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Effect of Litter Decomposition on Soil Chemical Properties During Shifting Cultivation in Northeast India

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ABSTRACT

Shifting cultivation commonly known as *jhumming* is widely practiced in Northeast India. The present study was designed to understand the effect of *Tephrosia candida* (Roxb.) DC. and *Oryza sativa* L. leaf litter decomposition alone and in combination on soil chemical properties in two fallows (3 years, FL-3 and 8 years, FL-8) during shifting cultivation. Additionally, the soils from the two fallow lands were brought to the laboratory and litters of the two species were placed in the same way over the known amount of soil (3 kg) in pots. Litters were enclosed in nylon net bags and placed over soil surface in July 2019 in Tanhril area of Mizoram. The soils beneath the litter bags were sampled at monthly interval and analyzed for various soil properties like pH, electrical conductivity, total organic carbon, total nitrogen, C/N ratio and available phosphorus. Soil total organic carbon in 8 years fallow field increased from 1.15% to 2.02% on the other hand in 3 years fallow field it increased from 1.02% to 1.53% after application of different leaf litters. Similarly, soil total nitrogen also increased from 0.04% to 0.23% in 8 years field and from 0.029% to 0.021% in 3 years fallow field. Contrastingly in control condition total organic carbon increased maximum in 8 years fallow from 1.15% to 1.62% and total nitrogen from 0.04% to 0.12%. Results indicate that nutrients in the soil increases at a much higher rate in longer fallow land as compared to shorter fallow land after application of leaf litters. It can be concluded that decomposition of different leaf litters may bring a promising increase in soil fertility in shifting cultivated field with different fallow length.

Keywords Shifting cultivation, Fallow land, Chemical properties, Decomposition, Leaf litter.

INTRODUCTION

Shifting cultivation (*jhumming*) also known as slash and burn cultivation, is a primitive form of agriculture being carried out by half a billion population in tropical moist forest of the world (Grogan *et al.* 2012). Shifting cultivation involves clearing the vegetation of an area, drying and *in situ* burning of biomass followed by cropping for 1-2 years depending on the soil fertility levels followed by land abandoned for few years to recover the soil fertility through natural regeneration (Grogan *et al.* 2012, Tripathi *et al.* 2017). In previous years, the *jhum* cultivators (*jummias*) were capable to abandon the land as fallow for > 20 years which allows the land to

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recover the soil fertility and support high productivity. However, in recent years, increasing population densities has led to reduce the fallow period (< 5 years), which substantially reduced soil fertility and crop productivity. Previous researchers reported that accumulation of forest floor litters (FFLs) has great impacts on soil physico-chemical and biological properties (Wapongnungsang *et al.* 2017). Addition of FFLs in the *jhu*m plots changes *jhum* soil characteristics considerably with the increasing length of fallow period (Saplalrinliana *et al.* 2016). Litters of *Tephrosia candida* has been reported to produce high biomass, dense vegetation cover and nitrogen fixing ability and show high potential in supplying carbon and nutrients to the soil (Nguyen and Thai 1993, Wapongnung sang *et al.* 2017). *Oryza sativa* is one of the major crop plants under *jhum* cultivation of Northeast India. *O. sativa* litter has been reported to release 15.4 to 38.4% of total organic carbon in the soil during the decomposition of 42 days (Gina Villegas-Pangga *et al.* 2000). *O. sativa* affects the soil C and N cycle and make chemical speciation and biological effectiveness of soil nutrients (Wei Zhou *et al.* 2014). It is hypothesized that the decomposition of two litters releases carbon and nutrients at different rates in fallow lands of two ages. This study aimed to determine the impacts of leaf litters of *T. candida*, *O. sativa* and *T. candida* + *O. sativa* on chemical properties of soil in two different fallow lands during decomposition in pot experiments under laboratory condition and in the field following shifting cultivation in Mizoram.

MATERIALS AND METHODS

Site description

The study was conducted in Tanhril, Mizoram at two fallow lands of 3 years (23°39´55´´ N, 92°31´48´´-92°33´24´´ E) and 8 years (23°43´55´´-23°44´48´´N, 92°38´43´´-92°40´4´´E). Tanhril is located about 15 km away from the capital city Aizawl. The average temperature and humidity during the study period varied from 26°C to 11°C and 82% to 90% respectively. The total annual rainfall was 2050 mm. The ages of the fallow lands were identified by interviewing the land owner. The soil of the study sites belongs to the order inceptisol and falls under red soil group having light to medium texture and slope of land varied between ~35° and 40° (Hauchhum and Tripathi 2017).

