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Decomposition of bamboo (*Dendrocalamus hamiltonii* Nees.) leaf-litter in relation to age of jhum fallows in Northeast India

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Summary Litter bags, containing bamboo (*Dendrocalamus hamiltonii* Nees.) leaf litter was used to compare the decomposition rates and microbial populations in litter under fallows of different ages. The age of the fallows were 0, 5 and 10 years. All were developed after Jhum (shifting) cultivation.

It was found that the fastest rate of decomposition occurred in the 10 year and the slowest in the 0 year old fallow. Changes in the litter components followed the following trend: sugar > amino acid > hemicellulose > cellulose > lignin.

Great fluctuations from month to month were found in the number of microbes. They reached their maximum during the rainy season. However, there was little variation in the composition of fungal taxa. Species of Penicillium, Trichoderma, Aspergillus, Cladosporium, Alternaria, yeasts and a dark sterile mycelia were dominant.

Introduction

Decomposition on the forest floor is a very complex phenomenon and is achieved by different groups of microorganisms. A major component of the top soil consists of different parts of plant materials. These are immediately colonized by various groups of organisms as they fall on the soil surface, and soon after the processes of decomposition start. Litter decomposition is also an important link in nutrient cycling of the forest[10].

Shifting cultivation, which is generally known as 'JHUM', is a very common agricultural practice in North-East India. The system involves the cutting and burning of vegetation, and after cultivating for 1 or 2 years the land is left as abandoned fallow due to the fast depletion of nutrients. During the fallow period accumulation of mineral nutrients and organic matter takes place under the secondary growth of vegetation[6,15,20]. Though many studies have been conducted on the decomposition and microbial colonization of leaf litter[4,5,8,11,14], very little information is available from this part of India.

This study investigated the rate of litter decomposition in relation to the age of fallow. It aimed to: i) evaluate the litter microflora, especially the mycoflora; ii) determine the seasonal trend in rate of litter decomposition in fallows of different ages; iii) assess the changes in the litter components like total carbohydrate, hemicellulose, cellulose and lignin of the decomposing litter.

Bamboo leaf-litter was selected for study because of the dominance of bamboo as secondary vegetation, and also because of its great economic value.

Table 1. Vegetation and soil physico-chemical characters of the jhum-fallows

Jhum-fallows (year)	Vegetation	Fire in	Soil texture	Soil pH	Moisture content (%)	Org. matter (%)	NH_4^+–N (ppm)	No_3^-–N (ppm)	Available P(ppm)
0	Herbaceous Vegetation, early colonizers like Imperata, Eupatorium Setaria and Paspalum dominant.	1978	Loamy sand	6.13	14.6	2.35	3.80	2.10	0.30
5	Second growth Bamboo dominant. Mixed hard woods sparsely distributed	1974	Loamy sand	6.00	25.4	3.69	5.10	1.15	0.28
10	Second growth Bamboo dominant, Also Schima, Cassia, Cedrella and Dillenia Species common.	1969	Loamy sand	5.79	28.0	3.16	10.91	0.74	0.32

All values are average of 12 observations.

Materials and methods

Study area

Field studies were conducted at Burnihat (Meghalaya), India, which is situated at an altitude of 100 m above the sea level (latitude 25°–26°N and longitude 90°–92.45°E). The climate of the region is subtropical. It is warm and moist from May to September, and December and January are usually the coldest months. The area receives an average annual rainfall of 2219 mm, and the minimum temperature is 7°C in the month of January. The soil is a lateritic sandy loam of pH 5–6.5.

When a field is abandoned, the site is rapidly occupied by weeds like *Imperata cylindrica*, *Eupatorium odoratum*, *Setaria palmifolia* and *Mikenia* sp. Later these species are replaced by woody species. Bamboo (*Dendrocalamus hamiltonii*) is the dominant second-growth vegetation in the older fallows. Table 1 gives a general picture of the three jhum-fallows of different ages that were studied.

Litter decomposition

The decomposition of bamboo leaf litter was determined over a period of one year in fallows of 0, 5 and 10 years of age. The nylon litter bag technique was used to study the decomposition of litter on the forest floor[3].

