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Effect of integrated nutrient management on quality parameters of sapota [*Manilkara achrus* (Mill) Forsberg] CV. Kalipatti

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Abstract
A field experiment was conducted at the Horticultural Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during the years 2015-16 and 2016-17. The fruit quality in terms of total soluble solids, acidity, ascorbic acid, reducing sugar, non-reducing sugar, total sugars, shelf life of fruits, fruit firmness and physiological loss in weight were recorded maximum in trees which were treated with (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree).

Keywords: Sapota, INM, Quality

1. Introduction
Sapota [*Manilkara achras* (Mill.) Forsberg] is a tropical fruit, belongs to family Sapotaceae, popularly known as chiku in India. Sapota is a hardy tropical fruit crop and it prefers warm but moist weather and grown in both dry and humid areas. The proper nutrient management approach is indispensable for sustaining high quality fruit production without detrimental effects on soil caused by inorganic fertilizers. It is also recognized that integrated nutrient management plays an important role in improving the soil fertility, physico-chemical conditions of soil and crop productivity.

Organic manures supply plants nutrients and micronutrients. They improve soil physical properties like soil structure, infiltration rate, porosity, water holding capacity, bulk density etc. and also increase the availability of nutrients. Organic manures acts as a buffering agents and supplies food for beneficial living organisms. Bio-fertilizers are microbial preparations containing living cells of different micro-organisms which have the ability to mobilize plant nutrients of soil from unusable to usable form through biological process. They are environmental friendly and play significant role in crop production.

Material and methods
The study was conducted on the pre-established 20 years old grafts of sapota orchard spaced at 10 x 10 meters at Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand during 2015-16 and 2016-17. The experiment was carried out with completely block design with thirteen treatments and replicated thrice. The treatments are T_1 (75% N +100% P + 100% K + FYM 50 kg + AAU *Azotobactor* 10 ml/ tree), T_2 (100% N + 75% P + 100% K + FYM 50 kg + AAU PSB 10 ml/ tree), T_3 (100% N + 100% P + 75% K + FYM 50 kg + AAU KMB 10 ml/ tree), T_4 (75% NPK + FYM 50 kg + AAU Bio NPK 10 ml/ tree), T_5 (75% N + 100% P + 100% K + Vermicompost 15 kg + AAU *Azotobactor* 10 ml/ tree), T_6 (100% N + 75% P + 100% K + Vermicompost 15 kg + AAU PSB 10 ml/ tree), T_7 (100% N +100% P + 75% K + Vermicompost 15 kg + AAU KMB 10 ml/ tree), T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/ tree), T_9 (75% N +100% P + 100% K + Castor cake 5 kg + AAU *Azotobactor* 10 ml/ tree), T_{10} (100% N + 75% P + 100% K + Castor cake 5 kg + AAU PSB 10 ml/ tree), T_{11} (100% N + 100% P + 75% K + Castor cake 5 kg + AAU KMB 10 ml/ tree), T_{12} (75% NPK + Castor cake 5 kg + AAU Bio NPK 10 ml/ tree), T_{13} (100% RDF *i.e*. 900: 450: 450 g NPK + 50 kg FYM/ tree Control).

Half dose of nitrogen and full dose of potassium, phosphorous was applied on first week of July and remaining half dose of nitrogen was applied on first week of October.

Fertilizer applied between the radial distances 200 to 260 cm away from trunk, 15-25 cm deep and then properly covered with soil. Bio-fertilizers were applied after one week of application of organic and inorganic fertilizers by diluted in water. For recording the fruit observations five mature fruits were randomly selected from each observational tree of sapota.

Table 1: Effect of integrated nutrient management on quality traits of sapota.

Treatment No.	TSS (°Brix)			Acidity (%)			Ascorbic Acid (%)			Shelf life (days)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	21.33	21.67	21.50	0.24	0.23	0.24	19.60	19.93	19.77	6.67	8.40	7.53
T_2	20.83	20.83	20.83	0.24	0.26	0.25	19.47	19.77	19.62	6.53	8.20	7.37
T_3	21.33	21.33	21.33	0.24	0.26	0.25	19.97	19.93	19.95	6.60	8.40	7.50
T_4	21.33	22.17	21.75	0.23	0.25	0.24	19.67	19.90	19.78	6.73	8.50	7.62
T_5	22.67	23.17	22.92	0.21	0.26	0.24	19.50	20.13	19.82	6.87	8.77	7.82
T_6	22.33	22.67	22.50	0.23	0.24	0.23	19.47	20.07	19.77	6.73	8.73	7.73
T_7	24.00	24.17	24.08	0.21	0.23	0.22	20.00	20.13	20.07	7.00	8.80	7.90
T_8	24.33	24.67	24.50	0.20	0.22	0.21	20.47	20.27	20.37	7.07	9.03	8.05
T_9	20.67	20.67	20.67	0.25	0.26	0.25	19.43	19.38	19.41	6.47	8.17	7.32
T_{10}	20.17	20.67	20.42	0.24	0.27	0.26	19.40	19.73	19.57	6.50	8.17	7.33
T_{11}	21.17	21.33	21.25	0.24	0.27	0.26	19.87	19.80	19.83	6.53	8.33	7.43
T_{12}	21.33	21.67	21.50	0.23	0.27	0.25	19.63	19.97	19.80	6.73	8.43	7.58
T_{13}	20.00	19.83	19.92	0.25	0.29	0.27	19.40	19.77	19.58	6.10	8.10	7.10
S.Em ±	0.85	0.74	0.53	0.01	0.01	0.01	0.23	0.25	0.17	0.17	0.20	0.12
CD at 5 % (T)	2.47	2.16	1.50	NS	NS	0.024	NS	NS	0.48	0.48	0.57	0.35
CD at 5 % (Y x T)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. %	6.80	5.88	6.35	8.05	8.82	8.49	2.05	2.19	2.12	4.29	3.99	4.14