Field experiment

T. candida and *O. sativa* leaf litters were collected in March-April 2019 and air dried. About 10 g litter materials were enclosed in nylon bags (20 cm × 20 cm, 2 mm mesh). A total of 150 litter bags for three species were prepared with 50 each for *T. candida*, *O. sativa* and *T. candida* + *O. sativa*. Six bags of each litter types along with the soil (10 cm) beneath the litter bags were retrieved monthly for 8 months. A total 8 recoveries were made.

Pot experiment

Soils were collected from the study sites for pot experiment. Fifty number of pots were set for three different litter types (*T. candida, O. sativa, T. candida* + *O. sativa*) from 3 years and 8 years fallow soil. Each pot containing 3 kg of soil, after 7 days of collection 10 g of leaf litters were added. Leaf litters and soil from 4 pots of each litter type and two fallow lands were retrieved for 8 months. Pot experiment was conducted under control condition.

Soil chemical properties

Soil pH was measured in soil water suspension (1:2.5 w/v H_2O) using a digital pH meter. Electrical conductivity (EC) was measured in 1 : 5 soil: H_2O suspensions using a standard conductivity meter (Eu Tech, Merck) with 2 cell constants and calibrated using standard solutions. Air-dried and finely ground soil was used for determination of soil organic carbon (SOC) by the potassium dichromate wet oxidation method (Walkley and Black method 1947). Total Nitrogen was determined by Kjeldahl method. Soil available P (avail-P) was determined by the stannous chloride blue color method (Bray and Kurtz 1945).

Statistical analysis

Microsoft excel was used for statistical analysis :

Fig. 1. Map of study area.

One-way analysis of variance (ANOVA) and least significant difference (LSD). Three treatment was regarded as distinct strategies for eight months.

RESULTS AND DISCUSSION

One-way ANOVA indicated that the soil chemical properties were significantly affected by the litter decomposition during the course of time in two fallow lands (Fig. 2). The effect was more pronounced in 8 years fallow field than 3 years fallow field. Similarly, the effect of litter amendment on soil chemical properties were significant for pot experiment (Fig. 3). Addition of FFLs has been reported greatly affect the soil physico-chemical and biological properties of soil under shifting cultivation (Wapongnungsang *et al.* 2017). Soil of both the fallow lands were strongly acidic, initially pH was 4.35 and 4.5 for 3 years and 8 years fallow lands, respectively. After the litter input in fallow lands and pots, there was a gradual increase in soil pH. In field experiment, increase in pH was higher in 8 years fallow (4.45 to 5.29) compared to 3 years fallow (3.96 to 4.62). Similar trend was also noticed in pot experiment. Our study show that EC value is much higher in longer fallow land as compared to shorter fallow land in both field and pot experiment. During the course of our study, maximum increase in EC was from 0.29 dSm^{-1} to 0.46 dSm^{-1} for field experiment followed by 0.28 dSm^{-1} to 0.46 dSm^{-1} for pot experiment.

According to our study, TOC content increased significantly (75% in the field experiment and 68% in the pot experiment) with increase in the length of fallow period. One-way ANOVA suggested that application of *T. candida*, *O. sativa* and *T. candida* + *O. sativa* significantly affected soil organic carbon in both field and pot experiment. Litter input has significantly increased (~4-5 times) total soil nitrogen content in the soil in field as well as in the pot experiments during the course of the study (Figs. 2, 3). Consequently, there was a steady decline in the soil C/N ratio during the course of litter decomposition in field as well as pot experiment. The maximum increase in soil nitrogen content was observed for *T. candida* litter inputs in 8 years fallow field. Addition of FFLs in the *jhum* plots changes *jhum* soil characteristics considerably with the increasing length of fallow period (Saplalrinliana *et al.* 2016). The study shows that the increase in nitrogen content in soil was much higher than the increase in total organic carbon content. So, a remarkable decrease in C/N of soil was observed for each treatment in both field and pot. In 3 years fallow land, the average decrease in C/N ratio for all the treatments was 229.6% and in 8 years fallow land it decreases by 91.6% on the other hand for pot experiment the average decrease was 212% and 95% for 3 years fallow and 8 years fallow soil respectively. One-way ANOVA showed significant changes in available soil phosphorus (P_{avail}) content in both field as well as pot experiments. Maximum increase in P_{avail} content occurred in 3 years fallow after the addition of *T. candida* followed by *T. candida* + *O. sativa* and *O. sativa*. However, maximum increase in soil P_{avail} content was observed

