Indian Journal of Natural Rubber Research, **14(2)** : 116 - 124, 2001.

ADDITION OF LITTER, ITS DECOMPOSITION AND NUTRIENT RELEASE IN RUBBER PLANTATIONS IN TRIPURA

Mary Verghese, A.C. Sharma and Jacob Pothen

Verghese, M., Sharma, A.C. and Pothen, J. (2001). Addition of litter, its decomposition and nutrient release in rubber plantations in Tripura. *Indian Journal of Natural Rubber Research*, **14(2)** : 116 - 124.

A study of litter fall from rubber trees, litter in standing crop and their decomposition was carried out for a period of two years at Agartala, Tripura, North East India. Annual litter fall was estimated in a 14 year old rubber plantation of clone RRIM 600 which had a density of 317 mature rubber trees per ha. Litter samples were collected at monthly intervals from 12 traps randomly placed in an area of one ha. The total annual litter fall ranged from 6.8 to 7.8 t per ha. Leaf litter accounted for 66 per cent of the total litter and the major portion of the leaf fall occurred from January to March. There were no significant differences in litter production between two consecutive years. Maximum litter in standing crop occurred in March and it decreased progressively as the rates of decomposition increased. Nutrients ranging from 94 to 130 kg of N, 5 to 6 kg of P, 22 to 25 kg of K, 106 to 168 kg of Ca and 17 to 33 kg of Mg were returned to the soil through total litter fall. Decomposition of leaf and petiole litter was studied for a period of 360 days. After 120 days a weight loss of 16-21 per cent was observed for leaf litter, whereas a higher weight loss of 28-30 per cent was observed for petiole litter indicating faster decomposition of petioles. As the decomposition progressed, the concentrations of K, Mg and Ca decreased markedly. Decomposition quotient (K_L) for leaves ranged from 1.97 to 2.92, for twigs from 3.24 to 4.06 and from 2.28 to 3.20 for petioles. The total quantity of leaf fall in the mature plantation in Tripura and the nutrient return through litter was comparable to that in the traditional rubber growing tracts.

Key words : Decomposition, *Hevea brasiliensis*, Litter, Nutrient release.

Mary Verghese (for correspondence), Jacob Pothen, Rubber Research Institute of India, Central Experiment Station, Chethackal, Ranny – 689 676, Kerala, India; A.C. Sharma, Rubber Research Institute of India, North East Research Complex, Agartala – 799 006, Tripura, India.

INTRODUCTION

The rubber tree, *Hevea brasiliensis*, is native to the rain forests of the Amazon basin lying within 5° latitudes south and north of the equator. The climate prevailing in this region is of wet equatorial type (Strahler, 1969) with no marked dry season. Commercial plantations of the crop were first extended to South East Asia in areas with similar latitude and climate. In India, rubber cultivation was confined till 1960 to the South West part of the country, mostly in Kerala State and Kanyakumari district of Tamil Nadu and also in the Andaman and Nicobar islands located between 8 to 12°N latitudes (Krishnakumar and Meenattoor, 2000). However, due to the non-availability of land in the traditional belt, rubber cultivation has been extended to non-traditional regions (Menon, 1980; Menon and Unny, 1990). Attempts to grow rubber in India at 20 to 28°N and in China at 18 to 24°N have been successful, in spite of the fact that the crop faces various stress conditions in these areas (Krishnakumar and Meenattoor, 2000). Rubber cultivation is being undertaken in large tracts in this state giving it the second place in the country in terms of area under rubber cultivation. Although rubber cultivation has become popular in Tripura, being an introduced crop, it is necessary to understand the ecological impact of this crop on a long-term basis.

Rubber plantations present a 'closed' ecosystem with a constant cycle of uptake and return of nutrients from and to the soil (Watson, 1989). Being deciduous in nature, the rubber trees shed almost all the leaves annually during January-February, a process termed as 'wintering'. The leaves, thus shed along with petioles, get accumulated on the plantation floor, which accounts for the major pathway of biomass recycling in rubber. The maintenance of soil fertility and the process of soil formation in the long run will be greatly influenced by the nature and quantity of litter fall. The importance of understanding litter dynamics lies not only in the key role it plays in the carbon and nutrient dynamics of ecosystems (Anderson and Swift, 1983) but also because litter cover reduces splash erosion and surface runoff (Wiersum, 1983). Very little work has been undertaken in India on litter fall studies in rubber. This paper is an attempt to quantify litter fall, standing crop litter, its decomposition and subsequent nutrient release in a rubber plantation in Tripura.

