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Evaluation of Soil Fertility Status of Oil Palm (*Elaeis guinensis*) Plantation in Mamit District, Mizoram, India

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ABSTRACT

Oil palm is one of the tree crops that require a lot of soil nutrients to grow and develop properly. This study was carried out to evaluate the fertility status of selected oil palm plantation in Mamit District, Mizoram. Soil sampling was carried out in November 2018 at Darlak village, Mamit District using standard protocol. Soil samples were taken at a depth of 0-5 cm, 5-15 cm for three different slopes, Upper (U), Middle (M) and Lower (L). Soil pH was observed to be acidic, ranging from 5.14-5.22. Soil Moisture Content (SMC) ranged between 17.58-24.50%, available Nitrogen (N) showed a low concentration ranging from 52.50- 89.85 kg/ha. Phosphorus (P) and Potassium (K) also showed a low concentration ranging from 4.5-14.2 kg/ha and 57-93.83 kg/ha respectively. Soil Organic Carbon (SOC) ranged from 0.68-0.96%. Soil Microbial Biomass Carbon (MBC) ranged from 416.09-500.68 mg/kg. These results showed that proper nutrient management approaches such as the application of inorganic fertilizer should be adopted to ensure long-term sustainability.

Keywords Oil palm, Soil nutrients, Soil organic carbon, Microbial biomass carbon.

INTRODUCTION

Oil palm is the most prolific vegetable oil crop per unit area in most emerging nations, and it contributes to economic development mostly in developing nations (Koh *et al.* 2007, Zimmer 2010). Palm oil is generally regarded as the most copious natural source of Vitamin E and dietary magnesium. However, clearing forest for agricultural reasons resulted in huge habitat loss, accounting for roughly 70% of deforestation in Africa, 50% in Asia, and 35% in America (Lino *et al.* 2016). For maximum growth and development, oil palm requires a considerable number of nutrients from the soil. This promotes excessive nitrogen extraction from the soil, resulting in a decrease of soil fertility. Several studies have demonstrated that inorganic and organic fertilizer avail-ability and application have been unsatisfactory, particularly in vast plantation areas. As a result, there is widespread loss of soil fertility in oil palm areas

According to numerous studies, the major soil nutrients required for oil palm for optimal vegetative growth and improved fruit bunch yield are N, P, K, and Mg (Joseph *et al*. 2017). Because of their function

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in soil productivity, carbon (C), nitrogen (N), and nutrient trans-formation, organic carbon and microbial features are important ecological indicators of soil quality conditions in both natural and agricultural areas (Bolat *et al.* 2016, Olatunji *et al.* 2018).

Oil palm cultivation in Mizoram was initiated around 2004-2005 with the State Department of Agriculture. The Government of Mizoram enacted the New Land Use Policy (NLUP) with the aim of lowering shifting cultivation. Not many research works have been carried out on its impacts on soil quality status. Therefore, the objective of this research was to analyse the fertility condition of oil palm plantation in Mamit District, Mizoram. The study will aid us educate farmers in the researched areas on fertilizer choices, dosage, and soil management techniques.

MATERIALS AND METHODS

Study area

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 flanked on the north by Assam's Hailakandi district, on the west by Tripura state and Bangladesh's North Tripura dis-trict, 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.

Selection of sampling site and Soil Sampling

15 years old Oil Palm Plantation located at Darlak village, Mamit District was selected. Soil samples were taken with an auger from three locations in a 'triangle' shape at depths of 0-5cm, 5-15cm for three different slope positions of upper, middle, and lower in post-monsoon season (November 2018). A portion of the newly collected soil samples was immediately placed in a refrigerator (4°C) for microbiological and biochemical analysis. The remaining portion of each sample was air dried at room temperature and hand-sieved through a 2mm sieve for analysis of physico - chemical properties (0.2mm sieve for SOC detection).

