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A STUDY OF THE RESPONSE IN YIELD AND GROWTH OF RUBBER GROWN IN ASSOCIATION WITH LEGUME AND NATURAL GROUND COVER DURING THE IMMATURE PHASE

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ABSTRACT

The results of two fertilizer experiments on rubber, one grown in association with legume cover and the other with natural cover during the immature phase are presented. The yield data for the first five years of tapping are presented and discussed.

In the legume cover area, the average effect of manuring was significant only during the first year of tapping (1980). There was response to application of 20 kg P_2O_5/ha and 32 kg K_2O/ha during this period. During 1981 there was response to application of 6 kg MgO/ha in the absence of application of P. There was no response to the main effects during the subsequent years.

In the natural cover area the average effect of manuring was significant during the first two years of tapping i.e., 1980 and 1981. During 1980 (first year of tapping) N application gave response only upto the 40 kg/ha level. But in 1981, 1982 and 1983, N gave response upto 80 kg/ha level. Application of Mg at 6 kg/ha increased yield in 1983 and 1984.

A comparison of the mean yield per hectare per year in the two trial areas showed that the legume cover area gave higher yield during the first three years of tapping. In the subsequent two years a reverse trend was noticed. The cumulative yield obtained during the first three years of tapping in the legume cover area, more than justifies the cost of establishment and maintenance of legume ground cover.

INTRODUCTION

Judicious application of fertilizers has been found to increase and sustain the yield and enhance proper girthing and bark renewal of rubber trees. The mature and degree of response will depend to a large extent on the management practices followed in the estate. Establishment and maintenance of legume ground covers has been recommended as a very useful agronomic practice, since long. Many planters take care to grow legume ground cover in their estate while a few others fail to adopt this practice due to one reason or other. In the latter case natural vegetation of a mixture of various species of

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dicots and monocots take the place of legume cover. Such natural covers are kept under control without assuming the proportion of weeds by periodic slashing during the early immature phase, and later on the heavy shade prevalent in rubber plantation keep the cover in minimal growth.

Studies conducted by the Rubber Research Institutes of India and Malaysia reveal that the fertilizer requirements of rubber grown with legume ground cover and natural ground cover vary considerably during the latter half of immaturity and during the early years of maturity. The higher growth rate of rubber noticed in legume cover areas could be achieved in natural cover areas only with the application of extra doses of nitrogenous fertilizers.

It was considered worthwhile to find out the fertilizer requirements of rubber, during the initial years of tapping, which was differentially grown during the immature phase under legume cover. For this purpose, two field experiments, one with legume cover and the other with natural cover maintained during the immature phase and manured with differential doses of N,P,K and Mg were continued through the mature phase. The observations in yield, soil and leaf nutrient status as influenced by the different fertilizer treatments are brought out and discussed.

MATERIALS AND METHODS

In 1971, two separate experiments were laid out in adjacent fields one with the leguminous ground cover *Pueraria phaseoloides* and the other where only the natural cover was allowed to grow under controlled conditions. Both the areas were planted with green budded stumps of clone RRIM-600 in 1971. The experiments were located at Central Experiment Station, Chethackal, Ranni.

Both the trials were laid out in Randomised Block Design with split-plot experiment having four replications.

Treatments

Whole plot treatments: Two stages of receipt of regular manuring viz; S_1 and S_2, after which the differential treatments begin.

S_1: 10:10:4:1.5 NPK Mg for $3\frac{1}{2}$ years and then the sub-plot treatments

S_2: 10:10:4:1.5 NPK Mg for 7 years and then the sub-plot treatments.

(Full annual dose of the above fertilizer mixture being 400 kg/ha)

Sub-plot treatments: Two levels each of N,P,K and Mg as follows.

Nutrients	Levels Kg/ha.	
	Legume cover	Natural cover
N_1	20	40
N_2	40	80
Po	0	0
P_1	20	20
K_1	16	16
K_2	32	32
MgO	0	0
Mg_1	6	6

(i.e. $2^4 = 16$ factorial combinations (confounded) plus 2 absolute unmanured control plots in each replication.

Plot size: Gross – 49 trees, Net: 25 trees.

Field upkeep: A good leguminous ground cover of *Pueraria phaseoloides* was maintained in the legume trail area till it started dying out from the 5th year onwards due to canopy closing of rubber trees. In the natural cover trial area all the naturally regenerated plants were allowed to grow. Their growth was kept under control by periodical slashing. This natural cover consisted mainly of *Chromoleana Odorata, Lantana sp; Borreria sp.* and *Panicum sp.* Other management practices were uniformly adopted during the immature and mature phases in both the trial areas. The trees were opened for tapping in 1979.

