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Effect of Organic Sources on Soil and Leaf Nutrient Status of Sapota [*Manilkara achras* (Mill.) Fosberg] 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

The soil and leaf nutrients play a key role in the flowering and fruiting parameters of a plant thus contributing to yield. Thus, a study was undertaken to evaluate the effect of organic sources on the soil and leaf nutrient status of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti during the years 2019-20 and 2020-21. The organic sources include the combination of green manure, vermicompost, Anubhav Bio NPK consortium and microbial consortium with inorganic fertilizers as a control. It has been found that available Nitrogen content (272 kg/ha) and Potassium content (298 kg/ha) in the soil, as well as Nitrogen (2.353 %) and Potassium (1.805 %) content in leaf, were recorded maximum with the application of 50% RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree (T_8) in both the years of pooled analysis data. Whereas, treatment i.e % RDN from vermicompost + 50% RDN from green

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manure of cowpea + microbial consortium (AMBC I) 105 ml per tree (T_9) was found to be maximum for the available phosphorus content (61.73 kg/ha) in soil and phosphorus (0.191 %) the content in leaf in both the years in pooled analysis data.

Keywords: Sapota; green manures; vermicompost; biofertilizer; soil-leaf nutrients.

1. INTRODUCTION

Sapota (*Manilkara achras* (Mill) Fosb.) belongs to the family Sapotaceae and is one of the major fruit crops grown in India, Mexico, Guatemala and Venezuela [1]. It is a slow-growing tropical fruit tree. It needs a warm (10 to 38 ºC) and humid (70 % relative humidity) climate, where it flowers and fruits throughout the year. It is grown in an area of 89,000 ha in India, with a yield of 10.03 lakh MT and a productivity of 11.26 MT/ha (Anon.) [2]. The major sapota-producing states in India are Karnataka, Gujarat, Tamil Nadu, Maharashtra and Andhra Pradesh. It is grown on 27,827 hectares in Gujarat, with an annual yield of 3,10,012 MT and a productivity of 11.14 MT per hectare [3]. Immature fruits are astringent, while ripe fruits are sweet and tasty [4]. Sunhemp (*Crotalaria juncea*) is the most common green manure crop. The plant has a lot of herbage and decomposes quickly. Dhaincha (*Sesbania aculeata*) is a West African native stem nodulating (Produces nitrogen-fixing nodules in both roots and stems) green manure crop and it is a quick-growing green manure crop that can be incorporated 45 to 60 days after sowing. Cowpea (*Vigna unguiculata*) is an herbaceous annual legume that is used green or as dry fodder. Vermicompost would increase the organic carbon status of the soil and make the soil and crop production more sustainable [5]. "Biofertilizer is a substance which contains living microorganisms which, when applied to seed, plant surfaces, or soil, colonizes the rhizosphere or the inside of the plant and stimulate development by increasing the supply or availability of primary nutrients to the host plant [6]. Microbial decomposers could help reduce a large amount of organic waste by converting it into compost more quickly than traditional composting procedures.

2. MATERIALS AND METHODS

The present investigation entitled Effect of organic sources on soil and leaf nutrient status of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti was carried out during the years 2019-20 and 2020-21 on 22-year-old trees at Horticulture Research Farm, Department of Horticulture, B. A. College of Agriculture, Anand Agricultural University, Anand. The soil of the experimental location was sandy loam with normal pH (7.5), low in available nitrogen (235.23 kg ha^{-1}), high in available phosphorus (43.17 kg ha^{-1}) and medium in available potassium (260.33 kg ha^{-1}). The nitrogen, phosphorus and potassium of the soil were determined as per the standard methods given by Olsen et al. [7], Subbiah and Asija [8] and Jackson [9]. The experiment was set up in a Completely Randomized Design (CRD) with three replications and ten treatments with a combination of different green manuring, biofertilizer, vermicompost and Microbial consortium (Decomposer). [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 sunhemp + 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 replicated thrice during the years 2019-20 and 2020-21. Green manuring crops were sowing after 15 June in another field of both years. Sun hemp, cowpea and dhaincha biomass were applied as recommended as nitrogen fertilizers for the sapota. The nitrogen content (%), analyzed for sunhemp (0.71% & 0.67%), cowpea (0.67% & 0.60%) and dhaincha (0.62% & 0.64%), during the years 2019-20 and 2020-21.

