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Total Carbon, Total Nitrogen and C/N ratio of Secondary Forest to Oil Palm (*Elaeis guinensis*) Plantation in Mamit District, Mizoram, India

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A B S T R A C T

Total carbon (TC), Total nitrogen (TN) and soil C/N ratio are important components of agricultural productivity and one of the most important metrics to evaluate in order to understand the condition of the soil. Soil samples were taken at a depth of 0-5cm, 5-15 cm for three slope position, Upper (U), Middle (M) and Lower (L). Total C & N was calculated using standard protocol. Oil palm soil reported a C/N ratio of < 10, ranging between 4.44 – 5.92 while, forest soil revealed a ratio of 7.47- 14.5. This study found a fairly reduction in soil C and N in oil palm soil as compared to forest soil, indicating that effective nutrient management is required to maintain long-term sustainability along the slope gradient.

***Key words*:** Oil palm, Total nitrogen, Total carbon, C/N ratio

Oil palm has become one of the most sought-after perennial crops lately as it has become the main source of oils and fats for various manufacturing purposes such as, food, soaps, cosmetics, detergents and other products [13]. However, the conversion of forest to agricultural land use is one of the major contributing factors in environmental disturbances, and is much of a concern lately especially to environmentalists and scientists across the world. The changes in land use from natural forest to agriculture plantation leads to declining of soil nutrients and ultimately affect the soil quality status of the area [12], [17]. Global oil palm output is estimated to be 272,055,131 tonnes from 18,917,400 hectares, with Asia leading the way (84.1 percent), followed by Africa (9 percent) [8]. The negative effects of oil palm on the climate include deforestation and loss of habitat for critically endangered species [6], a decrease in soil productivity, an increase in soil erosion, and soil biodiversity loss [7], [21] and a significant increase in greenhouse gas emissions [3], [11].

Soil carbon and nitrogen can be affected by land use as the result of the different input quantity of organic matter [9], [22]. It was recorded by [16] that, carbon stores in topsoil were shown to be lower in agricultural systems compared to the nearby primary forest in Amazonia. In agriculture, soil total carbon (TC), soil organic matter (SOM) and soil total nitrogen (STN) are the major determinants for soil fertility and indicators of quality, and are closely related to soil productivity [2]. Mizoram's oil palm farming began in 2004-2005 with the State Department of Agriculture in aiming to reduce shifting farming. However, there hasn't been a lot of study done on its effects on soil quality in the state. Therefore, the purpose of this study is to evaluate its effect on soil carbon and nitrogen from secondary forest to oil palm plantation along the slope gradients.

MATERIALS AND METHODS

Mamit District is situated in Mizoram's western portion. It is separated from Bangladesh by the Sajek river, which defines its international boundary. The district is located on the north by Assam's Hailakandi district, on the west by Tripura state and Bangladesh's North Tripura district, on the south by Lunglei district, and on the east by Kolasib and Aizawl districts. The district has a total size of 3025.75 km^2. It is situated between the latitude of 23° 55' 37.31" N and longitude of 92° 29' 22.85" E.

15 years old Oil Palm Plantation located in Darlak village; Mamit district was selected. Secondary forest which is located near the oil palm plantation was selected as control site which have been left undisturbed for decades. Soil samples were taken with an auger from three locations in a 'triangle' shape at a depth of 0-5cm, 5-15cm for three different slope positions- upper, middle, and lower. Soil samples were air dried, ground and passed through using a 2 mm sieve. Total nitrogen was evaluated using the micro-Kjeldahl digestion and distillation method [4] and Total Organic Carbon was measured by dry combustion on a Carbon Analyzer - LECO CNS-2000 (furnace at 1350°C in pure oxygen).

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RESULTS AND DISCUSSION

Total carbon

Highest value for TC at 0-5cm depth was seen in the middle slope of forest soil (1.89%), and the lowest was observed in the middle slope of oil palm soil (0.77%). The highest and lowest value at 5-15cm depth was observed in the middle slope of forest soil (1.43%) and in the lower slope of oil palm (0.70%) respectively. It is clear the TC concentration was observed higher in the forest soil than oil palm soil on both soil depth. Lower concentration of carbon in agricultural land was also observed by various researchers [5], [10], [14]. Lower carbon in oil palm soil could be due to lesser decomposition rate of plants or animal debris and micro-organisms in the soil. Low carbon content can be restored by mulching the farm with the pruned palm front. The pruned palm front should be split into smaller pieces for mulching to aid decomposition [1]. The upper slope of oil palm at 5-15cm depth showed the highest variable (6.54%) and the least variable was observed in middle slope of forest (0.03%) at 0-5cm depth.

Table 1 TN and TC concentrations, C/N ratio at 0-5cm depth

SP & LU	TN (%)						TC (%)						
	Mean	SE	SD	MIN	MAX	CV	Mean	SE	SD	MIN	MAX	CV	C/N
UOP	0.15	0.01	0.01	0.14	0.17	9.09	0.89	0.02	0.03	0.86	0.91	2.93	5.59
MOP	0.16	0.02	0.04	0.13	0.20	22.21	0.77	0.01	0.01	0.75	0.78	1.83	4.73
LOP	0.14	0.01	0.02	0.13	0.15	11.17	0.82	0.00	0.01	0.81	0.83	0.97	4.86
UF	0.18	0.02	0.03	0.15	0.21	16.43	1.56	0.02	0.03	1.54	1.59	1.76	8.66
MF	0.16	0.01	0.02	0.14	0.18	13.48	1.89	0.00	0.00	1.89	1.89	0.03	14.45
LF	0.16	0.00	0.01	0.15	0.17	5.09	1.30	0.01	0.02	1.28	1.31	1.24	11.91