MATERIALS AND METHODS

The study was conducted at the Regional Research Station of Rubber Research Institute of India, Taranagar, Agartala, India, in a 14 year old rubber plantation with clone RRIM 600. The station is situated at 91°15'E longitude and 23° 53'N latitude with an elevation of 30 m above msl. The one hectare experimental plot planted in 1981 had a density of 317 mature trees under tapping.

Litter fall

The estimation of the quantity of litter fall was carried out with the help of litter traps which had nylon net base with a mesh size of 1 mm. Twelve 1m^2 litter traps were randomly installed in the area. The bases of the traps were kept raised above ground (15 cm) to avoid contact with the soil and inclusion of ground flora litter. The litter in the trap were collected every month from January 1994 to March 1996, sorted out into leaves, twigs and petioles and oven-dried at 75°C to constant weight and the dry weight recorded. The fruits and seed coverings collected were negligible and hence not considered for the study.

Litter in standing crop

Litter in standing crop is the rubber litter present on the plantation floor at any given time. It includes fresh litter as well as litter at different stages of decay. Monthly litter in standing crop was estimated using a 0.25 m^2 quadrat. Sampling was done from 12 random spots in the plantation floor of the experimental area. The litter thus collected was sorted out into leaves, twigs and petioles and was washed gently under tap water over a fine soil sieve to remove soil contamination and then dried at 75°C to constant weight and the dry weight recorded.

Litter decomposition

To study the litter decomposition, the litter bag technique was used (Bocock *et al.*, 1960; Witkamp and Olson, 1963; Wieder *et al.*, 1983). Leaf and petiole litter collected during January 1994 and January 1995 were placed in 400 cm^2 nylon litter bags with a mesh size of 1 mm. In both the years 60 samples each of leaf litter and petiole litter were randomly placed in 12 spots in the experimental area so that each spot had five leaf litter and five petiole litter bags. In February 1994, 11.73 g oven dry leaf litter and 1.95 g oven dry petiole litter were placed in each litter bag and sealed and kept at the random spots mentioned above. However, in February 1995, only 5.94 g oven dry leaf litter and 0.77 g oven dry petiole litter were used for the study, the quantity being proportional to the litter fall of that year. One litter bag each of leaves and petioles were randomly selected from each of the twelve spots in March, June, September, December and February of 1994 and 1995. The material in each litter bag was taken to the laboratory where it was washed gently with tap water over a fine soil sieve to remove contamination and then oven dried at 75°C to constant weight. Percentage loss of dry matter was calculated for each sample.

Chemical analysis

From the monthly collections of litter and litter in standing crop estimation of N, P, K, Ca and Mg were carried out for leaf, twig and petioles , but decomposition studies were made only for leaf and petioles. The samples were oven dried at 75°C to constant weight and was ground to a fine powder. Sub samples of 50 mg were used for the analysis. N was determined after distillation by the microkjeldahl method, P by vanadomolybdate method using a UV spectrophotometer and K by flame photometric method while Ca and Mg were determined by atomic absorption method (Piper, 1966). Soil samples from 0-15 cm depth were taken with the help of an augur from four random sites near each spot where the litter traps were located. Pre- and post-experiment soil analysis were carried out for pH, organic carbon (OC), total N, P, K, Ca and Mg (Jackson, 1958).

