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Effect of different organic manures on yield, quality and shelf life of sapota

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ABSTRACT

An investigation was carried out during 2013-16 on 10 years old sapota plants of cv. Cricket Ball, in laterite soil with the view to optimize suitable organic manures, doses and time of application for higher production of quality fruits with better shelf life. The treatments included as application of FYM, vermicompost and mustard cake at different doses and time of year. However, fifty percent of recommended dose of N, P and K along with FYM was taken as another treatment to study the effectiveness of different organic manures in production of quality fruits for total elimination of chemical fertilizers for organic farming. The results of three consecutive years of study revealed that application of mustard cake at 5 kg/plant in the month of September gave highest fruit yield (33.30kg/plant) with higher fruit weight, maximum pulp content and better quality fruits in respect of TSS and vitamin C content. This treatment and all other organic manure treatments resulted in improved shelf life of fruits. Comparatively organic manure treatments resulted in higher production of quality fruits than the control and chemical fertilizers treatment. Application of FYM 25 kg/plant along with 50% of recommended NPK in the month of April and September also resulted in higher fruit yield with better shelf life of fruits however quality is slightly reduced compared to other organic manure treatments.

***Key words*: Fruit quality, organic manures, sapota, shelf life, yield**

INTRODUCTION

Sapota (*Manilkara achras*) is one of the most important fruit crops grown in India specifically in Maharashtra, Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh and Kerala. Ripe fruits are highly delicious and enriched with sugars, protein and minerals. Fruits are suitable for making jams, jellies, osmo-dehydrated slices, squash, sweet chutney, dried pieces, milk shake, nectar, blended drinks, pickle, preserve and candy. It has wide range of adaptability, low production costs and reasonably high economic returns with less pest and diseases incidence. In West Bengal, sapota is mainly grown along coastal belts; however it shows huge potentiality to be grown in laterite zone (Mathew *et al*., 2001) where vast barren areas can be utilized with this crop. It is highly responsive to fertilizer treatments and requires sufficient N, P and K nutrients for higher production of quality fruits (*Anonymous*, 1984). However, an excessive and indiscriminate use of chemical fertilizers adversely affect soil health by interfering with the beneficial soil microorganisms, lowering down soil pH and built up of P_2O_5 and K_2O. Now-a-days organic cultivation draws attention to researchers around the globe as it could be a useful tool to minimize soil contamination while improving fruit quality. Thus, chemical fertilizer are gradually supplemented with the optimum use of organic manures particularly FYM, vermicompost, poultry manures *etc*. Sapota as perennial crop can store the nutrients in the stems, branches and other parts of the plant and meet their requirement whenever needed. However, there is very little information available about the suitable organic manures and its dose required for optimum production of quality of sapota fruits in laterite soil. The main objectives of this experiment is to find out the suitable organic manures and their optimum doses for quality sapota production and also to study the effect of different organic manures on soil health and shelf life of the fruits as it highly perishable in storage due to its climacteric nature.

MATERIAL AND METHODS

The present investigation was conducted at a private farm of Jhargram during the year 2013-2016 with ten treatments and four replications. The experimental trees were about 10 years old sapota plants of *cv*. Cricket Ball, planted at a distance 7 m x 7 m having uniform growth and vigour. Different manures and fertilizers combinations (Table 1) were applied in circular ring of 2 feet wide, 15 cm deep and 3 feet away from the plant and then properly covered with soil. The manures and fertilizers were applied twice a year *i.e.*, one in April and another dose in the month of September. However, in some cases total dose of fertilizer was applied once in a year *i.e.* in September. Fruit quality was measured by randomly collected five mature fruits from each plant. The fruit physico-chemical parameters were determined following standard techniques (A.O.A.C., 1970). To estimate foliar N, P and K content, 10^{th} leaf from growing shoot tip from four direction of each plant was collected in the month of September (Bhargava, 1999). Leaf nitrogen was determined by using micro-kjedahl method, phosphorus by vandomolbdophosphoric acid method and potassium by flame photometer.

