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Soil Organic Carbon and Soil Microbial Biomass Under the Shifting Cultivation Systems of Kangchup Hills Manipur, North-East India

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ABSTRACT

The effect of soil organic carbon on the soil microbial biomass C, N and P was studied in four different shifting cultivation sites in a recent slash and burnt site – I, 3-year old fallow site – II, 7- year old fallow site –III and a protected forest site –IV. Soil organic carbon ranged from 150.00(March) to 4050.00 µg g^{-1} (August) across the sites. The soil microbial biomass C, N, P varied from 116.54 (December) to 748.27 µg g^{-1} (August), 9.42(January) to 84.40 µg g^{-1} (August) and 6.30 (December) to 56.88 µg g^{-1} (August) respectively across the sites. Soil organic carbon was found to be maximum in the slash and burnt site–I followed by protected forest site-IV, 7 – year old fallow site- III and minimum in the 3-year old fallow site-II. The protected forest site-IV exhibited the maximum microbial biomass C,N and P and minimum in recent slash and burnt site –I. A significant positive correlation between the soil organic carbon and soil microbial biomass C, N and P shows that the soil organic carbon has profound effect on the soil microbial biomass.

Keywords: Soil texture, slash and burnt site, Castanopsis tribuloides, 7-year old fallow land.

INTRODUCTION

Soil microbial biomass is an important component of soil quality assessment because of its important role in nutrient dynamics, decomposition of natural and organic amendments and physical stabilization of aggregates (Frazluebbers etal. 1999). Soil microbial biomass comprises about 2-3 % of total organic carbon in the soil and has been recognized as an important source of nutrients to plants because of its fast turnover (Jenkinson and Ladd 1981).

Microbial biomass and microbial activity is significantly related to several of the soil physical and chemical properties (Kaiser et al. 1992). Thus, microbial biomass measurement is considered to be a tool to understand and predict long term changes in soil conditions (Srivastava and Singh 1991, Roy and Chakrabartty 2004).Soil microbial biomass is involved in the decomposition of organic materials and thus the cycling of nutrients in soils. It is also used as an early indicator of the changes in soil chemical and physical properties resulting from soil management and environmental stresses in agricultural ecosystems (Brookes 1995, Jordan et al. 1995, Trasar-Cepeda et al.1998, Moore et al. 2000).

Studies on soil microbial biomass, its relationship with soil physical and chemical properties, particularly with soil organic carbon in the shifting cultivation systems of Manipur, North-East India are lacking. Hence, the present study was carried out to understand the relationship of soil organic carbon with the microbial biomass carbon, nitrogen and phosphorus in four different shifting cultivation sites of Kangchup hills, Manipur in North-East India.

MATERIALS AND METHODS

The study site is located in the Kangchup Hills (24° 50' N to 24° 55' N latitude, 93°45' to 93° 50' E longitude) in Senapati District about 14 km from Imphal town at an altitude ranging from 902 to 944 m above sea level. The climate of the area is monsoonal with warm wet summer, a distinct rainy season and cool dry winter.

The study was conducted at four different sites i.e., Slash and burnt site (site- I), three year old fallow site (site- II), seven year old fallow site (site-III) and a protected forest site (site-IV) dominated by *Castanopsis tribuloides* (A .DC.)and *Lithocarpus dealbata* (Miq.) Rehder.

The soil texture was analyzed by International pipette method (Poonia et al. 1972). Soil moisture by gravimetric method (oven drying until contant weight); soil temperature by a soil thermometer and soil pH (1:5 soil: water ratio) by digital pH meter. Soil organic carbon was analyzed by modified Walkley Black's Method and total soil N was determined by Kjeltec™ 2100 and total soil phosphorus by FIASTAR 5000 (Foss Tecator AB, Sweden).

The soil samples were collected from the upper layer of 0-10 cm in depth from the five different plots of slash and burnt site-I, three year old fallow site-II, seven year old fallow site-III and a protected forest site-IV for the estimation of microbial biomass. The soil samples were sieved (<2 mm) to remove stones, coarse and roots and were kept at room temperature for a day.

