Jl. Rubb. Res. Inst. Sri Lanka (1977) **54**, 291—298

MANAGEMENT OF COVERS UNDER *HEVEA* IN SRI LANKA

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SUMMARY

Results of two experiments, comparing the effects of leguminous creepers and naturals as ground covers on growth of immature rubber, are discussed. In one experiment the growth of rubber in plots under pure legume covers was better than that under naturals. Application of extra nitrogen to trees in plots with natural covers improved their growth but the latter was not comparable to that in legume plots. In the other experiment the increase in growth of rubber with higher levels of fertilizer nitrogen was observed irrespective of the type of cover.

Application of phosphate to covers led to better tree girths than where the phosphate was applied to the trees, irrespective of the type of cover grown.

These results are discussed in relation to the nitrogen content of rubber leaves, green matter, litter and C/N ratio of the litter of covers.

INTRODUCTION

Management of ground covers is an important aspect of rubber cultivation in a tropical country like Sri Lanka where both rainfall and temperature are high. Ground covers are essential for the preservation of fertility and soil conservation (Watson, 1961).

In the last two decades a great deal of work on the effects of different cover plants on rubber growth and yield have been reported (Watson *et al.*, 1964 ; Mainstone, 1969 ; Pushparajah & Chellapah, 1969 ; Soong & Yap, 1976). But the effects are known to vary from place to place and this has been attributed largely to variation in soil and climatic factors.

Two experiments were therefore laid down to study this aspect under local conditions. The objectives were : (1) to determine whether legumes are superior to naturals in increasing growth of young rubber trees (2) if so, whether the application of extra nitrogen in areas with non-legume covers could improve growth during immaturity and yield during early maturity to the extent obtainable by growing legumes (3) whether application of phosphate to covers and/or rubber is beneficial.

MATERIALS AND METHODS

The first experiment was started in 1970 on a sandy clay loam of the Agalawatta series (Silva, 1969) using clone RRIM 623. The design was a split plot, with treatments being replicated twice. Legumes (mainly *Mimosa invisa*) and naturals were in the main plots. Four levels of nitrogen (level two corresponds to the normally recommended rate and level four twice the normal recommendation) and four methods of application of phosphate *viz*, no phosphorus, phosphorus to cover, phosphorus to rubber and phosphorus to cover and rubber, were in the sub-plots (Table 1).

TABLE 1 : EXPERIMENT 1. FERTILIZER SCHEDULE

Year of application	Treatment fertilizers						Uniform applications	
	Ammonium Sulphate (oz/tree)				Rock Phosphate			
	N_1	N_2	N_3	N_4	(oz/tree) P_r	(cwt/ac) P_c	Muriate of Potash (oz/tree)	Epsom Salt (oz/tree)
May '70 — April '71	4	6	8	10	6	2	2	2
May '71 — April '72	8	12	16	20	12	2	4	4
May '72 — April '73	12	18	24	30	18	2	6	6
May '73 — April '74	12	18	24	30	18	1	6	6
May '74 — April '75	12	18	24	30	18	1	6	6
May '75 — April '76	12	18	24	30	—	—	6	6

The second experiment was started in 1972, on a sandy loam of the Boralu Series (Silva, 1969), using clone PB 28/59. The treatments that were studied in a randomized block design replicated four times are : (1) Sown mixed legumes (mainly *Pueraria phaseoloides* and *Desmodium ovalifolium*, L) (2) Selective elimination of non-legume cover constituents from the natural cover (L : S) (3) Non-selective control of natural cover (N : NS) (4) Non-selective control of natural cover with supplementary nitrogen equivalent to thrice the normal recommendation (N : NSn_1) (5) Non-selective control of natural cover with manuring of rubber controlled by leaf analysis to the levels with sown mixed cover legume (N : NSn_2).

Natural covers in both experiments were controlled by occasional non-selective slashing.

