THE CONTRIBUTION OF RUBBER PLANTATIONS TOWARDS A BETTER ENVIRONMENT

Lalani Samarappuli

The widespread luxuriant evergreen wet tropical forests are a vital natural heritage to the nation. Among terrestrial ecosystems, tropical rain forests sustain the greatest productivity, and most efficient soil and moisture conservation systems, and maintain the greatest diversity. Over the last century much of this heritage has been destroyed, along with many of its material benefits. Deforestation has now seriously made soils less productive, water supply more erratic, floods more frequent and severe and diminished timber supplies, all on a serious scale. People have only recently come to realize and appreciate many of the values of areas which are natural or near natural.

Hevea rubber has all the attributes of a forestry species. The plantations, although of only one species, cannot be regarded as totally unnatural. Even within the most untouched natural forests localized species dominance is observed (Bruning *et al.*, 1978). The first rubber plantations were established in Sri Lanka, Malaysia and Indonesia at the beginning of the century. Since then many individual plantations have undergone three planting cycles of approximately 30 years each, without any great adverse effect on the natural environment. In the mean time the commercial yields of rubber have risen from about 250 kg/ha to the present level of modern high yielding trees of about 2000 kg/ha; an eight fold increase. Over the years, the planters have taken into consideration the need to practice various soil conservation measures, in order to protect and preserve soil fertility. While conservation measures are being pursued to minimize deterioration and thereby maintain the native soil fertility, other agronomic practices are simultaneously introduced to sustain high crop performance through soil nutrient enrichment.

Conservation of soil fertility and productivity

On hilly and steep terrains, rubber is planted on the contour lines, and the inter-row areas are disturbed as little as possible. Surface soil erosion along the contours is minimized by drains and silt pits, which check the surface runoff during heavy rains. This has also been found to influence soil nutrient contents beneficially, apparently through enhanced soil and moisture conservation. On very rocky land, where it is impossible to cut continuous lateral drains, the soil conservation needs are partly satisfied by the construction of stone terraces (Samarappuli, 1983).

In preserving the productivity and fertility of a soil, the role of cover crops can be emphasized. The main purpose of cultivating cover plants is to control erosion. The influence of cover plants on soil improvement is also of considerable importance. This is brought about by the addition of organic matter and mineral nutrients to the soil through the natural decaying of leaves, stems and roots (Yogaratnam *et al.*, 1977; Yogaratnam *et al.*, 1984a). It is well known that materials with low C/N ratio would be expected to be mineralized rapidly with its nutrient becoming quickly available again for uptake by *Hevea* or cover plants. As leguminous covers such as *Pueraria* and *Desmodium* do not root deeply, the net effect would have been a rapid re-cycling of nitrogen from the upper soil layers. Leguminous creepers have been shown to mobilize greater quantities of nitrogen, phosphorus and calcium than have the other experimental covers during the first two years after planting (Watson, 1961).

In addition to plant covers, soil surface exposure is also lessened by applying mulching materials around the base of young rubber plants. Besides protecting against surface soil loss (Samarappuli & Yogaratnam, 1984), mulching also (more importantly) helps conserve soil moisture (Samarappuli, 1992a) and promotes better rubber growth (Samarappuli, 1992b).

Adequate and periodic application of NPKMg fertilizers during the immature phase promotes better growth and earlier attainment of tappable girths. Although some losses of applied fertilizer through leaching and erosion, significant amounts of nutrients are absorbed by the crop, and over a period of years, the soil P, K, Ca and Mg status increases (Yogaratnam *et al.*, 1984b).

Biomass and nutrient bank of *Hevea* ecosystem

A stand of conventionally planted budded rubber trees, provided with optimum agronomic inputs, can reach a tappable trunk girth of 45 to 50 cm in about 65-70 months or even earlier. The girthing rates, though sluggish during the early years, can reach one centimeter per month (12 cm per year) or more as the trees near tappability or five years (Chan, 1991). On commencement of tapping, girth increment gradually declines to low levels of about one centimeter per year or less (Ng *et al.*, 1969).

These girthing rates for rubber trees are similar or relatively higher than values obtained for other forest tree species (Whitmore, 1984). From these comparative girthing values it would appear that rubber is a faster growing tree compared to other common forest species. Such quick growth of the rubber tree is advantageous in that the stand can be expected to reach maximum biomass potential in relatively shorter time than trees in the forest situation.

