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Impact of Surface Treatment of Leaf Litter on Soil Respiration in a Jhum Fallow

Magdal Vanlalvuani and Angom Sarjubala Devi

Department of Environmental Science, Mizoram University

Abstract- Degradation of land mainly through jhumming cultivation or slash and burning agriculture is the main concern in the mountainous tracts of North-Eastern India. Removal of vegetation especially tree species leads to major changes in an ecosystem. Soil respiration is one such important aspect of soil. It indicates the activities of soil organisms and supplying of nutrients to the growing vegetation. The present study shows that removal of common tree species in three types of slope in a five year old jhum fallow leads to a decrease in soil respiration. It was found out by comparing with plots treated with leaf litter and untreated plots. In the present location the increase in soil respiration due to treatment of leaf litter on steeper slopes was more than the gentler slopes. The reason being gentler slopes are in the upper tracts where human disturbances are more.

Index Terms- Initial chemistry, jhum cultivation, leaf litter, slope angle

I. Introduction

Slash and burning agriculture is referred to as jhumming cultivation in the North-Eastern region of India. The fields which are abandoned after cultivation of crops for two to three years are known as jhum fallows. In these jhum fallows few trees are left by the farmers without cutting in the initial slash and burning period and some of them survives burning. However small the number is the role played by these trees on the soil is important in order to evaluate the impact of felling and burning the trees. In order to study change of soil characteristics due to such activities, soil respiration is an important factor. Soil respiration reflects the capacity of soil to sustain plant growth, soil fauna, and microorganisms. It indicates the level of microbial activity and soil organic matter content and its decomposition. It is one of the earliest and still one of the most frequently used indices for the estimation of biological activity of soil (Tulaphithak *et al*. 1985). Soil respiration can be used to estimate nutrient cycling in the soil and the soil's ability to sustain plant growth. Therefore the present study has been undertaken to evaluate the change in rate of soil respiration in soil due to removal of vegetation specially trees.

II. Materials and Methods

Study Sites

A five year old jhum fallow was selected in Tanhril village which is about 17 km westward from Aizawl lying between 23^o 43'25" N and 23^o 45'37" N latitudes and 92^{o}38'39"E and 92^o 40'23" E longitudes. Three types of slopes 25-35 %(steep), 5-25% (moderate) and 6-10 %(gentle) slopes were selected in the jhum fallow. Three types of common trees in the three slopes were selected out of the five to six trees remaining. They were *Duabanga grandiflora, Callicarpa arborea and Rhus chinensis*.

Surface treatment of leaf litter

Freshly fallen leaf litter of the three species were collected from the study sites. They were air dried till constant weight and kept in plastic mesh bags separately for each species and placed on the three slopes each in three different plots. They were fixed with small bamboo cuttings so that they were not flown away by wind or water. This type of placing of the leaf litter on soil was taken as surface treatment of the leaf litter on soil.

Soil respiration

Soil samples were collected from beneath the litter layer monthly from different locations and soil respiration was estimated monthly for 19 months starting from August, 2013 till February 2015. Soil respiration was estimated by using Alkali Absorbtion Method outlined by Anderson and Ingram (1993). Soil samples were also collected monthly from selected plots in the three slopes where there was no placing of the leaf litters. These plots were taken as control plots. The change in soil respiration due to presence of the litter was evaluated by comparing with these control plots.

Results and Discussion

The trend of CO_2 evolved was lower in the initial months and gradually increases attaining a maximum in the month of May, 14 in all the treatments and slopes (Figs. 1-3). The treatment plots have more evolution of CO_2 compared to the control in all the three slopes.