RESULTS AND DISCUSSION

Total litter fall and nutrient return

There was no significant difference between the two years in the case of the total litter fall (Table 1). The leaf litter was found to be the single largest component of total litter added to rubber plantations, which

Table 1. **Total litter fall and mean litter in standing crop**

Component	Quantity (g/m²) 1994	Quantity (g/m²) 1995	Paired t-value
Leaf fall	496.6	473.5	1.63 NS
Twig fall	191.8	122.8	1.33 NS
Petiole fall	96.0	85.9	1.82 NS
Total litter fall	784.4	682.2	1.75 NS
Leaf in standing crop	170.3	239.9	16.44 **
Twig in standing crop	47.2	37.9	1.96 NS
Petiole in standing crop	30.0	37.6	3.71 **
Mean litter in standing crop	247.5	315.4	9.05 **

** Significant at $P \leq 0.01$; NS : Not significant

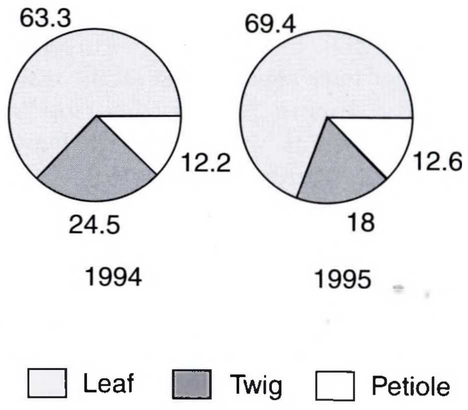

Fig. 1. Components of the total litter fall

accounted for 63 and 69 per cent of the total litter fall in 1994 and 1995 respectively (Fig. 1). This confirms the observation of Onyibe and Gill (1992) that leaf litter accounted for 65 per cent of the total litter fall for clone RRIM 600. Statistical analysis of the leaf fall during individual months revealed that the leaf fall pattern was significantly different in each year. It was observed that the major portion of leaf fall in 1994 and 1996 had occurred in January itself, while in 1995, leaf fall prolonged till March (Fig. 2). George *et al.* (1967) reported that the pattern of wintering depends on factors like nature of clone, age of plants, seasonal factors and location. In South India, wintering is reported to occur from December to February. The cumulative leaf fall from January to March for the three years did not show any significant differences (Table 2). The annual litter fall was 7.8 t per ha in 1994 and 6.8 t per ha in 1995. In March 1994, a severe attack of powdery mildew which led to almost total defoliation of newly emerged leaves occurred and therefore, a second peak of leaf fall was observed during the month. The defoliated immature leaves alone was 64.95 g per sqm which contributed 99 per cent of the observed leaf fall in March 1994. Similarly an abnormally

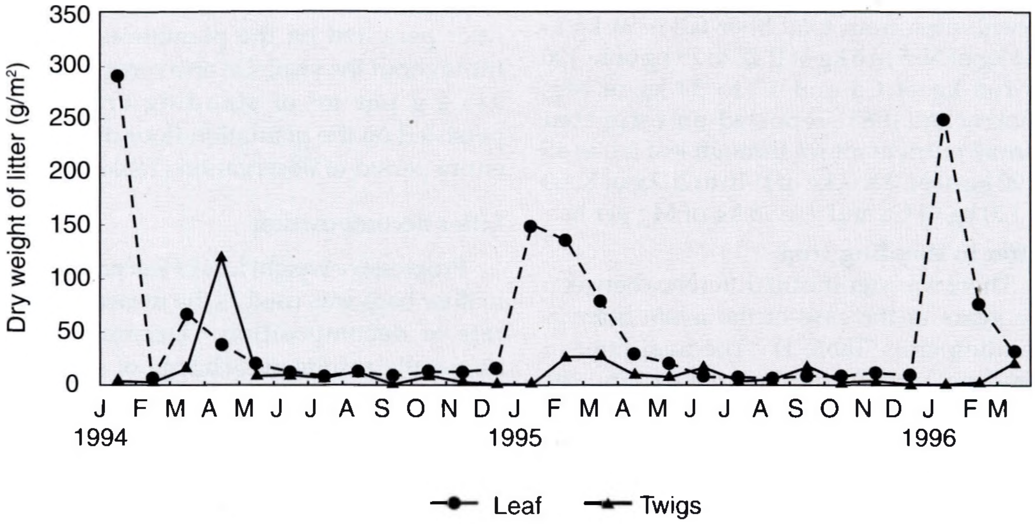

Fig. 2. Leaf and twig fall

high twig fall was observed in April 1994 due to a storm with a wind speed up to 125 km per h, which had lashed the experimental area. The contribution of the different components to the total litter fall during 1994 and 1995 was observed to be more or less similar (Fig. 1). Bulk of the litter fall occurred during January to March although the relative quantities in 1994 (72.7%) and 1995 (76.7%) showed significant differences as this period corresponds with the annual leaf fall period in Tripura.