Recording of observations

Yield was recorded from each plot once every month by the method of cup coagulation. The annual mean yield per tree per tapping for each plot was worked out for the years 1980 to 1984, the year 1980 being considered as the first year of tapping. The data were statistically analysed.

Soil and leaf samples were collected during 1979 and 1983 and the nutrient contents were determined. The percentages of leaf nutrients and the contents of organic carbon and available P,K,Ca and Mg contents were determined and the means presented in Table I to IV.

RESULTS AND DISCUSSION

The results of statistical analysis of the

Table I. *Mean Soil Fertility Status, 1979.*

A. Natural Cover

Organic carbon %			Av.P mg/100 g Soil			Av.K mg/100 g Soil			Av.Mg mg/100 g Soil		
No fertilizer	40 kg N/ha	80 kg N/ha	No fertilizer	No P_2O_5	P_2O_5 20 kg/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6kg MgO/ha
2.61	2.69	2.62	0.64	1.05	1.28	8.50	7.71	8.28	17.48	10.02	10.19
Mean (Weighted)	2.6		Mean (Weighted)	0.64		Mean (Weighted)	8.50		Mean (Weighted)	10.92	

B. Legume Cover

Organic carbon %			Av.P mg/100 g Soil			Av.K mg/100 g Soil			Av.Mg mg/100 g Soil		
No fertilizer	20 kg N/ha	40 kg N/ha	No fertilizer	No P_2O_5	P_2O_5 20 kg/ha	No fertilizer	K_2O 16 kg/ kg/ha	K_2O 32 kg/ ha	No fertilizer	No MgO	MgO 6 ha
2.41	2.35	2.42	0.67	0.84	1.06	5.28	5.31	5.18	7.84	5.33	6.55
Mean (Weighted)	2.39		Mean (Weighted)	0.92		Mean (Weighted)	5.25		Mean (Weighted)	6.15	

Table II. *Mean Leaf Nutrient contents, 1979.*
A. Natural Cover

N%			P%			K%			Mg%		
No fertilizer	40 kg N/ha	80 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6 kg MgO/ ha
3.66	3.75	3.72	0.22	0.23	0.25	1.06	1.08	1.22	0.46	0.46	0.47
Mean (Weighted)	3.73		Mean (Weighted)	0.24		Mean (Weighted)	1.14		Mean (Weighted)	0.46	

B. Legume Cover

N%			P%			K%			Mg%		
No fertilizer	20 kg N/ha	40 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6 kg MgO/ ha
3.88	3.75	3.61	0.29	0.28	0.28	1.26	1.20	1.19	0.59	0.51	0.55
Mean (Weighted)	3.70		Mean (Weighted)	0.28		Mean (Weighted)	1.20		Mean (Weighted)	0.54	

Table III. *Mean Soil Fertility Status, 1983.*
N. Natural Cover

Organic carbon %			Av.P mg/100 g Soil			Av.K mg/100 g Soil			Av.Mg mg/100 g Soil		
No fertilizer	40 kg N/ha	80 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6 kg ha
2.28	2.37	2.37	0.79	1.06	1.41	2.63	3.76	4.78	9.17	5.82	5.63
Mean (Weighted)	2.36		Mean (Weighted)	1.18		Mean (Weighted)	4.09		Mean (Weighted)	6.11	

B. Legume Cover

Organic carbon %			Av.P mg/100 g Soil			Av.K mg/100 g Soil			Av.Mg mg/100 g Soil		
No fertilizer	20 kg N/ha	40 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	MgO 6kg/ha
2.33	2.42	2.45	0.83	1.07	1.35	2.64	3.41	3.80	6.26	4.29	4.40
Mean (Weighted)	2.42		Mean (Weighted)	1.17		Mean (Weighted)	3.50		Mean (Weighted)	4.56	

Table IV. *Mean Leaf Nutrient contents, 1983.*
A. Natural Cover

N%			P%			K%			Mg%	
No fertilizer	40 kg N/ha	80 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6 kg MgO/ha
3.52	3.61	3.66	0.29	0.28	0.28	1.16	1.22	1.25	0.44	0.42	0.42
Mean (Weighted)	3.62		Mean (Weighted)	0.28		Mean (Weighted)	1.23		Mean (Weighted)	0.42	

B. Legume Cover

N%			P%			K%			Mg%	
No fertilizer	20 kg N/ha	40 kg N/ha	No fertilizer	No P_2O_5	20 kg P_2O_5/ha	No fertilizer	16 kg K_2O/ha	32 kg K_2O/ha	No fertilizer	No MgO	6 kg MgO/ha
3.60	3.48	3.52	0.27	0.27	0.78	1.26	1.20	1.23	0.36	0.45	0.46
Mean (Weighted)	3.51		Mean (Weighted)	0.27		Mean (Weighted)	1.22		Mean (Weighted)	0.44	

mean annual yield per tree per tapping of legume and natural cover areas from 1980 to 1984 are presented.

