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Effect of Shifting Cultivation on Soil Microbial Biomass C, N and P under the Shifting Cultivations Systems of Kangchup Hills, Manipur, North- East India

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ABSTRACT: The seasonal changes in the soil microbial biomass C, N and P have been carried out in four different shifting cultivation sites i.e., recently slashed and burnt site, 3-year old fallow site, 7-year old fallow site and a protected forest site. The soil microbial biomass C, N and P was found to be maximum in protected forest site followed by 7-year old fallow site, 3-year old fallow site and minimum in recently slash and burnt site. Seasonally microbial biomass C, N and P were highest during rainy season and lowest during winter in all the four study sites. A significant positive correlation was observed between the microbial biomass C, N and P with abiotic factors, such as, soil moisture, soil temperature and soil organic carbon in all the four study sites. Thereby it shows that soil temperature, soil moisture and organic carbon influences the microbial biomass C, N and P.

Key words: Carbon, Nitrogen, Phosphate, Shifting cultivation, Manipur

Introduction

Shifting cultivation or slash and burn agriculture is an age old farming system practiced in many parts of the world. Slashing and burning are usually prerequisites for shifting cultivation but it also enhances faunal and microbial deterioration, soil erosion and land degradation (Nair 1993; Marafa and Chau 1999). The system appears to be relatively sustainable if the fallow period is sufficiently long as it allows recovery of soil fertility. However, increased land use pressure has resulted in shortened fallow periods. Reduction in fallow period is followed by a reduction in biomass, nutrient depletion and low productivity (Borggaard et al. 2003). There are indications that as degradation take place, soil properties change, particularly soil microbial activities, and that high levels of microbial activity are fundamental in maintaining soil quality (Garcia et al. 2002). Soil microbial biomass is the primary catalyst of biogeochemical processes and also acts as an energy and nutrient reservoir (Bailey et al. 2002; Hargreaves et al. 2003; Hoffman et al. 2003; Graystone et al. 2004; McCully et al. 2004 and Moussa et al. 2007) Hence, in relatively low fertility soils like those of shifting cultivation systems, the study of soil microbial biomass and the proportion of nutrients (N, C and P) immobilized in the biomass is of prime importance. The present study was carried out to explore the seasonal changes in soil microbial biomass C, N and P and the relationship with abiotic factors under shifting cultivation systems of Kangchup Hills, Manipur, North-East India. The results of the study are reported in this communication.

Materials and Methods

The study site is located in the Kangchup Hills between 24° 50′ N - 24° 55′ N latitude and 93°45′ - 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. There are three distinct seasons comprising of mild summer (March-May), rainy season (June-October) and winter (November-February). However, March is the transition month between winter and summer whereas November is the transition month between rainy and winter seasons. The mean monthly maximum temperature ranges from 22.30 to 31.00°C and the mean monthly minimum temperature ranges from 5.80 to 22.20°C. Average annual rainfall of the area is 1253.00 mm with 80% of the rains occurring during the rainy season. 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* and *Lithocarpus dealbata*. The slash and burning operation was done by the local people three months before the onset of the experimental work to prepare the land for shifting cultivation.The soil texture was analyzed by International pipette method (Poonia et al. 1972). Soil moisture by Gravimetric method; 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).
Microbial C = KEC × 2.64
Microbial biomass N was determined by Microkjeldahl Method (Bremner and Mulvaney, 1982) and calculated by Brookes et al.1985.
Microbial N = KEN × 1.46
and microbial biomass P was determined by ammonium molybdate stannous chloride method (Sparling et al. 1985) and calculated by Brookes et al.1982.
Microbial P = KEP × 2.5
KEC, KEN and KEP are the difference between C, N and P extracted from fumigated and unfumigated soils.
Student's t-test, linear regression, Pearson's correlation coefficient, and ANOVA are used to statistically analyze the data.

