Impact of Slash and Burning on Microbial Biomass in Semi-Evergreen Tropical Deciduous Forest of Manipur, North-East India

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ABSTRACT : The impact of slash and burning on microbial biomass C, N and P in soils of semi-evergreen tropical deciduous forest were studied from February 1999 to January 2000. The experimental sites were located near Moreh town in the Chandel district of Manipur state (India) along the Indo-Myanmar border between 23°49′ N ~ 24°28′ N latitude and 93°45′ E ~ 94°16′ E longitude. Microbial biomass C ranged from 319.50 $\mu g\ g^{-1}$ to 905.50 $\mu g\ g^{-1}$ in the slash and burnt site and from 209.50 $\mu g\ g^{-1}$ to 708.80 $\mu g\ g^{-1}$ soil in the forest site. Microbial N ranged from 19.30 $\mu g\ g^{-1}$ to 99.45 $\mu g\ g^{-1}$ in the slash and burnt site and from 16.08 $\mu g\ g^{-1}$ to 88.90 $\mu g\ g^{-1}$ in the forest site. Microbial P varied from 10.90 $\mu g\ g^{-1}$ to 32.21 $\mu g\ g^{-1}$ in the slash and burnt site and from 2.50 $\mu g\ g^{-1}$ to 17.60 $\mu g\ g^{-1}$ in the forest site in different months throughout the year. Microbial biomass C, N and P were recorded to be higher in the slash and burnt site compared to the forest site .The conversion of forest into slash and burnt site for agriculture - the traditional shifting cultivation practiced by tribal people in the north- eastern India leads to addition of large amount of organic matter in the soil thereby exhibiting higher values of microbial biomass C, N and P in the recent slash and burnt site than that of the forest site. Relationship between the soil moisture, soil organic C and microbial biomass C, N and P were found to be correlated significantly in both the sites.

Key words : *Dipterocarpus tuberculatus*, Microbial biomass, Moist tropical deciduous forest, Organic carbon, Slash and burning

INTRODUCTION

The tropical semi-evergreen deciduous forests in the north-eastern India along the Indo-Myanmar border are under heavy biotic pressure owing to felling of trees for commercial purpose and also for shifting (jhooming) cultivation-the traditional form of cultivation performed by the local tribal people. The trees are cut down in the forest and burnt the remnants and used the land area for cultivation and plantation of paddy and banana. Soil microbial biomass is an important component in soil quality assessment because of its important roles in nutrient dynamics, decomposition of natural and organic amendments and physical stabilization of aggregates (Franzluebbers *et al.* 1999). Assessment and rehabilitation of degraded land can only be done effectively if the key processes and soil properties that rapidly respond to changes are qualified and quantified. The microbial biomass is a part of the active soil organic matter, it controls major key functions in soil as the decomposition and accumulation of soil organic matter or mineral nutrient transformations (Barbara Wick *et al.* 1998). Soil microbial biomass and its potential activity are important components for understanding early changes in biological soil quality following a change in land management (Powlson *et al.* 1987). The soil microbial biomass constitutes a transformation matrix for all the natural organic materials in the soil and acts as a labile reservoir of plant available nutrients (Jenkinson and Ladd 1981). Soil microbial biomass responds much more rapidly than the total organic matter to any change in organic inputs and its measurement is thus a valuable tool for understanding and predicting the long term effects of changes in soil conditions (Srivastava and Singh 1991). Few studies are available on the effect of slash and burning on the dynamics of soil microbial biomass in the tropical forest (Ayanaba *et al.* 1976, Srivastava and Singh 1991, Saranath and Singh 1995). However no information is available for semi evergreen tropical deciduous forest from north-east India. Therefore, the present study is undertaken to determine the effects of slash and burning on monthly and seasonal changes in the microbial biomass C, N and P and its relation with abiotic factors and physico-chemical properties of the soil in the moist tropical deciduous forest.

MATERIALS AND METHODS

Study sites

The experimental site is located near Moreh town in the Chandel district of Manipur state along the Indo-Myanmar border of north-

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east India, between 23° 49′ N~24° 28′ N latitude and 93° 45′ E~94° 16′ E longitude at 300~360 m above mean sea level. The forest is of moist tropical deciduous forest type and dominated by *Dipterocarpus tuberculatus*. Two experimental sites were earmarked for the present study. Site I is a forest and site II is a deforested site where slash and burning operation was done by the local people to prepare the burnt patch of land for shifting (jhooming) cultivation. Site II was burned down one month before the onset of the experimental work in the month of January and thereafter the local people planted paddy and banana in the slash and burnt site. Soils of the study area were sandy in texture and reddish in colour in site I and blackish gray in site II. The climate is tropical monsoonal with the year distinctly divisible into three seasons, summer (March~May), rainy (June~October) and winter (November~February). Mean monthly maximum temperature ranged from 17.00℃ to 34.50℃ and minimum from 2.00℃ to 22.00℃. The annual rainfall was found to be 993.60 mm of which more than 80% occurs in the rainy season.