A comparison of biomass potentials suggests that the rubber ecosystem at tappable maturity attains a relatively much lower biomass level than a mature forest ecosystem. However, with time the value for the rubber ecosystem increases; it reaches comparable levels at an age of beyond 30 years (Table 1). The biomass potential of a 33 year old stand of tapped trees was 444.9 t/ha, a value nearing those obtained for forest ecosystems. Interestingly, when the rubber was not tapped until the thirty third year, the potential biomass value was similar to those of tropical forests, or even higher.

Table 1. *Biomass (tree) nutrient banks for various ecosystems*

Ecosystem	Biomass (t/haDW)	Nutrient content (kg/ha DW)				
		N	P	K	Ca	Mg
Humid tropical evergreen forest						
	426.0	1938	52	618	759	230
Rubber Hevea Plantation						
5 years	48.6	470	56	234	360	48
11 years	206.1	839	107	242	466	93
24 years	248.6	1172	na	717	779	163
33 years	444.9	1595	241	1091	1854	351
33 years (untapped)	963.8	3598	925	3919	2932	777

As trees grow, a steady accumulation of dry matter accompanied by concomitant build up of mineral nutrients within the tree system results. Sivanadyan and Norhayati Moris (1992) conclude that between rubber and forest ecosystems, nutrient storage values for rubber stands at and beyond 24 years of age were comparable to those for the forest ecosystem (Table 1), although in the case of biomass accumulation, comparable biomass levels were attained only when the rubber trees reached 33 years of age. The comparatively higher nutrient storage levels in rubber stands at a relatively younger age than biomass accumulation, is most likely due to the regular application of fertilizers which resulted in an accelerated enhancement of the tree nutrient bank. However, nutrients are added to the forest ecosystem only by natural means (rainfall, dust, biological nitrogen fixation and weathering of rocks) and thus take relatively longer time to build up.

Organic matter and nutrient recycling *via* litter

Litter accumulation under rubber has been found to be lower than that of teak or natural forest (Table 2), (Krishnakumar *et al.*, 1991). This could be attributed to the faster rate of decomposition under a higher moisture regime and a higher content of P,K and Mg under rubber than teak.

Table 2. *Biomass and nutrient content of litter accumulation under different vegetation system*

Vegetation	Biomass (kg/ha)	Nutrients (kg/ha)					Total nutrients (kg/ha)
		N	P	K	Ca	Mg	
Rubber	5085.7	106.32	14.24	45.25	46.02	23.88	235.70
Teak	7039.2	156.77	17.61	59.50	45.73	43.77	323.36
Natural Forest	6384.21	127.37	7.28	52.11	53.67	36.31	276.72

A study done by Norhayati Moris and Lau, 1990 indicated that the forest recycled about 8.33t of dry litter per year as compared to about 4.43 t/year under legumes and 3.7-7.7 t/year under mature rubber (Table 3). Litter fall under mature rubber can reach values that are nearly as large as for forests. The amounts of nutrients cycled via the litter were generally greater for all nutrients under the forest ecosystem (Table 3), although in older rubber areas, nutrient cycling via the litter is likely to approach that in the forest ecosystem (Shorrocks, 1965).

Table 3. *Litter fall and nutrient cycling under various vegetations*

Vegetation	Mean annual litter fall D.W. (t/ha)	Nutrient content (Kg/ha)				
		N	P	K	Mg	Ca
Forest	8.33	133.1	3.9	32.4	22.8	78.7
Legume Cover	4.43	112.2	4.5	27.3	15.2	54.3
Rubber	3.7-7.7	45.9	3.7	10-20	9-18	60-120

Soil characteristics under rubber

Introduction of *Hevea* as an agricultural crop in land development programmes has to a considerable extent helped to improve the soil's chemical and physical characteristics and return it to its original stature (Norhayahti Moris and Lao, 1991). For example there was a tendency for organic carbon in the top soil to increase with time, presumably due to the presence of legume cover. Total nitrogen levels also tended to regain the original concentrations because of the release of nutrients from the legume cover. After planting of rubber the bulk density generally decreased but never reached the original values found under forest conditions, even in the presence of a legume cover 4 years after planting (Table 4).

A study in India also demonstrated an improvement of soil properties after the establishment of *Hevea* (Krishnakumar, *et al.*, 1991). It was observed that rubber plantations, in which proper agro-management practices, had been adopted, helped in the enrichment of organic matter, which consequently improved soil physical properties such as bulk density, soil porosity and moisture retention. Krishnakumar and Potty (1992) noted that under Indian conditions soil physical properties in denuded forests as well as in areas subjected to continuous shifting cultivation, are considerably improved once a rubber plantation is established. Krishnakumar *et al.* in 1991 concluded that in general there is no significant difference in soil nutrient contents under rubber, teak and natural forest conditions (Table 5).

