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Short communication: A laboratory study to validate the impact of the addition of *Alnus nepalensis* leaf litter on carbon and nutrients mineralization in soil

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Abstract. *Mishra G, Giri K, Dutta A, Hazarika S, Borgohain P. 2016. A laboratory study to validate the impact of the addition of Alnus nepalensis leaf litter on carbon and nutrients mineralization in soil. Nusantara Bioscience 8: 5-7.* Plant litter or residues can be used as soil amendment to maintain the carbon stock and soil fertility. The amount and rate of mineralization depend on biochemical composition of plant litter. *Alnus nepalensis* (Alder) is known for its symbiotic nitrogen fixation and capability to restore fertility of degraded lands. A laboratory incubation experiment was conducted for 60 days under controlled conditions to validate the carbon and nutrients mineralization potential of alder litter. Soil fertility indicators, i.e. soil organic carbon (SOC), available nitrogen (N), available phosphorus (P), and available potassium (K) were analyzed using standard procedures. Significant differences were observed in the soil properties after addition of litter. Nutrient composition of alder litter was found superior by providing significantly higher organic matter and helped in better nutrient cycling. Therefore, alder based land use system may be replicated in other degraded lands or areas for productivity enhancement which is important for sustaining biodiversity and soil fertility.

Keywords: *Alnus nepalensis*, carbon, nutrients, Nagaland

INTRODUCTION

Shifting or Jhum cultivation contributes significantly in alterations of soil properties and diminishes soil quality (Ayoubi et al. 2011). Despite being the site-specific nature of this land use pattern, it may also lead to desertification, soil erosion, biodiversity loss, climate change, etc. (Chase and Singh 2014). Concerning Northeast India, Jhum cultivation is predominant in all the seven states that pose a serious threat. This region witnessed drastic land use changes in the recent past which leads to decline in soil fertility and productivity. According to Oliveira et al. (2014), available organic materials can be used as soil amendments to manage the fertility status. Moreover, in context to small hold agriculture of this region, plant residues in the form of litter are the potential nutrient sources. Hence, to cope up with the problem of declining soil quality, people of this region developed some indigenous knowledge based agroforestry systems with the aim of sustaining the system (Ramakrishnan 1992). According to the report of NEPED and IIRR (1999), alder based agroforestry system provides at least 57 food crops to supplement the rice cultivation. *Alnus nepalensis* D. Don, or alder is a non-leguminous nitrogen-fixing tree species occurs naturally throughout the Himalayas.

The importance of alder tree was recognized by the tribal communities long back 200 years ago and utilized by the farmers of Angami, Chakhasang, Chang, Yimchaunger, and Konyak tribes (Gokhle et al. 1985). Alder is known for its symbiotic relationship with *Frankia* (nitrogen-fixing actinomycetes) and therefore able to restore fertility status of degraded Jhum lands (Rathore et al. 2010). Moreover, the litter of alder also add P, K, Ca and other nutrients through the biomass decomposition. Incorporation of alder plant litter in soils can maintain organic carbon (OC) content, improve soil physical properties, enhance biological activities and increase nutrient availability. Therefore, this study was aimed to validate the effect of incorporation of alder leaves on soil organic carbon (SOC)and nutrient content of soil incubated under laboratory conditions.

MATERIALS AND METHODS

The soil used in this study was collected from an abandoned Jhum land of Khonoma District of Nagaland, India. The study site is located at Longitude E95˚00'281" Latitude N25˚37'688 and an elevation of 1531m above mean sea level. The site was sandy loam in texture. Soil samples were collected from a depth of 30cm from three points. Physicochemical properties of the soil were determined in Soil Testing Laboratory of Rain Forest Research Institute, Jorhat, Assam, and initial soil analysis is presented in Table 1. Fresh alder leaves were collected from 10-year-old plantation, washed in distilled water, dried at 65ºC for 48 h, milled and passed through a 1mm sieve. The incubation study was done as per the methodology is given by Abbasi et al. (2011). 100 g soil sample was kept in glass jars and moisture content was maintained at field capacity via addition of distilled water. A total of 15 jars were used (5

Table 1. Physicochemical properties of the soil (0-30 cm) used in the study.