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. After applying green manure, a rotavator was used to tillage around the canopy of the trees. The biofertilizer was applied 7 days after applying green manure in both years. By creating rings around trees, 1-1.5 meters away from the trunk, we applied a mixture of 10 mg of the Bio-NPK consortium dissolved in 20 litres of water. Analysis of vermicompost was performed for the available nitrogen content and was found 1.7 % in 2019-20 and 1.5 % in 2020-21. Vermicompost was applied in the required amounts around the tree using the ring method, at 1-1.5 meters from the trunk. The Anubhav Microbial Bio-decomposer Consortium-I (AMBC-I) was applied in the second week of August after applying the green manure for both years. Soil samples were collected from the experimental site of the sapota orchard at a depth of 15-30 cm initially i.e in the month of May 2019 and after the final harvest of fruits i.e in the first week of June 2020 and 2021. The air-dried soil samples were ground with wooden mortar and pestle; and passed through a 2 mm sieve. The soil samples were preserved in polythene bags for their chemical analysis later. For the leaf parameters, a composite sample of recently matured tenth leaf from the apex was collected for analysis as suggested by Bhargava and Chadha, [10] initially i.e in the month of May 2019 and after the final harvest of the fruits i.e in the first week of June 2020 and 2021. The leaves samples were washed and dried. The dried plant samples were cut and ground in a stainless-steel blade mixer and were preserved in polythene bags. The chemical analysis of the plant samples was performed by digestion of 1 g of powdered plant samples with HNO_3: $HClO_4$ (3:1) di-acid mixture as per the procedure described by Jackson [9] and acid extracts were prepared and these acid extracts of plant samples were used to analyze N, P and K content.

3. RESULTS AND DISCUSSION

3.1 Soil Nutrient Parameters

The data pertaining to soil nutrient parameters such as soil pH, EC and Microbial count (cfu/g) in soil has been depicted in Table 1, as well as available nitrogen (kg/ha), phosphorus (kg/ha) and potash (kg/ha) in soil are given in Table 2.

The data pertaining to the soil pH as influenced by different treatments of organic sources in both the years of study and their pooled analysis are presented in Table 1. Data indicated that different organic sources treatment showed non-significant effects on soil pH in both the year of study and as well as in pooled analysis. The highest pH value was recorded at 7.25 in treatment T_4 and T_6 in 2019-20, while, in 2020-21 and pooled treatment T_1 recorded the highest pH value, i.e 7.26 and 7.25. Treatment T_2 recorded the lowest pH value i.e 7.20, 7.16 and 7.18 in 2019-20, 2020-21 and pooled analysis.

Soil EC was found not significantly influenced by different organic sources treatment in both the years as well as in pooled analysis is presented in Table 1. In 2019-20 and 2020-21 and pooled analysis, treatment T_1 recorded higher EC values i.e 0.263, 0.265 and 0.264 dS/m, respectively. Treatment T_{10} showed lower EC values i.e 0.255, 0.252 and 0.253 dS/m in 2019-20 and 2020-21 and pooled analysis and treatment T_9 also recorded lower EC value 0.252 dS/m in 2020-21.

Soil samples were collected before and after conducting the experiment for microbial count. Table 1 depicts the data related to microbial count (cfu/g) in soil in which significant influence was observed for different treatments of organic sources during both years of experiments. The data clearly indicated that the treatment, T_8 [50 % RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree] recorded a maximum microbial count of 5.9 x 10^8 cfu/g in 2019-20. While treatment T_5 [75% RDN from green manure of sun hemp + microbial consortium (AMBC I) 105 ml + 10 ml Anubhav Bio NPK consortium per tree] recorded a maximum microbial count of 6.4 × 10^8 cfu/g in the 2020-21. As the values of cfu/g range from 10^6 to 10^8, it is beyond the capacity of statistical inference rather than relying on total count. It is evident from the results that the Bio NPK consortium improved the microbial population of soil in consecutive years of study. The application of sun hemp as green manures also favoured the growth of microorganisms by providing the food material for the sustainability of the microbes in the soil. Confirmatory findings were reported by Mir et al. [11] in pomegranate with conjoint application of bio-regulators 80 g/tree, vermicompost 20 kg/tree, FYM 20 kg/tree and green manuring with sunhemp, Dutta et al. [12] in mango with application of biofertilizer (Azotobacter @ 50 g/plant + PSM @ 100 g/plant) and Sau et al. [13] in mango with application of Azotobacter + Azosprillium + AM + Panchagavya 3%.