Five replicates were collected every month from each site for the estimation of microbial biomass (C, N and P). Microbial biomass (C, N and P) were determined by fumigation extraction method (Anderson and Ingram, 1993). Microbial biomass C was determined by modified Walkley Black Method and calculated by using (Vance et al. 1987).

$$\text{Microbial C} = K_{EC} \times 2.64$$

Microbial biomass N was determined by Microkjeldahl Method (Bremner and Mulvaney, 1982) and calculated by Brookes et al. (1985)

$$\text{Microbial N} = K_{EN} \times 1.46$$

Microbial biomass P was determined by ammonium molybdate stannous chloride method (Sparling et al., 1985) and calculated by Brookes et al. (1982).

$$\text{Microbial P} = K_{EP} \times 2.5$$

K_{EC}, K_{EN} and K_{EP} are the difference between C, N and P extracted from fumigated and unfumigated soils.

Data were analyzed statistically using Student's t-test, linear regression, Pearson's correlation coefficient, and ANOVA.

RESULTS

Soil Characteristics.

The soil was sandy loamy with 69.00 to 72.50% sand, 16.50 – 17.50 % silt and 11.00 to 13.50 % clay across the four study sites. The soil moisture ranged from 15.6 7 % to 20.00 %, soil temperature from 20.0 to 22.9 °C, soil organic carbon from 540 to 2380 $\mu g\ g^{-1}$, total soil nitrogen 0.13 to 0.28% and total soil phosphorus 368.0 to 411.3 $\mu g\ g^{-1}$ soil across the four study sites (Table 1).

Table 1. Physico-chemical properties of soil in the recent slash and burn site (site-I), three-year old fallow (site-II), seven-year old fallow (site-III) and protected forest (site-IV).

Parameter	Site - I	Site - II	Site - III	Site - IV
Soil texture (%)				
i Sand	72.5±0.36	71.5±0.57	70.6±0.34	69.0±0.32
ii Silt	16.5±0.18	16.5±0.18	17.1±0.34	17.5±0.25
iii Clay	11.0±0.45	11.7±0.34	12.3±0.25	13.5±0.20
Soil pH	5.72	5.22	5.21	4.96
Soil Moisture (%)	15.67	16.67	18.67	20.00
Soil Temperature (^{0}C)	22.87	20.33	20.22	20.00
Soil Organic C ($\mu g g^{-1}$)	2380.0	540.0	650.0	1200.0
Total soil N (%)	0.28	0.13	0.14	0.19
Total soil P ($\mu g\ g^{-1}$ soil)	411.33	368.00	376.69	404.33

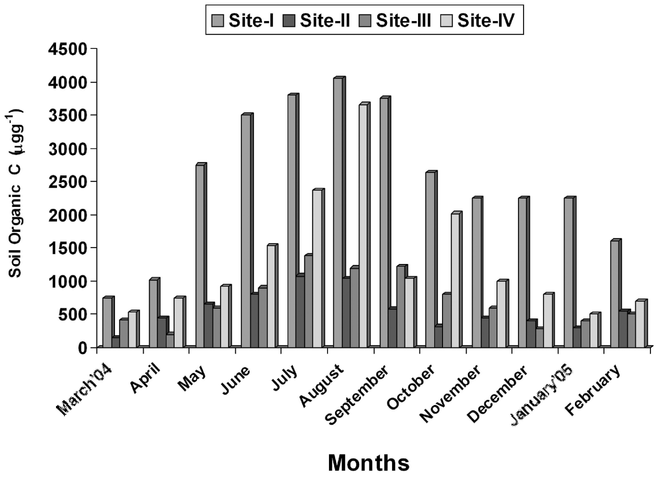

Figure 1. Monthly variation in Soil Organic Carbon in four study sites.