Table 4. *Chemical and physical properties of soil (top 0-15 cm) at different stages of land cultivation for rubber*

Stage	pH	Organic C (%)	Total N (%)	Total P (%)	Av.P mg/kg	Exch.K cmol/kg	Exch.Mg cmol/kg	Bulk density (mg/m^3)	Porosity (%)
Virgin soil	4.1	1.63	0.17	16.5	6	0.17	0.25	0.86	67
After clearing of forest	4.1	1.54	0.17	14.0	7	0.18	0.21	1.58	41
6 months after planting of cover crops and rubber	3.9	1.53	0.14	17.0	10	0.20	0.10	1.09	59
3 years after planting	3.9	1.40	0.14	15.5	5	0.20	0.24	0.92	65
4 years after planting	3.9	1.83	0.18	17.9	8	0.16	0.27	1.01	62

Table 5. *Some physical and chemical properties of soil under different vegetation systems*

Vegetation	Depth (cm)	pH	Organic Carbon (%)	Soil nutrient contents (kg/ha)				Bulk density (g/cm^3)	Porosity (%)	Available water storage (Vol. water cont. mm/m)
				P	K	Ca	Mg			
Rubber	0-15	4.3	2.93	3.4	120.8	388.8	117.6	1.33	48.05	209.08
	15-30	4.3	2.39	1.0	91.2	225.6	107.0	1.43	43.92	159.16
Teak	0-15	4.4	3.74	2.6	106.0	648.0	102.0	1.15	51.47	167.90
	15-30	4.3	2.34	2.2	84.6	269.4	76.2	1.32	45.90	140.18
Natural forest	0-15	4.4	2.64	5.6	140.0	413.4	108.6	1.39	42.79	179.03
	15-30	4.4	1.91	1.6	112.6	233.2	81.8	1.41	44.48	137.47

The nutritionally self-sustaining *Hevea* ecosystem

On the basis of various computations on nutrient outflow via crop, ecosystem and tree nutrient banks, the mature *Hevea* stand has recently been projected as a nutritionally self-sustaining ecosystem, unlike other agricultural ecosystems (Sivanadyan *et al.*, 1991).

Latex, the primary harvested crop from *Hevea* trees, contains a variety of nutrients besides rubber particles. The amounts of these nutrients, which are ultimately removed from the ecosystem via the latex crop, are relatively small in comparison with the amounts of nutrients in the harvested products from other tree crops (Table 6). Nutrient outflow via latex, besides being small in comparison with that for other crops, is also notably small in relation to the overall tree nutrient content or the tree nutrient bank (Sivanadyan *et al.*, 1991).

Table 6. *Nutrient removal of different crops via yield*

Crop	Yield (kg/ha)	Nutrient removal (kg/ha)			
		N	P	K	Mg
Rubber	1800	17.8	3.6	14.5	3.6
Tea	1300	60.0	5.0	30.0	4.8
Coconut	1400	62.0	17.0	56.0	16.5
Oil palm	2500	162.0	30.0	217.0	30.0

Rubber processing and by-products

The processing of field latex into sheet, crepe, block rubbers or latex concentrate results in the production of large quantities of effluent. Research programmes are currently being undertaken on more effective methods of treating effluent to a standard which will allow the effluent to be safely discharged into rivers and streams. The effluent which contains plant nutrients such as NPK may be applied to rubber lands as an organic manure. Where the topography permits, effluent can be cheaply applied by pumping it to the top of gentle slopes and allowing it to run down in furrows or channels.

The most important product of *Hevea* is latex and up-to-date the main emphasis of rubber husbandry efforts to improve the rubber tree has been from the point of obtaining high yield of latex rather than for timber production. However, after the useful latex-producing life of *Hevea* is over, the rubber wood can be used as timber and this commodity is gaining popularity and is fast becoming an alternative to timber from tropical rain forests. Although research and development activities on the industrial applications of rubber wood are of only recent origin, the commercial exploitation has been rapid so that *Hevea* timber currently commands a high value. Furthermore, the introduction of commercially valuable intercrops is expected to further enhance the economic and environmental potential of the *Hevea* ecosystem.

