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Biodegradation of leaf litter in the warm humid tropics of Kerala, India

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Abstract

Ex situ biodegradation of *Mangifera indica* L, *Artocarpus heterophyllus*.Lamk. and *Anacardium occidentale* L. leaf litter were examined in the warm humid tropics of southern Kerala adopting the standard litter bag technique. The time taken for the decay varied with the species and it followed the order *Mangifera* > *Artocarpus* > *Anacardium*. Weight loss accorded a linear decline and was better correlated with soil moisture than temperature. The half-life values were 3.2, 3.4 and 4.0 months for *Anacardium*, *Artocarpus* and *Mangifera*, respectively. Soil faunal and floral activities were monitored during the decay and the earthworms, fungi and bacteria proved the chief degraders of the intact litter. Actinomycetes were active during the final stages. The variations in decay rates of the three species are attributed to the differences in the litter quality and activity of the decomposer organisms in soil. NPK dynamics revealed temporary phases of immobilization for nitrogen and phosphorus before final release, while potassium recorded a continuous release. Decomposition apparently improved the available NPK status of soil, potassium being liable to leaching was soon lost from the surface soil.

Keywords: Actinomycetes; Bacteria; Decay rate; Earthworms; Fungi; Half-life; Immobilization; Leaching; Nutrient release

1. Introduction

Leaf litter is a potential, but unexploited, source of nutrient inputs in agriculture. Litter decomposition enriches the soil nutrient pool and also supports the saprophagic components of soil. However, the rates of decay and pathways of decomposition are determined by the quality of the litter material, the physical environment and the qualitative and quantitative composition of decomposer organisms (Swift et al., 1979). A slow rate of decay results in accumulations of organic matter and nutrient stocks in soil, while a fast rate of decay helps to meet the plant uptake requirements of annual crops. The use of litter can hence be as a mulch material and or as an organic fertilizer, depending upon the respective decomposition characteristics. Intrusive studies have been carried out worldwide on the litter dynamics of forest trees, but those pertaining to the popular multipurpose horticultural trees wherein ample quantities of litter are available (Mathew et al., 1996), are few. Keeping this in view, a field experiment was attempted on the decay of mango (*Mangifera indica* L.), jack (*Artocarpus heterophyllus* Lamk.) and cashew (*Anacardium occidentale* L.) foliage, three popular fruit trees of Kerala, India under ex situ conditions. The three selected trees are popular in the State for their multifarious uses, especially delicious fruits/nuts and timber. *Mangifera indica* and *Artocarpus heterophyllus* form a part and parcel of rural life and are components of almost all homesteads in Kerala. *Anacardium occidentale* is a multifaceted industrial and commercial crop contributing significantly to the agricultural and socioeconomic scenario of Kerala. The major share of the India's export of cashew kernels is from Kerala. Studies on the litter fall of these trees species revealed substantial litter and nutrient additions in homestead ecosystems (Mathew et al., 1996). The objectives of the present investigation were (i) to assess the decomposition characteristics of the leaf litter of the three species, (ii) to evaluate the nutrient release pattern from litter, (iii) to monitor the biological regulation of decay, and (iv) to assess changes in the available NPK status of soil with the decay.

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2. Materials and methods

2.1. Site description

The litter bag study was conducted in an open site at Vellayani, 17 km South of the Kerala state capital, Thiruvananthapuram (latitude 8.5°N, longitude 76.9°E, altitude 40 m above MSL). The site experienced a warm humid tropical climate. The annual rainfall of the ecozone was 1619 mm, mean minimum and maximum temperatures 24.1 and 30.7 °C, respectively (Fig. 1). The soil was of sandy clay loam texture and belonged to the oxisol group with a pH of 4.84. Prior to the experimental period, the area was covered with fodder grasses for three seasons.

