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Effect of Green Manures, Biofertilizers and Vermicompost on Quality Parameters of Sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti

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Abstract: Field experiment has been performed at Anand Agricultural University in Anand, Gujarat over the years 2019-20 and 2020-21, with ten treatments having components of green manures like sunhemp, dhaincha and cowpea, vermicompost, biofertilizer and microbial consortium. Organic fertilizers application has the potential to increase the biomass and productivity of a wide range of crops when used properly. Treatment 75% RDN from green manure of sun hemp + microbial consortium (AMBC I) 105 ml + 10 ml Anubhav Bio NPK consortium per tree gave the best results in terms of quality parameters compared to other treatments having a combination of green manure with dhaincha, cowpea, vermicompost and biofertilizers. The treatment also resulted in the highest total soluble solid (23.49 °Brix), reducing sugar content (6.08%), non-reducing sugar content (11.88%), total sugar content (17.96%), ascorbic acid content (21.48 mg/100g pulp) and shelf life (9.09 days) of the fruits in both years. Acidity content was also lowest (0.182%).

Keywords: *Manilkara achras*, Kalipatti, Green Manures, Biofertilizers, Vermicompost , Anubhav Bio NPK

Sapota, also known as *Manilkara achras*, is a slow-growing tropical fruit tree belonging to the Sapotaceae family. It is a major fruit crop in India, Mexico, Guatemala and Venezuela. In India, sapota is cultivated across 89,000 hectares of land, producing a yield of 10.03 lakh MT and a productivity rate of 11.26 MT/ha (Anonymous 2019[a]). The states of Karnataka, Gujarat, Tamil Nadu, Maharashtra, and Andhra Pradesh are the primary sapota-producing regions in India. Gujarat alone cultivates sapota on 27,827 hectares, yielding 3,10,012 MT annually with a productivity rate of 11.14 MT per hectare (Anonymous 2019[b]). There is a growing demand for organic fruits both domestically and internationally, and growers are benefitting from exporting organic fruits to other countries with better prices. The farmers are interested in organic farming. green manuring crops and biofertilizers as most effective sources of nutrients in organic sapota farming. Organic manures supply plants with nutrients and micronutrients. Chimouriya et al (2018) suggested that green manure is a cost-effective and environmentally friendly alternative to agrochemicals. Patel et al in (2023) observed that the application of double green manuring of sunhemp in the canopy area along with the use of 10 ml Bio NPK consortium per tree can significantly improve quality parameters in Mango. Han et al (2022) found that the use of different green manures can improve the quality of pear fruit crops. Zhou et al (2022) observed that incorporating organic manure and reducing chemical fertilizer by 30% is a promising fertilizer management strategy for sustainable productivity and environmental protection in citrus orchards. Very little research-based knowledge is available on the impact of organic fertilizers on sapota fruit quality and production parameters. Additionally, there is a lack of information on nutrient management through green manuring with bio-fertilizers and vermicompost in fruit crops. The current study was aimed to investigate the effect of different organic sources on the quality parameters of sapota [*Manilkara achras* (Mill.) Fosberg] cv. 'Kalipatti' on 22-year-old sapota trees.

MATERIAL AND METHODS

Field experiment was conducted at the Anand Agricultural University, Anand during 2019-20 and 2020-21. The experiment followed a completely randomized design with ten treatments, each consisting of a combination of different green manure, biofertilizer and vermicompost. [T_1: Control: 100 % RDF from chemical fertilizer (1000:500:500 g NPK) + 100 kg FYM per tree, T_2: 100% RDN from green manure of sun hemp + microbial consortium (AMBC I) 140 ml per tree, T_3: 100% RDN from green manure of cowpea + Microbial consortium (AMBC I) 150 ml per tree, T_4: 100% RDN from green manure of dhaincha + Microbial consortium (AMBC I) 160 ml per tree, T_5: 75% RDN from green manure of sun hemp + microbial consortium (AMBC I) 105 ml + 10 ml Anubhav Bio NPK consortium per tree, T_6: 75% RDN from green manure of cowpea + microbial consortium (AMBC I) 110 ml + 10 ml Anubhav Bio NPK consortium per tree, T_7:

75% RDN from green manure of dhaincha + microbial consortium (AMBC I) 120 ml + 10 ml Anubhav Bio NPK consortium per tree, T_8: 50% RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree, T_9: 50% RDN from vermicompost + 50% RDN from green manure of cowpea + microbial consortium (AMBC I) 105 ml per tree, T_{10}:50% RDN from vermicompost + 50% RDN from green manure of dhaincha + microbial consortium (AMBC I) 110 ml per tree] and was replicated thrice. The green manuring crops were sown separately in another field. Cowpea was sown using the line sowing method, while dhaincha and sun hemp were broadcasted. Sowing was done after 15 June for both years as green manures grow well in rainy season. The green manures were applied in the form of green biomass of sunhemp, cowpea and dhaincha. The green manures were applied in quantities respective to the treatment requirements according to the recommended dose of nitrogen applied in mature sapota trees which was 1000g. Sun hemp and dhaincha were analyzed for nitrogen content at 50 days after sowing while cowpea at 40 days after sowing in both the seasons 9 (Table 1). The required amount of green manure was applied in a ring around the tree's base during the first week of August for both years. Tillage was performed using a rotavator around the tree's canopy after applying the green manure.