Results

Physico-chemical properties of soil

The soils in all the four study sites are sandy loam in texture having a blackish grey colour in sites I, II and III and reddish colour in site IV. Soil texture composed of sand (69.00-72.50%), silt (16.50–17.50%) and clay (11.00-13.50%) across the sites. The soil is acidic in nature in all the four study sites with a mean pH range of 4.96-5.72. The mean soil temperature range was 20.00-22.870C; soil moisture 15.67-20.00%; soil organic carbon 0.54-2.38%; total soil N 0.13-0.28% and total soil phosphorus 368.00 µgg-1 - 411.33 µgg-1 soil across the four study sites. Table 1 summarizes the soil physico-chemical properties in the four study sites.

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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)

Sl.No.	Parameter	Site - I	Site - II	Site - III	Site - IV
1.	Soil texture				
	i Sand	72.50±0.36	71.50±0.57	70.60±0.34	69.00±0.32
	ii Silt	16.50±0.18	16.50±0.18	17.10±0.34	17.50±0.25
	iii Clay	11.00±0.45	11.70±0.34	12.30±0.25	13.50±0.20
2.	Soil pH	5.72	5.22	5.21	4.96
3.	Soil Moisture (%)	15.67	16.67	18.67	20.00
4.	Soil Temperature (0C)	22.87	20.33	20.22	20.00
5.	Soil Organic C (%)	2.38	0.54	0.65	1.20
6.	Total soil N (%)	0.28	0.13	0.14	0.19
7.	Total soil P (μgg-1 soil)	411.33	368.00	376.69	404.33

Seasonal variations in Microbial biomass C, N and P

The soil microbial biomass C ranged from 116.54(December)-650.25(July) μgg-1 soil in site -I; 124.60(January)-676.43(August) μgg-1 soil in site-II; 140.46(March)-716.80(July) μgg-1 soil in site-III and 138.33(December)-748.27(August) μgg-1 soil in site-IV (Fig. 1).

Fig.1. Monthly Variation in Soil Microbial Biomass Carbon in different sites

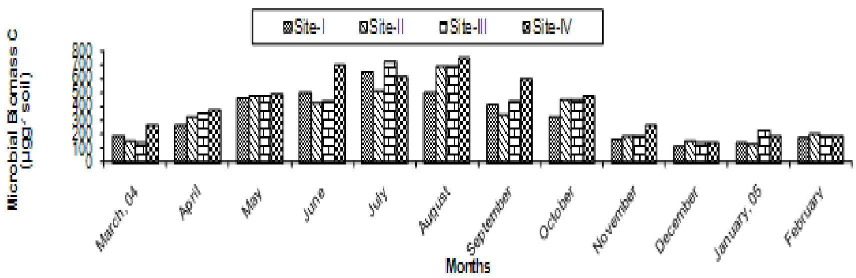
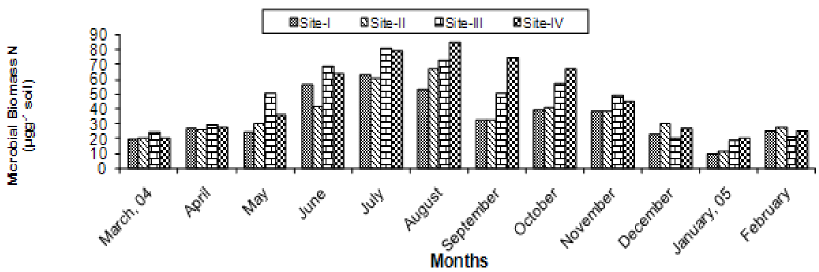


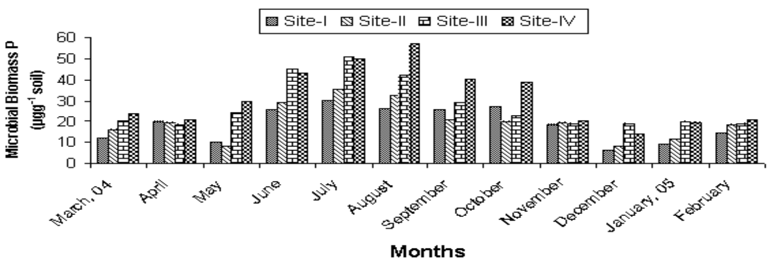
Fig.2. Monthly Variation in Soil Microbial Biomass Nitrogen in different sites



