ASSESSMENT OF SOIL ORGANIC CARBON (SOC) UNDER DIFFERENT AGROFORESTRY SYSTEMS IN MIZORAM, NORTHEAST INDIA.

Lalnunmawia*, PC Vanlalhluna, Tawnenga
Department of Botany, Pachhunga University College, Aizawl 796001, Mizoram, India.

Abstract

The present study reported soil organic carbon content in the year and after when the natural forest was converted into another land used management systems known as agroforestry. The experiment has 15 treatments laid down in randomize block design with three replications involving 45 subplots. The treatment consisted of three multipurpose trees (*Michelia champaca*, *Tectona grandis*, *Parkia roxburghii*) and three agricultural crops (*Zea mays, Curcuma longa* and *Glycine max*). Highest soil organic carbon content was recorded in the treatment T_7 (*Michelia champaca + Zea mays*) and minimum in T_{11} (*Tectona grandis + Curcuma longa*). Among the tree, T_4 (*Michelia champaca*) recorded maximum soil organic carbon followed by T_6 (*Parkia rogburghii*) and lowest in T_5 (*Tectona grandis*). Among the crop, T_1 (*Zea mays*) recorded highest soil organic carbon compared to that of T_3 (*Glycine max*) and T_2 (*Curcuma longa*). The content of soil organic carbon gradually decreased at the start of the experiment, but slightly increased towards the end of harvesting. Soil organic carbon content was higher in tree-crop interaction in comparison to the control plots. Similar patterns were observed for all the treatments. The study suggests that tree-based agroforestry system provides a good source and sink of carbon even though no significant variation was observed between the different treatments during the first year period of study.

Key words: Agroforestry, Mizoram, one year, rain-fed, soil organic carbon.

Introduction

Soil organic carbon is the carbon in soil organic constituents produced by dead plants, animals decomposed and soil microbial biomass. It is one of the most important indicators of soil quality, fertility, productivity and its role has been recognized for more than a decade (Tiessen et al., 1994). Soils are considered as the largest reservoirs of carbon in the terrestrial ecosystems. The carbon stored in soil is at least three times larger than the atmospheric pool of carbon dioxide (Schlesinger, 1977; Jobbagy & Jackson, 2000; Amundson, 2001). And therefore soil testing is an important tool for soil fertility management especially in the context of sustainable agricultural production as it provides the conditions of different available nutrients (Sahrawat et al., 2013).

It has been reported that agroforestry systems can function as a source and/or sink of carbon in the terrestrial carbon cycle (Dixon, 1995; Montagnini et al., 2004). Young (1997) reported that agroforestry practices increased the potential of soil in its organic carbon contents. Hence agroforestry can simply be defined as sustainable land used management system, which increases the yield of the land, combines production of both crops (including tree species) and forest plants. Kandji et al. (2006) reported that the type of agroforestry systems have impact on source or sink role of the trees. Soil organic carbon concentration is affected by human activities and its declining presence can be attributed to land conversion, soil disturbance and increase in different cultural activities (Wilson et al., 2011). It was also observed that reduction ofsoil organic carbon in cultivated land can be due to increasing cultivation period (Lemenih et al., 2005).

Only few information was available on soil organic carbon under agroforestry system in Mizoram. Lalthanzara et al. (2011) studied soil physico-chemical properties in relation to earthworm under agroforestry ecosystems in Mizoram. Vanlalfakawma et al. (2014) carried out works on soil carbon pool from bamboo forest in Mizoram. Impact of shifting cultivation on soil organic carbon was also carried out by Zodinpuii et al. (2016) in the tropical hilly terrain of Mizoram. And therefore, the present study aimed at evaluating soil organic carbon content under three different tree-based agroforestry systems in the state.

Material and Methods

Experimental Field

The experimental field was located at Tuithumhnar, Chawlhhmun area (23° 44’31.18” N latitude and 92° 41’ 25.95” E longitude) which is around 10 km in the south western part of Aizawl city, the capital of Mizoram. The temperature variation is small throughout the year. The mean minimum and maximum summer and winter temperature recorded during the study period were 21–34°C and 8-20°C respectively. The mean annual rainfall is 2500 mm. The study site is moderately slope and it ranges between 20% – 40%. The soil of the study site is sandy loam, red brown in color and acidic (pH 5.30 – 5.63) in nature.