Fresh litter was collected from the experimental sites and air dried. The nylon bags were 20 × 20 cm with a mesh size of 0.1 mm. The bags were filled with 20 grams of litter, closed by folding over the open end, and stitched. On April 19, 1979 the bags were placed randomly on the forest floor and allowed to decompose under natural conditions. They were sampled on May 19, 1979 and the subsequently at monthly intervals. Five replicate bags were collected from each fallow. The litter bags were washed in a 200 μm mesh sieve to remove all the adhering extraneous matter and then dried at 80°C. The percentage weight loss of litter was calculated on an oven dry basis. The changes in litter components like cellulose, hemicellulose, lignin, sugar and amino acids were estimated by methods described by Peach and Tracey[17].

Isolation of litter microflora

The dilution plate method was used to estimate the litter microflora. One gram fresh weight of the litter sample was cut into strips 1 cm wide by a flamed pair of scissors, and a series of dilutions were prepared. Finally, 0.5 ml aliquots of 1:1000 dilution were pipetted into petridishes containing Peptone-dextrose-rose bengal agar medium for the isolation of fungi. The litter mycoflora was also estimated by the direct plating method by inoculating 5 segments of leaf (1 cm length) in the same medium. For the cultivation of bacteria and actinomycetes, a 1:10,000 dilution was considered suitable, and the medium used was nutrient agar and starch-casein agar respectively. Plates for fungi were incubated at 25 ± 1°C for 6 days, whereas bacterial and actinomycetes plates were incubated at 30 ± 1°C for 24 hours and 7 days respectively. Three replicates were maintained for each set.

Results

Rate of litter decomposition

The rates of bamboo litter decomposition in relation to the age of the fallows are presented in the Figures 1–3. There was not much variation between fallows of different ages. The decomposition was rapid during the first few months from May to September and then the rate gradually slowed down. The percentage original dry weight remaining after 1 year of decomposition varied from 20–28% (Fig. 1).

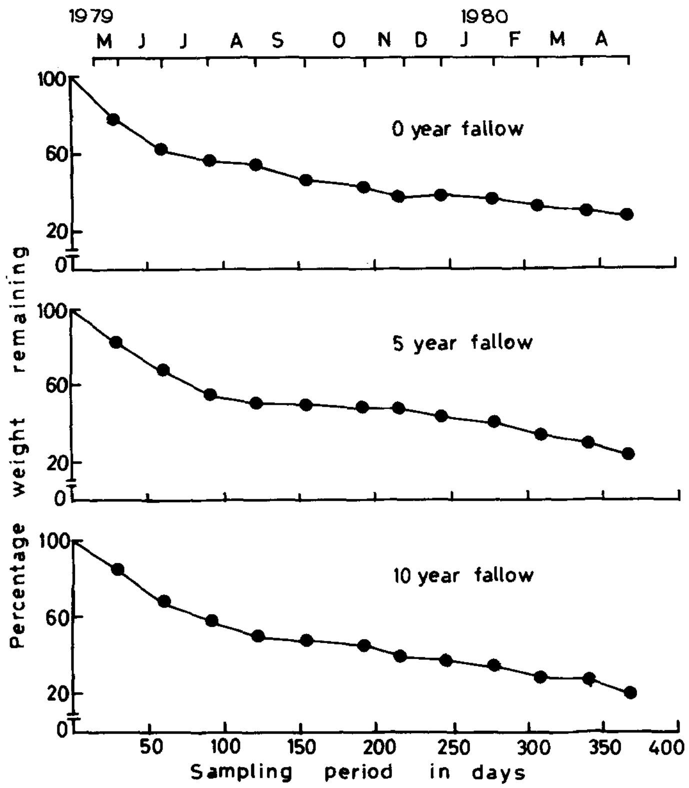

Fig. 1. Rate of bamboo litter decomposition under three Jhum-fallows.