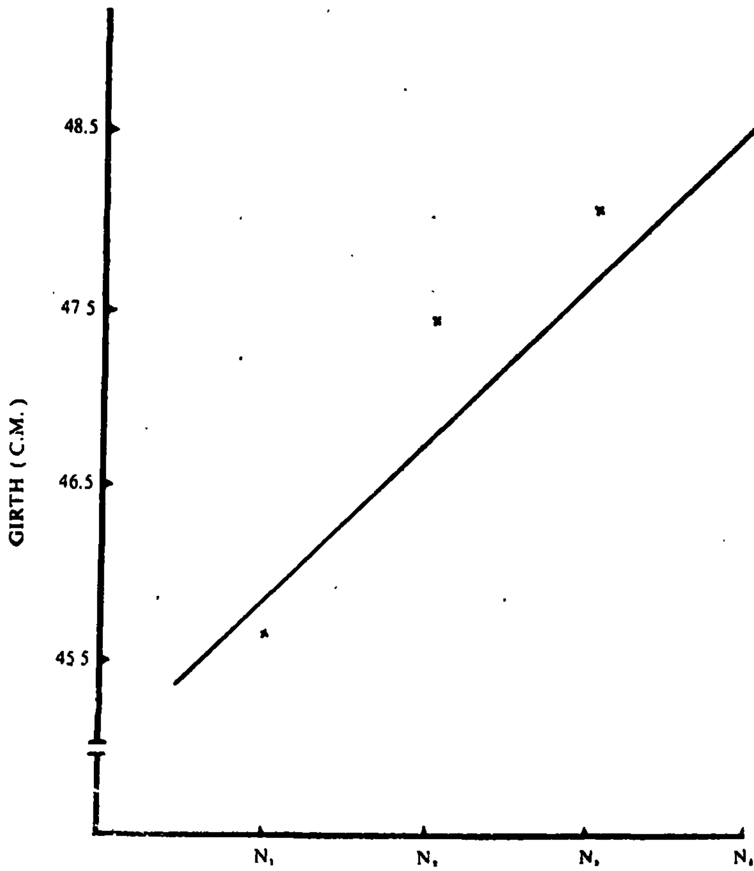
Growth of trees was measured yearly in Experiment 1 and at six monthly intervals in Experiment 2, as girth at 90 cm from the bud union.

Composite leaf samples from ten trees per plot were collected and analysed for total nitrogen, by Kjeldahl method ; phosphorus, by a colourimetric molybdenum blue ; and organic carbon by Walkley & Black's methods. Cover sampling was done by a square quadrat (30·5 cm) method.

RESULTS AND DISCUSSION

Nitrogen

Effect on growth : In Experiment 1, application of nitrogen showed a tendency to improve growth of rubber in the early stages of immaturity. This effect was significant at the end of six years ; the response being significantly linear (Fig 1). The increase in growth with higher levels of fertilizer nitrogen was observed irrespective of the type of cover grown. It is generally known (Mainstone, 1969 ; Pushparajah & Chellapah, 1969) that response to applied nitrogen is greater with naturals than with legumes. This is possibly due to, greater Rhizobial nitrogen fixation by legumes, either in the absence or at low levels of applied nitrogen. However, the results of this experiment seem to suggest that a leguminous cover of *Mimosa invisa* may not be very effective in this respect. Trees in natural plots receiving the lowest level of nitrogen had a girth of 91 cm compared to only 92 cm in the respective plots in *Mimosa*. It seems that higher rates of fertilizer nitrogen to rubber may be useful in such instances.



EFFECT OF LEVELS OF NITROGEN
ON GROWTH OF HEVEA

Fig. 1

On the other hand, in Experiment 2, the growth of trees in the sown legume plots was much better than in the plots in naturals. This effect was shown from the second 6 months period onwards (Table 2). The trees in naturals with supplementary nitrogen to rubber (N : n_1) also showed a similar tendency which was significant at the end of four years.

The rate of growth expressed as six monthly girth increments (Table 3) shows that there has been a steady increase in the rate of girthing of trees in the legume plots. A similar effect was shown by trees in naturals with supplementary nitrogen, but the growth was not comparable to that observed in the sown legume plots, The trees in naturals with extra nitrogen based on leaf analysis, did not show any improvement in growth.

TABLE 2 : EXPERIMENT 2. DIAMETER AND GIRTH MEASUREMENTS (CM)

Treatments	Diameter at 15 cm				Girth at 90 cm			
	Dec. 72	July 73	Dec. 73	July 74	Dec. 74	July 75	Dec. 75	July 76
L	1·33	3·01**	3·62*	14·49**	18·00**	23·87***	29·75***	34·34***
L : S	1·26	2·87*	3·42*	13·91**	17·17**	21·30**	25·91**	29·34**
N : NS (Control)	1·21	2·50	3·06	11·40	13·71	16·07	19·17	21·64
N : NSn_1	1·35	2·80	3·31	12·31	14·88	18·56	21·88	25·30*
N : NSn_2	1·32	2·61	3·18	11·98	14·40	17·40	20·10	22·23
LSD	NS	0·27	0·35	1·61	2·05	2·63	2·90	2·55

TABLE 3 : EXPERIMENT 2. SIX MONTHLY GIRTH INCREMENTS (CM)