Table 2 TN and TC concentrations, C/N ratio at 5-15cm depth

SP & LU	TN (%)						TC (%)						
	Mean	SE	SD	MIN	MAX	CV	Mean	SE	SD	MIN	MAX	CV	C/N
UOP	0.12	0.01	0.02	0.11	0.14	13.32	0.72	0.03	0.05	0.67	0.77	6.54	5.92
MOP	0.14	0.01	0.01	0.13	0.15	10.00	0.70	0.01	0.02	0.69	0.72	2.20	4.44
LOP	0.12	0.01	0.02	0.11	0.14	13.32	0.70	0.01	0.01	0.69	0.71	1.42	5.18
UF	0.17	0.00	0.01	0.17	0.18	4.68	1.29	0.02	0.04	1.25	1.33	2.98	7.47
MF	0.15	0.00	0.01	0.14	0.15	5.41	1.43	0.00	0.01	1.42	1.44	0.56	11.77
LF	0.13	0.01	0.01	0.11	0.14	11.11	1.19	0.01	0.02	1.16	1.21	2.03	11.53

SP Slope Position; *LU* Land use; *U* Upper; *M* Middle; *L* Lower; *OP* Oil Palm; *TN* Total Nitrogen; *TC* Total Carbon; *F* Forest; *SE* Standard Error; *SD* Standard Deviation; *MIN* Minimum; *MAX* Maximum; *CV* Coefficient of Variation; *C/N* Carbon to Nitrogen ratio

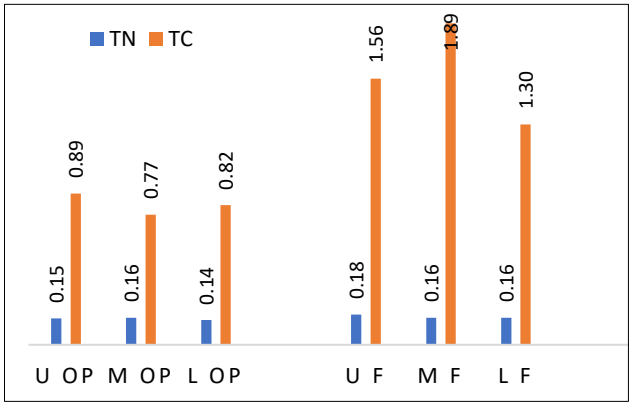

Fig 1 TN & TC concentration at 0-5cm depth

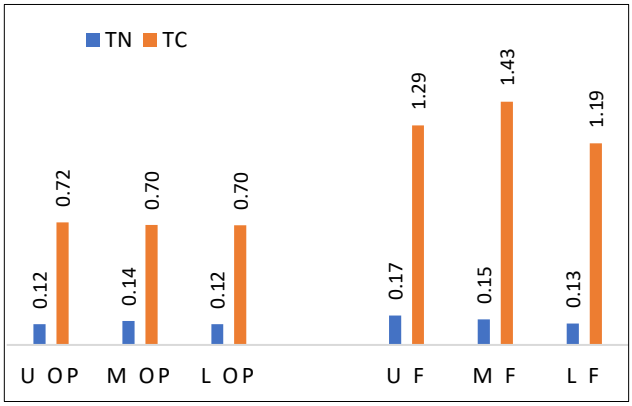

Fig 2 TN & TC concentration at 5-15cm depth

Total nitrogen

Soil total nitrogen is regarded as an essential metric for soil fertility evaluation, and indicates the soil nitrogen status [19]. Plants require a rather great amount of nitrogen for their growth. This explains why most of the plant development is inhibited by a shortage of nitrogen than any other nutrient. Highest and lowest concentration of TN at 0-5cm depth was observed in the upper layer of forest (0.18%) and lower slope of forest (0.14%) respectively. Highest and lowest value at 5-15cm depth was recorded in the upper slope of forest (0.17%) and in the upper and lower soil of oil palm (0.12%) respectively. Soil C and N are closely interlinked with each other and organic matter content is a good indicator of N condition of soils, a fairly higher input of N in secondary forest for both soil depth could be attributed to faster decomposition rate of litter fall. According to [18], the decline of organic matter in farmland soils is induced by a massive reduction in organic matter input and tillage practices, which frequently expose aggregates to physical disruption due to rapid wetting and rain drop impact, as well as shearing by agricultural implements. In tropical soils, most mineralized organic nitrogen is lost during cultivation, while phosphorus reverts to inaccessible forms coupled with calcium, iron, or aluminium [20]. The middle slope of oil palm at 0-5cm depth showed an extremely high variable rate at 22.21% and the least variable was seen in the upper slope of forest at 5-15cm depth (4.68%).

C/N ratio

The soil C/N ratio is a crucial predictor of soil quality and is used to determine how well soil can mineralize nitrogen.

High C/N ratios generally cause composting to take longer, whereas low C/N ratios increase the loss of nitrogen in the soil. The middle slope of forest at 0-5cm depth showed the highest C/N ratio of 14.45 and the middle slope of oil palm at 5-15cm depth showed the least C/N ratio of 4.44. Oil palm soil showed a C/N ratio of below 10 on both 0-5 and 5-15cm depth, ranging between 4.44 – 5.92. Forest soil showed a ratio between 7.47-14.5 on both soil depth.

CONCLUSION

Our results showed that soil C and N are very much interlinked with each other, and conversion of forest to other land use may lead to massive losses in soil carbon, soil nitrogen, and other nutrients as well. The C/N ratio of oil palm is comparatively low as compared to the forest soil. Therefore, more efforts should be given to increase the soil C/N ratio by increasing the application of organic manure to improve the level of soil organic carbon. It is also necessary to restore and preserve the nutritional balance along the varied slope gradients.

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