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NATURAL RUBBER PLANTATION: A NUTRITIONALLY SELF-SUSTAINING ECOSYSTEM

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A field experiment investigating the effect of skipping of fertilizer applications for one or more seasons or years on growth and yield of mature rubber was conducted in a 10-year-old mature rubber plantation of clone RRII 105 at Kodumon Estate, Kerala representing the traditional rubber growing tract in India. The experiment consisted of seven treatments, *viz*. 30:30:30 N, P and K /ha/year applied in two split doses *i.e*. pre-monsoon and post-monsoon, full dose as pre-monsoon (current recommendations), half the dose as pre-monsoon, half the dose as post-monsoon, skipping during alternate years, skipping for two years and application every third year and continuous skipping (without any fertilizer for seven years). Observations on growth, yield, soil and leaf nutrient status, and bark thickness were recorded periodically for a period of seven years. It was observed that the growth and yield of rubber were not significantly influenced by withdrawing the application of fertilizers for a period of seven years. The annual yield from 2002 to 2009, the girth increment (2002-2009) and the cumulative yield during the period did not show any significant difference among the treatments. The soil and leaf nutrient status six years after the commencement of the experiment also did not indicate any significant difference among the treatments, indicating that a mature *Hevea* plantation can be considered as a partially self- sustaining ecosystem with a constant cycle of uptake from and return of nutrients to the soil. Therefore, it appears that in well-maintained areas with favourable terrain, adequate manuring during the immature phase and where leguminous cover crop was established, it is possible to skip fertilizers at least for a short period. However, in steep terrains with highly eroded and impoverished soils, manuring mature rubber may be essential.

Keywords: Fertilizer response, *Hevea*, Nutrient dynamics, Yield

INTRODUCTION

Natural rubber is a prominent plantation crop of considerable significance to Indian economy. Manuring is an important agromanagement practice during both immature and mature phases of rubber. Improved growth and vigour during the immature phase are often associated with fertilizer application, but various fertilizer experiments in mature rubber did not give consistent positive yield response and in many cases, absence of response was observed (George, 1962; Punnoose *et al*., 1994; Jessy *et al*., 2004). Rubber plantations present an environmentally acceptable replacement for native forest, being a closed ecosystem with a constant cycle of uptake and return of nutrients from and to the soil (Watson, 1989). The establishment and maintenance of legume ground cover during

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the early years of growth prevent erosion and facilitate recycling significant quantity of nutrients in the immediate soil surface. Therefore, the nutrient requirement of mature rubber is generally considered to be low. However, considering the fact that rubber plantations are no longer raised in virgin forests and most of the plantations are either in the second or third cycle of replanting and more and more marginal and depleted soils are being brought under rubber cultivation to meet the increasing demand, sustaining high level of productivity through judicious nutrient management gains importance (Krishnakumar and Potty, 1992). In this context, an experiment investigating the effect of skipping fertilizers for one or more seasons or years, on growth and yield of mature rubber, was designed.

MATERIALS AND METHODS

A field experiment was established during 2001 in a 10-year-old mature rubber plantation of clone RRII 105 at Kodumon Estate, Kerala which represents the traditional rubber growing tract in India. The experiment was continued for seven yers. The soil of the experimental site was sandy clay loam in texture, acidic in reaction (pH 4.54), high in organic carbon content (1.97%) and medium in available P (1.39 mg/100 g) and K (7.15 mg/100 g). The area was under regular fertilizer application as per the recommendations of RRII and *Pueraria phaseoloides* was established as cover crop and maintained during the immature phase. The experiment consisted of seven treatments laid out in randomized complete block design with four replications. The treatments were 30:30:30 N, P and K /ha/year applied in two splits *i.e.* pre and post-monsoon (current recommendations), full dose as pre-monsoon, half the dose only as pre-monsoon, half the dose only as post-monsoon, skipping of fertilizers in alternate years, skipping for two years and fertilizer application during the third year and continuous skipping for seven years (without any fertilizer). Urea, rock phosphate and muriate of potash were the sources of N, P and K respectively. The plot size was 30 plants, with a net plot size of eight plants. The tapping system followed was S/2 d3 6d/7 with three stimulations per year using ethephon 2.5% as panel application.

Soil (0-30 cm depth) and leaf samples were collected periodically from the experimental plots. The soil samples were analysed for pH, organic carbon (Walkley and Black method, Jackson, 1973), available P (Bray and Kurtz, 1945) and available K (Morgan, 1941). The leaf samples were also analysed for nitrogen, phosphorus and potassium (Piper, 1966).