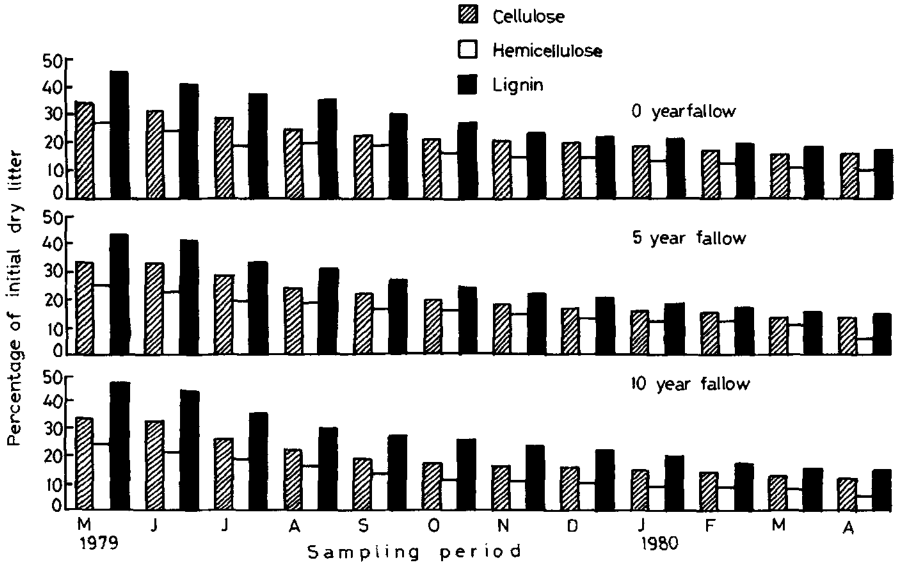

Fig. 2. Percentage of cellulose, hemicellulose and lignin of bamboo litter remaining after various periods of decomposition.

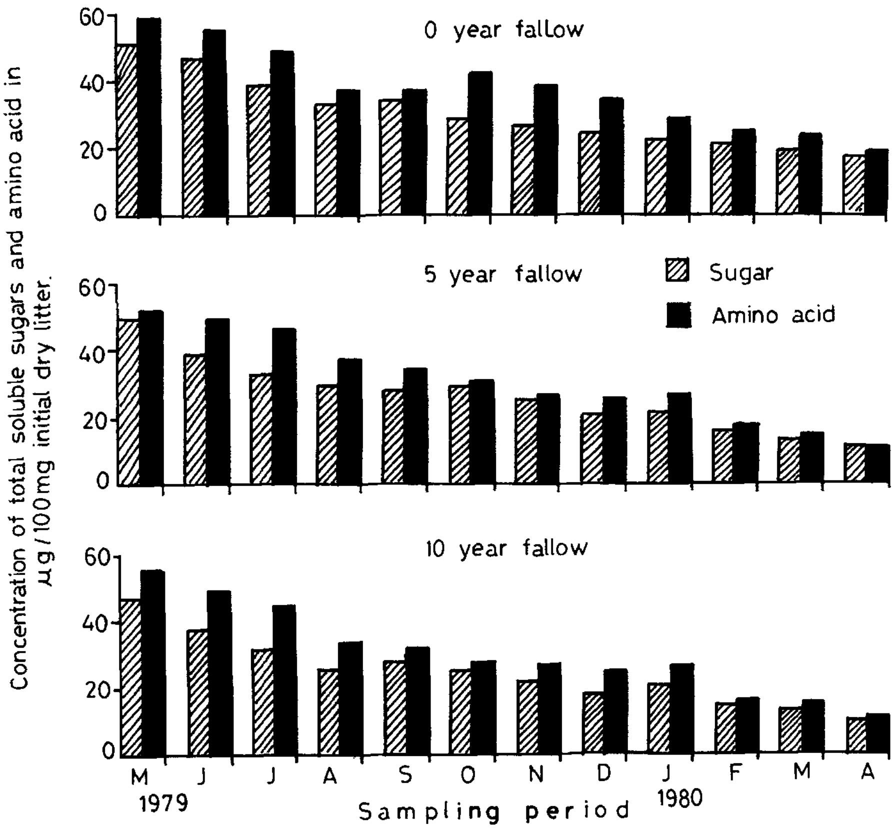

Fig. 3. Concentration of total sugar and amino acid of bamboo litter remaining after various periods of decomposition.