The shelf life of fruits were studied though weight loss (%) and fruit decay (%) and recorded up to 21 DAS (Days after storage) at every three days interval. Temperature range during storage was 15-20°C (8 a.m.) and 16-22°C (2 p.m.). End point for rejecting of sapota fruits during storage study was shrinkage of skin and foul smell coming out from the fruits. The data were statistically analyzed using randomized block design (RBD). The means for all the treatments were calculated; analysis of variances (ANOVA) and correlation analysis were performed by using SPSS version 24.0 at P< 0.05 probability level is regarded as statistically significant. Duncan Multiple Range Test (DMRT) (Duncan, 1955) was conducted to compare effect of different treatment combinations on different fruit quality and keeping quality parameters.

Table 1: Different treatment combinations of organic manures and inorganic fertilizers

Treatments	Details
T_1	FYM-50 kg/ plant in September
T_2	FYM-100 kg/ plant in September
T_3	FYM-50 kg/ plant in April and 50 kg/ plant in September
T_4	Vermicompost-5 kg/ plant in April and 5 kg/ plant in September
T_5	Vermicompost-10 kg/ plant in April and 10 kg/ plant in September
T_6	Mustard cake -5 kg/plant in September
T_7	FYM -50 kg/ plant in April and Mustard cake 5 kg/plant in September
T_8	Vermicompost-5 kg/ plant in April and Mustard cake 5 kg/plant in September
T_9	FYM -25 kg/ plant in April + 50% of recommended NPK + FYM 25 kg/ plant in September + 50% of recommended NPK (Full recommended dose followed as 400g N, 100g P_2O_5 and 300g K/plant/year)
T_{10}	Control (without fertilizer)

RESULTS AND DISCUSSION

The data presented in table 2 clearly indicated that fruit yield per plant was significantly influenced by various treatments. The highest yield (33.3kg/plant) was recorded in treatment T_6 (Mustard cake 5 kg/plant in September) which was found at par with treatment T_8 (32.2 kg/plant), T_4 (32.1 kg/plant) and T_9 (31.9 kg/plant). However, the control (T_{10}) treatment gave minimum fruit yield (18.4 kg/plant). Ghosh *et al.* (2012) worked with different doses of nitrogen and potassium in sapota and found differences in the fruit yield/plant in sapota which was due to interaction of N and K. There was significant increase in yield in almost all the treatments as compared to control might be attributed due to increase in levels of nutrients in

Table 2: Yield and Fruit quality of sapota cv. Cricket Ball (average of two years)

Treatments	Fruit yield/ plant (kg) (Average)	Fruit weight (g)	Pulp content (%)	TSS (0 Brix)	Acidity (%)	Total sugars (%)	Vitamin C (mg/100g)
T_1	24.3±1.01^{bc}	99.6±1.13^{a}	96.5±2.18^{a}	17.4±1.16^{bc}	0.04±0.008^{a}	12.7±1.28c^{de}	7.48±0.83^{d}
T_2	27.8±3.42^{b}	89.7±4.31b^{cd}	97.0±4.35^{a}	18.1±0.90^{ab}	0.04±0.008^{a}	13.8±1.24^{b}	9.05±0.67^{b}
T_3	25.2±1.26^{bc}	92.4±2.90b^{cd}	97.1±1.07^{a}	18.4±0.85^{ab}	0.05±0.014^{ab}	14.6±1.14^{a}	7.47±0.84^{d}
T_4	32.1±3.56^{a}	99.4±1.82^{a}	96.5±1.81^{a}	17.4±0.86^{bc}	0.04±0.008^{a}	12.6±0.91^{de}	6.97±0.60^{d}
T_5	22.0±1.12^{cd}	86.3±3.78^{d}	97.0±4.10^{a}	18.2±1.14^{ab}	0.05±0.014ab	13.1±1.41^{bcde}	8.17±0.74^{c}
T_6	33.3±5.05^{a}	95.7±6.07^{ab}	97.8±2.47^{a}	18.4±1.20^{ab}	0.04±0.008a	12.9±1.29^{cde}	9.26±0.60^{b}
T_7	25.7±0.62^{bc}	87.9±1.22^{cd}	97.1±1.60^{a}	17.8±1.12a^{bc}	0.04±0.008a	13.4±1.01^{bcd}	9.04±0.79^{b}
T_8	32.2±2.81^{a}	93.0±4.23^{bc}	97.6±2.33^{a}	19.0±0.59^{a}	0.06±0.08b	13.5±1.08^{bc}	10.81±0.89^{a}
T_9	31.9±2.73^{a}	88.1±5.70^{cd}	96.4±2.35^{a}	16.7±1.78^{cd}	0.05±0.014ab	12.6±0.95^{de}	7.30±0.91^{d}
T_{10}	18.4±1.27^{d}	80.4±4.21^{e}	78.2±2.21^{b}	15.9±1.17^{d}	0.07±0.012b	12.3±0.44^{e}	7.20±0.51^{b}