Table 2: Effect of integrated nutrient management on quality traits (Sugars) of sapota.

Treatment No.	Reducing Sugar (%)			Non reducing sugar (%)			Total Sugar (%)		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	8.60	9.27	8.93	11.57	11.23	11.40	20.17	20.50	20.33
T_2	8.50	9.43	8.97	10.67	10.40	10.53	19.17	19.83	19.50
T_3	8.60	9.60	9.10	12.57	10.73	11.65	21.17	20.33	20.75
T_4	9.24	10.13	9.69	11.42	10.92	11.17	20.67	21.05	20.86
T_5	9.49	10.59	10.04	10.68	11.30	10.99	20.17	21.89	21.03
T_6	9.30	10.37	9.83	10.87	11.30	11.08	20.17	21.67	20.92
T_7	9.50	10.50	10.00	12.00	11.56	11.78	21.50	22.05	21.78
T_8	10.04	11.00	10.52	11.62	12.39	12.01	21.67	23.39	22.53
T_9	8.38	9.38	8.88	10.45	10.28	10.37	18.83	19.67	19.25
T_{10}	8.14	9.13	8.64	9.69	9.87	9.78	17.83	19.00	18.42
T_{11}	8.50	9.43	8.97	12.67	10.90	11.78	21.17	20.33	20.75
T_{12}	8.82	9.80	9.31	11.68	11.03	11.36	20.50	20.83	20.67
T_{13}	8.04	7.88	7.96	8.12	10.96	9.54	16.17	18.83	17.50
S.Em ±	0.17	0.17	0.14	0.35	0.38	0.59	0.32	0.33	0.50
CD at 5 % (T)	0.51	0.50	0.38	1.03	1.12	1.05	0.92	0.96	1.53
CD at 5 % (Y x T)	-	-	NS	-	-	NS	-	-	0.92
C.V. %	3.42	3.08	3.24	5.55	6.12	8.84	2.75	2.75	2.75

Table 3: Effect of integrated nutrient management on quality traits of sapota after harvest.

Treatment No.	Fruit firmness (kgcm^{-2}) at 2nd day after harvest			Fruit firmness (kgcm^{-2}) at 4th day after harvest			PLW (%) at 2nd day after harvest			PLW (%) 4thday after harvest		
	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled	1st year	2nd year	Pooled
T_1	11.00	12.27	11.63	4.50	7.33	5.92	3.78	3.63	3.70	5.93	5.91	5.92
T_2	10.67	11.50	11.08	3.87	4.87	4.37	4.37	4.11	4.24	6.26	6.40	6.33
T_3	10.83	12.23	11.53	4.20	7.00	5.60	3.85	3.66	3.75	6.27	6.09	6.18
T_4	11.33	12.61	11.97	5.83	7.50	6.67	3.65	3.37	3.51	5.79	5.78	5.79
T_5	11.67	12.83	12.25	6.08	8.33	7.21	3.45	3.25	3.35	5.67	5.59	5.63
T_6	11.33	12.65	11.99	6.00	7.83	6.92	3.53	3.35	3.44	5.75	5.78	5.77
T_7	11.83	13.00	12.42	6.17	8.67	7.42	3.45	3.09	3.27	5.46	5.44	5.45
T_8	12.17	13.10	12.63	6.65	8.90	7.78	3.44	2.62	3.03	5.39	5.08	5.24
T_9	9.83	11.47	10.65	3.67	4.83	4.25	4.59	4.54	4.57	6.68	6.55	6.61
T_{10}	9.67	11.40	10.53	3.50	4.77	4.13	4.56	4.22	4.39	6.42	6.29	6.36
T_{11}	10.67	12.22	11.44	4.17	5.67	4.92	3.91	3.76	3.84	6.34	6.10	6.22
T_{12}	11.17	12.43	11.80	5.00	7.33	6.17	3.65	3.51	3.58	5.91	5.86	5.89
T_{13}	9.00	10.83	9.92	3.17	4.73	3.95	4.73	4.65	4.69	6.73	6.63	6.68
S.Em ±	0.55	0.47	0.35	0.28	0.36	0.25	0.17	0.12	0.12	0.21	0.28	0.17
CD at 5 % (T)	1.61	1.38	0.98	0.80	1.05	0.71	0.51	0.36	0.33	0.63	0.81	0.48
CD at 5 % (Y x T)	-	-	NS	-	-	NS	-	-	NS	-	-	NS
C.V. %	8.82	6.73	7.74	9.85	9.27	9.60	7.68	5.77	6.86	6.20	8.12	7.26