Table 1. Effect of organic sources on soil pH, EC and microbial count in soil of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti

Treatment No.		Soil pH			Soil EC (ds/m)			Microbial count (cfu/g) in soil	
		2019-20	**2020-21**	**Pooled**	**2019-20**	**2020-21**	**Pooled**	**2019**	**2020**
T_1		7.24	7.26	7.25	0.263	0.265	0.264	5.9×10^6	6.1×10^6
T_2		7.20	7.16	7.18	0.259	0.257	0.258	5.0×10^8	5.3×10^8
T_3		7.24	7.20	7.22	0.260	0.259	0.260	5.2×10^8	5.5×10^8
T_4		7.25	7.23	7.24	0.262	0.260	0.261	5.1×10^8	5.4×10^8
T_5		7.23	7.19	7.21	0.258	0.255	0.257	5.8×10^8	6.4×10^8
T_6		7.25	7.21	7.23	0.257	0.253	0.255	5.6×10^8	6.1×10^8
T_7		7.22	7.18	7.20	0.258	0.256	0.257	5.6×10^8	6.0×10^8
T_8		7.23	7.19	7.21	0.257	0.254	0.256	5.9×10^8	6.2×10^8
T_9		7.23	7.18	7.20	0.256	0.252	0.254	5.4×10^8	5.8×10^8
T_{10}		7.21	7.19	7.20	0.255	0.252	0.253	5.5×10^8	5.8×10^8
(T)	S.Em ±	0.17	0.17	0.12	0.012	0.012	0.008	-	-
	C. D. (P = 0.05)	NS	NS	NS	NS	NS	NS	-	-
(Y)	S.Em ±	-	-	0.05	-	-	0.003	-	-
	C. D. (P = 0.05)	-	-	NS	-	-	NS	-	-
(Y×T)	S.Em ±	-	-	0.17	-	-	0.012	-	-
	C. D. (P = 0.05)	-	-	NS	-	-	NS	-	-
C.V. %		4.06	4.14	4.10	8.04	8.36	8.20	-	-

Available N in soil (kg/ha) is presented in Table 2 and graphically depicted in Fig. 1. Under the application of treatments, T_8 [50% RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree] during the year 2019-20, 2020-21 and pooled analysis recorded significantly maximum available N in soil i.e 270, 273 and 272 kg/ha. The data revealed a non-significant interaction of year and treatments (Y x T) effect on available N (kg/ha). This might be due to the application of sunhemp as green manure supplies an efficient quantity of N on Phyto mass decomposition as well as N use efficiency of green manure is high as green manure N is less prone to loss mechanisms than mineral N fertilizers and may therefore contribute to enhanced soil N. The microbial number and urease activity are higher in vermicompost which leads to the higher available N in soil. Current findings were supported by Korwar et al. [14] in Aonla with the application of sun hemp as green manuring. Mouco et al. [15] in mango with intercropping of sun hemp as green manuring and Ghosh et al. [16] in sweet orange with the application of vermicompost 20 kg/tree.

Table 2 presents the data on available phosphorus and it was observed that among different treatments, T_9 [50 % RDN from vermicompost + 50% RDN from green manure of cowpea + microbial consortium (AMBC I) 105 ml per tree] has maximum available P_2O_5 in soil i.e 60.49, 62.96 and 61.73 kg/ha in 2019-20, 2020-21 and pooled. Statistical evaluation of data revealed that non-significant interaction of year and treatments (Y x T) effect on available P_2O_5 (kg/ha). The result may be attributed to the application of cowpeas as a green manure supply and an increase in the availability of Phosphorus through the mechanism of reduction and favourable changes in soil pH as well as mobilizing Phosphorus. The application of vermicompost led to the gradual release of P_2O_5 in the soil as well as the increase in alkaline phosphatase activity in the soil. Result observed was in accordance with the finding of Marathe et al. [17] in sweet orange with the application of green manuring of sun hemp along with vermicompost 25 kg and Kumar *et al*. [18] in mango with green manuring of sun hemp along with farm yard manure and NPK, Silva *et al*. [19] in papaya with biochar and green manure application and Ghosh *et al*. [16] in sweet orange with application of vermicompost 20 kg/tree.