Table 3: Leaf and soil nutrient content in different fertilizers treatment

Treatments	Foliar content (dry weight basis)			Soil content			
	Nitrogen (%)	Phosphorus (%)	Potassium (%)	pH	Available N	Available P_2O_5	Available K_2O
T_1	1.03±.03^{bc}	77±1.94^{c}	1.01±.03^{d}	4.92±.12^{ab}	429±10.8^{a}	274±6.93^{a}	40.0±1.01^{e}
T_2	0.96±.02de	97±2.03^{a}	1.12±.02^{c}	4.98±.10^{a}	253±5.31^{e}	241±5.07^{c}	36.3±0.76^{f}
T_3	1.00±.02^{cd}	82±1.67^{b}	1.19±.02^{b}	4.94±.10^{ab}	349±7.10^{b}	214±4.35^{e}	64.1±1.30^{a}
T_4	0.92±.04^{ef}	100±4.25^{a}	1.46±.06^{a}	4.91±.21^{ab}	319±8.61^{c}	249±5.6^{bc}	46.8±1.99^{c}
T_5	1.06±.01^{b}	81±0.34^{bc}	1.49±.01^{a}	4.77±.12^{abc}	232±2.98f	258±1.09^{b}	39.3±1.17^{e}
T_6	1.04±.02^{bc}	77±1.55^{c}	1.43±.03^{a}	4.60±.09^{c}	298±6.01^{d}	252±5.10^{b}	42.9±0.87^{d}
T_7	1.05±.03^{bc}	97±2.88^{a}	1.46±.04^{a}	4.56±.14^{c}	211±6.26^{g}	227±6.74^{d}	46.0±1.36^{c}
T_8	1.08±.05^{b}	63±2.83^{e}	1.18±.05^{b}	4.70±.21^{bc}	316±14.2^{c}	159±7.16^{f}	52.8±2.37^{b}
T_9	1.31±.03^{a}	83±1.85^{b}	1.04±.02^{d}	4.79±.11^{abc}	343±7.65^{b}	214±4.77^{e}	43.6±0.97^{d}
T_{10}	0.90±.02^{f}	71±1.57^{d}	1.00±.02^{d}	4.78±.11^{abc}	202±5.37^{g}	158±3.49^{f}	32.2±0.71^{g}

Table 4: Correlation between soil & leaf nutrient and fruit yield & quality parameters