Treatments	July 74 — Dec. 74	Dec. 74 — July 75	July 75 — Dec. 75	Dec. 75 — July 76
N	2·31	2·36	3·10	2·47
L	3·51**	5·87***	5·87***	4·59***
L : S	3·26**	4·13**	4·61	3·43*
N : n_1	2·57	3·68	3·32	3·42*
N : n_2	2·42	3·00	2·70	2·13
LSD	0·59	1·22	0·80	0·64

Effect on mineral composition : The leaf nitrogen concentrations in the legumes plots were greater than that in the naturals in the 2nd and 3rd years from planting (Table 4). This may indicate an increased availability of nitrogen from the legume covers. In 1975 and 1976, although the leaf nitrogen concentration in the legume plots did not differ very much from that in naturals, yet there has been an increased availability of nitrogen from the legume plots in these years. The total nitrogen uptake of the leaves of a given tree will depend, not only on the percentage of nitrogen in individual leaves, but also on the total canopy carried by the trees. A measure of the latter was therefore done by selecting three trees at random in each plot and determining the total dry weight of the entire leaves that were lopped down for this purpose.

TABLE 4 : EXPERIMENT 2. NITROGEN CONCENTRATION OF RUBBER LEAVES SAMPLED ANNUALLY (%)

Treat-ments	August/September			
	1973	1974	1975	1976
N	2·86	2·77	2·79	3·11
L	3·34*	3·03*	2·88	3·29
L : S	3·28	2·91	2·68	3·25
N : n_1	2·95	2·91	2·82	3·26
N : n_2	2·88	2·85	2·73	3·08
LSD	0·10	0·20	NS	NS

The trees in legume plots carried a much denser canopy (expressed as total dry weight of leaves per tree) than those in naturals (Table 5) which in this case is also associated with greater vigour of the tree. A similar effect was shown by the N : n_1 plots as well. Therefore, the denser canopy taken in conjunction with the nitrogen concentration in individual leaves, establishes the greater uptake of nitrogen by the trees in the leguminous covers and N : n_1 plots. An incidental but important point that emerges from this is that concentrations of nutrients in leaf tissues should be interpolated with vigour and total dry weight for better assessment of nutrient status of *Hevea*.

TABLE 5 : EXPERIMENT 1. TOTAL DRY WEIGHT AND NITROGEN CONTENT OF LEAF PER TREE (g)

Treatments	Dry wt. of leaves	N content of leaves
N (Control	455	14·78*
L	1856***	61·76***
L : S	896*	29·09*
N : n_1	794*	25·16*
N : n_2	435	13·40
LSD	258·76	7·82

The nitrogen content of the cover, leaves, green matter and litter was much greater and the C/N ratio of the litter lesser in the legumes than in naturals (Table 6). It is well known that materials with low C/N ratio would be expected to mineralise rapidly with its nutrient content becoming quickly available again for uptake by *Hevea* or cover plants (Watson, 1961). 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.

TABLE 6 : EXPERIMENT 2. NITROGEN CONCENTRATION (%) AND C/N RATIO ; 42 MONTHS

Treatments	Cover leaves	Green matter	Litter	Litter ratio C/N
N(Control)	1·60	1·03	1·65	22·26
L	2·22***	1·46***	2·26***	12·09***
L : S	1·98*	1·14	2·15***	13·39***
N : n_1	1·72	1·01	1·68	18·55
N : n_2	1·64	1·07	1·57	19·18
LSD	0·20	0·14	0·16	1·54

The poorer growth of rubber in the natural plots whose constituents were mainly grasses like *Axonopus* and *Paspalum* and composites like *Mikania* and *Hedyoties*, is probably due to the poorer return of essential nutrients to the soil by the natural cover and the competition for moisture by the grasses with their more dense root system. Moreover, it is known that *Mikania* exudes a growth inhibitory phenolic compound (Wong, 1964) and this may, besides reducing nitrification, also affect adversely the microbial population in the soil.

The poorer response in growth to supplementary nitrogen, as high as three times the normal recommendation, may have been due to greater leaching losses. It is known that leaching losses of nitrogen are generally high on sandy and sandy clay soil, particularly when ammonium of sulphate is used as the source of nitrogen (Anon, 1974). Moreover, under our conditions with an annual rainfall of 4000 to 5000 mm (Gunasekera, 1976), where both intensity and total rainfall are high, one would expect greater leaching losses than in countries receiving lesser rainfall *i.e.* Malaysia.

Effect on wintering : It was observed that the trees in naturals had started to defoliate from the 3rd year of planting whereas the trees in legumes showed the first sign of defoliation in the 4th year. Even then, the percentage of trees that defoliated was much lower.

