303951 | 2.81 |

**$T_1$ (100% RDF-1000:500:500 g NPK + 100 kg FYM /plant), $T_2$ (100% RDF + Bio fertilizers (Azospirillum + PSB @ 40ml/tree), $T_3$ (100% RDF + $GA_3$ @ 50 ppm), $T_4$ (100 % RDF + Grade 4 (micronutriment @ 0.5%), $T_5$ (100%RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)], $T_6$(75% RDF + Biofertilizers (Azospirillum + PSB @ 40ml/tree), $T_7$ (75 % RDF + $GA_3$ @ 50 ppm), $T_8$ (75% RDF + Grade 4 (micronutriment @ 0.5%) and $T_9$ (75% RDF + biofertilizers (Azospirillum + PSB@40ml/tree + $GA_3$ @ 50 ppm + Grade 4 (micronutriment @ 0.5%)*

of atmospheric nitrogen and soil phosphorus by microbial inoculants, synthesis of plant growth hormones at all the essential stages of growth and development by the combined application of biofertilizers and organic manure [15]. The exogenous application of gibberellic acid ($GA_3$) seemed to be very effective in enhancing growth and fruit development through its important role in enhancement of cell division, cell elongation and regulating the availability of water and nutrients [16].Application of $FeSo_4$ and borax at fruit setting stage increase fruit weight, pulp weight, stone weight and pulp stone ratio in ber [17].

The effect of different treatments on quality parameters viz., fruit diameter, TSS, pulp peel ratio, no. of seeds/fruit and days to ripening were found non-significant (Table 6).

The economics of various treatments of biofertilizers, growth regulatorand micronutrients showed that the higher income (4.12 lakh) and net return (3.04 lakh) as well as maximum BCR ratio (2.81) was recorded with treatment $T_9$ [75 % RDF + Biofertilizers-*Azospirillum* + PSB @ 40 ml/tree + GA3 @ 50 ppm + Grade 4 (micronutrient @ 0.5%)] (Table 7).

## 4. CONCLUSION

An investigation was carried out to study the synergistic effect of biofertilizers, growth regulator and micronutrients with RDF for enhancing fruit yield and economics of Sapota (*Manilkara zapota*). The results indicated that reproductive behavior and yield parameters as well as economics were better under application of $T_9$ [75% RDF + Biofertilizers- Azospirillum + PSB @ 40 ml/tree + GA3 @ 50 ppm + Grade 4 (micronutrient @ 0.5%)]. This was possibly due to Synergistic effect of organic sources and inorganic fertilizers as well growth regulator, which acted complementary and supplementary to each other and resulted into balance and steady supply of desired nutrients for photosynthesis and carbohydrates metabolism as well as cell enlargement. Thus, $T_9$ proved to be beneficial over other treatments for obtaining good fruit yield and economics of Sapota plantations in the South Gujarat region.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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**ANNEXURE-I. Economics of different treatments of biofertilizers, growth regulator and micronutrients in sapota cv. Kalipatti**

| SN | Particulars | Quantity | Rate | Cost (Rs./ha) | $T_1$ | $T_2$ | $T_3$ | $T_4$ | $T_5$ | $T_6$ | $T_7$ | $T_8$ | $T_9$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fixed cost expenditure | | | | | | | | | | | | |
| 1 | Land preparation | | | | | | | | | | | | |
| | Ploughing | 12 hrs | Rs. 400 /hr | 3600 | 3600 | 3600 | 3600 | 3600 | 3600 | 3600 | 3600 | 3600 | 3600 |
| | Harrowing | 9 hrs | Rs. 300 /hr | 2700 | 2700 | 2700 | 2700 | 2700 | 2700 | 2700 | 2700 | 2700 | 2700 |
| | Irrigation | 11 times | Rs. 40 /hr | 3520 | 3520 | 3520 | 3520 | 3520 | 3520 | 3520 | 3520 | 3520 | 3520 |
| | Labour cost for fertilizer application | 2 dose | 3000/dose | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 | 6000 |
| | Total | | | | 15820 | 15820 | 15820 | 15820 | 15820 | 15820 | 15820 | 15820 | 15820 |
| 2 | Plant protection measures (2000 liter solution) | | | | | | | | | | | | |
| | Profenophos | 2000 ml | Rs. 675/L | 1350 | 1350 | 1350 | 1350 | 1350 | 1350 | 1350 | 1350 | 1350 | 1350 |
| | Lymdacyclothrin | 2000 ml | Rs. 330 /kg | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 | 660 |
| | Carbendazim | 2000 ml | Rs. 550/kg | 1100 | 1100 | 1100 | 1100 | 1100 | 1100 | 1100 | 1100 | 1100 | 1100 |
| | Labour charge for spraying | 2 Spray | Rs. 1250 /Spray | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| | Total | | | | 5610 | 5610 | 5610 | 5610 | 5610 | 5610 | 5610 | 5610 | 5610 |
| 3 | Treatment cost | | | | 14920 | 15880 | 22420 | 18670 | 27130 | 12150 | 18690 | 14940 | 23400 |
| 4 | Harvesting cost | | | | 21105 | 23640 | 25485 | 23085 | 28680 | 22065 | 25005 | 22605 | 30915 |
| 5 | Working Cost (1+2+3+4) | | | | 57455 | 60950 | 69335 | 63185 | 77240 | 55645 | 65125 | 58975 | 75745 |
| 6 | Interest on working capital 7% | | | | 4022 | 4267 | 4853 | 4423 | 5407 | 3895 | 4559 | 4128 | 5302 |
| 7 | Rental value of own land | | | | 18760 | 21013 | 22653 | 20520 | 25493 | 19613 | 22227 | 20093 | 27480 |
| 8 | Cost-A (5+6) | | | | 61477 | 65217 | 74188 | 67608 | 82647 | 59540 | 69684 | 63103 | 81047 |
| 9 | Cost-B (7+8) | | | | 80237 | 86230 | 96842 | 88128 | 108140 | 79153 | 91910 | 83197 | 108527 |
| 10 | Cost-C | | | | 80237 | 86230 | 96842 | 88128 | 108140 | 79153 | 91910 | 83197 | 108527 |
| 11 | Total income (Rs.) | | | | 281400 | 315200 | 339800 | 307800 | 382400 | 294200 | 333400 | 301400 | 412200 |
| 12 | Net Income (Rs.) | | | | 201163 | 229248 | 242958 | 219672 | 274538 | 215325 | 241490 | 218203 | 303951 |
| 13 | BCR ratio | | | | 2.51 | 2.67 | 2.51 | 2.49 | 2.55 | 2.73 | 2.63 | 2.62 | 2.81 |



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