Bulletin of the Rubber Research Institute of Sri Lanka, (2000) **42**, 1-10

ECONOMICS AND EFFICIENCY OF FERTILIZER UTILIZATION IN IMMATURE RUBBER

Lalani Samarappuli

INTRODUCTION

Nutrient management in rubber cultivation has gained greater importance in recent years because of two major reasons: firstly, rubber plantations are no longer raised in virgin forest soils and secondly, most of the plantations are either in the second or third cycle of replantation. Large amounts of mineral elements are locked up in the process of biomass accumulation and are lost through timber during replanting. Gradual depletion of mineral resources through cycles of replantation warrants appropriate nutrient management and at the same time, more and more marginal and depleted soils are being brought under rubber cultivation and under such situations proper soil and nutrient management are essential to sustain higher growth during the immature unproductive period.

Further, the introduction of high yielding clones of *Hevea* has no doubt provided a mechanism to reduce the unproductive period, given a set of specific conditions. It is also a known fact that the implementation of a proper package of agro-management practices in accordance to soil and climate is a pre-requisite to the realization of the plant's potential growth capacity. In this package, economics and efficiency of fertilizer utilization are vital elements.

1. Nutrients required by rubber plants

Response of a perennial crop like rubber to nutrition is influenced by the nutrient supplying capacity of the soil on one hand and factors like clonal variation, stage of growth and ground cover management on the other. Like any other plant, *Hevea* is expected to require all the thirteen known essential mineral plant nutrients for growth and development. Optimum growth and yields of plants can be achieved only by properly balancing the nutrients according to the need of the tree. The optimum nutrient level can be maintained by implementation of a well-planned manuring programme.

1.1 *Macro nutrients*

The conditions in Sri Lanka necessitates the application of nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) which are required in relatively large amounts, and are known as macro nutrients in rubber.

1.2 *Micro nutrients*

Some mineral plant nutrients are required by the rubber tree in relatively small amounts or in tracers. These are called micro nutrients. It appears that rubber growing soils in Sri Lanka have adequate supplies of micro nutrients for satisfactory performance of rubber trees. While no serious problems are encountered in dealing with macro-nutrients, correction of micronutrient imbalance is not a simple task since very small amounts are involved. A small excess of micro nutrients may prove to be fatal to the rubber plant.

2. Economics and efficiency of fertilizer utilization

The fertilizer need for immature rubber is well established. Emphasis should be given to efficiency of fertilizer applications as this involves a large expenditure and is a very important cultural practice. Statistical data reveals that the cost of fertilizers account for about 17% of the total maintenance cost of immature rubber. The share of fertilizer cost during immature period is presented in Fig 1. The fertilizer input therefore constitutes an important investment. Fertilizers have to be utilized efficiently to maximize the profits. Systematic and efficient application of fertilizers throughout the pre-tapping phase should be achieved by adopting the RRISL recommendations in relation to following areas.

- Choice of fertilizer - straight/mixture
- Quantity per plant
- Frequency of application
- Time of application
- Method of application

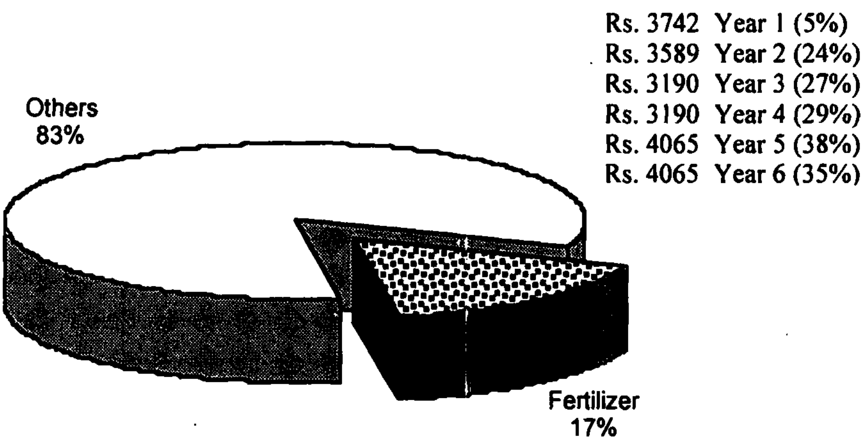

Fig. 1. The share of fertilizer cost during immature period

2.1 *Choice of fertilizer - straight/mixture*

Concentrated chemical fertilizers usually are the easiest and cheapest to apply. Other considerations include cost, physical state, solubility and stability of the material. Fertilizer cost can be minimized and fertilizer use efficiency can be improved by proper selection of straight fertilizer or fertilizer mixtures.