Soil arthropods were found in the litter bags of 0 year old fallow, whereas they were negligible in the other two fallows. Further, at the end of the experiment, the litter bags of the 0 year fallow were filled with soil, which was probably due to the insects activity alone.

The loss of litter components (cellulose, hemicellulose, lignin) followed a pattern similar to that of the total dry weight. In general, the rate of hemicellulose breakdown was the fastest followed by the cellulose and lignin (Fig. 2). The changes in the concentration of total carbohydrates (*i.e.* sugar and amino acid) also exhibited a similar trend. The rate of loss was similar in all the fallows (Fig. 3).

Litter microbial population

The fungal flora of the litter under the 0 and 5 year fallow followed a similar trend in distribution, and they were maximum during the month of July when the litter was moist. However, mycoflora of the litter placed under 10 year old fallow rose again suddenly during October when the litter was drying (Fig. 4). The population of bacteria and actinomycetes also exhibited a similar trend at all the

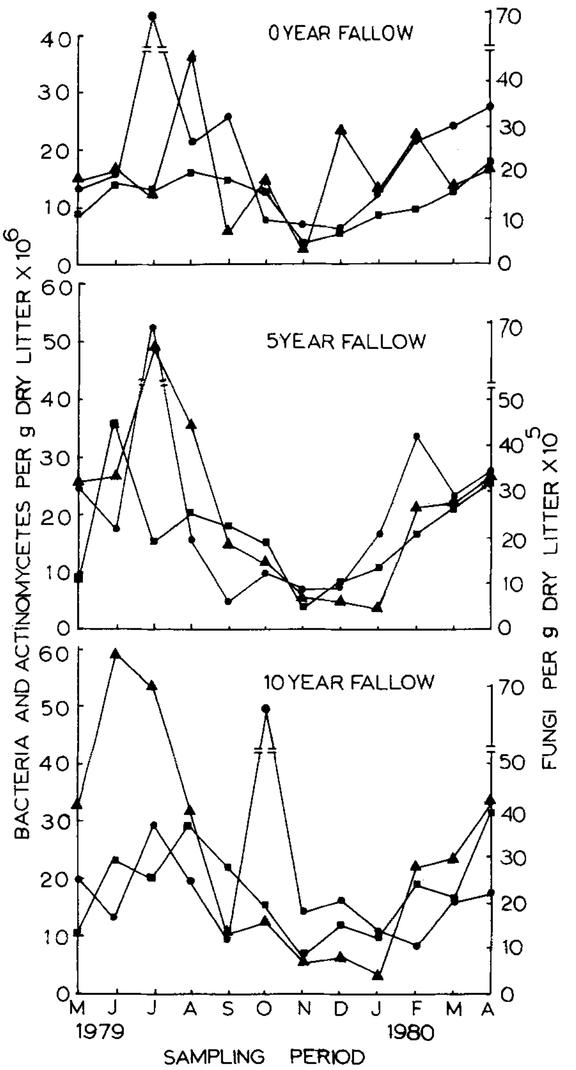

Fig. 4. Seasonal variation of fungi, bacteria and actinomycetes population of decomposing bamboo leaf litter (● = fungi; ▲ = bacteria; ■ = actinomycetes).

sites. The population isolated from the 0 year old fallow was lower than the other two. In general, the population was maximum during June–July and then decreased towards the later part of the decomposition (Fig. 4).

The fungal species isolated both by dilution plate and direct plating methods are summarized in Tables 2 and 3. A total of 22 fungal species were identified from the decomposed litter all of which are common soil fungi. The fungal taxa occuring in the litter at the three sites were similar. The dominant fungal genera were: Penicillium, Trichoderma, Aspergillus, Cladosporium and Alternaria. Besides these forms, filamentous yeasts (*Sporobolomyces roseus* and

Cryptoccoccus sp.) and a dark sterile mycelia were also the dominant taxa associated with the litter samples. Probably yeasts were amongst the most active organisms involved in the process of decomposition. It has also been noticed that the phycomycetes were rare in the litter.