Laboratory Analysis

Standard laboratory procedures were used to analyse the soil samples. In brief, the pH of soil was measured in a soil-water suspension (1:2.5 soil-water ratios) using a pH meter, and the Gravimetric Method (Hesse 1971) was used to determine Soil Moisture Content (SMC). The soil organic carbon (SOC) was determined using the wet-oxidation technique (Walkley *et al.* 1934). The available nitrogen was determined using the Alkaline Potassium Permanganate technique (Subbiah et al. 1956) The neutral 1N ammonium acetate extraction technique (Jackson 1973) was used to determine the exchangeable potassium. The available phosphorus was calculated using (Bray *et al.* 1945) method, and Chloroform fumigation method (Vance *et al.* 1987) was used to analyse Microbial Biomass Carbon (MBC).

RESULTS AND DISCUSSION

The results of soil properties are the mean of three replicates. SMC is the amount of water content in the soil. The value of SMC ranged between 17.58 - 24.50% along the slope positions (Table 1). Highest value was seen in the upper layer of 0-5cm depth (24.50%). Soil pH measures the activity of the hydrogen ion (H+) and hydroxyl ion (OH^-), which indicates whether the soil is acidic, neutral or alkaline in reaction (Shepherd et al. 1998) pH value ranged from 5.14 – 5.22. The pH reaction of the soils studied is attributed to the acidic nature of the parent rock combined with intensive base leaching.

Phosphorus (P) plays an important role in energy transformations and metabolic processes in plants (Rai *et al.* 2012). P value on the studied area was found to be quiet low, ranging from 4.5 – 14.2 kg/ha, and the highest value was observed in the upper layer (14.2 kg/ha) of 0-5cm depth (Table 1). The value of P was observed highest in the upper layer on both studied depth which may be due to rapid recycling of nutrients by decomposition and mineralization of litters on the top most layer. In contrast to our findings, it is recorded that P level under oil palm increases which they attributed to fertilizer use (Tanaka *et al.* 2009), whereas, there is a record of decrease in P concentration under oil palm plantation (Nelson *et al*. 2014) which is in agreement with our findings.

Table 1. Soil properties of the studied area at 0-5 cm and 5-15 cm depth.

SP	SG	0.5 cm depth Mean	SE	SD	CV (%)	Mean of CV (%)	5-15 cm depth Mean	SE	SD	CV (%)	Mean of CV (%)
	U	24.50	0.01	0.01	0.04		23.33	2.19	3.80	16.34	
SMC (%)	M	22.77	0.13	0.23	0.99	1.28	19.90	0.01	0.01	0.05	14.77
	L	20.63	0.34	0.58	2.82		17.58	2.83	4.91	27.91	
	U	5.22	0.05	0.09	1.72		5.21	0.03	0.05	0.96	
pH	M	5.19	0.03	0.05	0.96	1.06	5.23	0.02	0.03	0.57	0.80
	L	5.14	0.01	0.02	0.49		5.14	0.03	0.04	0.88	
	U	56.03	16.78	29.06	51.87		52.50	30.00	51.96	98.97	
N (kg/ha)	M	89.85	9.51	16.47	18.34	26.35	62.10	2.06	3.57	5.75	40.35
	L	84.00	4.29	7.43	8.84		67.88	6.39	11.07	16.32	
	U	14.2	4.45	7.71	54.50		7.0	1.83	3.18	45.49	
P (kg/ha)	M	7.9	0.12	0.21	2.66	21.57	4.9	0.04	0.07	1.43	38.33
	L	4.5	0.19	0.34	7.55		8.9	2.72	4.72	68.08	
	U	93.83	3.02	5.23	5.57		87.86	3.31	5.72	6.52	
K (kg/ha)	M	79.64	6.90	11.95	15.00	16.67	64.71	8.05	13.94	21.54	13.57
	L	72.68	12.36	21.40	29.45		57.00	4.17	7.21	12.66	
	U	0.93	0.02	0.02	0.03		0.78	0.02	0.02	0.03	
SOC (%)	M	0.81	0.03	0.03	0.06	0.05	0.96	0.05	0.05	0.09	0.07
	L	0.87	0.03	0.03	0.06		0.68	0.04	0.04	0.08	
	U	500.68	17.32	29.22	5.96		491.62	57.32	99.27	20.19	
MBC (mg/kg)	M	481.12	30.06	52.06	10.82	7.51	489.27	2.03	3.51	0.72	9.16
	L	415.09	13.86	24.00	5.77		464.85	17.61	30.49	6.56	

SP Slope Position SG Slope Gradient SE Standard Error SD Standard Deviation CV Coefficient of Variation SMC Soil Moisture Content N Nitrogen P Phosphorus K Potassium SOC Soil Organic Carbon MBC Microbial Biomass Carbon.