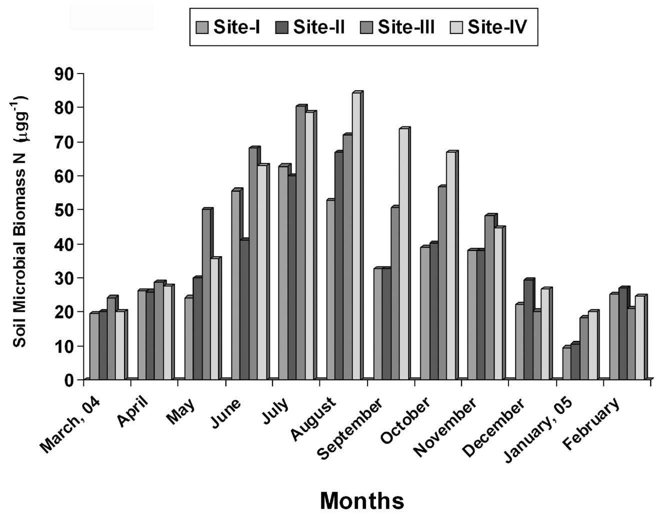

Figure 3. Monthly variation in soil microbial biomass nitrogen in four study sites.

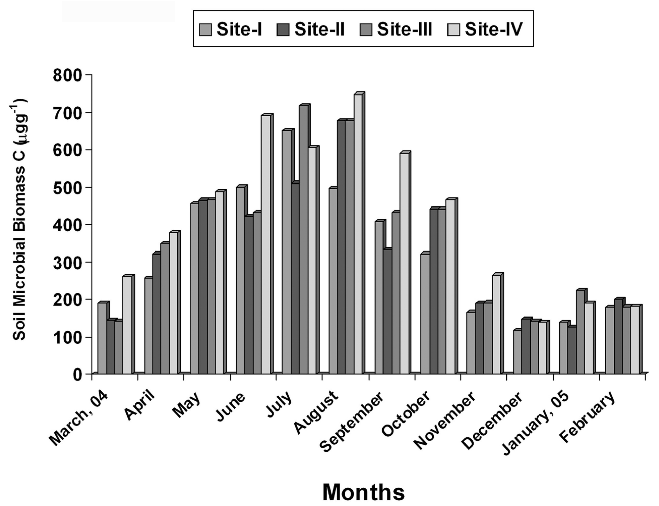

Figure 2. Monthly variation in Soil Microbial Biomass Carbon in four study sites.

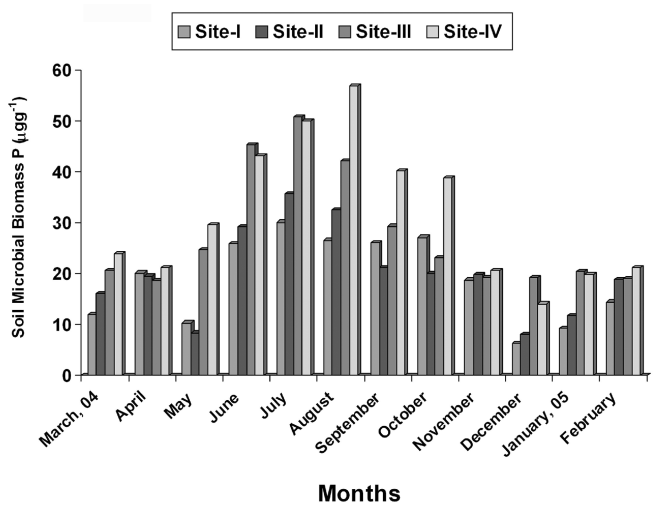

Figure 4. Monthly variation in Soil Microbial Biomass Phosphorus in four study sites.

