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LEAF LITTER DECOMPOSITION AND NUTRIENT RELEASE IN A FIFTEEN YEAR OLD RUBBER PLANTATION

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Leaf litter addition, decomposition and nutrient release therefrom in a fifteen year old rubber plantation were studied. The study revealed that 4824 kg/ha of leaf litter was added and 92 per cent of which decomposed in a period of six months releasing 88 kg N, 2.4 kg P, 45 kg K, 60 kg Ca, 16 kg Mg, 1.5 kg Mn and 0.25 kg Zn.

Key words : Litter decomposition, Nutrient addition.

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INTRODUCTION

Litter production and its decomposition are important aspects of nutrient cycling in natural forests and plantations since this acts as one of the input–output systems for nutrients. The forest / plantation floor is built up mainly by addition of litter. Decomposition is the primary mechanism by which the nutrients in litter are returned to soil. The amount, chemical composition and rate of decomposition of litter regulate the energy flow and nutrient cycling of a forest ecosystem (Ovington, 1962; Newbould, 1967). The rate of decomposition depends upon the climatic factors, soil organisms and chemical composition of the litter (Williams and Gray, 1974).

Rubber tree (*Hevea brasiliensis*), a native of the Amazon river basin has a defoliation cycle by which large quantities of litter is added to the soil. Among the different litter components, decomposition of leaf litter accounts for the major portion of nutrients added. This study was taken up to quantify the leaf litter production in a rubber plantation and to understand the pattern of nutrient addition through decomposition.

MATERIALS AND METHODS

The study was conducted during 1995-1996 at Central Experimental Station of the Rubber Research Institute of India at Chethackal (latitude 9° 22' N, longitude 76° 50' E and at an altitude of 80 m) in a 15 year old rubber plantation of clone RRII 105. The rainfall received during 1996 was 2979 mm. Mean maximum temperature varied from 29.1 to 36.4°C and minimum temperature from 20.2 to 24.1°C (Fig.1).

Twelve litter traps of size 1m x 1m were set up in the plantation floor at random in an area of one hectare during December 1995 before the commencement of leaf fall. The leaves fallen during wintering were allowed to deposit in the litter traps. When wintering was over during February 1996, the litter traps were covered with plastic nets to

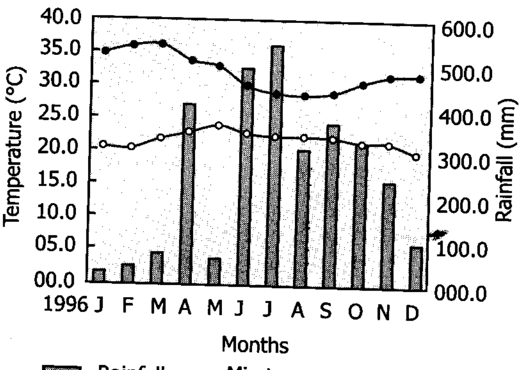

Fig. 1. Mean maximum and minimum temperature and rainfall at CES, Chethackal during 1996

prevent further addition of leaves. The initial weight of the leaf litter collected in each trap was recorded. Subsequently, the weight of the litter remaining in each trap was recorded at monthly intervals. About 20 g of litter samples were drawn every month from each trap, washed, oven dried at 70°C and weight recorded. The contents of N, P, K, Ca, Mg, Mn and Zn of these samples were determined following standard procedures (Piper, 1950).

RESULTS AND DISCUSSION

The initial weight of the leaf litter was found to be 4824 kg/ha. Monthly variation in dry weight of the litter up to August 1996 is given in Table 1. It was observed that by August, 92 per cent of the original litter was completely decomposed. A gradual increase in the rate of decomposition was noted from February and it was highest during June. Thereafter the decomposition became slow. The initial rapid decomposition may be due to the leaching of inorganic as well as soluble organic compounds such as carbohydrates, proteins etc. from the litter during the initial stage as reported by Swift *et al.* (1979). The slow rate of decomposition during the last two months may be due to the accumulation of resistant components like lignin and cellulose. The high decomposition during the rainy season may be due to the increased activity of soil microflora and mesofauna. Singh (1969) and Mentameyer (1978) reported that climatic conditions and changes in the relative proportions of chemical constituents of litter influence the rate of decomposition.

The monthly variation in nutrient content of the decomposing leaf litter is given in Table 2. During decomposition varying degrees of nitrogen immobilisation was observed. The concentration of N in the decomposing litter was higher during the first two months and then a reduction was observed in the third month. Thereafter an increase in N content was observed. As the decomposi-

Table 1. **Monthly variation in dry weight of rubber leaf litter**

Month	Dry weight (kg/ha)	Decomposition of litter (% of original)	
		During the months	Cumulative
February (1996)	4824	0	0
March	4115	15	15
April	3488	13	28
May	2495	20	48
June	1191	27	75
July	589	13	88
August	388	4	92

Table 2. **Mean monthly variation in nutrient content of decomposing rubber leaf litter**