The estimated nutrient return by way of litter fall for the two years is shown in Table 3. There is no significant difference between the values for the two years. It has been observed that plant nutrients ranging from 73 to 97 kg of N, 3 to 5 kg of P, 14 to 16 kg of K, 70 to 115 kg of Ca, 13 to 25 kg of Mg were returned to the soil in the form of leaf fall while the

Table 3. **Annual nutrient return by way of litter**

Nut-rient	Source	Nutrient return (kg/ha) 1994	1995	Paired t-value
N	Leaf	96.69	72.65	0.724 NS
	Twig	24.98	13.74	0.724 NS
	Petiole	8.96	7.69	0.405 NS
	Total	130.73	94.08	0.853 NS
P	Leaf	4.59	3.39	0.815 NS
	Twig	1.27	0.69	0.795 NS
	Petiole	0.56	0.46	0.356 NS
	Total	6.42	4.54	0.870 NS
K	Leaf	14.28	15.51	0.244 NS
	Twig	6.35	2.50	1.083 NS
	Petiole	4.51	4.13	0.175 NS
	Total	25.14	22.14	0.346 NS
Ca	Leaf	114.65	70.32	0.658 NS
	Twig	32.51	22.30	0.506 NS
	Petiole	20.62	13.37	0.651 NS
	Total	167.78	105.99	0.735 NS
Mg	Leaf	24.51	12.83	0.840 NS
	Twig	5.10	2.65	0.930 NS
	Petiole	3.61	1.51	0.999 NS
	Total	33.22	16.99	1.066 NS

NS : Not significant

Table 2. **Leaf fall for the period January to March**

Leaf fall period	Quantity (g/m²) 1994	1995	1996	Paired t-value 1994-95	1995-96	1996-97
January	288.8	148.6	249.9	9.8 **	8.2 *	3.0 **
February	6.5	135.4	76.7	15.6 **	15.1 **	11.5 **
March	65.8	78.9	30.7	4.8 **	18.9 **	17.2 **
Total	361.1	362.9	357.4	0.1 NS	0.5 NS	0.2 NS

** Significant at $P \leq 0.01$; NS : Not significant contribution from total litter fall is 94 kg to 131 kg of N, 5 to 6 kg of P, 22 to 25 kg of K, 106 to 168 kg of Ca and 17 to 33 kg of Mg. Shorrocks (1965) reported an estimated annual nutrient return through leaf fall as 45 to 90 kg of N, 3 to 7 kg of P, 10 to 20 kg of K, 60 to 120 kg of Ca and 9 to 18 kg of Mg per ha.

Litter in standing crop

There was significant difference between the years in the case of the mean litter in standing crop (Table 1). The total litter in standing crop in the months of January, February and March during 1994 did not show wide variations while in 1995, there was an appreciable difference between these months (Fig. 3). The variation in the total litter in standing crop of the two years under observation is mainly due to the differences in the rubber leaf fall patterns during the years (Fig. 4). It has been observed that maximum litter in standing crop occurred during March in both the years. Subsequently the litter in standing crop was observed to decrease progressively as the rates of decomposition exceeded those of litter fall and towards the end of the year annual minimum was reached. It was observed that litter persisted on the plantation floor all throughout the year. On an average 247.5 to 315.4 g per m^2 of standing crop litter persisted on the plantation floor during the entire period of observation (Table 1).