In both years, biofertilizer was applied 7 days after the green manure application. A mixture of 10 ml of Bio-NPK consortium was dissolved in 20 litres of water and applied by creating rings around the trees, positioned 1-1.5 meters away from the main trunk. Ten fruits were selected from each replication as per treatments at the time of the third harvest i.e., in April at a mature stage for analysing different quality parameters. To measure the TSS of ripe fruit pulp, a digital pocket hand refractometer with a range of 0-32 °Brix was used. The acidity, total sugar, reducing sugar, non-reducing sugar and ascorbic acid were also measured using the methods outlined by Ranganna (1979). The shelf life of the fruit was determined by keeping five mature fruits at the third harvest i.e., in the month of April under ambient temperature in the laboratory and observing every day up to the deterioration of the fruits. Statistical analysis was conducted on yearly data of various parameters.

RESULTS AND DISCUSSION

Treatment T_5 with 75% sunhemp, has an adequate amount of nitrogen content. Compared to other treatments, easily decomposes with the use of a microbial decomposer. This treatment can be used as a biofertilizer and promotes the growth of plants directly or indirectly by providing nutrition. In T_5, 75% RDN from green manure of sun hemp +105 ml of microbial consortium (AMBC I) + 10 ml of Anubhav Bio NPK consortium per tree, had the highest total soluble solid 23.49 ^{0}Brix. This might be due to the application of green manure with sun hemp and biofertilizers increasing the availability of nutrients, improving soil aeration, stimulating cell division, cell elongation, and better translocation of water uptake and deposition of nutrients, which leads to an increase in dry matter and total soluble solids of the fruits. Kumar et al. (2017) also observed significant improvements in mango cultivation when utilizing green manure from sun hemp, combined with farmyard manure and NPK. The application of double green manuring of sunhemp with 10 ml Bio NPK consortium per tree enhances significantly quality parameters in mango cv. Amarapali (Patel et al 2023). Similarly, Dey et al (2005) reported positive effects on guava growth with the use of 200 g of phosphate solubilizers (PSB) per plant annually. Sau et al (2017) observed better growth with the use of biofertilizers (*Azotobacter chorococcum* + *Azospirillum* brasilense + AM (*Glomus musseae*) + Panchagavya 3%) in mango cultivation.

Table 1. Nitrogen content (%) of green manures

Organic fertilizers	N content (%)	
	2019-20	2020-21
Sunhemp	0.71	0.67
Cowpea	0.67	0.60
Dhaincha	0.62	0.64

Table 2. Quantity of green manures applied with respective treatments

Treatment	Quantity (kg/tree)	
	2019-20	2020-21
100% RDN from green manure of sun hemp	140.84	149.25
100% RDN from green manure of cowpea	149.25	166.66
100% RDN from green manure of dhaincha	161.29	156.25
75% RDN from green manure of sun hemp	105.63	111.94
75% RDN from green manure of cowpea	111.94	125.00
75% RDN from green manure of dhaincha	120.96	117.18
50% RDN from green manure of sun hemp	70.42	74.62
50% RDN from green manure of cowpea	74.62	83.33
50% RDN from green manure of dhaincha	80.64	78.12

The maximum reducing sugar 6.08 % was observed in the application of a treatment, $T_{5.}$ This might be due to the application of sun hemp as green manure with bio fertilizers increasing the uptake and translocation of nutrients which leads to the increase in the photosynthetic ability and carbohydrate supply which increases the dry matter and sugar content of the fruits. Shukla et al (2009) found that guava plants responded well to a treatment of 50% recommended doses of NPK, along with 50 kg of FYM and 250 g of *Azotobacter* per plant. Singh and Varu (2013) recorded improvements in papaya growth with half-dose RDF, along with 50 g of *Azotobacter* per plant and 2.5 g of PSB per square meter. Lodaya and Masu (2019) also observed better growth in guava with soil application of 30% RDF through chemical fertilizers, 30% RDN through poultry manure and 20 ml of Bio NPK Consortium per tree. The treatment T_5 also recorded significantly higher non-reducing sugar 11.88 % in pooled data. Data presented in Table 1.3 revealed that an interaction of year and treatments (Y x T) effect on non-reducing sugar (%) was noted as non-significant. This could be attributed to the application of green manuring with sun hemp with bio-fertilizers, which increases nutrient uptake and translocation, increasing photosynthetic ability and carbohydrate supply, which might increase the dry matter and sugar content of the fruits. Parallel results were found by Singh and Varu (2013) in papaya with the application of half-dose RDF + Azotobacter @ 50 g/plant + PSB @ 2.5 g/m^2 and Sharma et al. (2016) in mango with an application of vermicompost (25 kg/plant) + Oil cake (2.5 kg/plant) + *Azotobacter* + VAM + *Trichoderma viridi* + PSB @ 100g/plant.