Treatments

Treatments in the present study can be described as growing of selected crop under tree species in a plot it consisted of three multipurpose trees such as *Michelia champaca* L., *Tectona grandis* L.f., *Parkia roxburghii* G.Don and three agricultural crops like *Zea mays* L., *Curcuma longa* L. and *Glycine max* (L.) Merr (Table 1). The experiment has 15 treatments laid down inrandomized block design (RBD) with three replications totaling 45 subplots. The field was prepared in the months of March and April, 2018 and seedlings were planted during May, 2018. *Zea mays* and *Curcuma longa* seeds were sown in April, *Glycine max* was in July. Weeding was carried out three times during the cropping period in order to prevent the growth of weeds and improve the crop growth. The trees were maintained at a uniform spacing of 2.5 m x 2.5 m apart. However, spacing between the intercrop were slightly different (for maize 40 cm x 60 cm, for turmeric 25 cm x 35 cm and for soyabean 40 cm x 50 cm). Chemical control measures and irrigation of any sort were not provided and the cropswere raised purely under rain-fed condition.

Table 1: The different tree-crop combination.

Combination Code	Tree-Crop Combination
T_1	*Zea mays* Alone
T_2	*Curcuma longa* Alone
T_3	*Glycine max* Alone
T_4	*Michelia champaca* Alone
T_5	*Tectona grandis* Alone
T_6	*Parkia roxburghii* Alone
T_7	*Michelia champaca + Zea mays*
T_8	*Michelia champaca + Curcuma longa*
T_9	*Michelia champaca + Glycine max*
T_{10}	*Tectona grandis + Zea mays*
T_{11}	*Tectona grandis + Curcuma longa*
T_{12}	*Tectona grandis + Glycine max*
T_{13}	*Parkia roxburghii + Zea mays*
T_{14}	*Parkia roxburghii + Curcuma longa*
T_{15}	*Parkia roxburghii + Glycine max*

Soil Sampling

Soil samples were collected from each treatments up to 15 cm depth using steel corer (2.5 cm diameter), tightly packed in a polythene bag with properly labeled and taken to the laboratory for analysis. The soil samples were oven dried, grinded with mortar and pestle and then passed through 2 mm sieved. The plant roots and other visible fractions were removed. Soil samples were collected from the experimental field in the months of April (at the start of the experiment), June, August, October and December (after harvesting of crops). Soil organic carbon (SOC) content was estimated by rapid titration method (Walkley & Black, 1934) and is expressed in percentage (%).

Statistical Analysis

All the data were presented as means ± standard error of means of three replicates. To determine statistical difference between the treatments, variance analysis and least significant difference (LSD) test were performed using SPSS Software (Standard release version 16 for windows, SPSS Inc., IL, USA) programme. Level of significance was considered at $P<0.05$.

Results and Discussion

The observation (Table 2) shows that among tree-crop interaction, the highest soil organic carbon (SOC) content (1. 67) was recorded in treatment T_7 (*Michelia champaca* + *Zea mays*), followed by T_9 (*Michelia champaca* + *Glycine max* (1.61), T_8 (*Michelia champaca* + *Curcuma longa*, (1.60), T_{13} (*Parkia roxburghii* + *Zea mays* (1.56), T_{15} (*Parkia roxburghii* + *Glycine max* (1.55), T_{14} (*Parkia roxburghii* + *Curcuma longa* (1.53), T_{10} (*Tectona grandis* + *Zea mays* (1.49), T_{12} (*Tectona grandis* + *Glycine max* (1.45), and lowest in T_{11} (*Tectona grandis* + *Curcuma longa*) (1.39). Among the tree species,T_4 (*Michelia champaca*) recorded maximum (1.38) SOC followed by T_6 (*Parkia rogburghii* (1.33) and lowest in T_5 (*Tectona grandis* (1.18). Among the crop species, T_1 (*Zea mays*) recorded highest (1.24) SOC compared to T_3 (*Glycine max*) (1.19) and T_2 (*Curcuma longa*) (0.96) respectively. During the study period, it was observed that the soil organic carbon content was higher in the tree-crop interaction in comparison to the control plots. Similar patterns were observed for all the treatments. This may be due to higher decomposition of leaf litter, decay of root biomass and decaying plant raw material (Vanlalhluna & Sahoo, 2008). It may also be due to species mixture in the intercrop plot significantly increased soil organic carbon (Schroth, 1999; Meinen et al., 2009). Also, species richness and density can result in higher SOC contents in agroforestry systems (Saha et al., 2009).

Table 2: Soil organic carbon (%) as influenced by different treatments during the study period.

