Natural rubber as a green commodity – Part 1*

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NATURAL RUBBER is an inherently environmentally-friendly material. In the past 30 years this journal has featured many articles supporting this fact. Now, the growing importance of 'green' issues and an increasing awareness of our need for sensitivity to the environment, makes it an excellent opportunity to promote natural rubber as a highly desirable eco-friendly material.

Part 1 of this article looks at the environmental impact of raw rubber production and Part 2, to appear in the next issue, will deal with the more complex subject of natural rubber as an industrial material.

It is becoming obvious that the deep concern caused by the serious deterioration in the environment is affecting more and more countries all over the world. The evidence continues to grow to indicate that dramatic and irreversible changes may be occurring in the earth's ecosystem. These changes pose a serious threat to the well-being of present and future generations. Fossil fuel combustion arising from industrial activities, deforestation and biomass burning have contributed significantly to the increase in chemical pollution and there is full consensus that today there is much more CO_2, methane and nitrous oxide in the atmosphere than ever before. Of these greenhouse gases, CO_2 is by far the most important. Concentrations of CO_2 are now 25% higher than in pre-industrial times and are rising by 0.5% each year.[1]

The carbon cycle and balance in the biosphere are governed by two main processes: the photosynthetic assimilation of CO_2 by plants, and the metabolism and release of CO_2 by living organisms and by burning fossil carbon or recent fuels. The world CO_2 production by vegetation burning amounts to 1×10^9 t/a of carbon and is increasing. However, the released CO_2 will eventually be fixed again by vegetation, with plants reacting to the increased CO_2 content of the atmosphere by a greater rate of photosynthesis.[2] The amount of photosynthesis presently occurring on earth is a staggering figure. Estimates vary greatly, but a value of about 70 billion metric

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LEFT *Hevea seeds.*

tons of carbon (170 billion tons of dry matter) fixed per year has been reported.[3] The equatorial region has been identified as the region of highest photosynthetic activity.[4]

Currently, some 27.6% of the world is under forest cover, 23.6% of Africa, 25% of North America, 48.6% of South America, 52.6% of South East Asia, 17.9% of Oceana and 32.1% of Europe. Tropical forests, covering 20% of the earth's land surface, account for at least 25% of the global terrestrial carbon fixation. These tropical forests play a vital role in the global climate, especially in distributing heat away from the equator, and their loss on a massive scale through deforestation is of great concern to everyone. The destruction of these forests has long been suspected for changing the weather of a particular region and its periphery. Much has been written and debated about deforestation and its consequent effects. Many environmental organizations have been pushing for some time now for restrictions or a ban on the import of tropical timber. There are, however, many misconceptions about the deforestation phenomenon and criticism is often targeted at the tropical countries when facts have not been checked. For example, Malaysia is one country that has embarked on sustainable forest management long before the concern on global environmental degradation became such a talked about issue. Forest accounts for 19.4 million hectares and tree plantation 4.2 million hectares of Malaysia's land area of 32.86 million hectares. In short, 72% of the land is under tree cover and this makes Malaysia one of the most forested countries in the world. Malaysia's successful forest management began in 1901 and is second to none among tropical countries.

Hevea brasiliensis is indigenous to the forests of the Amazon basin, ocurring generally within 5 degrees latitude of the equator and known to perform best in climates of the tropical lowland, evergreen rainforest regions with an annual rainfall of 2000–4000mm. Due to its robust nature and economic importance, its cultivation has since extended away from the equator to latitudes as far north as 29° N in India and China, down to 23° S in Sao Paulo State, Brazil. Currently *Hevea* is planted in over 20 countries with an estimated cultivated area of nine million hectares.

Like other green plants, *Hevea brasiliensis* can be considered as a plant factory for solar energy conversion and a carbon sink by virtue of the process of photosynthesis. The rate of photosynthesis differs between clones and has been recorded with a range in the maximum photosynthesis to be from 1.14mg/M^2/S in clone PR107 to 0.36mg/M^2/S in clone RRIM 623.[5] The influence of the rubber trees on the atmospheric carbon balance is also indicated by the amounts stored in the biomass (see Table 1), with values comparable to that of forest ecosystems, particularly beyond a certain age of growth. A monoculture of *Hevea* has been reported to be a relatively efficient converter of solar energy into dry matter production. It has been estimated that the rate of dry matter production of a 5½ to 6½ years stand of RRIM 501 was 35.5 tonnes/hectares/year,[6] a relatively high value among tree species. At this rate of dry matter production, the efficiency of utilisation of solar radiation in a stand of *Hevea* trees with a closed canopy has been calculated to be about 2.8%.[7]

As *Hevea* is mainly cultivated in regions of highest photosynthetic productivity and has a capacity to fix 90 million tonnes of carbon per year,[8] it would appear that a rubber plantation is almost as effective during photosynthesis as a virgin forest in consuming the products of fossil fuel burning, as well as producing life sustaining oxygen.