The T_5 treatment resulted in the highest total sugar levels of 17.96%. The interaction of treatments (Y x T) effect on total sugar (%) was significant. The cumulative effect of different treatments on building up the sugar content was observed. This might be due to the application of sun hemp as green manure improving soil nutrient status and bio-fertilizers making them available to the plants and helping them with uptake and translocation of the nutrients, which led to the increase in dry matter accumulation and total sugar content of the fruits. Similar trend was observed by Khachi et al (2015 in kiwifruit vines using sun hemp as green leaf manure. T_5 treatment had the highest amount of ascorbic acid 21.48 mg/100 g pulp. This might be due to the application of green manuring with sun hemp and biofertilizers increasing the availability, uptake and translocation of plant nutrients, especially nitrogen, which might lead to the synthesis of organic acids in fruits, increasing ascorbic acid content in fruits. The trend was observed by Kumar et al (2017) in mango with use of sun

Table 3. Effect of green manures, biofertilizers and vermicompost on the quality parameters of sapota [*Manilkara achras* (Mill.) Fosberg] cv. 'Kalipatti'

Treatment	Total soluble solids (^{0}Brix)	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar (%)	Ascorbic acid (mg/100 g pulp)	Acidity (%)	Shelf life of fruits (days)
Pooled data (2019-20 and 2020-21)							
T_1	19.44	4.34	9.63	13.98	18.86	0.232	6.90
T_2	21.26	5.23	10.79	16.15	20.07	0.217	8.11
T_3	20.96	5.10	10.64	16.30	19.98	0.221	7.68
T_4	19.94	4.63	10.09	14.72	19.05	0.224	7.12
T_5	23.49	6.08	11.88	17.96	21.48	0.182	9.09
T_6	22.28	5.66	11.20	16.86	20.41	0.202	8.31
T_7	20.33	4.83	10.40	15.23	19.52	0.223	7.36
T_8	22.81	5.90	11.61	17.51	21.17	0.187	8.96
T_9	22.46	5.72	11.39	17.11	20.82	0.200	8.59
T_{10}	21.86	5.57	10.97	16.54	20.65	0.210	8.25
CD (p =0.05)							
(T)	0.41	0.49	0.41	0.32	0.57	0.007	0.19
(Y)	0.18	NS	NS	0.14	NS	0.003	0.09
(Y x T)	NS	NS	NS	0.46	NS	NS	NS
C.V. %	1.63	7.99	3.29	1.69	2.44	3.07	2.04

Plate 1. Cultural practices sapota [*Manilkara Achras* (Mill.) Fosberg] cv. Kalipatti

hemp green manure along with farm yard manure and NPK. Kundu et al (2011) observed that mango plants treated with 100% NPK + Azotobacter + VAM (98.1 kg/plant) also showed positive results. The interaction of year and treatments (Y x T) on ascorbic acid was non-significant.

The acidity (%) of sapota cv. Kalipatti can be greatly affected by various treatments using organic sources, as shown in Table 3. Treatment T_5 consistently resulted in the lowest acidity levels of 0.182% in the pooled data, which was at par with treatment T_8 (0.187 %). A perusal of data revealed that an interaction of year and treatments (Y x T) effect on acidity (%) was non-significant. This might be due to the greater availability of dry matter for sugar conservation due to the application of sun hemp as green manure and biofertilizers. The findings of Dutta et al (2010) showed that treating papaya with Azotobacter + Azospirillum + VAM + 2 kg FYM yielded positive results. Similarly, Singh et al (2014) found that applying FYM + Azotobacter + VAM to Aonla was effective.

The effect of various organic treatments on the shelf life (days) of sapota cv. Kalipatti in both years of the study, as well as their pooled analysis, are shown in Table 3. It was observed that among different treatments T_5 had significant maximum shelf life 9.09 days in pooled results. Statistical perusal of data revealed that an interaction of year and treatments (Y x T) effect on acidity (%) was non-significant. It might be because green manure as sun hemp and biofertilizers increase the availability and uptake of plant nutrients which increases fruit quality and shelf-life of fruits. Patel et al (2017) discovered comparable outcomes in sapota when 75% NPK + 15 kg vermicompost + 10 ml/tree AAU Bio NPK was applied, while Lodaya and Masu (2019) found similar results in guava with a soil application of 30% RDF through chemical fertilisers + 30% RDN through poultry manure + 20 ml Bio NPK Consortium per tree.

CONCLUSION

The quality parameters of sapota fruit can be be improved by using 75% RDN from sun hemp green manure and a microbial consortium (AMBC I) of 105 ml, along with 10 ml of Anubhav Bio NPK consortium per tree . These results can be helpful for further research on organic methods for increasing fruit production, as well as for farmers who wish to transition to organic farming for their fruit cultivation.

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