Month	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Mn (ppm)	Zn (ppm)
Feb (1996)	1.96 (0.05)	0.055 (0.002)	0.94 (0.03)	1.37 (0.05)	0.34 (0.01)	346 (9.8)	60 (1.2)
Mar	2.06 (0.04)	0.062 (0.002)	0.84 (0.02)	1.43 (0.03)	0.35 (0.005)	331 (13.9)	62 (1.3)
April	1.52 (0.07)	0.059 (0.001)	0.27 (0.01)	1.30 (0.06)	0.28 (0.01)	352 (11.5)	71 (2.3)
May	1.67 (0.05)	0.058 (0.001)	0.26 (0.01)	1.57 (0.05)	0.27 (0.009)	421 (11.5)	76 (3.2)
June	1.75 (0.06)	0.062 (0.001)	0.23 (0.01)	1.51 (0.05)	0.21 (0.008)	375 (10.7)	82 (2.1)
July	1.77 (0.08)	0.064 (0.002)	0.22 (0.01)	1.55 (0.05)	0.19 (0.006)	426 (15.7)	84 (1.1)
Aug	1.77 (0.04)	0.064 (0.002)	0.21 (0.01)	1.63 (0.04)	0.18 (0.006)	481 (27.1)	96 (3.3)

Standard errors in parentheses

tion proceeded P, Ca and Zn content in the leaf litter increased over the months with slight fluctuations, whereas the K and Mg content decreased markedly. In the case of Mn no definite pattern was observed. However, in all cases the absolute values declined along with the loss of weight of decomposing litter.

Nutrient release or accumulation during decomposition is the net result of mineralisation, leaching and the import and export of nutrients through microbial activity, and abiotic process (O'Connell, 1988). Plant nutrients are released from litter either by physical leaching or by breakdown of structural organic components by soil micro organisms. The differential behaviour of the elements could largely be explained by their concentration in litter in relation to the needs of micro-organism and to their solubility. Elements that limit microbial growth is expected to be retained or accumulated in litter to a certain minimum concentration and thereafter released at the same rate as original weight loss, while elements that do not limit are released during the whole decomposition period (Berg and Staff, 1981).

The initial increase in N content may be attributed to the more rapid loss of carbon than nitrogen and immobilisation of N by micro-organisms. The observed decline in N content later indicates faster rate of leaching. The probable reason for the increase in concentration of P in decomposing litter is the immobilisation of the element by the microbial population infesting the litter. Nutrient dynamics is further influenced by the nature of chemical bonds, which attach the elements to the organic matter. Elements such as K and Mg, which are either not structural parts of the litter or are only partly so are susceptible to leaching losses (Staff, 1980). This would possibly explain the rapid decline in K and Mg content.

To evaluate the nutrient release pattern, nutrients remaining in decomposing leaf litter were estimated by the equation used by Bockhelm *et al.*, (1991) and presented in Fig 2.

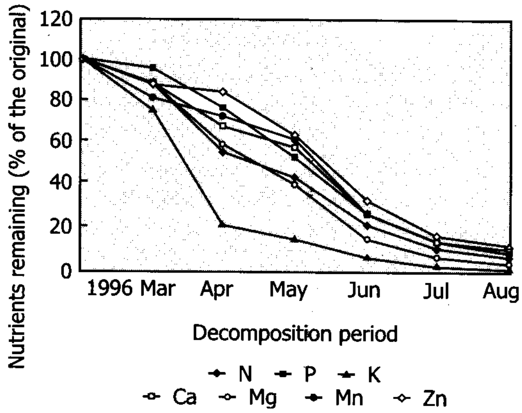

Fig. 2. Changes in relative proportions of nutrients (as % of the original) remaining in decomposing litter (1996)

$$\text{Nutrient (\%) remaining} = \frac{C \times DM \times 100}{C_0 \times DM_0}$$

where C and C_0 are the concentration of nutrient element and DM and DM_0 are the mass of dry matter of the litter at the time of sampling and at the beginning of the study respectively.

The nutrients showed variations in their relative concentration during decomposition. Zinc was retained most strongly and Potassium the least. The rate of decrease of each element was statistically analysed and it was found to be significant for each element, but between elements all were at par except K (Table3). The nutrient concentration after a period of decomposition depends upon the

Table 3. **Rate of decomposition of nutrients**

Nutrient	Rate of decomposition
N	-12.15
P	-13.98
K	- 9.40
Ca	-12.53
Mg	-12.25
Mn	-12.49
Zn	-12.62

Table 4. **Nutrients released (kg/ha) during the decomposition of rubber leaf litter**

Month	N	P	K	Ca	Mg	Mn	Zn
March(1996)	9.78	0.10	10.78	7.24	2.00	0.31	0.03
April	31.75	0.49	25.15	13.50	4.64	0.14	0.01
May	11.36	0.62	2.93	6.17	3.02	0.17	0.06
June	20.82	0.70	3.75	21.19	4.24	0.60	0.10
July	10.42	0.36	1.45	8.85	1.38	0.20	0.04
August	3.61	0.13	0.48	2.81	0.42	0.06	0.01
Total	87.74	2.40	44.54	59.76	15.70	1.48	0.25

rate of weight loss, mobility of the nutrient in consideration and the critical nutrient requirements of soil organisms. Mobility of the nutrients from decomposing rubber leaf litter was observed in the order of K > Mg > N> P > Ca > Mn > Zn.

Nutrients released from the rubber leaf litter is given in Table 4. It was noted that maximum release of N, K and Mg occurred during April whereas for P, Ca, Mn and Zn it occurred in June. Nutrient addition through 92 per cent decomposition of rubber leaf litter was estimated and it was found that 88 kg N, 2.4 kg P, 45 kg K, 60 kg Ca, 16 kg Mg, 1.5 kg Mn and 0.25 kg Zn were returned to the soil by the leaf litter in a hectare.

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