The need for more effective and efficient use of land resources was one of the points highlighted at the Earth Summit in Rio de Janeiro, Brazil, in 1992. The Summit recognised that soil, water and nutrients are primary resources essential for sustained agricultural production. Land use systems which degrade the resource base must be replaced by sustainable systems,

Table 1
Estimates of floral biomass potential for various ecosystems (estimate of biomass mainly made for above ground plant parts).

Ecosystem	Biomass dry weight, t/ha
Humid tropical evergreen forest	
Malaysia: Pasoh	475-664[a]
Mulu	210-650[b]
Thailand: Khao Chong	331[a]
New Guinea	295-310[c]
Brazil: Manaus	473[d]
Hevea rubber plantations	
Five years (fertiliser trials)	60.1-76.8[e]
(commercial)	48.6[f]
Eleven years	206.1[f]
Twenty-four years	248.6[f]
Thirty-three years	444.9[f]
Thirty-three years (untapped)	963.8[f]

a. Ref. 9. b. Ref. 10. c. Ref. 11. d. Ref. 12. e. Ref. 13. f. Ref. 14.

and this is where rubber plantations can play a part in the role of improved soil, water and nutrient management. When virgin or secondary forests or old rubber stands are felled and cleared, the closed nutrient cycle is broken, the water regime is changed and the productive potential of the site can deteriorate rapidly. Detrimental changes to the environment can occur unless efficient land practices are exercised from the onset of new plantings or replanting. Exposure of the bare soil to the sun and to the impact of rainfall can lead to accelerated decomposition of the organic matter, leaching of nutrients, breakdown of the aggregate structure of the surface soil, diminished infiltration and increased run-off and erosion. To avoid these problems, various conservation approaches have been developed over the years and are now widely practised in rubber plantings. These include terracing,[15] silt pitting and bunding,[16] and establishment of ground covers of naturally regenerating vegetation or leguminous cover plants sown between the rubber rows.[17] Once the trees have established a complete canopy, the rate of runoff generally differs little from that for similar areas with natural forest. The absence of tillage after the planting of the rubber also renders the land less susceptible to erosion.

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The loss of plant and animal species in a tropical forest which is converted for agricultural purposes is a problem that can be minimized. Other plants which can perform the functions achieved by a natural forest can be introduced and some degree of regeneration and recolonization, by at least some small succulent and shrubby plant types typical of secondary forest in the new ecosystem, normally happens. The degree of regeneration however, is dependent on the intensity of the burn and the nature of agromanagement practices subsequently pursued. To reduce CO_2 emission through biomass burning,[18] planting of rubber without burning and undershade planting[19] have been advocated. Even if burning is required generally a light burn has been recommended. Legume creepers and shrubs can form an excellent association with rubber: they are tolerant of acid soil conditions, they have a high capacity for nitrogen fixation and produce nutrient rich litter which decomposes easily and returns nutrients to the soil. They are ideal cover plants for rehabilitation of the soil or restoring soil fertility particularly during the immature period of rubber growth. Selective rather than clean weeding is generally practised in rubber plantations both during the immature and mature stages of rubber growth. Only noxious weeds are removed leaving the desirable plant species and this practice ensures the retention of the diverse flora compositions and the maintenance of some form of ground cover against possible soil erosion. An additional protective cover is provided by leaf litter. As well as leaf fall due to senescence, mature rubber is known to shed its leaves annually during the dry months: this process also adds nutrients to the soil. In view of the large amounts of nutrients cycled and the substantial reserves occurring as tree nutrient banks, the mature rubber ecosystem can be viewed as a nutritionally, self-sustaining ecosystem.[20]

Rubber plantations, with a 25–30 year replanting cycle, are primarily harvested for latex. However, non latex resources, specifically timber, have become increasingly important in recent years. The plantations, in fact, are capable of yielding a high volume of wood per unit area in a relatively short period of time. The increase in demand for timber and timber products and the current, regulated extraction of existing timber from Malaysia's forests, has prompted policy makers to seriously look again at the cultivation of rubber not as a source of latex, but solely as a source of timber, through the development of rubber forests. Establishment of rubber through this concept of rubber forest to supplement wood production is expected to make up for any shortfall that may arise towards the turn of the 21st century. This programme of regreening through maintaining or expanding the existing green hectares of rubber particularly in deforested areas will inevitably reduce the pressure on the natural forests and also contribute towards environmental and ecological stability. The expanding rubberwood industry in Malaysia will be looked at in the future in *Rubber Developments*.