The soil microbial biomass N ranged was 9.42(January)-62.84(July) μgg^{-1} soil in site-I; 10.65(January)-66.88(August) μgg^{-1} soil in site-II; 18.22(January)-80.47(July) μgg^{-1}soil in site-III and 20.14(January)-84.40(August) μgg^{-1} soil in site-IV (Fig. 2).

Microbial biomass P ranged from 6.30December)-30.10(July) μgg^{-1} soil in site-I; 8.00(December)-35.75(July) μgg^{-1} soil in site-II; 18.68 (April) -50.73 (July) μgg^{-1} soil in site-III and 14.00 (December) -56.88 (August) μgg^{-1} soil in site-IV (Fig. 3).

Fig.3. Monthly Variation in Soil Microbial Biomass Phosphorus in different sites



Seasonally, 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).

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

Site	Season	Soil Microbial Biomass C (μgg^{-1} soil)	Soil Microbial Biomass N (μgg^{-1} soil)	Soil Microbial Biomass P (μgg^{-1} soil)
	Summer	300.47	23.25	14.13
	Rainy	474.92	48.58	27.15
I	Winter	149.92	23.75	12.76
	Annual	308.44	31.86	18.01
	Summer	310.29	26.15	14.63
	Rainy	476.41	48.14	27.74
II	Winter	165.01	26.30	14.59
	Annual	317.24	35.53	18.99
	Summer	319.15	26.32	21.29
	Rainy	539.64	65.61	38.13
III	Winter	184.50	26.94	19.45
	Annual	347.76	39.62	26.29
	Summer	375.45	27.82	24.99
	Rainy	620.46	73.38	45.86
IV	Winter	193.20	29.05	18.90
	Annual	363.03	40.08	29.90

SOC = Soil organic carbon, * = P<0.01

The maximum microbial biomass C, N and P was recorded in the protected forest site (site-IV) followed by the seven year old fallow (site-III), three year old fallow (site-II) and minimum in the recent slash and burnt site (site-I).
The analysis of variance (ANOVA) indicated a significant difference in soil microbial biomass C, N and P between the different sampling months of summer (P<0.01), rainy (P<0.01), winter (P<0.01) and annually (P<0.01).

Influence of abiotic factors on soil microbial biomass

A significant positive correlation was obtained between microbial biomass C, N and P with soil moisture (P<0.01, soil temperature P<0.01 and soil organic C P<0.01. However, microbial biomass C, N and P was not statistically significantly correlated with soil pH in all the four study sites (Table 3).

Table 3. Relationship of Soil microbial biomass C, N and P with abiotic variables [Pearson's correlation coefficients (r)]

Site	Parameters	Soil Moisture	Soil Temperature	SOC
	Soil Microbial Biomass C	0.86*	0.80*	0.72*
I	Soil Microbial Biomass N	0.82*	0.63*	0.73*
	Soil Microbial Biomass P	0.86*	0.76*	0.63*
	Soil Microbial Biomass C	0.92*	0.77*	0.80*
II	Soil Microbial Biomass N	0.80*	0.68*	0.81*
	Soil Microbial Biomass P	0.70*	0.77*	0.76*
	Soil Microbial Biomass C	0.83*	0.83*	0.82*
III	Soil Microbial Biomass N	0.95*	0.80*	0.87*
	Soil Microbial Biomass P	0.76*	0.74*	0.84*
	Soil Microbial Biomass C	0.87*	0.77*	0.75*
IV	Soil Microbial Biomass N	0.95*	0.79*	0.82*
	Soil Microbial Biomass P	0.90*	0.79*	0.88*