Analysis of abiotic factors and soil properties

At each site five soil sampling plots were selected and soil samples were collected from a depth of 0~10 cm at an interval of one month from February 1999 ~ January 2000. Organic C, soil pH, total N and soil available P were analysed after air-drying the soil from both the sites. Soil texture was analysed by using International pipette method. Soil pH was measured with a glass electrode (1:5; soil: water ratio). Organic C was analysed by Modified Walkly and Black's method and total soil N was determined by Micro kjeldahls's method outlined by Anderson and Ingram (1993). Total P was determined by the Ammonium molybdate stannous chloride method (Sparling *et al.* 1985).

Analysis of microbial biomass C, N and P

Microbial biomass C, N and P were analysed on monthly basis for a period of one year from February 1999 ~ January 2000. For analysis of microbial biomass C, N and P the soil samples were stored at room temperature for a day. About 50 g of moist soil from each samples were sieved to removed stones and roots and fumigated by placing the beaker with moist soils in a large vacuum desiccator with a beaker containing 50 ml of alcohol free chloroform. The desiccator was evacuated until the chloroform boils and disconnected from the pump and placed in the dark for 18 hours at room temperature. Microbial biomass C was estimated by the determination of C extracted from chloroform fumigated soils (5 days) by 0.5 M KCl using modified Walkley and Black method and microbial biomass N was determined by Micro Kjeldahl's method given by Anderson and Ingram (1993) after extraction with 0.5 KCl (5 days). Microbial biomass P was determined by the ammonium molybdate stannous chloride method (Sparling *et al.* 1985) after extraction with 0.5 M $NaHCO_3$ (for 5 days). Simultaneously the same procedures were performed for the unfumigated soils for microbial biomass C, N and P. Microbial biomass C, N and P were calculated as below:

Microbial biomass C= 2.64 E^c (Vance *et al.* 1987).

Where E^c is the difference between C extracted from fumigated and unfumigated samples.

Microbial biomass N= 1.46E^n (Brooks *et al.* 1985).

Where E^n is the difference between N extracted from fumigated and unfumigated samples.

Microbial biomass P= 2.5E^p (Brooks *et al.* 1982).

Where E^p is the difference between P extracted from fumigated and unfumigated samples.

RESULTS AND DISCUSSION

Physico-chemical characteristics of soil

Soil pH varied from 6.2 to 7.2 in the slash and burnt site II and 5.2 to 6.8 in the forest site I in different months throughout the year. Higher pH value in the slash and burnt site may be due to the addition of burnt organic matter in the form of ash through release of alkaline ions in soils. Fritze *et al.* (1998) also reported the application of wood ash raised the soil pH and the degree of base saturation to the same extent as burning. Soil moisture ranged from 6.10% to 23.30% in the forest site I and 4.40% to 24.85% in the slash and burnt site II. Soil temperature varied from 15.60℃ to 30.00℃ in the forest site I and from 19.30℃ to 31.16℃ in the slash and burnt site II. Higher soil temperature in the slash and burnt site may be due to exposure to direct sunlight in absence of vegetation. Total soil organic C and total N were found to be higher in the slash and burnt site II which ranged from 5466.05 to 39142.30 $\mu g\ g^{-1}$ soil and 1130.00 to 3081.20 $\mu g\ g^{-1}$ soil respectively. In the forest site total soil organic C and total N varied from 2082.30 to 13607.14 $\mu g\ g^{-1}$ soil and 948.86 to 2430.00 $\mu g\ g^{-1}$ soil respectively. The conversion of forest into slash and burnt site for cultivation leads to an increase of 70.30% of organic C and 33.20% of total N in the soil. The increase in organic C was due to addition of burnt and partly burnt organic matters due to slash and burning. The increase in N in the slash and burnt site may be due to the increase in the organic C as there was a significant positive correlation between total N and organic C (r=0.90, p<0.01, site I; r=0.90, p<0.01, site II). Haron *et al.* (1997) have reported similar relationship between % organic C and total N in oil palm plantations in West Malaya. However total P was found to be higher in the forest site I which ranged from 308.60 to 615.20 $\mu g\ g^{-1}$ soil and it ranged from 136.60 to 723.16 $\mu g\ g^{-1}$ soil in the slash and burnt site in different months throughout the year (Table 1). There was a loss of 4.24 % of total P in the slash and burnt site II which maybe due to lower inorganic form of P and more of organic P in the soil. The organic P was retained in the plant as microbial biomass whereas the inorganic P got mobilized and leached out by precipitation as P has high mobility rate.