Litter decomposition

Progressive weight loss of leaf and petiole in litter bags was used as the measure of the rate of decomposition. Decomposition essentially results in a change of state of a resource as a decrease in mass of the resource under the influence of a number of biological and abiotic factors (Swift *et al.*, 1979). Dry weight changes in leaf and petiole litter components after exposure in litter bags for 30, 120, 210, 300 and 360 days are presented in Table 4. The loss of weight was minimal in the first 120 days for leaf litter wherein 16 to 21 per cent weight loss was observed. However, a higher weight loss of 28 to 30 per cent was recorded for the petiole litter during the same period. It was observed that 34.34 to 41.18 per cent of leaf litter and 45.45 to 45.64 per cent of petiole litter persisted in decomposition bags even after 360 days of exposure (Table 4).

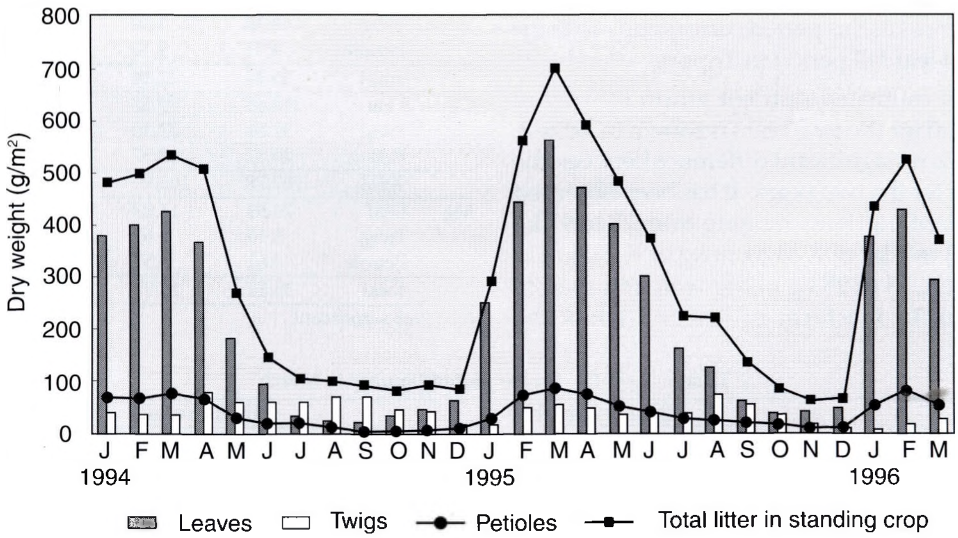

Fig. 3 Litter in standing crop

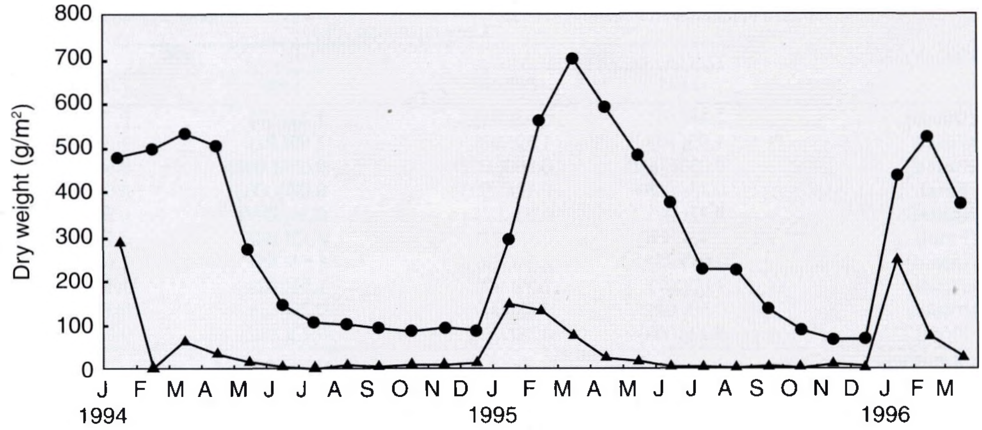

Fig. 4 Leaf fall and litter in standing crop

Table 4. **Dry weight (%) of litter components after decomposition**

Days of exposure	1994 Leaf	1994 Petiole	1995 Leaf	1995 Petiole
30	99.15	96.92	94.78	93.51
120	84.14	70.26	79.29	72.73
210	67.78	60.00	66.84	55.84
300	49.19	46.67	45.45	46.75
360	41.18	45.64	34.34	45.45

Based on litter fall and litter in standing crop, decomposition quotient (K_L) was calculated (Jenny *et al.*, 1949; Olson, 1963) to reflect the turnover of litter, though such a quotient is considered as an imperfect index for litter in standing crop. High values of K_L indicate rapid decomposition rates and therefore, twigs followed by petioles were observed to decompose relatively faster than leaves (Table 5).