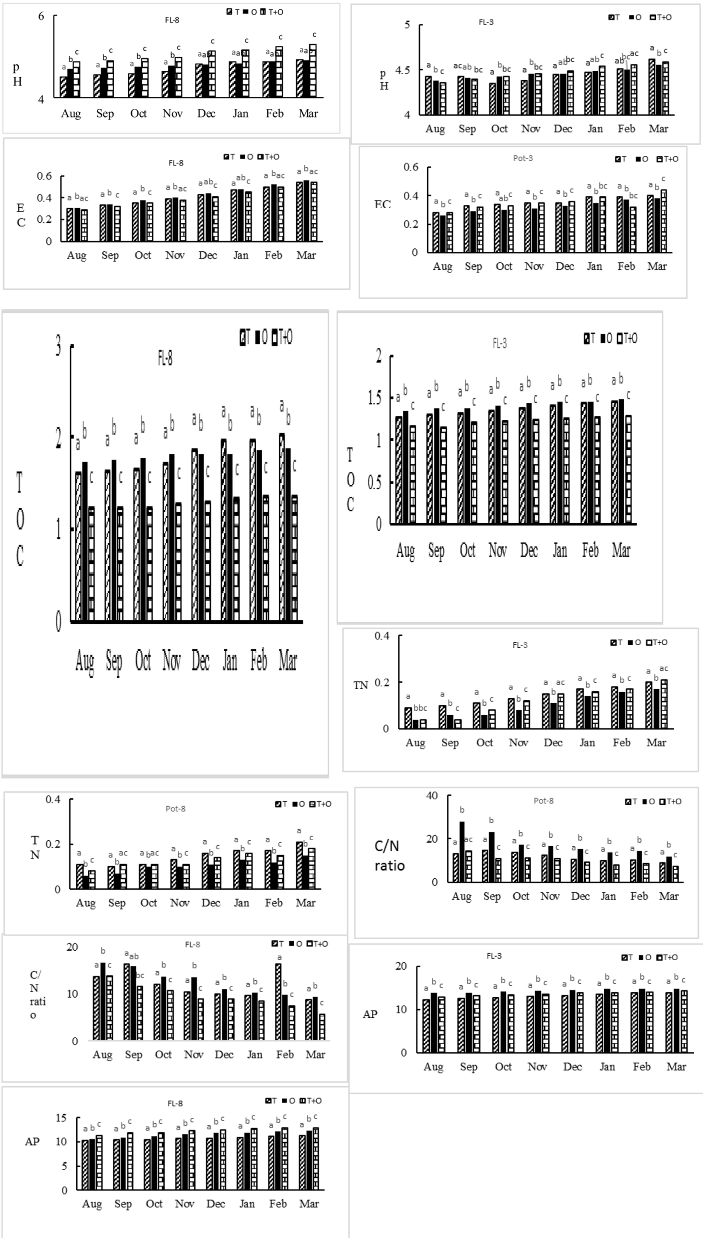

Fig. 2. Changes in soil physico-chemical properties during the decomposition under field condition. Abbreviations are: EC- Electrical Conductivity; TOC- Total Organic Carbon; TN-Total Nitrogen; AP-Available Phosphorus; T-*Tephrosia* sp.; O-*Oryza* sp.; T+O-*Tephrosia* sp.+*Oryza* sp. ; FL-Fallow land. Different small letters denote significant differences ($p < 0.05$) among the different months.

in 8 years old fallow after the addition of *O. sativa* followed by *T. candida* + *O. sativa* and *T. candida* inputs. Maximum increase in soil P_{avail} in both fallows (8 years and 3 years) was observed after *T. candida* + *O. sativa* additions.

EC. The present Increase in soil pH in longer fallow period in this study may be associated with the addition of more alkaline cations from burning of greater plant biomass in FL-8 than FL-3 (Dikici and Yilmaz 2006, Granged *et al.* 2011). Further,