Monthly and seasonal changes in microbial biomass C, N and P

Microbial biomass C ranged from 209.50 to 708.82 $\mu g\ g^{-1}$ soil in the forest site I and 319.45 to 905.50 $\mu g\ g^{-1}$ soil in the slash and burnt site II in different months throughout the year. Microbial biomass N ranged from 17.00 to 88.93 $\mu g\ g^{-1}$ soil in the forest site I and 19.30 to 99.45 $\mu g\ g^{-1}$ soil in the slash and burnt site II. Microbial P varied from 2.55 to 17.60 $\mu g\ g^{-1}$ soil in the forest site I and 10.90 to 32.21 $\mu g\ g^{-1}$ soil in the slash and burnt site II in different months throughout the year (Table 2). The average value of microbial biomass C, N and P were higher in the slash and burnt

Table 1. Physico-chemical characteristics of soil (Mean ± SE)

Parameters	Forest site I	Slash and burnt Site II
Soil texture (%)		
Sand	70.00±0.93	71.00±0.57
Silt	18.00±0.40	17.40±0.32
Clay	12.00±0.41	11.60±0.21
Soil pH	6.2 ±0.11	6.8 ±0.06
Soil moisture (%)	13.35±1.32	13.04±1.70
Soil temperature (℃)	23.23±0.86	25.55±0.65
Total soil organic C ($\mu g\ g^{-1}$)	6,973.00±707.66	2,3475.30±2,130.02
Total soil N ($\mu g\ g^{-1}$)	1,386.43±88.62	2,075.14±137.84
Total soil P ($\mu g\ g^{-1}$)	399.43±18.44	382.50± 33.80
C:N ratio	4.81	11.47

site than that of forest site. There was an increase of 29.05% of microbial C, 14.47% of microbial N and 32.17% of microbial P in the slash and burnt site compared to the forest site. Several workers have reported that removal of vegetation cover and alternate land use pattern from natural forest, reduced microbial C, N and P, organic C and other soil nutrients (Srivastava and Singh 1991, Henrot and Robertson 1994, Saranath and Singh 1995, Pascual *et al.* 2000; Regina *et al.* 1992). In all their studies there was a decline in organic C in the alternate land use pattern and there were significant positive correlation between organic C and microbial biomass. In the present study the organic C was 70.30% higher in the slash and burnt site, which may contribute to higher microbial biomass in the slash and burnt site. The amount of microbial biomass N increased immediately after the addition of organic material in an experimental farm at Hirosaki (Japan) (Aoyama and Nozawa 1993) compared to controls. Large long-term additions of organic matter in the alley cropping treatments increased microbial C and N, water soluble C and soil moisture in tropical agroecosytem in Costa Rica (Mazzarino *et al.* 1993). All factors of soil increased with soil organic mater in a cropland of Sweden (Schunrer *et al.* 1985). Increasing amounts of resources (organic carbon) which are of detrital origin have stabilizing effects on the soil microbial biomass (Wardle 1998).

Microbial biomass C, N and P increased to maximum value during the rainy season in both the sites which coincides with high soil moisture (18.30% and 18.53% for site I and II respectively). This may be due to higher decomposition rate and microbial activities during the active plant growth period (rainy season). The microbial biomass C, N and P were lowest in cold and dry winter season in the forest site (8.21% soil moisture) due to slow activities of microorganisms. However microbial biomass C, N and P decease to lowest in summer season (10.32% of soil moisture) in slashed and burnt site as the activities of the microorganisms were hampered owing to clear felling and burning in the beginning of summer months. Thereafter it increased during the rainy season due to high activities when there was sprouting of new leaves of the burnt plants as well as saplings of the felled trees grows on the availability of

Table 2. Seasonal changes in microbial biomass C, N and P ($\mu g\ g^{-1}$ soil) in forest site I and slash and burnt site II. Mean±SE

Season	Site I			Site II		
	Microbial C	Microbial N	Microbial P	Microbial C	Microbial N	Microbial P
Summer	299.00±48.25	58.26±9.25	11.45±1.80	391.40±24.67	41.06±12.57	12.54±0.47
Rainy	558.60±35.57	77.60±0.50	13.80±0.82	729.86±44.24	85.10± 3.45	20.10±1.94
Winter	248.41±11.60	28.75±5.20	6.93±1.33	444.50± 6.10	61.02± 2.86	13.76±0.63
Mean	390.31±35.20	56.50±5.20	10.92±0.94	550.12±36.90	66.06± 5.10	16.10±1.10

rain showers. Similar seasonal trend were reported in forest soils by Wardle and Parkinson (1990) and Ravina *et al.* (1993). An analysis of variance (ANOVA) on microbial C and N in different months throughout the year in both the sites were found to be significant at the level of $p<0.01$ and microbial biomass P was significant at the level of $p<0.05$ in the slash and burnt site and it was significant at the level of $p< 0.01$ in the forest site.