1980: Legume and Natural Cover

Table V indicates that the fertilizer applied plots recorded significantly higher yield compared to un-manured control plots in both the experiments. There was no significant increase in yield either in the legume cover or natural cover area by increasing the dose of nitrogen over 20 kg and 40 kg/ha respectively. Significant increase in yield was noticed by enhancing the doses of P and K in the case of legume cover. No such effect was noticed in the natural cover area. This may be due to the fact that large quantities of N released from dying legume require higher amounts of P and K to keep the

Table V. *Mean Yield per tree per tapping (g).*

Levels of Nutrients	Legume Cover		Natural Cover	
	S_1	S_2	S_1	S_2
N_1	26.0	26.0	23.0	26.1
N_2	26.3	26.6	26.0	27.1
P_o	25.5	25.7	24.9	26.4
P_1	26.8	26.8	24.0	26.8
K_1	25.2	25.7	24.9	25.6
K_2	27.2	26.8	24.6	27.7
MgO	25.8	26.7	24.6	26.3
Mg_1	26.6	25.9	29.4	26.9
Unmanured control	21.7		20.7	
Fertilized	26.2		25.5	
C.D. at 5% (for comparison between manured & unmanured)	1.68		3.5	
C.D. for comparison of levels of P and K	1.1			

Table VI. *Mean Yield/tree/tapping (g).*

	No MgO	6 Kg MgO/ha	Mean SE:0.89 CD: ..
No P_2O_5	39.52	45.70	42.61
20 kg P_2O_5/ha	44.77	43.93	44.35
Mean SE:0.89 CD:2.56	42.15	44.82	43.48
For means in the body of the table			SE: 1.25 CD: 3.59

nutrient ratios at optimum levels in plants for higher yields. These results are in agreement with the earlier findings made by the Rubber Research Institutes of India and Malaysia.

1981: Legume Cover

Analysis of the yield data given in Table VI indicates a significant response for Mg and a PxMg interaction. The average effect of Mg showed a significant positive response. But a closer examination of the results shows that there is response to Mg only in the absence of P. When P is applied it also adds Ca to soil by way of Rock Phosphate. This Ca could have an antagonistic effect with Mg. This may be the reason why Mg had response only when P is not applied.

Table VII. *Mean Yield/tree/tapping (g).*

Control (Unmanured)	Manured	Mean
33.07	37.62	37.12
SE: 1.84	0.65	
CD: (5%)	3.96	

There was no difference between the manured and unmanured plots. This could be due to the beneficial effect of the legume ground cover as evidenced by the high nutrient status even in unmanured plots.

1981: Natural Cover

The average effect of manuring was significant as noticed from Table VII. The manured plots gave significantly higher yield compared to unmanured plots. This is because when legume ground cover is not maintained during the immature phase there is definite need for manuring to obtain proper yield.

Table VIII reveals that the effect of N was significant. Application of N at 80 kg/ha gave significantly higher yield compared to 40 kg/ha. In the absence of legume cover there was no enrichment of soil N and hence there was need for a higher level of applied N for optimum yield. Similar results were reported by the Rubber Research Institute of India, Malaysia and Sri Lanka.

1982: Legume Cover

Neither the average effect of manuring nor the simple effect of any of the nutrients was significant. However, the interaction SXMg was significant. It is seen from Table IX that in the absence of Mg application, the treatment application of

Table VIII. *Mean Yield/tree/tapping (g).*

40 kg N/ha	80 kg N/ha	Mean
35.85	39.39	SE : 0.92 CD : (5%): 2.64

Table IX. *Mean Yield/tree/tapping (g).*

	S1	S2	Mean SE:0.91 CD:
No MgO	39.69	47.63	43.66
6 kg/MgO/ha	43.01	43.73	43.37
Mean	41.35	45.68	43.51
For 'Mg' means in a given level of 'S'			SE: 1.28 CD: 3.67
For 'S' means in a given level of 'Mg' or at different levels of 'Mg'			SE: 1.70 CD: 4.88

NPK Mg mixture upto 7 years (S2) of planting gave higher yield compared to cessation of the same mixture at $3\frac{1}{2}$ years (S1) of planting. This may be due to the favourable effect of Mg accumulated in the S2 treatment. But when Mg was applied there was no difference between S1 and S2. With S2, application of Mg significantly reduced yield whereas with S1 a favourable trend was noticed for applied Mg. The yield depression in S2 plots with Mg application may be due to the role of Mg in inducing early plugging of latex vessels.