2.2. Field experiment

Decomposition of the leaf litters of (*Mangifera indica* L.), (*Artocarpus heterophyllus* Lamk.) and (*Anacardium occidentale* L.) were studied using the standard mesh bag technique. Freshly fallen litter of each species were collected from mature bearing trees in a nearby agro forestry home garden (gross cropped area = 0.74 ha; cropping intensity = 187%) during March–April 1998 and air-dried for 2 days in shade to prepare the litter material for decomposition. Twenty grams of the air-dried material were placed within 25 × 20 cm litter bags (mesh size 4 mm) and 200 such single species bags were prepared for each species. An air-dry to oven-dry mass conversion factor was determined by oven-drying separate samples at 70 °C for 48 h. The bags were randomly staked on the soil surface in the plot marked for each species (10 × 5 m^2) on 1st May. Samples were drawn at monthly intervals from the month of June until 95% weight loss occurred. Five bags were retrieved in each species during every sampling. The bags were brought to the lab, contents of each bag carefully brushed and gently rinsed to remove visible soil particles, oven dried at 70 °C for 48 h and weighed to record the weight loss.

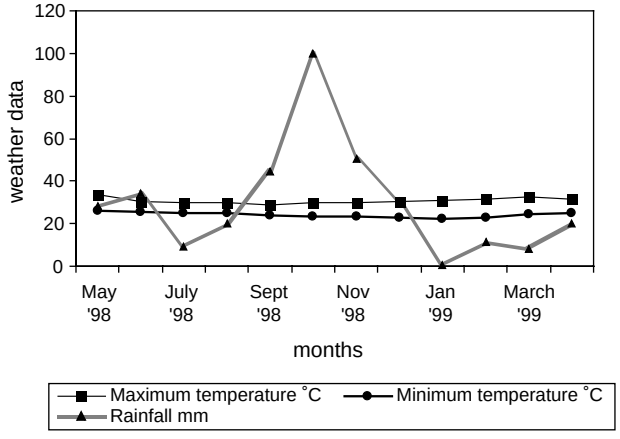

Fig. 1. Weather data.

2.3. Nutrient and biochemical analysis

Samples of the initial litter material of the three species and those retrieved during each sampling were finely ground and subjected to NPK analyses (Jackson, 1973).

The biochemical constituents: cellulose, lignin and total phenol contents were analysed in the initial materials according to the procedures described by Sadasivan and Manickam (1992). The acid detergent fibre method was used for lignin estimation and Folin Ciocalteau method for total phenols. The former was determined by refluxing the sample material with acid detergent solution (cetyl trimethyl NH_4Br, 20 g, in 1 N H_2SO_4) and the left out material was weighed after filtration and drying. The residue was treated with 72% H_2SO_4, filtered, dried and ashed. The loss of weight on ignition gives the acid detergent lignin. Total phenols was estimated by extraction in ethanol (80%) and the extractant was allowed to react with phosphomolybdic acid in the Folin Ciocalteau reagent in an alkaline medium (Na_2CO_3). The blue colour developed was measured at 650 nm against reagent blank using catechol as standard.

2.4. Soil biology

Soil samples for assessing earthworm, fungi, bacteria and actinomycete populations were taken from the plots before the start of the experiment and subsequently, at monthly intervals.

2.4.1. Earthworm count

Soil samples of 0.1 m^2 area and 0.1 m deep were taken from each plot and sorted against a pale coloured background for easy detection of the earthworms and cocoons. Counts from five different parts served as replications during each assessment.

2.4.2. Isolation of microorganisms

The microbial counts (bacteria, fungi and actinomycetes) were taken from soil samples lying immediately beneath the decomposing litter (top 10 cm). The dilution plate technique (Parkinson et al., 1971) was employed for the isolation. Fungi were cultured in Rose bengal agar media, bacteria in soil extract agar media and actinomycetes in Conn's glycerol asparaginate agar media. The colony counts were taken after incubation at room temperature (28–32 °C) for 5, 7 and 12 days, respectively. The data were used to compute the average number of microorganisms per gram oven dry weight of soil.

The soil moisture and soil temperature at 15 cm depth were recorded at monthly intervals. Soil moisture was measured gravimetrically and soil temperature, using soil thermometers. The measurements were made at 1100 h.