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JEB
Journal of Environmental Biology

ISSN: 0254-8704
CODEN: JEBIDP

Nitrogen release pattern in decomposing leaf litter of banj oak and chir pine seedlings leaf under glass house condition

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Publication Info

Paper received:
04 November 2010

Revised received:
25 May 2011

Re-revised received:
29 September 2011

Re-re-revised received:
17 December 2011

Accepted:
17 March 2012

Abstract

Decomposition rate for leaf litter of banj oak (*Quercus leucotrichophora*) and chir pine (*Pinus roxburghii*), seedlings was studied over a period of one year, under glass house condition. The leaf litter of *Quercus leucotrichophora* decomposed faster as compared to *Pinus roxburghii*. Initially during 0-62 days of placement, the decomposition rate was slower for leaf litter of both species but after 123 days of placement it was 53% for *Quercus leucotrichophora* leaf litter and 33% for *Pinus roxburghii* leaf litter. The *Quercus leucotrichophora* leaf litter was completely decomposed after 11 months; however, 65% weight loss was recorded in *Pinus roxburghii* leaf litter after 12 months study. In *Quercus leucotrichophora* leaf litter the, initial (at the start of decomposition) nitrogen concentration was much higher (1.15%) than that of *Pinus roxburghii* leaf litter(1.41%), release of N was slower in chir pine leaf litter compared to banj oak leaf litter. Material with higher C/N ratio had longer duration of immobilization and in turn slower release phase. The concentration of N increased approximately linearly as a function of mass loss towards the end of annual cycle. Concentration of N was about 1.2 to 1.9 fold higher than the initial litter for seedlings of both the species.

Key words

Banj oak, Chir pine, Seedling, Leaf litter

Introduction

The decomposition of plant litter is one of the most crucial processes in the biogeochemical cycle of forest ecosystems (Tripathi *et al.,* 2006). It is to be regulated by soil organism, environmental conditions and chemical nature of the litter. Decomposition of root litter of *Quercus leucotrichophora* (banj oak) and *Pinus roxburghii* (chir pine) forests in central Himalaya was studied by Usman *et al.,* (2000). The quality of plant litter with respect to decomposition can be defined as its relative case of mineralization by decomposing organisms (Paustian e*t al.,* 1997). The C:N ratio is accepted as a general index of quality (Sebeviratne, 2000) in mineralization tends to decrease with increasing C:N ratio, second lignin contribution to recalcitrance of plant to decomposition by occluding more easily decomposable polysaccharides (Singh *et al.*, 1999).

Plant litter quality involves intrinsic characteristics of plant material that affects its assimilation by decomposers. Most of the experimental studies on plant litter quality define chemical quality indices using various ratios of C, N and lignin (Vanlauwe *et al.,* 1997) wealth of information is available on decomposition and dynamics of nutrient return of above-ground litter and on factors controlling these processes in different forest ecosystems of the world. (Vogt *et al.,* 1991; Bargali *et al.,* 1993; Singh and Gupta, 1997; Usman *et al.,* 2000). So far no report is available on decomposition of litter under controlled glasshouse conditions. Present study was designed to compare litter mass loss pattern of leaf litter decomposition of seedlings of two dominant tree species (*Q. leucotrichophora* and *P. roxburghii).*

Materials and Methods

The seedlings of *Quercus leucotrichophora* and *Pinus roxburghii* were planted in glass house in Nainital (Uttarakhand) for two years in 2002 and then harvested to examine the processes of decomposition. After harvest, the seedlings were air dried till constant weight was obtained. The leaf litter was separated from other organic matter by hands and filled in the litter bags (5 g leaf litter in each bags). The litter bag technique was used to quantify the decomposition rate following Upadhyay *et al.* (1989) and Bargali *et al.* (1993) . A total of 120 leaf litter bags were placed (60 for oak leaf litter and 60 for pine leaf litter) into 24 pots (12 for oak and 12 for pine leaf litter). Each pot containing 5 replicates were placed in glass house condition at Nainital during 2002 for leaf litter decomposition The size of each pot was 250 mm in diameter and 240 mm in height. The pots were filled with forest soil.12 pot filled with soil were placed in the glass house for oak leaf litter decomposition and 12 pots for pine leaf litter decomposition. The recovery of litter bags was done at one month intervals over a period of one year. Five litter bags of leaf litter were collected monthly for each species. The litter bags were placed in individual polythene bags and then transported to the laboratory. The residual material were carefully cleaned and brushed free of adhering soil and other debris. This material was dried at 60°C to constant mass and ground (<1 mm) in a Wiley Mill. Samples of initial as well as exposed material were analysed for N by the micro-Kjeldhal method (Jackson, 1958) and Carbon estimation Walkey and Black's titration method (Jackson, 1958).