Seasonal Changes in the Soil Organic Carbon

Soil organic carbon ranged from 750 (March) to 4050 µg g^{-1} (August) at site –I, 150 (March) to 1080 µg g^{-1} (July) at site-II, 200 (April) to 1380 µg g^{-1} (July) at site-III and 500 (January) to 3660 µg g^{-1} (August) at site-IV in different months throughout the year (Figure 1). Site-II had maximum soil organic carbon and site I the minimum.

Soil Microbial Biomass C, N and P

Soil microbial biomass C, N and P ranged from 116.54 (December) to 748.27 µg g^{-1} (August), 9.42 (January) to 80.47 µg g^{-1} (July), and 6.30 (December) to 56.88 µg g^{-1} (August) respectively, in different months during the year across the four sites. Soil microbial biomass C, N and P were in the order of site IV> site III> site II> site I.

Seasonally soil microbial biomass C, N and P was recorded to be maximum during the rainy season and minimum during the winter season in all the four study sites (Table 2).Comparatively, the mean soil biomass C, N and P were maximum at site I (Table 2).

Table 2. Soil microbial biomass C, N and P (μg g^{-1} soil) at the four study sites

Site	Season	Carbon	Nitrogen	Phosphorus
I	Summer	300.47	23.25	14.13
	Rainy	474.92	48.58	27.15
	Winter	149.92	23.75	12.76
	Annual	308.44	31.86	18.01
II	Summer	310.29	26.15	14.63
	Rainy	476.41	48.14	27.74
	Winter	165.01	26.30	14.59
	Annual	317.24	35.53	18.99
III	Summer	319.15	26.32	21.29
	Rainy	539.64	65.61	38.13
	Winter	184.50	26.94	19.45
	Annual	347.76	39.62	26.29
IV	Summer	375.45	27.82	24.99
	Rainy	620.46	73.38	45.86
	Winter	193.20	29.05	18.90
	Annual	363.03	40.08	29.90

Soil Organic C and its Relationship with Microbial Biomass C, N and P

Soil organic carbon showed a significant positive correlation with soil microbial biomass C (r = 0.72, P<0.01 in site-I; r = 0.87, P<0.01 in site-II; r = 0.88, P<0.01 in site-III; r = 0.75, P<0.01 in site-IV), soil microbial biomass N (r = 0.72 P<0.01 in site-I; r = 0.85, P<0.01 in site-II; r = 0.88, P<0.01 in site-III; r = 0.82, P<0.01 in site-IV) and soil microbial biomass P (r = 0.63 P<0.01 in site-I; r = 0.79, P<0.01 in site-II; r = 0.84, P<0.01 in site-III; r = 0.88, P<0.01 in site-IV (Table 3). The soil organic carbon showed a linear correlation with soil microbial biomass C, N and P (Table 4).

Table 3. Relationship of soil microbial biomass C, N and P with soil organic carbon (SOC) content [Pearson's correlation coefficients (r)].

Site	Parameters	SOC
I	Soil Microbial Biomass C	0.72*
	Soil Microbial Biomass N	0.72*
	Soil Microbial Biomass P	0.63*
II	Soil Microbial Biomass C	0.87*
	Soil Microbial Biomass N	0.85*
	Soil Microbial Biomass P	0.79*
III	Soil Microbial Biomass C	0.88*
	Soil Microbial Biomass N	0.88*
	Soil Microbial Biomass P	0.84*
IV	Soil Microbial Biomass C	0.75*
	Soil Microbial Biomass N	0.82*
	Soil Microbial Biomass P	0.88*

* = P<0.01

DISCUSSION

Results of the soil physico-chemical analysis are shown in table 1. The soil is sandy loam and acidic in nature (pH 4.6 to 5.72) in all the four study sites. Though the soil in all the four study sites were found to be acidic, site –I (recent slash and burnt site) had a high pH value compared to the other three sites probably because of addition of burnt organic matter or ash in the soil (Tanaka et al. 1997, Castelli and Lazzari 2002).