The leaf nitrogen concentration in samples collected one week before defoliation occurred showed that the N concentration in leaves in legume plots remained more or less the same as it was in August, but in the natural plots, there was a decrease (Table 7). Since there was no marked change in the dry weight of the leaves during this period, it would appear that the fall in concentration was not due to dilution, but probably because of back translocation from the leaf to the tree. This shows that a setback in growth in the natural plots may have occurred even before the actual defoliation occurred. Moreover, as wintering is believed to be related to soil moisture level, it may be that the soil under legumes retained more moisture than under naturals.

TABLE 7 : EXPERIMENT 2. NITROGEN CONCENTRATION IN RUBBER LEAVES SAMPLED IN AUGUST AND PRIOR TO WINTERING : 1975

Treatment	August	Prior to wintering
Legumes	2·88	2·81*
Naturals	2·79	2·55
LSD	NS	2·25

Phosphorus

Effect on growth : Application of phosphate to cover in Experiment 1 had led to better girths, irrespective of the type of cover grown (Table 8). Phosphate to rubber only, also showed a similar tendency, although the effect was not always significant. Moreover, from 1974 *i.e.* 4 years from planting, phosphate to cover had even led to better girths over that of the trees that received phosphate.

Effect on mineral composition : The method of phosphate application influenced the leaf P concentration in line with the observation on growth. This implies that the increase in growth of *Hevea* shown by phosphate treatments may be due to a greater phosphate uptake.

TABLE 8 : EXPERIMENT 1 — GIRTH (CM)

Treatments	At 90 cm 1972 (Nov.)	1973 (Nov.)	1974 (Nov.)	1975 (Nov.)	At 150 cm 1976 (Oct.)
P_o	19·61	27·44	37·65	41·70	45·51
P_r	20·92	29·89*	40·63*	44·76	46·71
P_c	21·30*	31·26***	43·32***	48·24**	49·76***
P_{rc}	21·76*	32·51***	44·20***	48·66**	50·14***
LSD	1·38	1·74	2·25	3·23	2·06

The results confirm that the technique of applying Rock phosphate to covers (Pushparajah & Chellapah, 1969), in this instance both legumes and naturals, allows easier uptake of phosphate by *Hevea.* Phosphate taken up by the covers, become incorporated in the organic matter of the soil as the litter decays (Watson, 1957). An increase in the organic matter of the soil is known to increase phosphate availability (Dalton *et al.*, 1952). Moreover the residual mulch of ground covers may also promote microbial activity possibly resulting in greater mycorrhizal feeding. The role of mycorrhiza on phosphate nutrition of plants is now well known (Mosse *et al.*, 1973).

Effect on yield : Experiment 1, was brought into tapping in the early part of 1976. As would be expected, better growth during immaturity resulted in early opening of a greater number of trees in plots that received higher levels of nitrogen (Table 9). Similarly, the percentage of trees opened in plots that received phosphate to cover was also greater than in the plots where phosphate was applied to rubber only. This initial advantage, resulted in a greater yield/ac, but the yield per tree was not different, during the first six months of tapping.

TABLE 9 : EXPERIMENT 1. PERCENTAGE OF TREES OPENED FOR TAPPING (AT 50 CM) IN MARCH, 1976

Treatments	%	Treatments	%
N_1	36	P_o	28
N_2	43	P_r	39*
N_3	48	P_c	55***
N_4	52*	P_{rc}	57***

Although a detailed economic evaluation is not possible at this stage, yet the results obtained so far seem to suggest that application of extra nitrogen to compensate for the absence of legumes during immaturity may not be economical.

PRACTICAL APPLICATIONS

1. Endeavour to establish a leguminous cover at replanting. This can be achieved by sowing suitable legumes and by selective elimination of non-legume cover constituents from the natural cover.

Choose legumes with high N content in leaves, green matter and litter, but low in C/N ratio. A mixed growth of *Pueraria* and *Desmodium* seems suitable.

2. If legume establishment and maintenance becomes difficult, extra nitrogen to rubber at rates three times the normal recommendation may improve growth, but not comparable to that in legumes.
3. Applying Rock phosphate to rubber is likely to improve growth, but a greater benefit may be obtained when it is applied to the covers, irrespective of what cover persists.
4. When using leaf analysis for diagnostic purposes in *Hevea*, concentrations of nutrients, at least nitrogen, should be interpolated with vigour and total dry weight.

ACKNOWLEDGEMENTS

Our Director and Head of Department, Dr. O. S. Peries, gave up his time generously throughout in helpful discussion, criticism and encouragement, and we wish to express our sincere gratitude for his sustaining support. Our thanks are also due to Mr. V. Abeywardena, Consultant Biometrician, for his assistance in the statistical analysis of some of the data and the Superintendents of the estates where experiments were carried out for their cooperation.

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