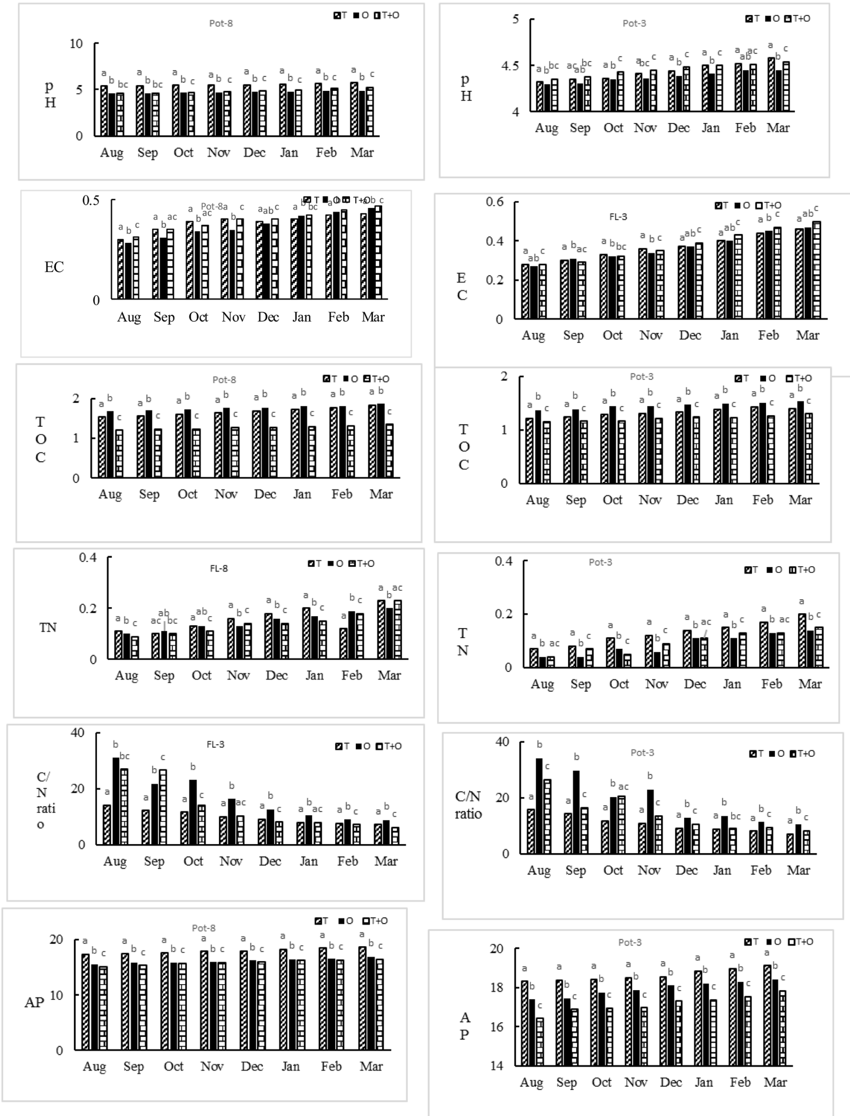

Fig. 3. Changes in soil chemical properties during litter decomposition under pot experiment. Abbreviations area same as in Fig. 2. Different small letters denote significant differences ($p < 0.05$) among different months. **Fig. 3.** Soil chemical properties for field experiment. EC- Electrical Conductivity, TOC- Total Organic Carbon, TN- Total Nitrogen, P- Available Phosphorus. T- *T. candida*, O- *O. sativa*, T+O- *T. candida+O.sativa* Different letters denote significant differences ($p < 0.05$) with leaf litters Changes in soil properties were significant ($p < 0.05$) during decomposition of leaf litters in 8 years and 3 years fallows.

soil pH affected the activity of microbes (Pathak and Rao 1998) and the increase in pH at different rate may be associated with the activities of microbes as affected by different organic inputs. According to Saplalrinliana *et al* . (2016), the length of the fallow period showed a distinctive influence on soil study also indicated an increase in EC with increase in fallow period for both field and pot experiment. An increase in EC indicated an increase in more soil salts (Pathak and Rao 1998) in longer fallow land. In *jhum* field, soil heating due to burning activity alters TOC content. The fallow sites with higher soil organic matter content are susceptible to burning loss although maintained higher TOC up to 2 years as a result of high temperature during burning due to accumulation of more biomass in longer fallow land compared to shorter fallow land (Lungmuana *et al.* 2017). The decay of leaf litter yields high amount of dissolved organic carbon compounds (Singh and Gupta 1977). Higher soil Nitrogen content in the longer fallow compared to shorter fallow in the present study was in accordance with the past finding (Neff *et al.* 2005). Higher initial Nitrogen content in litter component favors the release of Nitrogen in the soil (Hoorman *et al.* 2010) as *T. candida* contains higher Nitrogen content so during decomposition it releases more Nitrogen to the soil. The gradual decrease in C/N ratio during our study can be corresponded with the findings (Wapongnungsang *et al.* 2017). The maximum increase in Pavail was observed in 8 years fallow land. An increase of P_{avail} in soil can be attributed with decomposition of organic inputs and length of fallow period (Saplalrinliana *et al.* 2016).