1982: Natural Cover

The effect of N alone was significant. Nitrogen at 80 kg level significantly increased yield compared to the 40 kg level.

Table X. *Mean Yield/tree/tapping (g).*

40 kg N/ha	80 kg N/ha	Mean SE: 1.03 CD: 2.96
38.67	41.59	40.08

Table XI. *Mean Yield/tree/tapping (g).*

40 kg N/ha	80 kg N/ha	Mean SE: 0.99 CD: 2.84
45.16	49.25	47.22

1983: Legume Cover

None of the main effect nor any of the interactions was significant.

1983: Natural Cover

The effect of N was significant. Nitrogen at 80 kg/ha was superior to the 40 kg level in increasing the mean yield (Table XI).

The effect of Mg application also was significant. Table XII) indicates that Mg significantly increased the yield.

1984: Legume Cover

The interaction NP Mg alone was significant. It is seen from Table XIII that when 40 kg N is applied in presence of P and Mg there was significant yield drop compared to 20 kg N level. Similarly the higher level of N also depressed yield in the absence of P and Mg in comparison to the lower level of N in presence of P and Mg. This yield depression could be due to an imbalance of nutrients created by heavy application of N where the favourable effects of previous legume cover already existed.

Table XII. *Mean Yield/tree/tapping (g).*

No MgO	6 kg MgO/ha	Mean SE: 0.99 CD: 2.84
45.35	49.06	47.21

Table XIII. *Mean Yield/tree/tapping (g).*

	No MgO		6 kg MgO/ha		Mean SE: 1.18
	No P_2O_5	20 kg ha P_2O_5/ha	P_2O_5/ CD: ..	No P_2O_5/ha	20 kg
20 kg N/ha	50.81	50.44	51.00	56.88	52.28
40 kg N-ha	47.18	53.19	50.73	49.24	50.09
Mean SE: 1.66 CD: –	49.00	51.81	50.86	53.06	51.18

For means in the body of the table SE: 2.35 CD: 6.75

1984: Natural Cover

Table XIV reveals that application of Mg significantly increased the yield. The response to Mg application in the Natural Cover area may be due to a better balance of nutrients within the tree with the application of higher levels of nitrogen.

Comparison of Mean Yield in Legume and Natural Cover areas

Table XV indicates that during the first three years of tapping i.e. 1980, 1981 and 1982 the annual yield per hectare was higher in the legume cover area and a cumulative yield increase of 466 kg was obtained in three years time. But during 1983 and 1984 the Natural Cover area registered higher yield compared to the Legume Cover area. These results indicate that the beneficial effects of legume ground cover will be visible upto the initial years of tapping. This is in agreement with the finding of the Rubber Research Institute of Malaysia. The increase in yield in 1983 and 1984 in the Natural Cover area might be due to the higher levels of N applied in the Natural Cover area and the diminishing effects of legume in the Legume Cover area.

Table XIV. *Mean Yield/tree/tapping (g).*

No MgO	6 kg MgO/ha	Mean SE: 1.39 CD: 3.99
49.89	55.87	52.88

Table XV. *Mean Yield of rubber in legume and natural cover trial areas (Kg/ha*).*

Year	Legumer Cover	Natural Cover	% Increase in Legume Cover Area
1980	1175	1145	2.62
1981	1948	1685	15.60
1982	1949	1796	8.52
1983	2010	2115	..
1984	2293	2369	..
Cumulative yield (1980 to 1982)	50.72	4626	9.64

*140 tapping days/year and 320 trees/ha.

The additional yield obtained in Legume Cover area for the first three years of tapping more than justifies the cost of establishment and maintenance of the legume cover.

CONCLUSIONS

Based on the results obtained in these experiments the following conclusions may be drawn.

1. While making fertilizer recommendations due consideration has to be given to the history of ground cover maintenance in the plantation.

2. In areas where legume cover is established the additional yield obtained during the initial years of tapping will more than justify the cost of establishment and maintenance of the legume cover.

3. When legume cover is not established there will be need for higher doses of N application during the initial years of tapping to obtain optimum yields.

4. In legume maintained areas there is scope for saving a lot of fertilizers during the initial years of tapping and hence discriminatory fertilizer application should be necessarily followed based on soil and leaf analysis.

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