Table 5. **Litter turnover parameters**

Source	1994	1995
Input to soil (t/ha/year)		
Leaves	4.966	4.735
Twigs	1.918	1.228
Petioles	0.960	0.859
Total	7.844	6.822
Mean litter in standing crop (t/ha/year)		
Leaves	1.703	2.399
Twigs	0.472	0.379
Petioles	0.300	0.376
Total	2.475	3.154
K_L values (turnover/year)*		
Leaves	2.92	1.97
Twigs	4.06	3.24
Petioles	3.20	2.28
Total	3.17	2.16

* Annual decay constant (turnover coefficient)
K_L = input/mean in standing crop

Chemical composition of fresh and decomposed litter

The initial element concentrations of major litter component before placement in the field and their final concentration after 360 days of exposure in litter bags on the plantation floor are presented in Table 6. The N and P concentrations in leaf and petiole litter increased after one year. Anderson *et al.* (1983) reported a similar observation on conservation of N and P during decomposition. Changes in leaf and petiole weight and N content during decomposition are shown in Figs. 5 and 6. As the decomposition progressed the leaf and petiole weights decreased and nitrogen concentration increased. Joseph *et al.* (1986) has reported that nitrogen concentration in decaying leaf litter increased rapidly and steadily during leaf decay. The patterns of

Table 6. **Nutrient concentration of major litter components**

Nutrient		Concentration (%)			
		1994		1995	
		Leaf	Petiole	Leaf	Petiole
N	(Initial)	1.46(.01)	0.63(.01)	1.22(.03)	0.75(.02)
	(Final)	1.95(.04)	1.32(.03)	1.85(.02)	1.31(.04)
P	(Initial)	0.051(.002)	0.060(.002)	0.056(.003)	0.050(.002)
	(Final)	0.13(.008)	0.106(.003)	0.070(.002)	0.061(.002)
K	(Initial)	0.27(.02)	0.53(.02)	0.36(.009)	0.56(.01)
	(Final)	0.13(.004)	0.17(.01)	0.12(.002)	0.11(.003)
Ca	(Initial)	2.97(.23)	2.71(.26)	1.54(.05)	1.65(.03)
	(Final)	1.07(.07)	1.09(.03)	1.51(.02)	1.51(.02)
Mg	(Initial)	0.58(.04)	0.48(.06)	0.23(.01)	0.13(.007)
	(Final)	0.13(.008)	0.14(.003)	0.13(.002)	0.10(.002)

SE in parentheses

release of Ca, K and Mg were more or less similar in all the components of litter in both the years under observation. It was generally observed that the mobility of elements in leaf litter decreased in the order of Mg>Ca>K>N>P with minor exceptions.

Pre- and post-experiment soil analyses were carried out and it was observed that there were significant increases in the OC and available K contents of the soil over the period (Table 7). The Mg and pH of the soil also showed an increase, while P and Ca were observed to show a decrease.

Table 7. **Pre- and post-experiment soil analyses**

Element	Pre Jan 1994	Post Jan 1994	Paired t-value
Carbon (%)	1.09	1.37	4.93 **
Available P (mg/100 g)	1.44	1.10	NS
Available K (mg/100 g)	4.28	7.35	4.65 **
Available Ca (mg/100 g)	11.85	10.15	NS
Available Mg (mg/100 g)	3.21	3.38	NS
pH	4.59	4.69	NS

** significant at 1% level ; NS : Not significant

The persistence of litter cover on the ground all throughout the year, as observed in this study, would probably help in