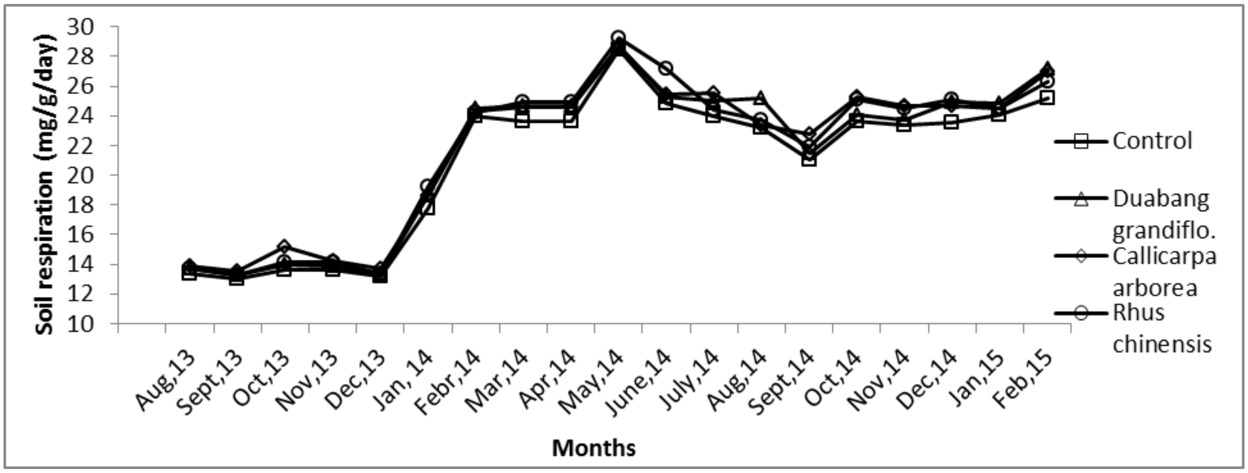

Fig.1 :Soil respiration in the leaf litter treated jhum fallow in the steep slope.

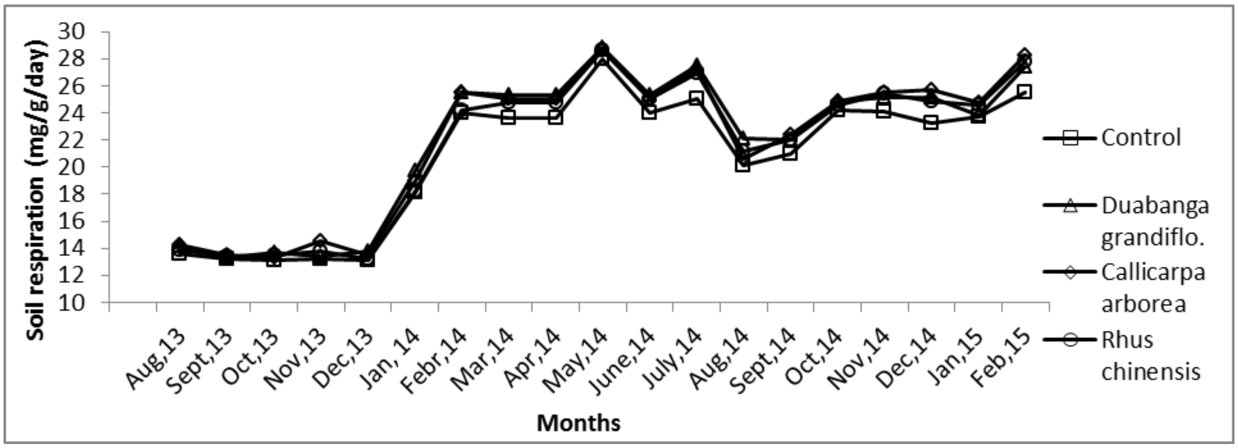

Fig.2 :Soil respiration in the leaf litter treated jhum fallow in the moderate slope.

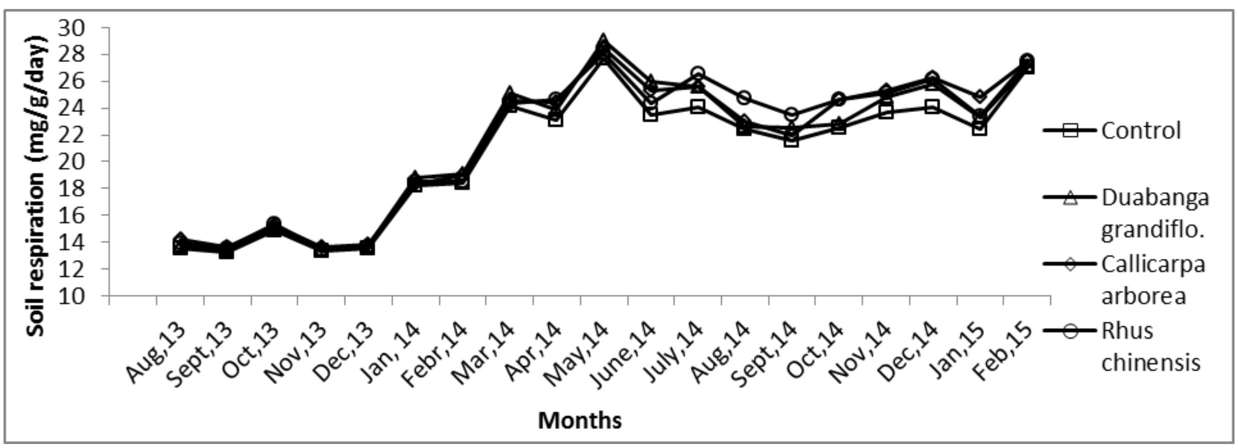

Fig.3 :Soil respiration in the leaf litter treated jhum fallow in the gentle slope

By comparing between the three control plots for the three slopes average soil respiration was higher in the steep slope (21.15mg/g/d) but the moderate and gentle slopes have the same average soil respiration rate (20.60 mg/g/d) (Table 1).