Discussion

Changes in soil properties

The soils of all the four study sites were found to be acidic in nature with a very narrow pH range (4.6-5.72). Site – I exhibited highest pH value than that of the other three sites may be because of addition of burnt organic matter or ash in the soil and cataions freed after burning of standing vegetation. Several workers has also reported enhancement in pH value on burning (Ulery and Graham, 1993, Tanaka et al. 1997, Casteli and Lazzari, 2002).
Soil texture was more or less similar in all the four sites. However, marked differences were observed in the moisture content, soil organic C, total soil N and total soil P content of the soils. The maximum moisture content was recorded in site-IV (Protected forest) which may be due to the dense vegetation whereas, the minimum soil moisture content was recorded in site-I (slash and burnt site) which was bare and exposed to direct sunlight The maximum organic carbon, nitrogen and phosphorus content was found in the soil in site – I as compared to the other three sites which may be attributed to burnt or partially burnt organic matter added to the soil during the slash and burn treatment (Castelli and Lazzari,2002) Has also reported enhancement of soil organic matter, N and C in the soil in central semiarid Argentina due to fire.

Relationship between Abiotic factors and soil microbial biomass

Soil moisture, organic C and temperature have marked influence on the soil microbial biomass C, N and P. It is evident from significant positive correlation between soil microbial biomass C, N and P with abiotic factors such as soil moisture, soil organic C and soil temperature. Significant positive correlations of microbial biomass with soil moisture and organic C have been reported by several workers in different ecosystems (Stephan J. Wirth 2001; Taylor et al. 1999; Tanaka et al. 2002; Pascual et al. 2000; Yadava and Devi 2004).

Seasonal changes in Microbial biomass C, N and P

Seasonally, microbial biomass C, N and P peaked during the rainy season and was lowest during the winter season. The high microbial biomass C, N and P during the rainy season may be the result of increased soil moisture and relative humidity which is ideal for microbial activity. Several workers have reported a close relationship between soil moisture and microbial biomass (Ravina et al. 1995; Devi and Yadava 2006). Increase in fallow soil microbial biomass accumulation in the tropics with increasing rainfall has also been reported (Szott et al. 1999; Alfred, 2004). 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. It is evident from the significant positive correlation observed between soil moisture and microbial biomass C, N and P in the present study.
A comparison of the four study sites show that site-IV (protected forest) site exhibited the maximum microbial biomass C, N and P whereas the minimum values were recorded in the site-I (slash and burnt site). The comparatively high microbial biomass C, N and P values in site-IV may be because of the abundance of diverse vegetation and vegetation cover which contributes high amount of substrate for the activities of micro organisms Several workers have reported a close relationship between high plant richness and increases of microbial biomass (Bardget et al. 1999; Broughton et al. 2000; Spechn et al. 2000). The minimum microbial biomass C, N and P recorded in site-I may be attributed to the burn treatment, and lack of vegetation cover. The average value of soil microbial biomass C, N and P increased in the order of site-I, site-II, site-III and site-IV respectively. Thereby it shows that soil microbial recovered with increase of fallow period exhibiting high value in site-

III as compared to site-I and site-II. A greater depletion of organic C in the soil possibly due to reduced quality and quantity of organic matter in the soil result in loss of microbial activity (Degens et al, 2000). Tanaka et al. in 2002, reported a decrease in microbial C and microbial N after burning by 20 to 80%. Moreover, declined and degraded plant cover also mean lower organic matter added to the soil which inhibits the activity of soil microorganisms (Garcia et al. 2002; Moussa et al. 2007).

Conclusion

The present study seems to indicate that slash and burn treatment has a detrimental effect on the soil microbial biomass C, N and P probably because of the lack of vegetation diversity and cover. Soil microbial biomass C, N and P also showed a seasonal variation with high microbial biomass content in the wet season and low during the winter and dry season. The soil microbial biomass C, N and P also enhanced with increases of fallow period Soil microbial biomass also seems to be highly influenced by abiotic variables such as soil temperature, soil moisture and organic C content of the soil.

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