From Table 2, it appeared that available K_2O in soil (kg/ha) of sapota cv. Kalipatti was influenced by different organic sources treatment in both the years of the experiment as well as in pooled analysis, among different treatments T_8 [50% RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree] recorded significantly maximum available K_2O in soil i.e 297, 300 and 298 kg/ha in 2019-20, 2020-21 and pooled statistical result. An interaction of year and treatments (Y x T) effect on available K_2O (kg/ha) was found non-significant. The increased availability of potassium in soil is attributed to the biomass decomposition of the applied sun hemp, which led to an increase in the humus content of the soil as well as an increased cation exchange capacity of the soil. Corresponding confirmatory results were found by Marathe et al. [17] in sweet orange with the application of green manuring of sun hemp along with vermicompost 25 kg application.

3.2 Leaf Nutrient Parameters

The data of leaf nutrient parameters like Nitrogen (%), Phosphorus (%) and Potash (%) have been shown in Table 3.

Among different treatments under the application as shown in Table 3, treatment T_8 [50 % RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree] resulted in significant maximum total nitrogen content in leaf i.e 2.320, 2.387 and 2.353 % in 2019-20, 2020-21 and pooled. The data indicate that non-significant interaction of year and treatments (Y x T) on total nitrogen content (%) in leaves of sapota. Higher nitrogen content due to the application of vermicompost and sun hemp might be attributed to the improvement in soil aeration, better soil moisture in the root zone, increased microbial nitrogen fixation due to conjugant application and thus improved availability to the plants. Current findings were supported by Khachi et al. [20] in kiwifruit with green manuring with sun hemp treatments, Thakur et al. [21] in plum with application of 75% NPK + bio-fertilizers (60 g each/tree basin) + green manuring (sun hemp @ 25 g seeds/tree basin) and Meena et al. [4] in sapota with application of 2/3 of RDF +10 kg Vermicompost + 250 g Azospirillum + 250 g Azotobacter plant.

Table 2. Effect of Organic Sources on available nitrogen, phosphorus and potassium in soil of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti

Treatment No.		Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
		2019-20	**2020-21**	**Pooled**	**2019-20**	**2020-21**	**Pooled**	**2019-20**	**2020-21**	**Pooled**
T_1		234	236	235	50.38	53.19	51.79	269	272	270
T_2		256	257	257	51.46	54.01	52.74	266	268	267
T_3		262	264	263	52.56	54.83	53.70	266	269	268
T_4		236	235	235	50.05	51.52	50.78	257	259	258
T_5		252	253	253	55.18	57.42	56.30	286	289	288
T_6		240	242	241	56.05	58.74	57.40	276	277	276
T_7		243	245	244	54.10	56.47	55.29	279	280	280
T_8		270	273	272	57.41	60.02	58.71	297	300	298
T_9		266	267	267	60.49	62.96	61.73	287	288	287
T_{10}		264	265	264	56.05	58.19	57.12	279	283	281
(T)	S.Em ±	7.68	8.38	5.68	1.80	1.46	1.16	6.39	6.54	4.57
	C. D. (P = 0.05)	22.67	24.71	16.24	5.31	4.32	3.31	18.85	19.30	13.07
(Y)	S.Em ±	-	-	2.54	-	-	0.52	-	-	2.05
	C. D. (P = 0.05)	-	-	NS	-	-	1.48	-	-	NS
(Y×T)	S.Em ±	-	-	8.03	-	-	1.64	-	-	6.47
	C. D. (P = 0.05)	-	-	NS	-	-	NS	-	-	NS
C.V. %		5.27	5.71	5.50	5.74	4.47	5.11	4.03	4.07	4.03

Table 3. Effect of Organic Sources on nitrogen, phosphorus and potassium content in the leaf of sapota [*Manilkara achras* (Mill.) Fosberg] cv. Kalipatti