Discussion

In the present investigation the rate of bamboo leaf litter decomposition was found to be rapid. The fast rate of decomposition can be attributed mainly due to the soft cuticle, low lignin content, high moisture content and suitable temperature. Many workers have reported that changes in the relative proportions of chemical consituents of litter may influence the rate of decomposition[18,19]. The decomposition rate of litters in all the fallows was accelerated during the rainy season from May to September, and this probably includes some loss by leaching. At this period the microbial population was also quite high. A leaching of soluble nutrients from the litters may have provided a suitable substrate for microbial growth. It has been suggested that the high

Table 2. Percentage relative abundance of fungal species isolated by dilution-plate method from bamboo litter. Values are mean of 12 observations

Fungi isolated	Fallows		
	0 year	5 year	10 year
Cunninghamella echinulata	–	–	0.58
Gongronella sp.	–	–	0.13
Mucor hiemalis	1.32	0.74	0.77
Acremonium sp.	1.27	2.22	1.62
Alternaria alternata	6.67	5.16	2.32
Aspergillus niger	10.63	8.75	5.46
A. fumigatus	0.79	1.26	0.83
A. flavus	1.15	1.15	–
Bahusakala sp.	1.17	–	–
Cephalosporium coremioides	3.08	1.32	1.99
Chaetomium globosum	0.27	2.04	–
Cladosporium herbarum	10.55	13.23	10.21
Curvularia lunata	0.12	0.33	0.71
Fusarium solani	3.01	1.24	2.69
Mycogone sp.	–	0.26	–
Penicillium chrysogenum	6.78	9.66	9.68
P. humicola	2.20	1.29	3.21
Phoma sp.	–	1.01	–
Thialaviopsis sp.	0.28	–	–
Trichoderma viride	12.22	17.07	10.61
Yeasts	35.47	30.23	47.12
Sterile black mycelia	3.02	3.04	2.07

Table 3. Fungi isolated from the litters by direct plating method

Fungi recorded	Fallows		
	0 year	5 year	10 year
Cunninghamella echinulata	+	+	+
Mucor hiemalis	+ +	+ +	+ +
Rhizopus nigricans	+	+	+
Alternaria alternata	+ +	+ +	+ +
Asptergillus niger	+ + +	+ + +	+ + +
Aspergillus sp.	+ +	+ +	+ +
Ascomycetes sp. (unidentified)	+	+	+
Cladosporium herbarum	+ +	+ + +	+ + +
Fusarium solani	+ +	+ +	+ +
Penicillium sp.	+ + +	+ + +	+ + +
Phoma sp.	+	+	+
Pythium sp.	+	+	+
Trichoderma viride	+ + +	+ + +	+ + +
Yeasts	+ +	+ +	+ +
Sterile black mycelia	+ +	+ +	+ +

+ + +, dominant; + +, common; +, rare.

decomposition rate of litter is due mainly to leaching effect rather than biological activity[2,9]. However, no attempt has been made in this work to assess the weight loss due either to leaching effect or soil fauna.

The rate of litter breakdown was similar in all the fallows. However, statistically no significant difference ($P < .05$) in the weight loss was recorded for the litter decomposition between the fallows. Ewel[7] reported that negligible difference exist in decomposition rates in various successional stages in forest in Guatemala. However, when the exponential decay model (Olson[16]) was applied, it was found that in 10 year fallow 95% life is 719.96 days, while in 0 year fallow it is 955.05 days. The decomposition rate (k) and 95% life values are of a comparable order of magnitude to those of Lawrey[12,13] and MacLean and Wein[14]. Possibly the greater fluctuations in daily temperatures and other environmental factors on the open surface retards the decomposition rate. In a similar study, Ewel[7] stated that such conditions are generally more rigorous for decomposer organisms than those found in the litter beneath a vegetation cover.