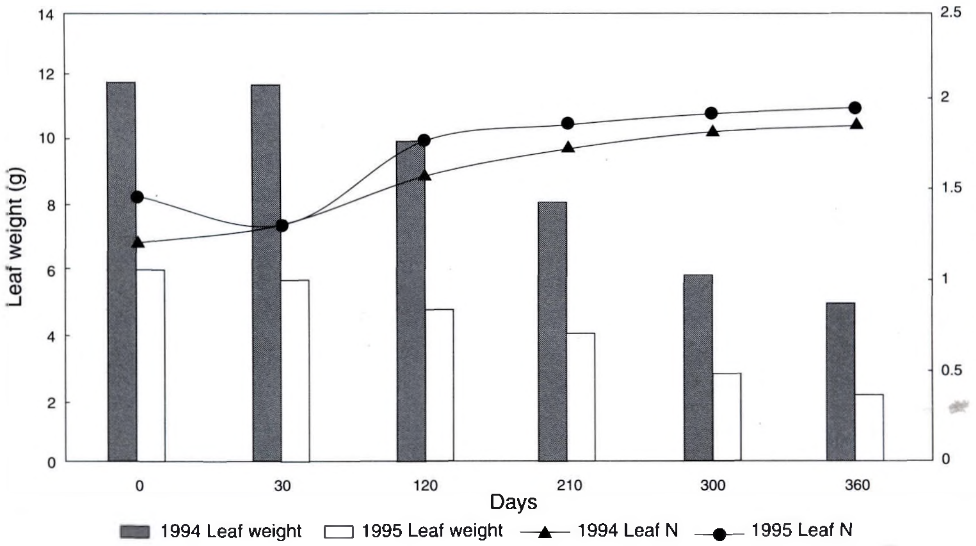

Fig. 5. Changes in leaf weight and N content during decomposition

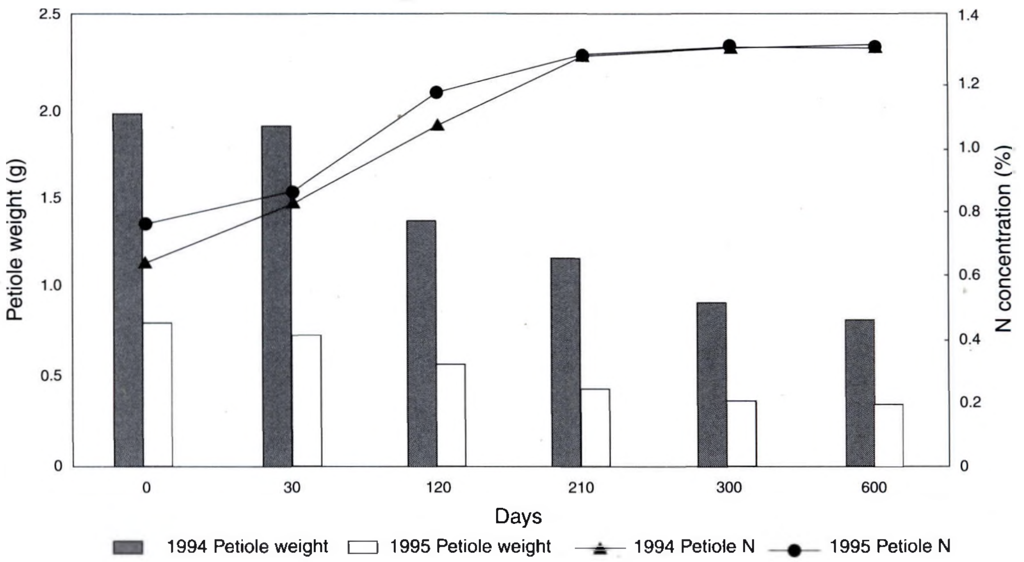

Fig. 6. Changes in petiole weight and N content during decomposition

reducing soil erosion in rubber plantations. Proper management of the litter would result in appreciable enrichment of soil which could in the long run reduce the requirement of inorganic fertilizers in the mature phase.

REFERENCES

Anderson, J.M. and Swift, M.J. (1983). Decomposition in tropical forests. In: *The Tropical Rainforest : Ecology and Management* (Eds. S.K. Sutton, T.C. Whitemore and A.C. Chadwick). Blackwell Scientific Publications, Oxford, pp. 287-311.