Treatment No.		Total nitrogen content (%)			Total phosphorus content (%)			Total potassium content (%)		
		2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1		1.759	1.790	1.774	0.143	0.151	0.147	1.477	1.490	1.483
T_2		1.977	2.047	2.012	0.148	0.161	0.155	1.373	1.397	1.385
T_3		1.983	2.091	2.037	0.153	0.165	0.159	1.347	1.373	1.360
T_4		1.773	1.793	1.783	0.133	0.144	0.139	1.193	1.200	1.197
T_5		1.937	2.007	1.972	0.160	0.169	0.165	1.737	1.767	1.752
T_6		1.883	1.903	1.893	0.173	0.179	0.176	1.657	1.693	1.675
T_7		1.933	1.957	1.945	0.157	0.167	0.162	1.700	1.720	1.710
T_8		2.320	2.387	2.353	0.177	0.188	0.182	1.783	1.827	1.805
T_9		2.080	2.163	2.122	0.187	0.195	0.191	1.727	1.750	1.738
T_{10}		2.013	2.083	2.048	0.167	0.171	0.169	1.703	1.740	1.722
(T)	S.Em ±	0.094	0.093	0.066	0.008	0.008	0.006	0.067	0.071	0.048
	C. D. (P = 0.05)	0.27	0.27	0.18	0.02	0.02	0.01	0.19	0.22	0.13
(Y)	S.Em ±	-	-	0.029	-	-	0.002	-	-	0.021
	C. D. (P = 0.05)	-	-	NS	-	-	0.008	-	-	NS
(Y×T)	S.Em ±	-	-	0.093	-	-	0.008	-	-	0.069
	C. D. (P = 0.05)	-	-	NS	-	-	NS	-	-	NS
C.V. %		8.30	8.02	8.16	9.45	8.75	9.09	7.41	7.71	7.57