2.1.1 *Selection of urea based mixtures (instead of SA mixtures) during immature period*

Two types of nitrogenous fertilizers are used for rubber in Sri Lanka *i.e.* Urea and Sulphate of Ammonia (SA). Urea has been subsidized by the Government of Sri Lanka according to the revised fertilizer subsidy scheme. As a result, urea based fertilizer mixtures have become much cheaper compared to SA based mixtures. The Table 1 indicates that a sum of Rs.18,500/ha could be saved during the six year immature period by using urea based mixtures.

Table 1. *Savings on fertilizer by using urea based mixtures (instead of SA mixtures) during immature period*

Year	Cost of Urea based* (Rs/ha)	Cost of SA based* (Rs/ha)	Difference (Rs/ha)
1	1,894	2,450	556
2	2,705	4,900	2,195
3	3,916	7,351	3,435
4	3,916	7,351	3,435
5	5,360	9,801	4,441
6	5,360	9,801	4,441
		Net Saving	18,500

* Based on 1999 fertilizer prices

2.1.2 *Use of Dolomite (instead of kieserite) during immature period*

Kieserite and Dolomite are the two sources of Mg used in rubber cultivation. It is evident that at higher rates of application, Dolomite is as effective as kieserite in promoting growth, but at lower rates of application, kieserite is more effective, indicating that the availability of Mg from Dolomite is lower than that from kieserite. Dolomite is, therefore, more appropriate and more economical to use from 2nd year of planting until tapping. If urea based fertilizers are used there is an option available to use either kieserite or Dolomite as the source of Mg, from the second year onwards. A sum of Rs.8,180/ha could be saved by using Dolomite (instead of kieserite) for immature rubber from 2nd year up to tapping (Table 2). This clearly demonstrates that cost consideration overrides the effectiveness of source of Mg.

Table 2. *Savings on fertilizer by using Dolomite compared to keiserite during immature period*

Year	Cost of Dolomite (Rs/ha)	Cost of Kieserite (Rs/ha)	Difference (Rs/ha)
2	150	938	788
3	200	1,777	1,577
4	200	1,777	1,577
5	250	2,369	2,119
6	250	2,369	2,119
		Net Saving	8,180

2.1.3 *Market intelligence*

A wide variation in the price of fertilizers can be observed in the market, *i.e.* the same fertilizer mixture is sold at different prices by different companies. For instance, a recent study reveals that the rubber fertilizer mixture, R/U 12:14:14 (with IRP) is sold at different prices by five different companies ranging from Rs.8,110 to Rs.9,350 per MT (Table 3). Hence, it is advisable to be aware of the difference in prices and quality of the fertilizer mixtures prevailing in the market.

Table 3. *Price of R/U 12:14:14 mixture (with IRP) by different companies*

Fertilizer company	Price per MT (Rs)
A	9,350
B	9,290
C	8,980
D	8,910
E	8,110

2.2 ***Quantity per plant (Rate of application)***

Generally, the rate of fertilizer application should be dictated by the tree's requirement. In the immature period the requirement is for vegetative growth *i.e.* trunk girth increment. Long-term experiments carried out have clearly demonstrated the importance of fertilizer application for immature rubber. The rubber trees immobilize substantial quantities of nutrients in the trunks, branches and roots during the pre-tapping phase. The effect of correct application of fertilizers during initial stages are given in the Tables 4, 5 and 6.