From the time of planting to the time of replanting the rubber plantation presents an environmentally acceptable replacement for the native forest, being a closed ecosystem with a constant cycle of uptake and return of nutrients from and to the soil. This system produces a considerable amount of biomass on a scale comparable to forests. It concludes that commercially grown rubber plantations can be considered as an alternative to an agroforestry system, which will be sustainable, conveniently renewable and also compatible with nature.

REFERENCES

Bruning, E F, Heuveldop, J and Schneidar, T W (1978). Dependence of productivity and stability on structure in natural and modified ecosystems in the tropical rain forest zone: Preliminary conclusion from the MAB-pilot project at San Carlos de Rio Negro for the design of optimal agro-silvicultural and silvicultural systems. *Proceedings of 8th World Forestry Congress 1978, Jakarta.* FFF/7-15.

Chan, W H (1991). Commercial Performance of Clones Planted in the last Fifteen Years in a Large Group of Rubber Estates. *Proceedings Rubber Research Institute Malaysia Rubber Growers' Conference Malacca* 1989, 36.

Krishnakumar, A K, Chandra Gupta, Sinh, R R, Sethuraj, M R, Potty S N, Thomas Eappen and Krishna Das (1991). Ecological impact of rubber (*Hevea brasiliensis*) plantations in North East India: 2. Soil properties and biomass recycling. *Indian Journal of Natural Rubber Research* 4, 134-141.

Krishnakumar, A K and Potty, S N (1992). Nutrition of *Hevea*. In: *Natural Rubber Biology: Cultivation and Technology*, pp. 239-62 (Eds. M R Sethuraj and N M Mathew), Elsevier, Amsterdam.

Ng, E K, Abraham, P D, P'Ng, T C and Lee, C K (1969). Exploitation of Modern *Hevea* Clones, *Journal of the Rubber Research Institute of Malaysia* **21**, 292.

Norhayati, Moris and Lau, C H (1990). Soil Fertility Changes Following Land Clearing and Rubber Cultivation. *International Soil Science Congress, Kyoto, Japan*.

Samarappuli, L (1983). Soil conservation. In: *A practical Guide to Rubber Planting and Processing*,pp. 33-36 (Eds. Liyanage, A de S and Peries, O S), Rubber Research Institute of Sri Lanka, Agalawatta, Sri Lanka, 33-36.

Samarappuli, L and Yogaratnam, N (1984). Some aspects of Moisture and Soil conservation in Rubber Plantations. *Proceedings International Rubber Conference* 1984, Vol **1**, Part II: 529-543.

Samarappuli, L (1992a). Effects of some soil management practices and moisture regimes on the performance of *Hevea*. *PhD Thesis*, University of Peradeniya.

Samarappuli, L (1992b). Some agronomic aspects in overcoming moisture stress in *Hevea brasiliensis*. *Indian Journal of Natural Rubber Research* **5**, 127-132.

Shorrocks, V M (1965). Mineral Nutrition, Growth and Nutrient Cycle of *Hevea brasiliensis* II. Nutrient cycle and fertilizer requirements. *Journal of the Rubb. Research Institute of Malaya*, **19**, 48.

Sivandyan, K, Ghandimathi Harihar and Haridas, G (1991). Rubber A Unique crop: The mature *Hevea* stand as a nutritionally self sustaining Ecosystem in relation to latex yield. (In Press).

Sivanadyan, K and Norhayati Moris (1992). Consequence of transforming tropical rain forests to *Hevea* Plantations. *Planter*, Kuala Lumpur **68**, 547-67.

Watson, G A (1961). Cover plants and soil nutrient cycle on *Hevea* cultivation. *Proceedings National Rubber Research Conference Kuala Lumpur*, 1960, 352-356.

Whitmore, T C (1984). Tropical rain forests of the east. *English Language Book Society/Oxford University Press.*

Yogaratnam, N, Sulaiman, H, Karunaratna, A D M and Pieris, K S A C (1977). Management of covers under *Hevea* in Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka* **54**, 291-298.

Yogaratnam, N, Perera, A M A and De Mel, G G (1984a). Management of ground covers for optimum production. *Proceedings International Rubber Conference* 1984, Sri Lanka, 1 (2) : 521-527.

Yogaratnam, N, Silva, F P W and Weerasuriya, S M (1984b). Recent developments in the nutrition of *Hevea* in Sri Lanka. *Proceedings International Rubber Conference*, 1984, Sri Lanka, 1 (1) 204-207.