R	Fruit yield/ plant (kg) (Average)	Fruit weight (g)	Pulp content (%)	TSS (^{O}Brix)	Acidity (%)	Total sugars (%)	Vitamin C (mg/100g)
Leaf Nitrogen %	0.399	-0.061	0.403	0.027	0.307	-0.075	-0.133
Leaf Phosphorus %	0.128	0.149	0.311	-0.066	-0.711	0.124	-0.489
Leaf Potassium %	0.240	0.174	0.433	0.454	-0.268	0.099	-0.016
Soil pH	-0.161	0.245	-0.007	-0.135	-0.099	0.205	-0.536
Soil available N	0.378	0.762*	0.434	0.141	-0.028	0.044	-0.470
Soil available P_2O_5	0.117	0.544	0.567	0.182	-0.744*	-0.034	-0.584
Soil available K_2O	0.345	0.371	0.490	0.559	0.325	0.691*	-0.131

'R'- represented with Multiple Correlation coefficient

Table 5: Weight loss (%) of sapota cv. Cricket Ball during storage

Treatments	3-DFS-weight loss (%)	6-DFS-weight loss (%)	9-DFS-weight loss (%)	12-DFS-weight loss (%)	15-DFS-weight loss (%)	18-DFS-weight loss (%)	21-DFS-weight loss (%)
T_1	6.4±0.42^{de}	11.6±0.37^{c}	15.9±0.62^{c}	20.1±0.42^{fg}	29.0±0.42^{g}	34.8±0.22^{e}	44.3±0.61^{f}
T_2	6.5±0.51^{cde}	11.7±0.39^{c}	16.0±0.39^{c}	25.1±0.71^{c}	30.5±0.42^{e}	39.1±0.59^{c}	55.6±0.63^{c}
T_3	6.0±0.44^{e}	10.5±0.42^{d}	14.7±0.57^{d}	19.0±0.59^{g}	31.4±0.37^{d}	48.4±0.37^{b}	-
T_4	6.8±0.52^{bcd}	11.5±0.56^{c}	15.8±0.50^{c}	20.1±0.34^{fg}	29.7±0.47^{f}	37.1±0.75^{d}	53.2±0.91^{d}
T_5	7.3±0.31^{b}	12.7±0.67^{b}	17.6±0.37^{b}	22.5±0.29^{d}	31.8±0.32^{d}	37.4±0.67^{d}	49.5±0.92^{e}
T_6	6.9±0.39^{bcd}	12.1±0.26^{bc}	16.6±0.47^{c}	26.3±0.42^{b}	30.9±0.32^{e}	37.8±0.29^{d}	62.9±0.34^{a}
T_7	6.8±0.18^{bcd}	11.8±0.42^{c}	16.3±0.61^{c}	21.2±0.44^{ef}	32.6±0.45^{c}	48.6±0.56^{b}	-
T_8	6.8±0.56^{bcd}	12.0±0.54^{c}	16.6±0.36^{c}	21.7±0.73^{de}	33.6±0.39^{b}	37.4±0.65^{d}	58.4±1.40^{b}
T_9	7.1±0.42^{bc}	12.1±0.29^{bc}	16.4±0.59^{c}	20.2±0.50^{f}	26.8±0.48^{h}	37.5±0.61^{d}	53.1±0.74^{d}
T_{10}	9.58±0.46^{a}	16.6±0.58^{a}	20.2±0.92^{a}	31.6±0.99^{a}	48.4±1.05^{a}	60.9±1.27^{a}	-