Table 4. *Effect of fertilizers on growth of rubber plants (6 and 12 months after planting)*

Clone	Fertilizer	Months after planting		Increment (cm)	
		6	12	(cm)	(%)
RRIC 121	No fert.	3.7	6.6	2.9	100
	Rec. level	3.4	8.0	4.6	159
RRIC 110	No fert.	3.2	6.5	3.3	100
	Rec. level	3.5	8.1	4.6	139
PB 260	No fert.	2.9	6.3	3.4	100
	Rec. level	3.0	7.9	4.9	144
RRIM 712	No fert.	3.1	5.2	2.1	100
	Rec. level.	3.1	6.8	3.7	176

Table 5. *Effect of fertilizers on growth of rubber plants (2 yrs after planting)*

Treatment	Girth (2 yrs after planting)	
	(cm)	(%)
Without fertilizer	12.5	100.0
With fertilizer	18.2	133.0

Table 6. *Effect of fertilizers on growth of rubber plants (1 and 4 years after planting)*

Clone	Fertilizer	Years after planting		Increment (cm)	
		1	4	(cm)	(%)
PB 86	No fert.	4.5	19.5	15.0	100
	Rec. level	6.9	26.9	20.0	113
RRIC 100	No fert.	6.2	32.3	26.1	100
	Rec. level	8.2	40.2	32.0	123
RRIC 121	No fert.	6.6	28.7	22.1	100
	Rec. level	8.0	35.7	27.7	125
RRIC 110	No fert.	6.5	31.2	24.7	100
	Rec. level	8.1	41.4	33.3	135
PB 260	No fert.	6.3	33.4	27.1	100
	Rec. level	7.9	38.6	30.7	113
RRIM 712	No fert.	5.2	27.2	22.0	100
	Rec. level	6.8	36.3	29.5	134

Data on girth, girth increment and percentage tappability (Table 7) have shown that consistent increases in growth and consequently shortening of unproductive period by 15 months from fertilizer application (Fig 2). It is estimated that the savings on inputs amounted to Rs.14,000 per hectare. The close pattern of responses between girthing and percentage tappability suggests that the fertilizer effects which influenced girthing were equally effective on tappability.

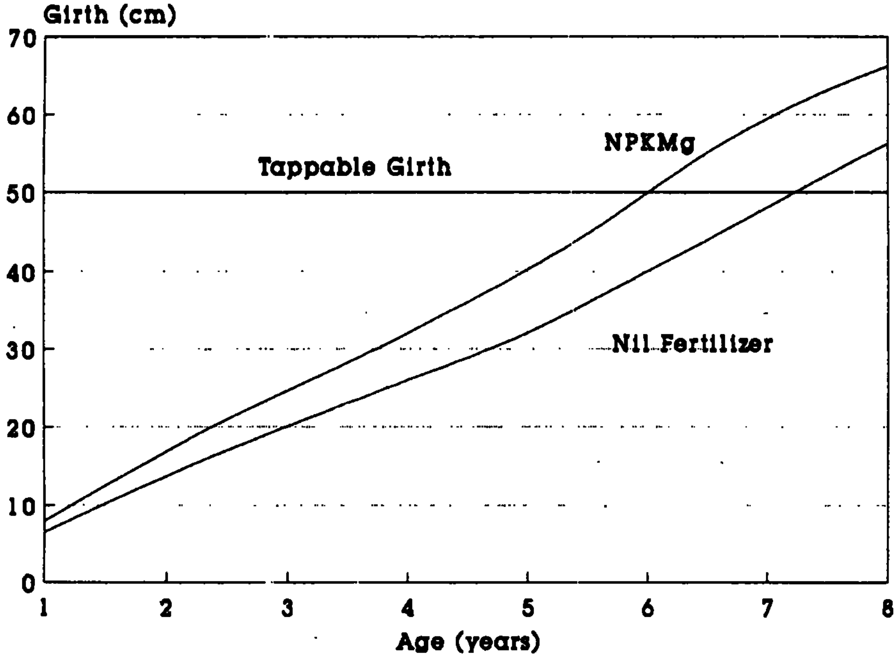

Fig. 2. Effect of fertilizers on girthing during immature period

Table 7. *Effect of fertilizers on tappability of rubber plants at the end of six years*

Treatment	Tappability (%)
Without fertilizer	31.3
With fertilizer	78.1

Although fertilizer gives a consistent response throughout the growth period during immaturity, additional N, P and K beyond the recommended level is unlikely to be beneficial for rubber plants (Tables 8, 9 and 10) and result in non-recovery of the cost for the additional fertilizers applied. Moreover, it is observed that the response for N is evident during the first three years after planting and thereafter there is relatively no response to N. However, it is also observed that responses to P, K and Mg are evident throughout the immature period (Table. 11).