Soil properties	Values
Bulk density	0.80
Silt (%)	26.8
Sand (%)	25.9
Clay (%)	47.2
pH	4.51
CEC (c mol kg^{-1})	5.06
OC (%)	3.18
Available N (%)	0.001
Available P (ppm)	9.0
Available K (ppm)	223.00

treatments and 3 replications). The treatments were mixing of dry milled alder leaves in different doses, i.e.: (i) control; (ii) 2.5 g; (iii) 5 g; (iv) 7.5 g and (v) 10 g. This soil sampling and analysis were repeated after every 15 days. SOC, N, P, and K were estimated using previously described standard methodology (Walkley and Black 1934; Subbiah and Asija 1956; Bray and Kurtz 1945; Morwin and Peach 1951). Significance of various parameters was tested by F-tests (P <0.05) and Duncan Multiple Range Test (DMRT) using SPSS version 16.0.

RESULTS AND DISCUSSION

Soil organic matter (SOM) is the main component of soil as it provides major portion of soil carbon pool, supports microbiological diversity and ensures the long term supply of nutrients through decomposition (Woomer et al. 1994). The valve of SOC decreased in control as compared to other treatments during the study period. Addition of alder leaf litter produced significant effect on SOC content in incubated soil at 30, 45 and 60 days (Figure 1). Among the treatments, after 60 days of incubation, the value ranged from a minimum of 2.39% in control and a maximum of 3.96% (Treatment 5). The differences were statistically highly significant at 60 days (F=23.288, p=.0.00), where higher dose of alder leaves was found to be superior in maintaining SOC status in long term basis. In general, the added plant residues increased organic matter stock in soil and thereby increased N mineralization and N transformation processes in soil (Abbasi et al. 2015).

Nitrogen is an important macronutrient and plays major role in plant growth and development, but its availability in soil is a major factor in governing the productivity of any ecosystem (Gairola et al. 2012). Soil N content was found to be more in treatment 5 in all sampling dates. After 15 days of incubation is no significant effect of leaf addition, but after 30 days, N content in all the treatments was significantly superior to control (Figure 2). Sudden increase in N content can be supported by the fact that initial low N availability in soil increased the mineralization of litter. The effect of leaf addition also produces significant effect at 45 and 60 days. After 60 days of addition, effects were