Table 6: Fruit decay (%) of sapota cv. Cricket Ball during storage

Treatments	3-DFS-Decay (%)	6-DFS-Decay (%)	9-DFS-Decay (%)	12-DFS-Decay (%)	15-DFS-Decay (%)	18-DFS-Decay (%)	21-DFS-Decay (%)
T_1	0.00	0.00	0.00	23.5±0.84^{g}	33.3±0.71^{d}	47.1±0.88^{i}	70.6±0.52^{f}
T_2	0.00	0.00	0.00	31.3±0.65^{d}	43.8±0.68^{c}	68.8±0.55^{d}	87.5±0.47^{c}
T_3	0.00	0.00	0.00	30.0±0.51^{e}	55.0±0.85^{a}	80.0±1.10^{a}	-
T_4	0.00	0.00	0.00	25.0±0.0.55^{f}	35.0±1.62^{d}	65.0±0.93^{e}	95.0±0.55^{a}
T_5	0.00	0.00	0.00	11.8±0.85^{i}	18.8±0.50^{g}	50.0±0.81^{h}	68.8±0.98^{g}
T_6	0.00	0.00	0.00	25.0±0.42^{f}	30.0±0.91^{e}	70.0±1.36^{c}	85.0±0.36^{d}
T_7	0.00	0.00	0.00	33.3±0.54^{c}	44.4±0.59^{c}	72.2±0.57^{b}	-
T_8	0.00	0.00	5.6±0.65^{b}	38.9±0.75^{a}	49.9±2.4^{b}	61.4±1.69^{f}	88.9±1.57^{b}
T_9	0.00	0.00	0.00	13.3±0.42^{h}	28.2±1.36^{f}	60.0±0.91^{g}	73.3±0.36^{e}
T_{10}	0.00	0.00	10.34±1.26^{a}	37.7±1.17^{b}	-	-	-

assimilating area of crop which also enhanced the rate of dry matter production. The above results were in conformity with the findings of Harimohan *et al.* (2018) in sapota cultivar Kalipatti. Rahman *et al.* (2018) also supported the findings by reporting the impact of applying vermicompost, as it is an excellent source of different nutrients that influence microbial activities; high in available NPK and growth regulators. Mustard cake has also unique properties of organic ingredients that make it a favorable fertilizer and even herbicide source. Rahman *et al.*(2018) suggested the use of mustard cake as growers can get both fertilizer and pesticide benefits from it.

In case of physical fruit quality (Table 2), significant variation in fruit weight was observed among the treatments and the maximum (99.6 g) weighted fruit was recorded in T_1 (FYM-50 kg/ plant in September) closely followed by T_4 (vermicompost-5 kg/ plant in April and 5 kg/ plant in September) while minimum (80.4 g) was observed in control (T_{10}). Another physical fruit quality parameter *i.e.,* pulp content rather showed insignificant variation among the treatments. However, the highest pulp content (97.8%) was associated with the treatment T_6 (mustard cake 5 kg/plant in September) which was statistically at per with all other treatments except the control (78.2%). Vermicompost is most popular bio-degradation and stabilization of organic materials produced through interactions between earthworms and micro-organisms (Edwards and Burrows, 1988).

The fruit quality (Table 2) in terms of maximum Total Soluble Solids (19°B) and vitamin-C (10.81mg/100g) were recorded with treatment T_8 (vermicompost 5 kg/ plant in the month of April and mustard cake 5 kg/plant in September) whereas, the lowest total soluble solid, total sugar, maximum acidity and vitamin-C recorded in treatment T_{10} (Control). But the combination of FYM and mustard cake showed more Total Soluble Solids in bael (Sharath *et al.,* 2016). Maximum total sugar (14.6%) was obtained in T_3 (FYM-50 kg/ plant in the month of April and 50 kg/ plant in September) followed by T_2 and T_8. Zang *et al.* (2015) also reported that the application of organic manures enhanced the soluble solids and reduced the content of titratable acid. This might have been due to a gradual and steady release of nutrients during the growth period. This could be attributed to a higher C/N ratio which led to increased synthesis of carbohydrates and increased plant metabolism (Devashi, 2012). During ripening of fruits, the carbohydrates reserves of the root and stem are drawn upon heavily and hydrolyzed into sugars hence results in better fruit quality (Jadhav *et al.,* 2018). Some studies suggested that organic fertilizer alone significantly promote the absorption of calcium, promote the transformation of nitrate nitrogen and adjust the soil nitrate content changes (Hu *et al.,* 2011) as observed in the present study. In the present study minimum acidity (0.04) was obtained in T_6 (mustard cake 5 kg/plant in the month of September) which was found at par with treatment T_1, T_2, T_4 and T_7.