Along with N and P, Potassium (K) is one of the three major nutrients required for the growth of biomass in plants. The highest value was observed in the upper layer (93.83 kg/ha) of 0-5cm depth and lowest was observed in the lower layer (57 kg/ha) of 5-15cm depth (Table 1). The value of K in the studied area was rated as low according to Methods Manual of Soil Testing in India, 2011. Low K content might also be ascribed to the use of less Farm Yard Manure (FYM), the lack of chemical fertilizers, and inadequate nutrient recycling from litter leftovers (Chase *et al.* 2014). Low K content on the studied area is in agreement with (Hartemink 2005 and Nelson *et al.* 2014).

Soil organic carbon (SOC) is the carbon stored in soil organic matter. It is one of the most important factors for determining the soil quality status and the main source of energy for soil microorganisms. The concentration of SOC on the studied area was observed to be between 0.68 – 0.93% (Table 1).

In Ghana, after 25 years of oil palm plantations, there is 28% loss of SOC in the upper 0-30 cm layer in an area converted from primary forests to oil palm plantations (Chiti *et al.* 2014). Soil erosion has also been identified as a factor influencing SOC loss in oil palm plantations in Peninsular Malaysia (Gharibreza *et al.* 2013). Use of organic supplements such as

Table 2. Ranking soil properties by coefficient of variability (CV) of 0-5 and 5-15 cm depth.

Ranking	Range of CV	Properties	Range of CV	Properties
Least variable	<15%	pH, SMC, SOC, MBC	<15%	pH, SMC, SOC, MBC, K
Moderately variable	15-35%	N, P, K	15-35%	NA
Extremely Vvriable	>35%	NA	>35%	NP

Table 3. Soil fertility ratings based on soil test values.

Nutrient	Low	Medium	High
Available Nitrogen (N)	<280	280 to 560	>560
Available Phosphorus (P)	<10	10-25	>25
Available Potassium (K)	<108	108-280	>280

Source: Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India (2011); b- [18].

bovine dung, plant debris, composts, and sewage bio-solids, which are typically applied to agricultural soils, since they are rich in organic carbon, and so provide more carbon in the soil. Some of these recovered organics have a high plant nutritional content and may be utilized as organic fertilizers, thus, lowering the requirement for inorganic fertilizers.

The value of MBC in the studied area ranged from 416.09 – 500.68 mg/kg. It has been proposed that soil moisture is an important factor in regulating MBC and is a key element affecting the microbial biomass (Diaz *et al.* 1995) accounting for the slightly higher MBC values observed in 0-5cm depth (Table 1). Some researchers have also found a close connection between soil moisture and microbial biomass carbon (Devi *et al.* 2006, Singh *et al.* 2010).

Table 2 shows the grouping of soil properties using their CV values. SMC, pH, SOC and MBC were the least variable at 0-5 cm and 5-15 cm depth. N, P, K was moderately variable at 0-5 cm depth and N and P was extremely variable at 5-15 cm depth. Table 3 shows the rating chart for soil test data, rating the value of SOC in the studied area as medium to high and N, P, K as Low. Some studies have also indicated that oil palm plantation does have major influence on soil chemical properties (Kamaruzaman 2004, Kang 1977, Ogunkunle 1986).

CONCLUSION

The nutrient level of oil palm plantation in the studied area is rated as low, which shows that, in order to ensure long-term sustainability, there should be proper nutrient management practices on different slope gradient. Soil microbial biomass and organic carbon are important driving factors for organic matter decomposition and nutrients. Reduction of the examined soil characteristics will be a limiting issue for crop yield; hence solutions to restore soil nutrients and microbial properties must be devised for long-term crop production and should also be further confirmed with further research.

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