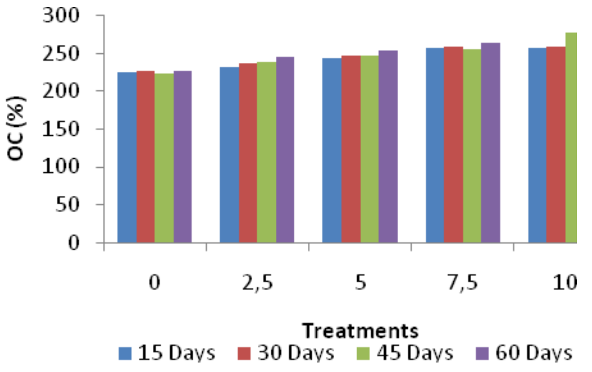

Figure 1. Soil organic carbon (%) under different treatments

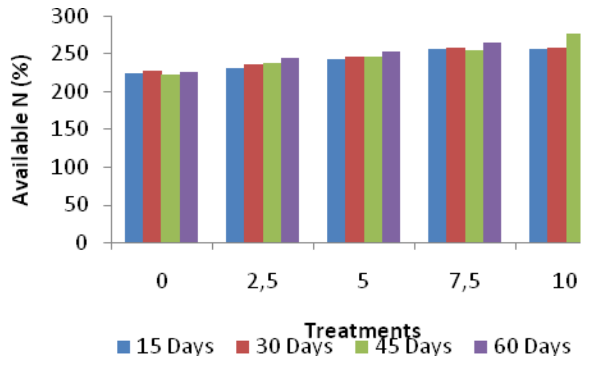

Figure 2. Available N (%) under different treatments

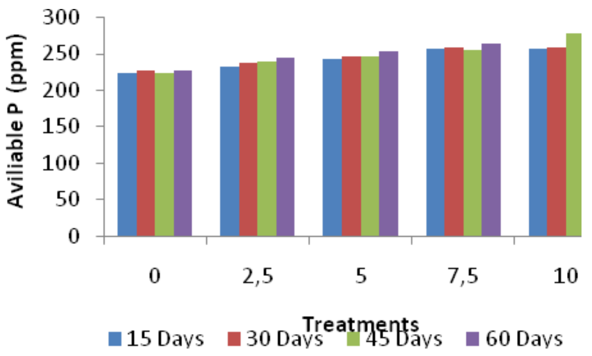

Figure 3. Available P (ppm) under different treatments

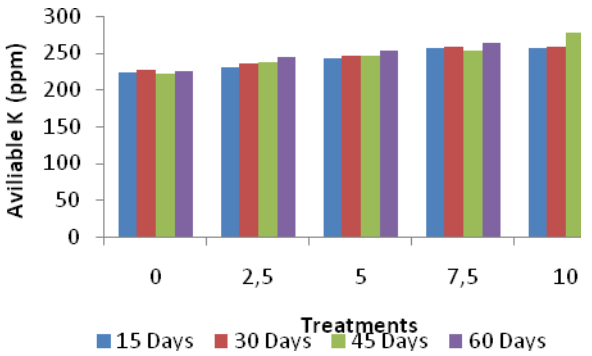

Figure 4. Available K (ppm) under different treatments

pronounced and value ranged between 0.016% (control) to 0.096% (Treatment 5). Alder leaves provides significant amount of litter and organic matter, as evident by a significant increase in soil N after 60 days (F=163.152, p=0.00). Our results were in accordance with findings of Tripathi et al. (2009), who reported about the role of alder litter in increasing the nitrogen content of soil. N mineralization is slowed down after 45 days as high N contents in soils slowed down the decomposition rates of litter (Liu et al. 2010).

Like N, P is also equally important for plant growth and development. Huge amount of P is stored in soil in different forms but the major concern regarding the availability of P is fixation (Chatterjee et al. 2014**)**. Among the treatments, no significant differences were observed after 15 days, while the effects are more prominent after 30, 45 and 60 days, respectively (Figure 3). After 60 days of incubation, amount of P ranged from 9.17 ppm (Control) to 10.93 ppm (Treatment 5) and alder leaves contributed significantly in maintaining the P status in comparison to control (F=6.298, p=0.008). Similarly, K in plants plays a key role in biochemical processes like enzyme activation, synthesis of macromolecules, regulation of transpiration, etc. (Brady 1996). No significant difference was observed in K content after 15 and 30 days can be supported by the fact that amount of K in soil is directly related to the parent rock material (Figure 4). Moreover, the effects are more and less similar after 45 (F=3.755, p=0.041) and 60 (F=5.936, p=0.010) days. After 60 days of incubation, amount of K ranged from 206.00 ppm (Control) to 262.00 ppm (Treatment 5). This is due to the fact that organic matter through its slow decomposition maintains the availability of K (Basumatary and Bordoloi 1992).

In conclusion, the experiment showed that soil amended with alder leaves displayed wide variation of SOC and nutrient mineralization depending on the amount of plant litter added. This study suggested that alder litter showing rapid N mineralization so can be used for early N demands of a crop in degraded lands. Uses of such locally available plant materials in the regions prone to low fertility status may be a useful management strategy for nutrient restoration. Our study provides the scientific validation of alder based system in enhancing the fertility status of abandoned Jhum land. In view of this, there is an urgent need to replicate alder based system for productivity enhancement in Jhum lands. In addition, to mitigate the impacts of climate change, the fallow Jhum lands can be considered as potential areas for alder reforestation for increasing the carbon stock.

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