Results and Discussion

Weight loss of litter continued during decomposition process over the annual cycle. Much faster weight loss was recorded after 62 days of placement of the litterbags. After 123 days of placement of seedlings, the decomposition rate was greater for banj oak (53%) and 33% for pine seedlings. Upadhyay *et al.* (1984) averaged decomposition for 4 months, in case of oak and pine leaves (40% and 21%, respectively.) According to Tripathi *et al.* (2006) the relative decomposition rate was higher in first growth period than the second one. Our study is consistent with the aforesaid findings. The oak leaf litter was completely decomposed after the placement of 11 months; however, after 12 months of placement the pine needle was not fully decomposed (65%).

To search for the temporal pattern of weight loss of leaf litter the natural logarithm of percentage weight remaining was regressed against the time elapsed (days). Bergali *et al.* (1993) argued that it is possible to fit such negative exponential curves between weight losses and time elapsed if one can assume a constant fractional weight loss from the material in the litter bags. The regression parameters for both the species were significant at $P<0.01$. The correlation coefficient ranged from 0.95 to 0.97. the relationships between days elapsed and relative mass leaf litter of both species.

In the present study the, the leaf litter of the oak seedling decomposed faster than that of pine, The rate of leaf decomposition of seedlings (%per day) was 0.33% for oak and 0.18% for pine. The decomposition rates for both oak and pine seedlings were higher than leaf litter of oak and pine tree under natural condition(Upadhyay *et al*. 1989). Low rate of decomposition in pine leaf litter due to the resistant pine leaf litter and low nitrogen content showed lower population of bacteria, actinomycetes and

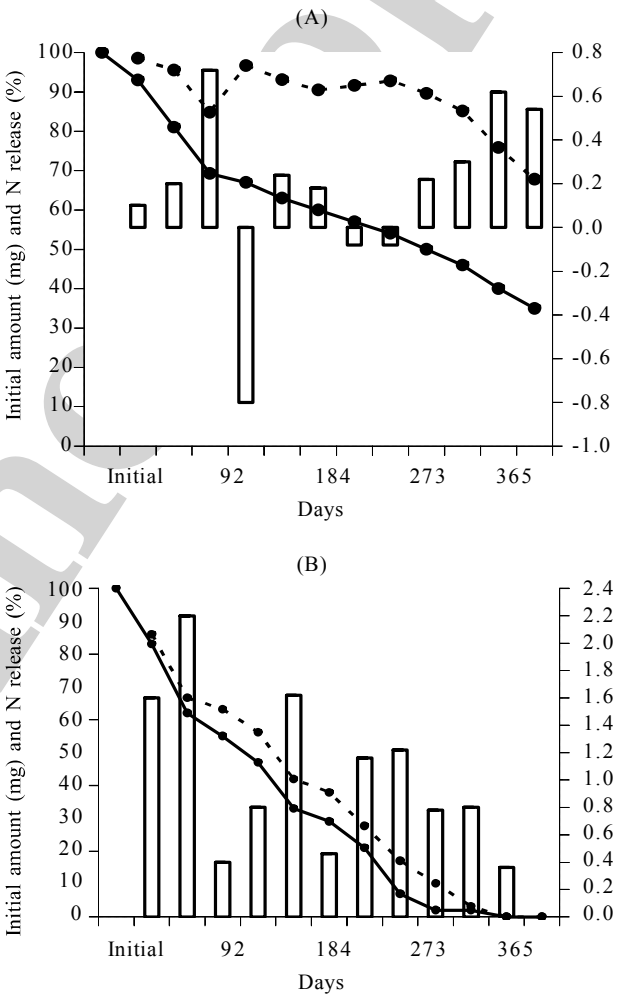

Fig. 1 : Percent change in absolute amount on nitrogen in the leaf litter mass of seedling component of (a) chir pine (*Pinus roxburghii*) and (b) banj oak (*Quercus leucotrichophor*a) enclosed in the litter bags.The percent change in the mass of nitrogen in the bags as Y axis. The column shows the net changes between measurement over a span of 365 days (right hand axis). Indicates the percent of mass remaining in the enclosed litter as Y axis

microarthropods (Cornelissen, 1996) as compared to oak. The poor physico-chemical properties were also responsible for the slow decomposition rate in chir pine needles. Wardle *et al.,* (2004, 2006) also found that fauna diversity often respond to quantity and quality change.This was also consistant with the findings of Atiqur Rehman *et al.* (2008), Levalle *et al.* (1993), Liu *et al.* (2002) and Xiao dong and Jin (2009). According to their findings the initial chemical composition of the litter showed significant positive correlation with decay rates, carbon and lignin content, lignin:N and C:N showed significant negative correlation with decay rates, and also found that high litter quality (low C/N ratio) would accelerate decomposition. Similarly in our study banj oak with high nitrogen content , low lignin content and low C/N ratio decomposed faster as compared to chir pine, having low nitrogen content, high C/N ratio and high lignin content.