According to our study, leaf litters of *T. candida* + *O. sativa* may add more salts in to the soil. For *T. candida* litter inputs in both field and pot, more increase in total Nitrogen content in soil was seen as compared to *Oryza* sp. and *T. candida* + *O. sativa* inputs which may be due to its nitrogen fixing ability. In longer fallow lands TOC of soil increases drastically for different organic inputs which may be due to the release of dissolved carbon compounds from decomposing litters. Our results indicate that application of different organic inputs in *jhum* soil may increase soil chemical properties and crop productivity in a very short period of time.

CONCLUSION

This study concludes that different litter components can be used as green manure in *jhum* field for sustaine farming practices in this region. Different leaf litters in shorter fallow period may positively affect the soil fertility and crop productivity through addition of electrolytes, Carbon, Nitrogen and Phosphorus in a quite short time. Due to the presence of potential microorganisms, longer fallow land may add greater organic matter and nutrients to the soil as a result of higher decomposition rate. Litter decomposition and nutrient release can be associated with crop demand for nutrients that may enhance agricultural productivity in *jhum* field.

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REFERENCES

Bray RH, Kurtz LT (1945) Determination of total, organic and available forms of Phosphorus in soils. *Soil Sci* 59 (1) : 39—46.

Dikici H, Yilmaz CH (2006) Peat fire effects on some properties of an artificially drained peatland. *J Environ Qual* 35 : 866—870.

Granged AJP, Zavala LM, Jordan A, Moreno GB (2011) Post-fire evolution of soil properties and vegetation cover in a Mediterranean health and after experimental burning: A 3-year study. *Geoderma* 16 : 85—94.

Grogan P, Lalnunmawia F, Tripathi SK (2012) Shifting cultivation in steeply sloped regions: A review of management options and research priorities for Mizoram state, Northeast India. *Agrofor Syst* 84 : 163—177.

Hauchhum R, Tripathi SK (2017) Rhizosphere effects of *Melocanna baccifera* on soil microbial properties under different fallow phases following shifting cultivation. *IJPS* 17 : 1—9.

Hoorman JJ (2010) Understanding soil microbes and nutrient recycling. Agriculture and natural resources. SAG, Ohio State University, USA.

Jonna S, Badrinath KVS, Chandrasekhar G, Amminedu E, Chand KTR (2007) Crop surface temperature estimation in irrigated command areas using MODIS satellite data. *J Ind Soc Remote* 28 (23) : 5195—5205.

Neff J, Harden J, Gleixner G (2005) Fire effects on soil organic matter content, composition and nutrients in boreal interior Alaska. *Can J For Res* 35 : 2178—2187.

Nguyen TS, Thai P (1993) Tephrosia candida-a soil ameliorator plant in Vietnam. *Contour* (*Jakarta*) 5 (1) : 27—28.

Pangga GV, Blair G, Lefroy R (2000) Measurement of decomposition and associated nutrient release from straw (*Oryza sativa* L.) of different rice varieties using a perfusion system. *Pl Soil* 223 : 1—11.

Pathak H, Rao DLN (1998) Carbon and nitrogen mineralization from added organic matter in saline and alkali soils. *Soil Biol Biochem* 30 : 695—702.

Saplalrinliana H, Thakuria D, Changkija S, Hazarika S (2016) Impact of shifting cultivation on litter accumulation and properties of *jhum* soils in North east India. *J Ind Soc Soil Sci* 64 (4) : 402—413.

Singh JS, Gupta SR (1977) Plant decomposition and soil repirations in terrestrial ecosystems. *Bot Rev* 43 : 449—528.

Lungmuana, Singh SB, Vanthawmliana, Saha S, Dutta SK, Rambuatsaiha, Singh AR, Boopathi T (2017) Impact of secondary forest fallow period on soil microbial biomass carbon and enzyme activity dynamics under sifting cultivation in Northeastern Hill region, India. *Catena* 156 : 10—17.

Walkley A, Black IA (1934) An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromatic acid titration method. *Soil Sci* 37 (1) : 29—38.

Wapongnungsang, Hauchhum R, Tripathi SK (2017) Litter decomposition vis-a-vis carbon and nitrogen dynamics of *Tephrosia candida* components in different Fallow land. *Ind J Ecol* 44 (4) : 791—796.