The relationship between soil or leaf nutrient content and fruit yield and quality characters was complex. As presented in Table 4, the leaf nitrogen content was negatively correlated with the fruit weight, total sugar and vitamin C content. Leaf phosphorus content was negatively correlated with fruit quality parameters like TSS, acidity and vitamin C content. Leaf potassium content was positively correlated with TSS and Total Sugar and negatively with acidity and vitamin C content. The soil pH value was negatively correlated with all the characters except fruit weight and total sugar. Among the soil nutrient content studied, soil nitrogen showed positive significant correlation with fruit weight and soil potassium revealed positive correlation with total sugar content whereas soil available phosphorus revealed negative significant correlation with fruit acidity.

Fruit yield character was positively correlated with both soil and leaf N, P and K content that might be due to the fact that organic manures are potential to increase soil organic matter, total N, available P, available K, exchangeable Ca, exchangeable Mg, pH value and soil fertility (Zang *et al.*, 2015) which is justified in the present study (Table 4). In this experiment, the results showed that the nutrient contents in soil significantly increased with organic manures application. The nutrient content in T_1, T_8 and T_3 were indicated that application of organic manures was beneficial to improve soil available nutrients. Even organic manures with chemical fertilizers were very effective (T_9). Furthermore, the nutrient content of leaves in most treatments were significantly improved (Table 3). It indicated that most of the nutrients in the tree came from the soil, therefore the leaf nutrient was closely related to the soil nutrient (Zhao *et al.,* 2013). Ghosh *et al.* (2014) also stated that the available nitrogen content of soil was found to be higher (73.39 and 66.32 kg ha^{-1}) with vermicompost and mustard cake at higher doses in sweet Orange. They also stated that vermicompost and neem cake can be applied for enhanced vegetative growth and production of quality fruits in 'Mosambi' sweet orange.

Observation during storage of sapota fruits revealed that the physiological loss in weight (Table 5) was increased in all the treatments as the storage period progressed. On 3rd day, the physiological loss in weight was found minimum (6.0%) in T_3 followed by T_1 (6.4%) where as it was maximum (9.58%) in the fruits under control (T_{10}). On 6th day, 9th day and 12th day of storage physiological loss in weight was found minimum in T_3 (10.5%, 14.7% and 19.0% respectively) followed by T_4 (11.5%, 15.8% and 20.1% respectively) while the control fruits showed maximum weight loss (16.6%, 20.2% and 31.6% respectively). It is clear from the investigation that organic fertilizers application resulted in comparative better shelf life and the result was in agreement with the findings of Reganold *et al*. (2010) in strawberry that reported organic fertilizers produced quality fruits with sweetness in taste, longer shelf life and better flavor.

The results presented in table 6 indicated that matured sapota fruits could be stored well up to six days where no decay of fruits in any treatment was noted. On 9th day of storage, fruit decay was started in some treatments however; most of the treatments showed minimum decay loss except control. On 12th day and 15th day of storage, minimum decay % was observed in T_5 (11.8% and 18.8 %) followed by T_9 (13.3% and 28.2 % respectively) and maximum in control (37.7 and 100% respectively). From 18th of storage higher decay (more than 60 %) was noted in most of the treatments.

CONCLUSION

The present study concluded that organic fertilizer having a positive and significant effect on yield and fruit quality. Shelf life of sapota also increased with lower physiological weight loss and percentage of decay without any coating in ambient room temperature in the month of January. Maximum effect was recognized in terms of maximum yield and good fruit quality with the treatment of mustard cake @5 kg/plant in the month of September and vermicompost @ 5 kg/ plant in the month of April and mustard cake @ 5 kg/plant in September. It is concluded that sapota can be grown organically in laterite soil and choice of organic manures *viz.,* vermicompost or mustard cake depends on their area of availability.

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