Table 1: Average soil respiration (mg/g/d) in the control and treated plots.

Slope	Species			
	Control	*Duabanga grandiflora*	*Callicarpa arborea*	*Rhus chinensis*
Steep	21.15	21.90	21.92	21.62
Moderate	20.60	21.35	21.92	21.62
Gentle	20.60	21.35	21.55	21.55

The initial substrate quality shows that *Callicarpa arborea* have highest C and N content followed *Rhus chinensis* and least was observed in *Duabanga grandiflora*. By looking at C:N ratio all the ratios are above 30. Among the three *Callicarpa arborea* have lowest and *Rhus chinensis* have highest C:N ratio (Table 2).

Table 2: Initial C, N and C:N ratio of the leaf litter.

Species	C(%)	N(%)	C:N
Duabanga grandiflora	41.23	0.75	54.32
Callicarpa arborea	51.01	1.08	47.15
Rhus chinensis	47.41	0.84	56.37

Due to treatment of the three types of leaf litter *Callicarpa arborea* treated plots leads to highest increase in the rate of soil respiration in all the three slopes 0.921mg/g/d in steep slope, 1.226 mg/g/d (moderate slope) and 0.963mg/g/d (gentle slope) (Table 3). These calculations were done by subtracting control values from treated values for different plots and treatmnents. After *Callicarps arborea* it was followed by *Rhus chinensis* having 0.873mg/g/d (steep) and 0.963mg/g/d (gentle). However in the moderate slope *Duabanga grandiflora* have more increase in the rate of soil respiration. The reason for highest increase in *Callicarpa arborea* treated plots can be attributed to its leaf litter having more initial C and N content and lesser C:N ratio (47.15). The correlation studies also shows negative and significant correlation between the change in soil respiration and initial C:N

Table 3: Average increase in soil respiration (mg/g/d) in treated plots.

Slope	Species		
	Duabanga grandiflora	*Callicarpa arborea*	*Rhus chinensis*
Steep	0.784	0.921	0.873
Moderate	1.152	1.226	0.868
Gentle	0.757	0.963	0.963

ratio in steep and moderate slopes (Table 4). There was significant and positive correlation between change in soil respiration with initial C and N in the steep and gentle slopes. By taking account C:N ratio only it was evident that treating with species having lesser C:N ratio leads to more rate of soil respiration in steep and moderate slopes. However in the gentle slope the relation was not evident moreover in the average soil respiration also steep slope was having the highest and least was found in gentle slope.

Table 4: Pearson's coefficient of correlation (r) between increase in soil respiration with initial C, N and C:N ratio.

Slope	r(n=3)		
	C	N	C:N
Steep	0.99	0.90	-0.61
Moderate	0.04	0.43	-0.80
Gentle	0.93	0.71	-0.30

The study also shows that removal of vegetation specially the present tree species leads to a loss on soil respiration rates. A principal mechanism by which vegetation may control soil respiration rates is via the production of plant detritus, which feeds soil organisms. Raich and Nadelhoffer (1989) found that soil respiration increased with increasing litterfall in relatively mature forest ecosystems. Raich and Tufekcioglu (2000) also conclude that litter production and soil respiration are positively correlated. They also stated that soil respiration rates are controlled primarily by climatic and substrate factors with vegetation having a secondary effect only. However plants produce the organic matter that feeds soil organisms and soil biota transform organically bound nutrients into forms that can be utilized by plats. The production and consumption of organic matter are inextricably linked processes that together are controlled by temperature, moisture availability and substrate conditions that are largely independent of the plants present (Raich and Tufekcioglu, 2000).

In between the three slopes between the leaf litter treatment plots the soil respiration was found to be highest in the steep slope followed by moderate slope. In the gentle slope least was observed in all the treatments. This shows that in mountainous region the role of steeper tracts are very important. Moreover in this landscape the gentler slopes are in upper tracts where human habitation is possible thereby more disturbances occurs in gentler slopes. The steeper and moderate slopes are the lower tracts below the gentler slopes where lesser disturbances occurs.

Therefore it can be conclude that steeper slopes are playing key role in maintaining the level of soil quality. The initial chemistry specially C:N ratio of plant litter in these slopes is an important indicator of the change in soil respiration due to change in vegetation. Overall rate of soil respiration was decreased by removing tree species.

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Authors

First Author – Magdal Vanlalvuani, Department of Environmental Science, Mizoram University, angom75@yahoo.com

Second Author – Angom Sarjubala Devi, Department of Environmental Science, Mizoram University, angom75@yahoo.com