Nutrient ratios in the microbial biomass

Microbial C to N ratio was higher in the slash and burnt site than that of forest site but microbial C to P followed reverse trend (Table 3). The values of microbial C to N ratios in the present study falls within the range reported by Srivastava (1992) and Joergensen *et al.* (1995a) in forest soils. However the values of microbial C to P were higher from that reported by Brookes *et al.* (1984) and Srivastava and Singh (1988). Although there was higher microbial biomass C and N in the slash and burnt site, their contributions to total soil organic C and total N were lower (2.81% and 3.12% respectively) compared to the forest site (6.11% and 4.10% respectively). Thus it shows that microbial biomass immobilized greater amount of C and N in the soils of forest site. Similar trend was also reported by Ravina *et al.* (1995) which indicates that the soil with a low organic C content had less biomass but higher microbial biomass content in the total organic C. There was higher contribution of microbial P to total P in the slash and burnt site (4.74%) than that of forest site (2.74%) which may be attributed to higher immobilization of P in microbial biomass in the soils of slash and brunt site. Concentration of microbial biomass C to total organic C falls within the range reported by Joergenson *et al.* (1995a) and contribution of microbial biomass N in total soil N falls within the range reported by Ravina *et al.* (1993) and Joergenson *et al.* (1995a). The contribution of microbial biomass P to total P falls within the range reported by Joergensen *et al.* (1995b). Mean microbial biomass C: N: P ratio were 39:5:1 and 34:4:1 in the forest and the slash and burnt site respectively. The present values were higher than that reported by Srivastava (1992) from dry tropical forest soil of U.P (India) which may be due to higher microbial biomass C, N and P in the present study than that of his study.

Table 3. Nutrient ratios in microbial biomass in forest site I and slash and burnt site II

	Microbial C:N ratio	Microbial C:P ratio	Mic. C / Organic C (%)	Mic. N / Total N (%)	Mic. P / Soil P (%)
Site I	7.70	35.51	6.11	4.10	2.74
Site II	9.55	34.41	2.81	3.12	4.74

Table 4. Relationship between microbial biomass C, N and P and soil properties of the soil in forest site I and slash and burnt site II (df=10)

	r	y = a + bx	Variability (%)
Forest Site I			
Microbial biomass C vs.			
Organic C	0.93**	69.51+0.04x	86
Soil moisture	0.90**	69.37+24.04x	81
Soil temperature	ns		
Soil pH	ns		
Microbial biomass N vs.			
Organic C	0.66**	22.32+0.005x	43
Soil moisture	0.77**	16.05+3.03x	59
Soil temperature	0.78**	−52.91+4.79x	61
Soil pH	0.72**	−150.7 +333.10x	52
Microbial biomass P vs.			
Organic C	0.80**	−40.68+0.007x	64
Soil moisture	0.81**	3.31+0.57x	65
Soil temperature	ns		
Soil pH	ns		
Slash and burnt Site II			
Microbial biomass C vs.			
Organic C	0.87**	198.0 +0.01x	76
Soil moisture	0.55*	395.72+11.84x	30
Soil temperature	ns		
Soil pH	ns		
Microbial biomass N vs			
Organic C	0.90**	19.10+0.002x	81
Soil moisture	0.70**	38.67+2.10x	49
Soil temperature	ns		
Soil pH	ns		
Microbial biomass P vs			
Organic C	0.70**	7.64+0.003x	49
Soil moisture	0.58	7.64+0.37x	34
Soil temperature	ns		86
Soil pH	ns		81

Significant at $^{*}p<0.05$, $^{**}p<0.01$, ns=not significant.

Relationship between microbial biomass with other soil properties

Microbial biomass C, N and P were found to be significantly correlated with soil organic C and soil moisture in both the sites (Table 4). However influence of soil temperature and pH on microbial biomass was not statistically significant in both the sites but microbial N was significantly correlated with soil temperature and pH only in the forest site. Taylor *et al.* (1999) have reported significant positive correlation between soil moisture and microbial biomass. Degens *et al.* (2000) reported evidence of a generalized relationship exists between organic C pools and microbial catabolic diversity. Significant positive correlation between microbial biomass and organic C were also reported by Srivastava and Singh (1991) in tropical forest, Joergensen *et al.* (1995a) in beech forest and Pascual *et al.* (2000).

Thus conversion of forests into agricultural land through slash and burning resulted in a remarkable increase in the amount of soil nutrients and microbial biomass C, N and P in the current year. However on the long term, addition of plant organic matter is required to check the decline in the fertility of soil in successive years under shifting cultivation in this region.

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