Maybe the biggest attribute of natural rubber in terms of environmental friendliness is the relatively small amount of energy that is needed to produce it as compared with that needed to produce synthetic rubbers. It is obvious that natural rubber enjoys a very considerable competitive edge in energy terms as compared with synthetics. Although the argument that natural rubber should be preferred to synthetic rubbers is a simplistic one, it does need to be emphasized that the energy required to harvest, process and transport natural rubber is approximately one quarter of that required for the feedstock for synthetics.

Natural rubber production: energy costs in GJ/tonne

Fertilisers and other chemicals	5
Primary processing	3
Transport	5-8
Total	15-16

These figures were obtained from two large processors who quoted similar amounts: the energy required for some techniques employed by smallholders will be much lower. The transport includes transport from South East Asia to Europe or North America.

Prior to the second energy crisis of 1979, the energy content of some synthetic rubbers was quoted and these are listed in Table 2 in the first column. The data in the second column are taken from a slightly later source in the case of the asterisked date and the remaining data have been adjusted to conform to the lower estimates for SBR.

As an industrial material, natural rubber does not have the immediate obvious merits that it does as a plantation crop. If an extreme stance is taken, no industrial material can be environmentally friendly, as the processes or in many cases the end users exploit the use of fossil fuels. There is, however, still considerable merit in moving towards more natural rubber and less synthetic and this will be the subject of Part 2 of this article to appear in the next issue of Rubber Developments.

Table 2
Energy content of some synthetic rubbers.

Material	Energy consumption, GJ/tonne	
Polychloroprene	144	120
SBR	156	130*
Polybutadiene		108*
EPDM	170	142
Polyurethane	209	174
Butyl rubber	209	174
Polypropylene		110*

* Data from a later and probably more reliable source (remaining data adjusted)

References

1. United Nations Environment Programme, Protecting the Atmosphere, *Our Planet*, 1992, **4**, 8-9.
2. Fairhall, A. W., *Nature*, 1973, **245**, 20-23.
3. Whittaker, R. H., *Communities and Ecosystems*, 2nd edn. New York: Macmillan, Inc., 1975.
4. Calvin, M., *Proc. Int. Rubb. Conf.*, Malaysia, Kuala Lumpur, 1975, 69-105.
5. Ceulemans, R., Gabriels, R., Impens, I., Yoon, P. K., Leong, W. and NG, A. P., *Trop. Agric. (Trinidad)*, 1984, **61**, 273-275.
6. Templeton, J. K., *J. Rubb. Res. Inst.*, 1968, **20**, 136-146.
7. Templeton, J. K., *J. Rubb. Res. Inst.*, 1969, **21**, 259-263.
8. Naimah, I., Zainol, E. and Yoon, P.K., Rubber: a Social Economic Environment-friendly (SEE) Industrial Product, presented at Third World Organization of Women Scientists Conference, Cairo, Egypt, January, 1993.
9. Kato, R., Tadaki, Y. and Ogawa, H., *Malay. Nat. J.*, 1978, **30**, 211.
10. Proctor, J., Anderson, J. M., Fogden, S. C. and Vallach, H. W., *J. Ecol.*, 1983, **71**, 261.
11. Edwards, P. J. and Grubb, P. J., *J. Ecol.*, 1977, **70**, 623.
12. Jose M. Toledo and Jaime Nava, Land Clearing for Pastures in the Amazon in Land Clearing and Development in the Tropics, ed. Lol, R., Sanchez, P. A., and Cummings Jr, R. W. A. A. Balhema/Rotterdam/Bostai, 1986, page 97.
13. Sivandadjan, K. and Norhajah Moris, Consequence of Transforming Tropical Rain Forests to Hevea Plantations, presented at FADINAP Regional Seminar on Fertilization and Environment, Chiang Mai, Thailand, September, 1992.
14. Shorrocks, V. M., *J. Rubb. Res. Inst. Malaya*, 1965, **19**, 332.
15. Moore, A., *Rubb. Res. Inst. Malaya, Plant Manual No.7*, 1938.
16. Haines, W. B., *Quart. J. Rubb. Res. Inst. Malaya*, 1929, **1**, 20.
17. Watson, G. A., *Plrs' Bull. Rubb. Res. Inst. Malaya*, 1963, **68**, 123.
18. RRIM, *Plrs' Bull. Rubb. Res. Inst. Malaya*, 1939, **6**, 1-5.
19. RRIM, *Plrs' Bull. Rubb. Res. Inst. Malaya*, 1957, **33**, 105-107.
20. Sivanadjan, K., Ghandimathi Harihar and Haridas, G., Rubber a Unique Crop: The Mature *Hevea* Stand as a Nutritionally Self-sustaining Ecosystem in Relation to Latex Yield, in the press.

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