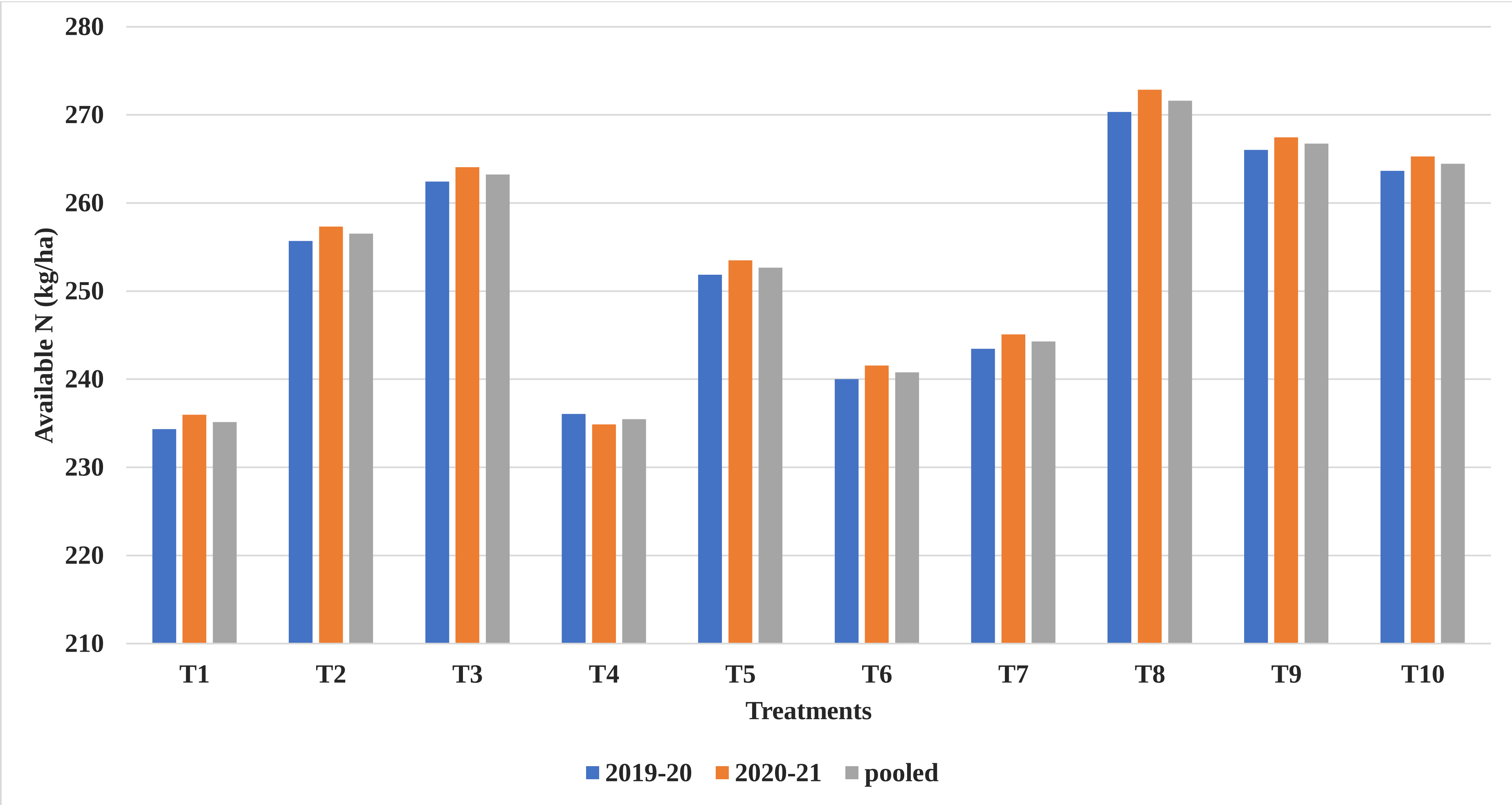

Fig. 1. Effect of organic sources on available nitrogen (kg/ha) in soil of sapota [Manilkara achras (Mill.) Fosberg] cv. Kalipatti

The data depicted is given in Table 3. Among different treatments, T_9 [50 % RDN from vermicompost + 50% RDN from green manure of cowpea + microbial consortium (AMBC I) 105 ml per tree] reported significant maximum total phosphorus content in leaf i.e 0.187, 0.195 and 0.191 % in 2019-20, 2020- 21 and pooled result. An interaction of year and treatments (Y x T) effect on total phosphorus content (%) in leaves of sapota was found non-significant. The application of cowpea as green manure and vermicompost led to the buildup of humus in soil and the decomposition of biomass led to the formation of organic acids in soils which might helped in phosphorous solubilization, leading to the increased uptake of phosphorus. These results were like the findings of Phukan et al. [22] in bananas with treatment combinations of FYM, neem cake, vermicompost, wood ash + triple green manuring (dhaincha + cowpea + cowpea as intercrop) + biofertilizers and Das *et al*. [23] in guava with application of vermicompost @ 10 kg/plant + FYM @ 20 kg/plant.

Among various treatments, Table 3 describes treatment T_8 [50 % RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree] recorded significant maximum total potassium content in leaf i.e 1.783, 1.827 and 1.805 % in 2019-20, 2020-21 and pooled. Statistical summarization of both the year's data insights that the interaction of year and treatments (Y x T) effect on total potassium content (%) in the leaf of sapota was observed non-significant. The higher potassium content in sapota leaves due to the application of sun hemp as green manure and vermicompost might be attributed to the favourable soil conditions due to an increase in soil humus, which results in an increased cation exchange capacity of the soil, leading to the higher potassium uptake by trees. Supporting results were found by Thakur et al. [21] in plum with application of 75% NPK + bio-fertilizers (60 g each/tree basin) + green manuring (sun hemp 25 g seeds/tree basin) and Kamalakannan et al. [24] in sapota with application of vermicompost 12.5 kg/ tree + RDF (1000:1000:1500 g NPK/tree).

4. CONCLUSIONS

A conclusion can be drawn from the experiment that available nitrogen content and potassium content in soil and leaf were recorded maximum with the application of 50% RDN from vermicompost + 50% RDN from green manure of sun hemp + microbial consortium (AMBC I) 100 ml per tree (T_8) while available phosphorus content in soil and leaf was found maximum in treatment (T_9) having 50% RDN from vermicompost + 50% RDN from green manure of cowpea + microbial consortium (AMBC I) 105 ml per tree over the years 2019-20 and 2020-21.

FUTURE SCOPE

As we know the increasing use of fertilizers and chemicals has an adverse effect on human health and the environment. It also degraded the soil productivity day by day. So, by using organic fertilizers and green manuring, we can overcome this problem and we can also increase the yield of the crop. Our findings become helpful for the researcher involved in experiments related to green manuring and organic manures.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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