Differences in soil chemical properties such as soil organic carbon, soil total nitrogen, and soil total phosphorus found between the four different study sites may have led to differences in the soil microbial biomass C, N and P in these soils. Moore et al. (2000) have reported significant responses in microbial biomass due to crop rotation in the cropping systems of Iowa. Compared to the other three sites, soils from the slash and burnt site-I had far more organic carbon and nitrogen which may be due to the addition of burnt or partially burnt organic matter during the slash and burn treatment. Surface organic carbon and total nitrogen increases after low intensity fires have been reported by Castelli and Lazzari (2002) in semi-arid Argentina.

Table 4. Equations for linear correlation of soil organic carbon with microbial biomass carbon, nitrogen and phosphorus at the four study sites.

Site	Equation (Y= a + bX)	r	p<
	Soil biomass C = 39.75 + 0.12 soil organic C	0.72	0.01
Slash and burnt site-I	Soil biomass N = 5.40 +0.010 soil organic C	0.72	0.01
	Soil biomass P = 9.06 +0.004 soil organic C	0.63	0.05
	Soil biomass C = 45.64 + 0.64 soil organic C	0.87	0.01
3 year fallow site-II	Soil biomass N = 0.22 + 0.5 soil organic C	0.85	0.01
	Soil biomass P = 2.92 + 0.029 soil organic C	0.79	0.01
	Soil biomass C = 11.44 +0.48 soil organic C	0.88	0.01
7 year fallow site-III	Soil biomass N = 5.58 +0.053 soil organic C	0.88	0.01
	Soil biomass P = 7.74 +0.027 soil organic C	0.84	0.01
	Soil biomass C = 174.42 + 0.18 soil organic C	0.75	0.01
Protected forest site-IV	Soil biomass N = 23.99 + 0.02 soil organic C	0.82	0.01
	Soil biomass P = 14.62 +0.013 soil organic C	0.88	0.01

The soil microbial biomass C, N and P showed a significant correlation with soil organic carbon content as evident from the Pearson's correlation coefficient analysis (Table 4) and the linear regression analysis (Table 5). This is an indication that soil organic carbon content has significant positive impact on soil microbial biomass. The ratio of soil organic carbon to soil microbial biomass carbon reflects the availability of substrate to the soil microflora (Dinesh et al. 2003). It shows that increase in soil organic carbon content provides more substrate to the soil microflora. Similar positive correlation between soil organic carbon and soil microbial biomass carbon, nitrogen and phosphorus have been reported by other workers (Kaiser et al.1992, Roy and Chakrabartty 2004).

On seasonal basis, maximum soil microbial biomass C , N and P were recorded during rainy season and lowest in winter season. Similar trend has also been reported by Ravina et al. (1995) and Devi and Yadava (2006). High value in rainy season may be resulted owing to increase soil moisture and congenial temperature for the microbial activities. However minimum values of microbial biomass C, N and P during the winter season which is cold and dry season may be due to lack of rainfall and resultant low soil moisture.

The soil microbial biomass carbon, nitrogen and phosphorus were found to be maximum in site IV and minimum in site I. The maximum values of microbial biomass carbon, nitrogen and phosphorus in site IV may be due to high density of forest vegetation. A close relationship between diverse and abundant vegetation and increase in microbial biomass have been reported by several workers. (Bardgett et al.1999, Spechn et al 2000). The low value in site I may be because of the burn treatment and the lack of vegetation cover afterwards which adversely affect soil microflora and consequently, soil microbial biomass. Degens et al. (2002) reported a decrease, by 20 to 80%, in microbial biomass carbon and nitrogen after a burn treatment. In the present study, there is 34.61% decline in the soil microbial biomass C on slash and burn treatment.

CONCLUSION

Slash and burnt treatment increases the soil organic C but decreases the microbial biomass. Significant positive correlation between soil organic C and soil microbial biomass C, N and P indicates that the soil organic C has a strong influence on the microbial biomass dynamics in the shifting cultivation systems except at the slash and burn treatment site where burning might have lowered the activities of microbes.

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