Treatments	April (2018)	June (2018)	August (2018)	October (2018)	December (2018)	Mean
T_1	1.22 ± 0.04	1.20 ± 0.05	1.17 ± 0.07	1.27 ± 0.03	1.32 ± 0.09	1.24 ± 0.02
T_2	1.59 ± 0.06	0.88 ± 0.32	0.42 ± 0.04	0.79 ± 0.03	1.09 ± 0.09	0.96 ± 0.11
T_3	1.47 ± 0.04	1.25 ± 0.03	0.81 ± 0.06	1.19 ± 0.17	1.22 ± 0.12	1.19 ± 0.06
T_4	1.32 ± 0.01	1.25 ± 0.05	1.24 ± 0.03	1.47 ± 0.03	1.60 ± 0.03	1.38 ± 0.03
T_5	1.44 ± 0.06	1.18 ± 0.03	0.95 ± 0.01	1.12 ± 0.10	1.18 ± 0.10	1.18 ± 0.05
T_6	1.77 ± 0.06	1.43 ± 0.05	0.87 ± 0.03	1.13 ± 0.03	1.46 ± 0.02	1.33 ± 0.08
T_7	2.36 ± 0.05	1.78 ± 0.29	0.91 ± 0.15	1.36 ± 0.08	1.93 ± 0.03	1.67 ± 0.14
T_8	1.40 ± 0.03	1.20 ± 0.01	1.17 ± 0.03	1.95 ± 0.07	2.28 ± 0.03	1.60 ± 0.11
T_9	2.11 ± 0.01	1.77 ± 0.14	1.29 ± 0.07	1.37 ± 0.04	1.49 ± 0.01	1.61 ± 0.08
T_{10}	1.93 ± 0.06	1.58 ± 0.07	0.91 ± 0.03	0.99 ± 0.11	2.04 ± 0.04	1.49 ± 0.12
T_{11}	2.00 ± 0.03	1.33 ± 0.14	1.05 ± 0.05	1.17 ± 0.05	1.39 ± 0.07	1.39 ± 0.09
T_{12}	1.81 ± 0.05	1.42 ± 0.02	1.22 ± 0.05	1.30 ± 0.04	1.49 ± 0.16	1.45 ± 0.06
T_{13}	2.11 ± 0.03	1.92 ± 0.04	1.05 ± 0.03	1.23 ± 0.03	1.48 ± 0.27	1.56 ± 0.11
T_{14}	1.70 ± 0.12	1.52 ± 0.07	1.11 ± 0.01	1.41 ± 0.03	1.88 ± 0.06	1.53 ± 0.07
T_{15}	1.93 ± 0.04	1.54 ± 0.07	1.27 ± 0.05	1.37 ± 0.04	1.64 ± 0.02	1.55 ± 0.06

Values are mean ± S.E. n=3

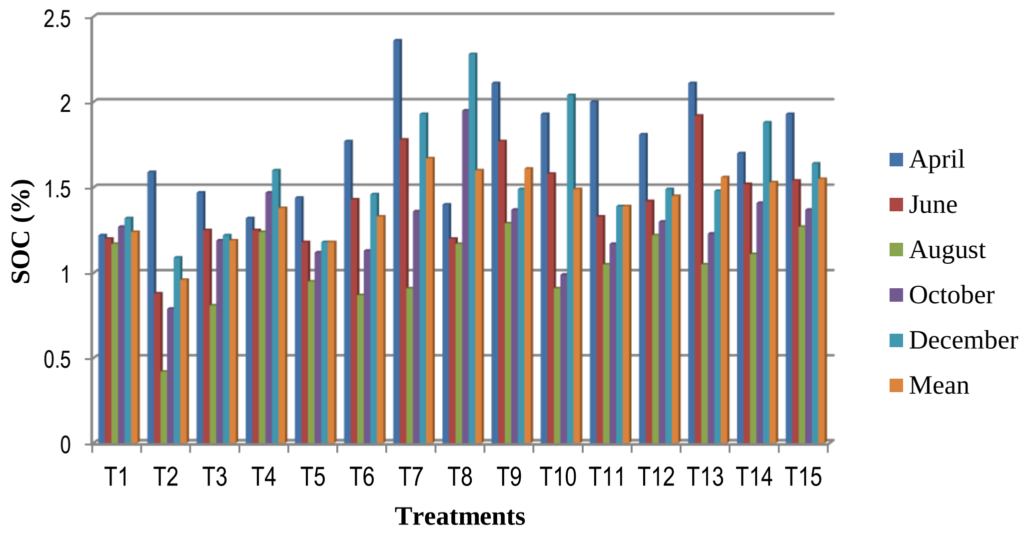

Figure 1: Bar diagram showing SOC (%) influenced by different treatments.

It was also observed that the content of soil organic carbon gradually decreased at the start of the experiment, but slightly increased towards the end of harvesting. This may be due to newly conversion of natural land into another land used management systems like agroforestry declined soil organic carbon stock (Deng et al., 2016). Also the newly planted seedlings did not developed well rooted systems during the first year period that leads to less root interaction between the crops and other weeds/plants (Kell, 2012). So, the observation revealed that the newly conversion of land to another land used management systems effect the soil organic carbon. The study also suggests that agroforestry is one of the best land used management systems in the hilly terrain of Mizoram. Besides, tree-based agroforestry system provided a good source and sink of carbon even though no significant variation was observed between the different treatments during the study period.

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