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RESEARCH ARTICLE

SOIL PROPERTIES AND NUTRIENT AVAILABILITY UNDER TEAK BASED AGROFORESTRY SYSTEM

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Abstract: Since the last century, unwise utilization of soil resource has caused dramatic reduction in soil organic carbon pool, a foundation of soil life. Considering this fact, the present research experiment was carried out to assess the role of teak based agroforestry systems in improving the soil organic carbon status of soil and its influence on soil fertility. The results revealed that alkalinity and salinity of soil were significantly decreased under teak based agroforestry systems as compared to nearby agricultural land. Moreover, soil organic carbon (SOC) was increased by 59.61 per cent in soil of teak based agroforestry over the agricultural soil. Like SOC, the availability of primary nutrients (N, P_2O_5 and K_2O) and DTPA-extractable Fe and Zn were also significantly improved in soil of teak based agroforestry systems grown under South Gujarat agroclimatic condition.

Keywords: Soil organic carbon, Agroforestry system, Available primary nutrients, DTPA- extractable Fe, Zinc

INTRODUCTION

The pressure on the agricultural lands has increased manifolds due to overpopulation, urbanization and industrialization process. These factors have not only affected the agricultural production but the environmental conditions have also got degraded. There is a global crisis of energy and man is striving hard to find out some alternative source of energy.

Agroforestry is a land use system in which woody perennials are association with herbaceous plants and/or livestock in a spatial arrangement, rotation or both, and in which there are both ecological and economic interactions between the tree and non-tree components of the system. The agroforestry has both productive and protective potential and it can play an important role in enhancing the productivity of the lands to meet the demand of ever growing human and livestock population. The role of trees in soil conservation and erosion control is one of the most widely acclaimed and compelling reasons for including trees on farm lands prone to erosion hazards. Agroforestry systems have a stabilizing or beneficial effect upon the soil properties, which might be helpful in reverse land degradation especially in the tropics. Trees under agroforestry besides providing the tree products, improves soil productivity through ecological and physico-chemical changes (Chauhan *et al.*, 2012). The large root system of trees potentially accumulates nutrients from a large volume of soil, while litter fall concentrates nutrients near the soil surface. Addition of litter fall and fine root in the soil turnover may increase soil organic matter concentration. Component crops in an agroforestry system often make a better use of resources and therefore complement each other than when crops are grown as sole crops.

Tectona grandis Linn. (Family - Lamiaceae) is one of the most well-known woods in the world, renowned for its dimensional stability, extreme durability, and hardness, as well as its resistance to decay even when unprotected by paints and preservatives. This tree is commonly called as teak and locally known as sagon, sagwan etc. It is one of the most important heartwood of the world over. Teak is now grown in smallholder agroforestry systems in many tropical countries.

Presence of tree species on farm land plays a vital role in increases the organic matter through addition of leaf litter, reduce nutrient losses through run off and enhance nutrient use efficiency. One of the major advantages of agroforestry in terms of improving or sustaining soil productivity was through its effect on soil conservation.

The present investigation was aimed to assess the effect of two different land use systems on soil properties and available nutrients (macro and micro) in soil.

MATERIALS AND METHODS

Experimental site and details

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Teak based agroforestry system and agricultural land was selected for present study is situated in main campus of Navsari Agricultural University, Navsari, Gujarat state, India, which, lies between $20^0$55'25"N latitude and $72^0$54'29"E longitude with an average elevation of 10 m above mean sea level. According to agro-climatic conditions, Navsari falls in agro-ecological situation III of South Gujarat heavy rainfall zone-I, which is typically characterized by humid and warm monsoon with heavy rainfall (around 1500 mm), moderately cold winter and fairly hot and humid summer.

Experimental soil

As per the soil taxonomy, the experimental soils belong to the order *Inceptisols,* suborder *Ochrepts* and great group of *vertic Ustochrepts*. It was heavy textured clay in nature and moderately drained with good water holding capacity. The representative surface soil (0 - 15 cm depth) samples were collected randomly from 24 years old teak plantation, which was frequently used for intercropping with mostly vegetable crops such as brinjal, lady finger, cucurbits, cluster bean *etc.* during the summer and rabi season. For comparing soil properties, surface soil samples were also collected from surrounding agricultural soils that was widely used for cultivating the pulses, rice, sugarcane and vegetables. The soil sampling was done in summer season of year 2022 in both land use system. The collected soil samples were sun dried, ground and sieved with 2.00 mm sieve. In order to fulfill the objectives of the present study, soil properties such as pH, EC, OC and available nutrient status were determined from the processed soil samples by adopting standard procedures as given in table 1.

Statistical analysis

T-test using equal variance was used to see the statistical significance between two land use system for soil properties.