Result and discussion

The integrated nutrient treatments significantly influenced the quality parameters over the control. The TSS was found significantly the highest (24.33, 24.67 and 24.50 ^{0}Brix) under the application of 75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree (T_8) during both the individual year of experimentation as well as on pooled analysis, followed by treatment T_7, T_5 and T_6. This is might be due its converting complex substances into simple sugar, which enhances the metabolic activity in fruits and resulted in increased TSS of fruit. The results of present findings are in conformation with the earlier workers Dutta (2016) [2] and Yadav *et al.* (2011) in mango; Kumrawat (2016), Thakkar (2015) [8] and Godage *et al*. (2013) [3] in guava; Bhavisar *et al.* (2011) [1] and Patel and Naik (2010) [7] in sapota.

During the first and second year acidity found non-significant result. However in pooled analysis the treatment T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree) recorded minimum acidity (0.21 %) as compared to control. This may be due to the utilization of acid under the respiratory process or conversion of acid into sugar in the fruit. Likewise, it is possible that conversion of acids into the sugars may be at lesser rate due to retardants or to suppression of ethylene formation, which are responsible for ripening process as reported by Dutta *et al.* (2016) [2] in mango.

The results indicate that treatment T_8 recorded maximum ascorbic acid (20.37 mg/100 g pulp during the pooled analysis) as compared to control. It was at par with T_7 and T_3. This is mainly due to continuous supply of nutrients and growth promoting substance. These results were conformity with findings of Thakkar (2015) [8] in guava; Nurbhanej (2014) [5] in acid lime; Patel and Patel (2011) [6] in banana.

The response of organic fertilizers, biofertilizer and chemical fertilizer on total, reducing and non-reducing sugar differed significantly. Further, it was observed that significantly the maximum total sugars (21.67, 23.39 and 22.53 %) and reducing sugar (10.04, 11.00 and 10.52 %) during first year, second year and pooled analysis respectively) were recorded with treatment T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree). It is clear from the results that treatment T_8 recorded significantly the maximum non-reducing sugar (12.39 and 12.01 % during the second year and in pooled analysis respectively), whereas during the first year significantly the highest non-reducing sugar (12.67 %) was recorded with T_{11} *i.e.* 100% N + 100% P + 75% K + Castorcake 5 kg + AAU KMB 10 ml/ tree. This may be due to the increased in sugars content might be attributed to the involvement of N in various energy sources like amino acids and amino sugars. These findings are supported by the results obtained by Thakkar (2015) [8] in guava; Bhavisar *et al.* (2011) [1] and Patel and Naik (2010) [7] in sapota; Patel and Patel (2011) [6] in banana; Mahindra *et al.* (2009) [4] in ber.

The maximum shelf life of fruits (7.07, 9.03 and 8.05 days during the first year, second year and pooled analysis under the treatment T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree followed by T_7, T_5 and T_4. This extended shelf life has been the consequence of slow down the ethylene synthesis and ultimately ripening process through minimum reduction in weight loss and other physiological parameters as well as bio-chemical changes in fruits. The results of present findings are in conformation with the earlier workers Thakkar (2015) [8] and Godage *et al.* (2013) [3] in guava and Patel and Naik (2010) [7] in sapota.

In present investigation, the firmness of sapota fruits was decreased as the storage period. Data showed that significantly highest firmness at 2nd day after harvest (12.17, 13.10 and 12.63 kgcm^{-2}) and at 4th day after harvest (6.65, 8.90 and 7.78 kgcm^{-2}) during the first year, second year and pooled analysis respectively under the treatment T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree). This change in firmness during storage may be due to slower rate of ripening and softening of pulp composition along with slower biochemical changes in conversion of starch to sugar fraction. This result is in agreement with Patel and Naik (2010) [7] in sapota.

The physiological loss in weight of sapota fruits was showed significantly the minimum at 2nd day after harvest (3.44, 2.62 and 3.03 %) and at 4th day after harvest (5.39, 5.08 and 5.24 %) in the treatment T_8 (75% NPK + Vermicompost 15 kg + AAU Bio NPK 10 ml/tree during the first year, second year and in pooled analysis respectively. The reduction in fruit weight loss by the different treatment may be due to reduction in rate of respiration and transpiration, which delayed ripening process by supporting the ethylene synthesis during the fruit ripening.

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