Anderson, J.M., Proctor, J. and Vallack, H.W. (1983). Ecological studies in four contrasting lowland rain forests in Gunung Mulu National Park, Sarawak : 3. Decomposition processes and nutrient losses from leaf litter. *Journal of Ecology*, **71** : 503-527.

Bocock, K.L., Gilbert, O.J., Capstick, C.K., Turner, D.C., Ward, J.S. and Woodman, M.J. (1960). Changes in leaf litter when placed on the surface of soil with contrasting humus type. *Journal of Soil Science*, **11** : 1-9.

George, P.J., Panicker, A.O.N. and Nair, V.K.B. (1967). Observation on the floral biology and fruit set in *Hevea brasiliensis* Muell. Arg. *Rubber Board Bulletin*, 9(2) : 18-27.

Jackson, M.L. (1958). Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, pp. 82 - 294.

Jenny, N., Gessel, S.P. and Bingham, F.T. (1949). Comparative studies of decomposition rates of organic matter in temperate and tropical regions. *Soil Science*, **68** : 419-432.

Joseph, B., Yavitt and Timothy, J. Fahey (1986). Litter decay and leaching from the forest floor in *Pinus contorta* (Lodgepole pine) ecosystems. *Journal of Ecology* (1986), **74** : 525-545.

Krishnakumar, A.K. and Meenattoor, R. (2000). Cultivation in non-traditional areas. In: *Natural Rubber : Agromanagement and Crop Processing* (Eds. P.J. George and C. Kuruvilla Jacob). Rubber Research Institute of India, Kottayam, pp. 555-568.

Menon, P.M. (1980). Glimpse of the rubber plantation industry in India. *Rubber Board Bulletin*, **16**(2) : 6-10.

Menon, P.M. and Unny, R.G. (1990). Natural rubber production : Prospects on a long-term basis. *Rubber Board Bulletin*, **25**(4) : 7-15.

Olson, J.S. (1963). Energy storage and the balance of producers and decomposers in ecological systems. *Ecology*, **44** : 322-331.

Onyibe, H.I. and Gill, L.S. (1992). Litter production and disappearance in three clones of rubber. *Journal of Plantation Crops*, **20**(1) : 22-31.

Piper, C.S. (1966). Soil and plant analysis. Hans Publishing House, Bombay, 368 p.

Shorrocks, V.M. (1965). Mineral nutrition, growth and nutrient cycle of *Hevea brasiliensis* : II. Nutrient cycle and fertilizer requirements. *Journal of the Rubber Research Institute of Malaya*, **19**(1) : 48-61.

Spain, A.V. (1984). Litter fall and the standing crop of litter in three tropical Australian rain forests. *Journal of Ecology*, **72** : 947-961.

Strahler, A.N. (1969). Physical geography, Ed. 3. Wiley, New York, pp. 57-84.

Swift, M.J., Heal, O.W. and Anderson, J.M. (1979). Decomposition in terrestrial ecosystem. Blackwell Scientific Publications, Oxford, pp. 49-57.

Watson, G.A. (1989). Nutrition. In: *Rubber* (Eds. C.C. Webster and W.J. Baulkwill). Tropical Agricultural Series, Longman Scientific & Technical, U.K., pp. 291-348.

Wiersum, K.F. (1983). Effect of various vegetation layers in an *Acacia auriculiformis* forest plantation on surface erosion in Java, Indonesia. In: *Soil Erosion and Conservation* (Eds. S.A. El-Swaify, W.C. Moldenhauer and A. Lo). Soil Conservation Society of America, Ankey, pp. 79-89.

Wieder, R.K., Carrel, J.E., Rapp, J.K. and Kucera, C.L. (1983). Decomposition of tall grass (*Festuca elatior var. arundinacea*) and cellulose litter on surface mines and a tall grass prairie in Central Missouri, U.S.A. *Journal of Applied Ecology*, **20** : 30-321.

Witkamp, M. and Olson, J.S. (1963). Breakdown of confined and non-confined oak litter. *Oikos*, **14** : 138-147.