Girth of the trees was recorded annually at a height of 150 cm above the bud union and average girth increment over a period of seven years after the commencement of the experiment was computed. Latex yield was recorded once in a month from individual plots and the per tree yield was worked out as g/tree/tap. Bark thickness was measured using a bark gauge. The data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Growth and yield

It was observed that the growth and yield of rubber were not significantly influenced by withdrawing the application of fertilizers for a period of seven years. Throughout the study period (2002-2009)

annual yield and cumulative yield did not indicate any positive response to the application of N, P and K fertilizers (Table 1). The lack of response or inconsistent response in terms of yield to the application of fertilizers in mature rubber was reported in many field experiments (Pushpadas and Ahammed, 1980; Sivanadyan, 1983). The girth increment during this period (2002-2009) also followed a similar trend (Fig.1a). No significant difference was noticed in growth response among the treatments. Though bark thickness is yet another parameter getting affected by lack of proper nutrition, there was apparently no positive manuring effect on bark thickness and renewal (Fig.1b).

The absence of response even after seven years of continuous withdrawal of fertilizers may be due to the better agromanagement inputs the trees received during the immaturity period. The experimental field was under regular fertilizer application prior to the commencement of the experiment. With sufficient manuring during the immature phase, a nutrient build up occurs within the whole- tree system. The tree nutrient bank for all the nutrients increases in magnitude with growth. This build-up can sustain the nutrient requirement for some years of maturity (Sivanadyan *et al*., 1995). Moreover, the cover crop *P. phaseoloides* was well established and maintained during the immature phase which would have subscribed significantly to the nutrient economy of the system. Leguminous cover crops add about 5-7 t/ha of organic matter and the nutrient accumulation in a two-year-old legume cover ranged from 174-236, 13-15 and 79-104 kg/ha N, P and K, respectively (Philip *et al*., 2005). The beneficial residual effect of legume ground

Table 1. **Effect of skipping of fertilizers on yield of rubber**

Treatment	Yield (g/t/t)							Cumulative yield (g/tree) 2002-09
	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	
NPK 30:30:30 kg/ha/ year in two splits	63.84	83.03	71.32	64.15	88.18	102.55	64.85	537.92
Full dose every year as pre-monsoon	66.87	75.81	69.80	68.12	106.30	120.03	59.63	566.56
Half the dose as pre-monsoon	69.31	70.52	65.78	63.49	100.63	97.03	61.28	529.04
Half the dose as post- monsoon	69.10	82.09	65.11	72.54	94.38	111.39	70.28	564.89
Skipping during alternate years	65.81	81.37	76.36	74.31	102.37	118.61	66.12	584.95
Skipping for two years and application every third year	72.00	82.52	68.42	67.99	120.17	126.21	75.05	612.16
Continuous skipping	67.23	81.38	72.14	73.86	104.15	118.66	68.84	586.26
SE	6.14	4.24	5.34	6.48	10.57	12.14	6.71	34.84
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