The loss of each chemical component was quite regular throughout the study period. Sugar and amino acid, being soluble, lost more readily than other macromolecules. In general, the loss of components was in the following order: sugar > amino acid > hemicellulose > cellulose > lignin. Alexander[1] also concluded that during decomposition hemicellulose disappeared at a more rapid rate than cellulose and lignin.

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References

1 Alexander M 1961 Introduction to soil microbiology. John Wiley and Sons, Inc., New York.
2 Anderson J M 1973 The breakdown and decomposition of sweet chestnut (*Castanea sativa* Mill.) and beech (*Fagus sylvatica* L.) leaf litter in two deciduous woodland soils. I. Breakdown, leaching and decomposition. Oecologia 12, 261–274.
3 Bocock K L, Gilbert O J, Capstick C K, Twinn D C, Waid J S and Woodman M J 1960 Changes in leaf litter when placed on the surface of soils with contrasting humus types. I. Losses in dry weight of oak and ash leaf litter. J. Soil Sci. 11, 1–9.
4 Cuevas V C and Uyenco F R 1977 Mycoflora of decomposing leaf litters. Nat. Appl. Sci. Bull. 29, 107–169.
5 Edmonds R L 1979 Microbiological characteristics of dewatered sludge following application to forest soils and clear cut areas. *In* Utilization of municipal sewage effluent and sludge on forest and disturbed land. Eds. W E Sopper and S N Kerr. Penn. State University Press. University Park, 537 p.
6 Ewel J J 1971 Biomass changes in early tropical succession. Turrialba 21, 110–112.
7 Ewel J J 1976 Litterfall and leaf decomposition in a tropical forest succession in eastern Guatemala. J. Ecol. 64, 293–308.
8 Frankland J C 1966 Succession of fungi on decaying petioles of *Pteridium aquilinum*. J. Ecol. 54, 41–63.
9 Gosz J R, Likens G E and Bormann F H 1973 Nutrient release from decomposing leaf and branch litter in the Hubbard Brook Forest, New Hampshire. Ecol. Monogr. 43, 173–191.
10 Grigal D F and McColl J G 1977 Litter decomposition following forest fire in northeastern Minnesota. J. Appl. Ecol. 14, 531–538.
11 Ivarson K C 1973 Fungal flora and rate of decomposition of leaf litter at low temperatures. Can. J. Soil Sci. 53, 79–84.
12 Lawrey, J. D. 1977 The relative decomposition potential of habits variously affected by surface coal mining. Can. J. Bot. 55, 1544–1552.
13 Lawrey J D 1978 Trace metal dynamics in decomposing leaf litter in habitats variously influenced by coal strip mining. Can. J. Bot. 56, 953–962.
14 MacLean D A and Wein R W 1978 Weight loss and nutrient changes in decomposing litter and forest floor material in New Brunswick forest stands. Can. J. Bot. 56, 2730–2749.
15 Nye P H and Greenland D J 1960 The soil under shifting cultivation. Tech. Comm. No. 51, Comm. Bur. Soils, Harpenden.
16 Olson J S 1963 Energy storage and the balance of producers decomposers in ecological systems. Ecology 44, 322–331.
17 Peach K and Tracey M V 1955 Modern methods of Plant analysis (ed.) Vol. I. Springer Verlag, Berlin, 542 p.
18 Singh K P 1969 Studies in decomposition of leaf litter of important trees of tropical deciduous forests at Varanasi. Trop. Ecol. 10, 292–311.
19 Van Cleve K 1974 Organic matter quality in relation to decomposition. *In* Soil organisms and decomposition in tundra. Eds. Holding, Heal, MacLean Jr., and Flanagan. Swedish IBP Committee, Stockholm, Sweden. pp 311–324.
20 Zinke P J, Sabhasri S and Kunstadter P 1970 Soil fertility aspects of the Lua forest fallow system of shifting cultivation. International seminar on shifting cultivation and Economic Development in Northern Thailand, Land Development Department, Bangkok, Thailand. pp 251–293.