Table 8. *Effect of N fertilizers on girth (cm)*

Treatment	Years after planting					
	1	2	3	4	5	6
No N	6.9	13.9	21.9	30.1	38.1	46.1
Rec. level	8.3	18.2	29.3	38.3	46.6	51.2
Double Rec. level	8.3	18.8	29.6	38.8	48.1	52.7

Table 9. *Effect of P fertilizers on girth (cm)*

Treatment	Years after planting					
	1	2	3	4	5	6
No P	6.7	13.6	21.5	27.8	35.7	44.5
Rec. level	8.3	18.2	29.3	38.3	46.6	51.2
Double Rec. level	8.1	18.5	29.0	38.0	45.1	51.0

Table 10. *Effect of K fertilizers on girth (cm)*

Treatment	Years after planting					
	1	2	3	4	5	6
No K	7.8	14.8	23.2	30.6	36.7	42.9
Rec. level	8.3	18.2	29.3	38.3	46.6	51.2
Double Rec. level	8.5	18.8	30.1	38.9	47.1	52.0

Table 11. *The impact on girth by different nutrients*

Nutrient	Highest impact on girth	
	Year (after planting)	Share of impact (%)
N	3	25
P	4	27
K	5	21
Mg	4	25

During the immature phase the N requirement is estimated to be much greater than the recommended fertilizer input. The deficit has to be met from the N gradually released by leguminous ground cover once the canopy of rubber closes (Fig 3). This could have been the reason for the poor response to N fertilizers from the third year after planting. It is apparent that legume covers are the most economical source of nitrogen and hence led to enhanced returns from the rubber. Legume covers give an additional return of Rs.2,200 per hectare per year over the non legume treatments receiving compensatory inorganic nitrogenous fertilizers. Hence for immature rubber, the cheapest source of N would be from creeping leguminous covers.

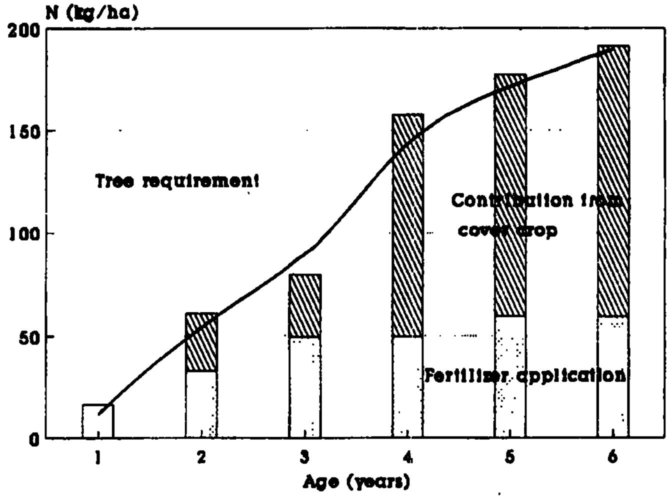

Fig. 3. Tree requirement and supply source of N during immature period

2.3 *Frequency and time of application*

During the early stages after establishment the fertilizers are applied within a small circle (25-30 cm radius) around the plant. The fertilizers applied during the first year amount to about 175 kg per hectare. However, the effective zone of application is only about 0.006 ha considering the effective radius of application around the plants. It is evident that at this rate (175 kg/ha), a considerable proportion of the fertilizers can be lost by leaching. If 2-5 cm of rainfall per day is experienced within ten days of fertilizer application, a large proportion (up to 50% or more) of the applied N and K can be lost by leaching. Thus, as a general rule, fertilizer application to young rubber has to be made in split applications (at more frequencies). Accordingly, higher frequencies or 3 to 4 split applications are recommended by the RRISL. Further, during the initial growth phase, until the fourth to fifth year, the trees grow actively and there is continuous flushing of leaves. Thus, during this period, frequent dressing of fertilizers are needed as low frequency of application (at high rates) would be wasteful and inefficient (a considerable proportion of the unused fertilizer would be leached away).