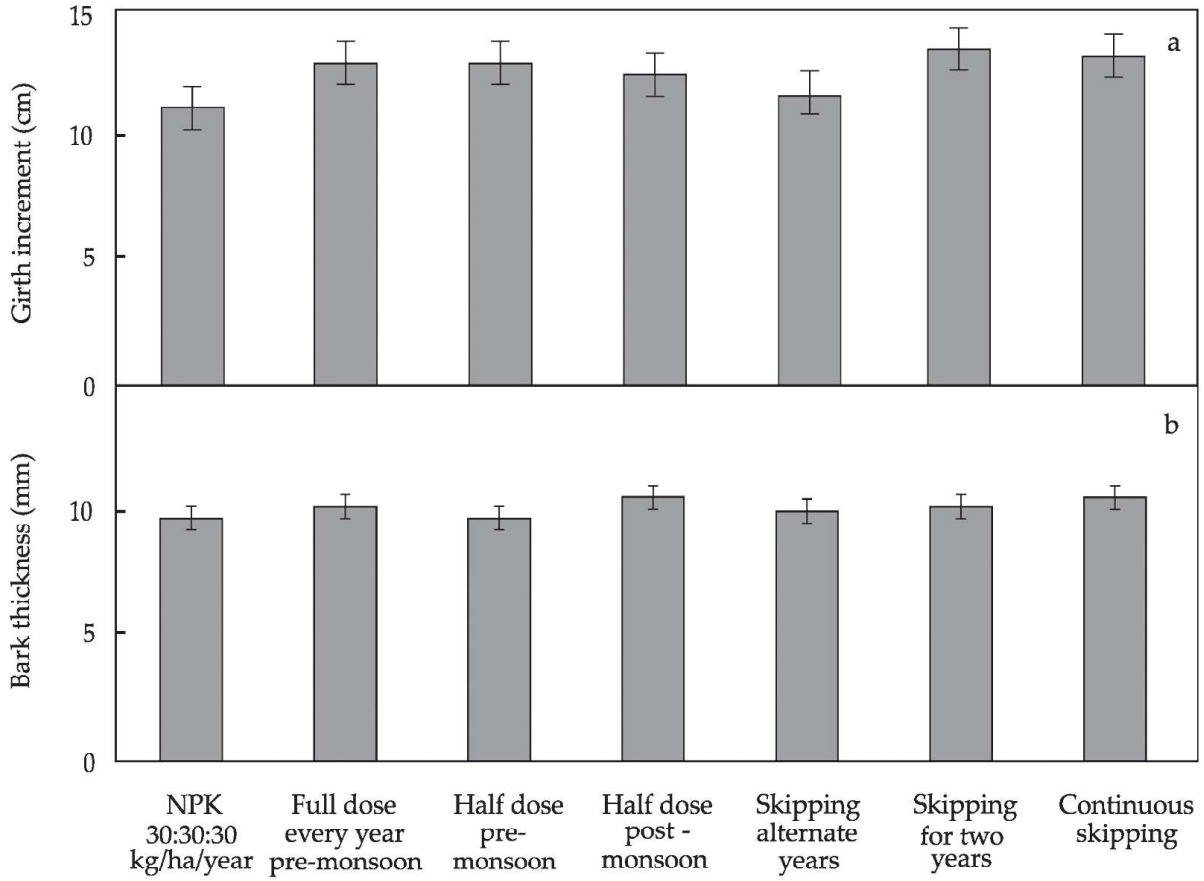

Fig. 1. Effect of skipping of fertilizers; a. on growth of rubber, b. on bark thickness. Error bars are ± standard error

cover on yield of rubber is well documented. It has been observed in earlier field experiments that the fertilizer requirement of rubber grown in association with legume ground cover is always low in comparison with the plants grown in association with natural cover (Mathew *et al*., 1989; Punnoose *et al*., 1994).

Soil and leaf nutrient status

The soil nutrient status at the beginning of the experiment and six years after also did not show any significant difference among the treatments (Table 2), indicating that mature rubber plantation is a self-sustaining ecosystem with a constant cycle of uptake and return of nutrients from and to the soil. Over the years, there was a build-up of organic carbon and available K, while the available P status was maintained in the medium range. The leaf nutrient status was maintained in the sufficiency level irrespective of the treatments (Table 3). Significant addition of nutrients takes place through leaf litter as rubber adds about 7-8 t of litter per ha every year (Varghese *et al*., 2001) which, upon decomposition, releases about 88-130 kg N, 2-5 kg P and 45-60 kg K into the soil. The tree retrieves a part of the lost nutrients from the decomposing litter through the mat of feeder roots formed on

Table 2. **Effect of skipping of fertilizers on soil nutrient status**

Treatment	Soil nutrient status					
	2002			2008		
	OC (%)	Av.P mg/100g	Av.K mg/100g	OC (%)	Av.P mg/100g	Av.K mg/100g
NPK 30:30:30 kg/ha/year in two splits	1.87	1.63	7.12	2.43	1.34	11.72
Full dose every year as pre-monsoon	2.08	1.57	7.81	2.19	1.17	9.68
Half the dose as pre-monsoon	1.84	1.55	7.00	2.16	1.50	10.26
Half the dose as post- monsoon	1.83	1.22	6.81	2.51	1.35	10.21
Skipping during alternate years	2.00	1.37	7.50	2.50	1.35	10.59
Skipping for two years and application every third year	2.09	1.16	7.25	2.09	1.33	9.05
Continuous skipping	2.03	1.45	6.91	2.59	0.94	10.81
SE	0.29	0.29	0.64	0.11	0.38	0.61
CD(P=0.05)	NS	NS	NS	NS	NS	NS

Table 3**. Effect of skipping of fertilizers on leaf nutrient status**

Treatment	Leaf nutrient status (%)		
	N	P	K
NPK 30:30:30 kg/ha/year in two splits	3.62	0.22	1.23
Full dose every year as pre - monsoon	3.54	0.22	1.26
Half the dose as pre - monsoon	3.51	0.22	1.11
Half the dose as post - monsoon	3.20	0.22	1.01
Skipping during alternate years	3.37	0.22	1.10
Skipping for two years and application every third year	3.47	0.21	1.12
Continuous skipping	3.48	0.25	1.19
SE	0.13	0.02	0.05
CD (P =0.05)	NS	NS	NS

the surface of the soil. The ecosystem is also replenished with various major nutrients through rainfall (Meti and George, 2009). The nutrient removal from the system is through latex and wood. Relatively low amounts of nutrients are removed through latex (Krishnakumar and Potty, 1992). The average nutrient removal through latex for 2000 kg dry rubber yield was estimated to be 12.4, 2.8 and 11.4 kg N, P and K, respectively and the average per tree removal was worked out as 7.9 kg N, 0.9 kg P and 6.4 kg K (Krishnakumar and Potty, 1992). Therefore, the nutrient outflow is comparatively less and an efficient nutrient economy operates for *H. brasiliensis*.

In view of the nutrient dynamics operating within the mature *Hevea* ecosystem, it may be considered at least as a partially self-sustainable one, and this may be the reason for the lack of response

to fertilizers. Therefore, it appears that in well-maintained areas with favourable terrain, adequate manuring during the immature phase and where leguminous cover crop was established, it is possible to skip fertilizers at least for a short period during the yielding phase. However, in steep terrains with highly eroded and impoverished soils, manuring of mature rubber may be essential for good yield.

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