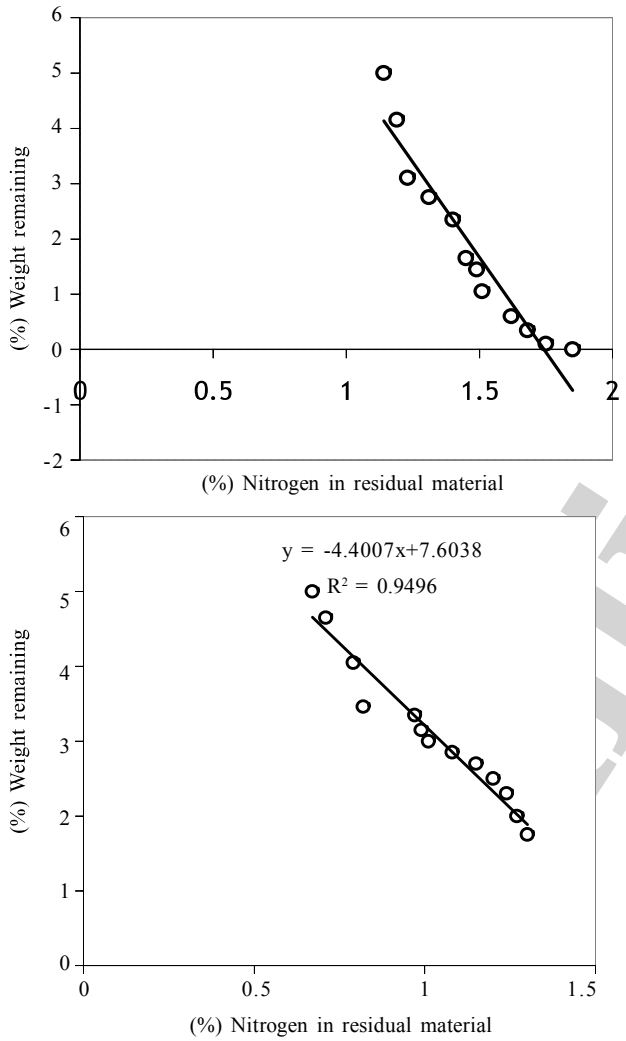

Fig. 2 : Linear regression between (%) nitrogen in the residual material and (%) weight remaining of the decomposing leaf litter of (a) banj oak (*Quercus leucotrichophor*a) and (b) chir pine (*Pinus roxburghii*) seedlings

Table 1 : Initial N-concentration and percent carbon , lignin and C/N ratio in different components of banj oak (*Q. leucotrichophora*) and chir pine (*Pinus roxburghii*) seedlings

	Banj oak	Chir pine
	% Nitrogen	
Green leaf	1.15	1.41
Leaf litter	1.22	0.63
Fine root	0.78	0.65
Soil	0.30	0.25
	% Carbon concentration	
Leaf litter	5.12	32.25
Root	3.65	1.50
Soil	2.45	3.02
Lignin		
Leaf litter	16.7	23.2
	C/N ratio	
Soil	8.2	16.7

There is a continuous release of N of residual material throughout the decomposition period in both oak as well as pine seedlings leaf litter, although the magnitude of the increase for both species defined considerably. In both banj oak and chir pine leaf litter, at the end of first year the N concentration was about 1.5-1.9 fold higher than that of initial material . (Fig. 1) The initial release was only 1.5 % in pine and 14.1% in oak leaf litter. The rate of N release from the leaf litter is positively correlated with initial N concentration; net immobilization increased with decreasing initial N concentration this was consistent with the findings of Daniela *et at.* (2009). According to them the increase in N concentration in decomposing leaf litter shown in this study is a generally occurring phenomenon brought about by microbial immobilization of N while C is mineralized (Berg, 2000) a significant negative relationship were found between N concentration in residual material and the percent weight remaining for both species (Fig 2). Usman *et al.* (2000) emphasized the significance of the relationship in the framework of immobilization and mineralization of N during decomposition. The weight loss in enclosed litterbag and increased concentration in the residual material reflect carbon metabolization and immobilization, respectively by microorganism. Initial nutrient composition especially lignin and N exert greater influence on N accumulation (Berg, 2000). In the present study, N accumulation in pine needles took place for a longer period as this species have lowest initial N concentration and highest lignin content compared to the oak (Table 1). Upadhyay and Singh (1985) and Tripathi *et al.* (2006) found that lignin fraction have relatively low availability to plant and cause low turn over for pine. From

the result is was found that the decomposition rate was directly related to substrate quality and its nutrient concentration (positively) and C/N ration (negatively). The leaf litter of banj oak seedlings with higher nitrogen concentration and low C/N ration completely decomposed after 11 months, however, chir pine (leaf litter of seedling) with low initial nitrogen concentration and high C/N ratio and high lignin content decomposed slowly as compared to banj oak forest.

Acknowledgments

The author gratefully acknowledges the financial support given by the Department of Science and Technology, New Delhi as Young Scientist as well as Woman Scientist.

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