Table 1. Methods used for analysis of various properties of soil

Sr. No.	Soil characteristics	Methods employed for determination
1	EC (dS m^{-1}) (1:2.5 soil: water ratio)	Conductometric method (EC meter) (Jackson, 1973)
2	Soil pH (1:2.5 soil: water ratio)	Potentiometric method (pH meter) (Jackson, 1973)
3	Organic carbon (%)	Walkley and Black's rapid titration method (Jackson, 1973)
4	Available N (kg ha^{-1})	Alkaline potassium permanganate method (Subbiah and Asijah,1956)
5	Available P_2O_5(kg ha^{-1})	Olsen's method (Jackson, 1973)
6	Available K_2O (kg ha^{-1})	1 N NH_4OAC Extraction method (Jackson, 1973)
7	Extractable Fe and Zn (mg kg^{-1})	DTPA-$CaCl_2$-TEA followed by Atomic Absorption Spectrophotometric method (Lindsay and Norvel, 1978)

RESULTS

Soil pH

Soil pH was significantly ($p < 0.05$) influenced by teak based agroforestry system and agriculture land. Furthermore, the pH was recorded lowest under teak based agroforestry system as compare to agriculture land (Table 2).

Soil EC

Statistically significant ($p < 0.05$) difference was found between two land use system for soil EC. It was recorded lower under teak based agroforestry as compare to agriculture land (Table 2).

Soil organic carbon (%)

In both land use system, soil organic carbon was significantly ($p < 0.05$) varied.In comparison to agriculture land, teak based agroforestry system recorded increased soil organic carbon (Table 2).

Available N (kg ha^{-1})

Available N in soil was differ significantly ($p < 0.05$) with both cropping systems. Higher amount of available N in soil was observed under teak based agroforestry system as compare to agriculture land (Table 3).

Table 2. Effect of land use systems on chemical properties of soil

Treatments	pH	EC	Soil organic carbon (%)
Land use system			
Teak based agroforestry system	7.51	0.66	0.83
Agriculture land	7.83	0.84	0.52
t Stat	-60.25	-37.58	61.56
P(T<=t) two-tail	0.00	0.00	0.00

Table 3. Effect of land use systems on available macro and micro nutrients in soil

Treatments	**Available primary nutrients (kg ha^{-1})**			**DTPA-extractable micronutrients (mg kg^{-1})**	
	N	**P_2O_5**	**K_2O**	**Zn**	**Fe**
Land use systems					
Teak based agroforestry system	325.82	75.22	547.12	0.88	12.50
Agriculture land	243.69	57.10	523.87	0.48	7.89
t Stat	59.44	23.96	10.16	51.38	49.27
P(T<=t) two-tail	0.00	0.00	0.00	0.00	0.00

Available P_2O_5 (kg ha^{-1})

Both land use systems give significant ($p < 0.05$) variation for available P_2O_5 in soil. Result shows that as compare to agriculture land, teak based agroforestry system was recorded higher availability of P_2O_5 (Kg ha^{-1}) in soil (Table 3).

Available K_2O (kg ha^{-1})

It is evident from data presented in Table 3 that two land use systems significantly ($p < 0.05$) affected the available K_2O in soil. It was recorded maximum in teak based agroforestry system.

DTPA-extractable Zn (mg Kg^{-1})

Statistically significant difference ($p < 0.05$) between both land use systems on extractable Zn in soil was found. Teak based agroforestry system recorded higher extractable Zn in soil in comparison to agriculture land (Table 3).

DTPA-extractable Fe (mg Kg^{-1})

The effect of two land use system found significant ($p < 0.05$) for extractable Fe in soil. In comparison to agriculture land, teak based agroforestry system recorded increased extractable Fe (Table 3).

DISCUSSION

Teak based agroforestry system observed low pH and EC as compared to sole cropping. This might be due to substantial addition of organic matter to the surface soil under trees and the release of organic acid during decomposition of litter (Singh *et al.*, 2018, Sarvade *et al.*, 2014 and Swaminathan, 2001). Mevada *et al.* (2021) reported that various chemical properties of soil were improved under integrated nitrogen management in teak based agroforestry system as compared to sole cropping system.

The soil enrichment in SOC content under teak based agroforestry system might be because of several factors such as addition of litter, annual recycling of fine root biomass and root exudates and its reduced oxidation of organic matter under tree shades. Further, this can be attributed to the recycling of organic matter through roots in the layers they occur. When the decomposition of a root residue takes place, they supply nutrients to the soil through the process of mineralization and also contribute to the addition of carbon in the soil through the humification process. The higher SOC of the surface layer is due to fact that the litter fall takes place mainly on the surface layers (Mongia *et al.* 1998).