2.4 *Method of application*

When urea is applied on the soil surface without forking into the soil, N losses of up to 24% is observed. The RRISL recommendations should therefore be adopted in relation to method of application to maximize fertilizer use efficiency and minimize dilution through external forces. Moreover, it is very important that the fertilizer application should be carried out under careful supervision.

3. Soil management practices

The trend of response to applied fertilizers in rubber is influenced to a great extent by the soil management practices adopted during planting. The most important among such practices are the establishment and maintenance of a legume ground cover and mulching during the early immaturity period.

3.1 *Inter-row leguminous cover management*

Among the many factors that contribute to the agronomic and economic advantages of legume covers over naturals is the return of a large amount of N in the region of 120 kg/ha/yr, to the soil (Table 12). Non legume covers are not able to contribute such a large amount of N and could thus compete with the rubber plants for available N in the soil.

Leguminous covers immobilize a large amount of nutrients in their green materials during the first two years after planting. It is well known that materials with low C/N ratio would be expected to mineralize rapidly with its nutrient becoming quickly available again for uptake by rubber plants. As leguminous covers do not root deeply, the net effect would have been a rapid re-cycling of nutrient from the upper soil layers. The net nutrient contribution from legume cover compared to natural weeds is over Rs.2000/ha/yr during the 3-6 year period after planting (Table 12).

Table 12. *Contribution of nutrients from legume cover compared to naturals (between 3-6 years after planting)*

Nutrient	Contribution of nutrients (kg/ha/yr)		Difference in [(3)-(2)] as equivalent fertilizer	Value of (4) (Rs/ha/yr)
	Naturals	Legumes	(kg/ha/yr)	
(1)	(2)	(3)	(4)	
N	50	120	152 (Urea)	1,900
P	6.	10	33 (IRP)	198
K	28	30	4 (MOP)	42
Mg	17	20	25 (Dol)	48
	Net nutrient contribution from legumes			Rs 2,188/ha/yr

3.2 *Mulching around the base of the plant*

Mulching with rice straw is considered as a cost-effective agronomic practice to enhance fertilizer use efficiency and growth of rubber plants. Rice straw contains about 0.6-0.7% N, 0.7-0.1% P, 1.4-1.9% K, 0.2-0.3% Mg and 30-40% carbon. Incorporation of 23 MT of rice straw per hectare during the 6 years of immature period (2-5 kg/plant/application, once in 6 months) would contribute approximately 120 kg of N, 345 kg of K and 23 kg of P. These quantities represent about 43% of N and more than 100% of K presently recommended as chemical fertilizer for rubber during the immature period. Rice straw can also be considered as a source of micro nutrients.

One objection for using straw as a manure to short term crops is that it temporarily immobilizes the available soil N due to its high C/N ratio. Yet, this should not be considered as a disadvantage for rubber as no adverse effects like retardation of growth or deficiency symptoms were observed at any stage. In fact, a certain degree of immobilization can be regarded as advantageous as it will reduce N losses from the rhizophere and also perhaps regulate N supply to rubber plants to satisfy its needs. In addition, straw is a good source of energy to micro-organisms in the soil. It has been shown that application of rice straw markedly increased both heterotrophic and phototrophic N fixation. As a result, application of rice straw may also have increased the N fixation capacity in rubber soils.

Fertilizers are important and are costly inputs in rubber cultivation. The benefits of investment in fertilizers can be completely realized only when the fertilizers are used efficiently. This can be based on the effective cost per unit nutrient, efficiency of uptake by the rubber plant and the return on investment. Necessarily, the appropriate fertilizer at the correct rate must be applied at the proper time and the resultant benefits are of economic advantage.