Lower availability of nutrient in sole cropping system than teak based agroforestry system indicates towards better nutrient cycling in teak based agroforestry systems than without the tree component. Higher availability of nutrient in teak based agroforestry systems may be due to nutrient rich litter of trees, which may have contributed to higher amount of nutrient returned back to the soil in the form of litter and relatively higher pumping of nutrient from the subsoil by vegetation. The increase in available K concentration may be due to release of K from the K-bearing minerals and partly due to recycling of K on account of litter decomposition. In addition, the organic acids released during decomposition of residues and organic matter enhanced P release by reducing metal ions binding phosphates through chelation as well as by competing for exchange sites (Basak *et al.* 2016). Litter fall and favorable environmental conditions may facilitate the decomposition and consequently increase the concentration of available micro nutrients (Swaminathan 2001). Furthermore, on decomposition organic matter produce organic molecules which form chelates of micronutrient and increase their availability in soils. Available N, P and DTPA extractable Zn in soil was greater in eucalyptus based agroforestry system compared to the monocrop sugarcane. The result was in conformity with Singh *et al.* (2014), Singh *et al.* (2017) and Singh *et al.* (2018).

CONCLUSION

Maintenance of soil organic matter in cultivated soils has become one of the great challenges in natural resource management to sustain the crop productivity. The results of present study revealed that teak based agroforestry system seems to be play vital role in improving the major soil properties such as pH, EC and SOC. Improvement in these parameters also enhanced the fertility status of experimental soils.

REFERENCES

Basak, N., Datta, A., Biswas, S., Mitran, T. and Mandal, B. (2016). Organic amendment influences soil quality in farmers' field under rice-based cropping systems in Indo-Gangetic plains of India. *J. Indian Soc. Soil Sci.*,**64**: 138-147.

Google Scholar

Chauhan, S.K., Sharma, R., Sharma, S.C., Gupta, N. and Ritu (2012). Evaluation of poplar (*Populusdeltoides* Bartr. Ex Marsh.) boundary plantation based agrisilvicultural system for wheat-paddy yield and carbon storage. *International Journal of Agriculture and Forestry*, **2**(5): 239-246.
Google Scholar

Jackson, M. (1973). "*Soil chemical analysis prentice"*. Hall of India Private Limited, New Delhi, 498(1).
Google Scholar

Kumar, P., Mishra, A. K., Chaudhari, S. K., Basak, N., Rai, P., Singh, K., Singh, R., Pandey, C. B. and Sharma, D. K. (2018). Carbon pools and nutrient dynamics under eucalyptus-based agroforestry system in semi-arid region of North-west India.*J. Indian Soc. Soil Sci.*, **66**(2):188-199.
Google Scholar

Lindsay, W. L. and Norwell, W. A. (1978). Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. Am. J.*, **42**: 421–428.
Google Scholar

Mevada, R. J., Tandel, M. B., Prajapati, V. M., Patel, D. P., Patel, N. K., Pathak, J. and Prajapati, D. R. (2021). Impact of INM and intercrop on soil properties under teak (*Tectonagrandis* L. f.) based agroforestry system. *International Journal of Chemical Studies*, **9**(1): 902-906.
Google Scholar

Mongia, A.D., Dey, P. and Singh, G. (1998). Ameliorating effect of forest trees on a highly sodic soil in Haryana. *J. Indian Soc. Soil Sci.*,**46**:664–668.
Google Scholar

Sarvade, S., Mishra, H. S., Kaushal, R., Chaturvedi, S., Tewari, S. and Jadhav, T. A. (2014). Performance of wheat (*Triticum aestivum* L.) crop under different spacings of trees and fertility levels. *Afr. J. Agric. Res.*, **9**(9): 866-873.
Google Scholar

Singh, I., Rawat, P., Kumar, A. and Bhatt, P. (2018). Soil physico-bio-chemical properties under different agroforestry systems in Terai region of the Garhwal Hiamalayas. *J. Pharmacogn. Phytochem.*, **7**(5): 2813-2821.
Google Scholar

Singh, N. R., Jhariya, M. K. and Loushambam, R. S. (2014). Performance of soybean and soil properties under poplar-based agroforestry system in tarai belt of Uttarakhand, India. *Eco. Env. Cons.*, **20**(4): 1569-1573.
Google Scholar

Singh, R., Bhardwaj, D. R., Pala, N. A. and Rajput, B. S. (2017). Variation in soil properties under different land uses and attitudinal gradients in soils of the Indian Himalayas. *Acta Ecological Sinica*, 1-7.
Google Scholar

Subbiah, B. V. and Asija, G. L. (1956). A rapid method for the estimation of nitrogen in soil. *Current Science*, **26**: 259-260.
Google Scholar

Swaminathan, C. (2001). Sustainable tree mixtures: Optimum species combination for a tropical Alfisol of southern India. *Biological, Agriculture and Horticulture*, **18**: 259-268.
Google Scholar