

FERTILIZER USE AMONG PERENNIAL CROPS

By

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INTRODUCTION

Sri Lanka being a predominantly agricultural country has her agricultural activities focussed on two main sectors ; the export cash crop sector consisting of the three main perennial crops tea, rubber and coconut as well as minor exports such as coffee, cardamom pepper etc, and the domestic food production sector comprising mainly of food crops for local consumption. Agricultural exports, mainly of perennial crops, provide 75% of the foreign exchange earnings, with tea as the largest foreign exchange earner followed by rubber and coconut.

The country's total extent under the tree crops, tea, rubber, and coconut, their production and average yields have not shown much variation (Ann. Rep. Central Bank, 1982) over the last 10 years (Table 1).

Table 1. *Total extent, production and average yield per acre of tea, rubber and coconut*

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Tea										
Total acreage (000'ha)	242	242	242	240	242	244	244	245	245	242
Production (Mn.Kg)	212.0	204.7	214.3	197.0	209.3	199.7	206.4	191.4	210.1	187.8
Av. yield/kg/ha	904	990	1033	942	1009	941	993	922	914	827
Rubber										
Total acreage (000'ha)	228.8	227.8	227.2	226.7	226.7	226.4	226.4	273.3	205.6	205.7
Production (Mn.Kg.)	155	132	149	152	146	156	153	133	124	125
Av. yield/kg/ha	779	711	775	791	683	845	820	718	705	726
Coconut										
Production (Mn. Nut)	1935	2031	2398	2330	1821	2207	2393	2026	2258	2510

Source : Annual Report of the Central Bank of Ceylon, 1982.

Improvements in production of any crop could be achieved either by an extension of the area under cultivation or by intensification of production. As the land resources for growing perennial crops in Sri Lanka are limited, any future improvement must come mainly through increased yields from existing lands by replanting with high yielding clonal material and using optimum rates of fertilizers and other agromanagement inputs.

Consumption of fertilizer

Tree and plantation crops are all significant users of fertilizers and this practice has gained a degree of sophistication unknown in earlier days. In many tree and plantation crops, fertilizer use is based on diagnostic techniques using the results of soil and leaf analyses together with data from large scale long and medium-term fertilizer experiments sited on local soils. Fertilizers are applied to replace nutrients lost in the crop and also those immobilised in the trunk and leaves. In very high yielding material, losses of nutrient in the crop can be so high as to require compensatory fertilizer application. The actual consumption of fertilizer by the plantation sector over the years 1962 to 1982 is shown in Figs. 1, 2 and 3.

Tea sector

Figure 1, shows the development of nutrient consumption in the tea sector during this period. The nutrient level of around 34,000 tons has been rather consistent from as far back as 1967 with an exceptional increase in 1978 after relatively low consumption in 1977.

Rubber sector

Approximately 230,000 ha of rubber lands, which is nearly identical to the tea acreage, used 5,307 tons and 4,520 tons of fertilizer nutrients in 1981 and 1982, respectively (Fig 2). This shows a reduction of 21% and 15% from the 1980 and 1981 figures of 6,737 tons and 5,307 tons, respectively.

As for tea, rubber plantations are made up of three different categories :

- large public estates (managed by government organisations)
- large and medium private estates
- smallholdings.

In general, the degree of consistency in fertilizer application falls in the order of large, medium and small plantations. The consumption in the smallholder sector in particular which accounts for 65% of the total acreage, is definitely far from satisfactory. In addition to the higher costs of fertilizer, low prices for rubber recently added a further disincentive to the application of fertilizers.

Coconut sector

Unlike tea and rubber, the coconut sector showed a remarkable increase in the rate of consumption in 1980 (Fig 3) this trend was however not maintained in the succeeding years. In 1981, the nutrient consumption rate dropped by 32% in relation to the previous year and a further drop of 36% was recorded in 1982. As the majority of the

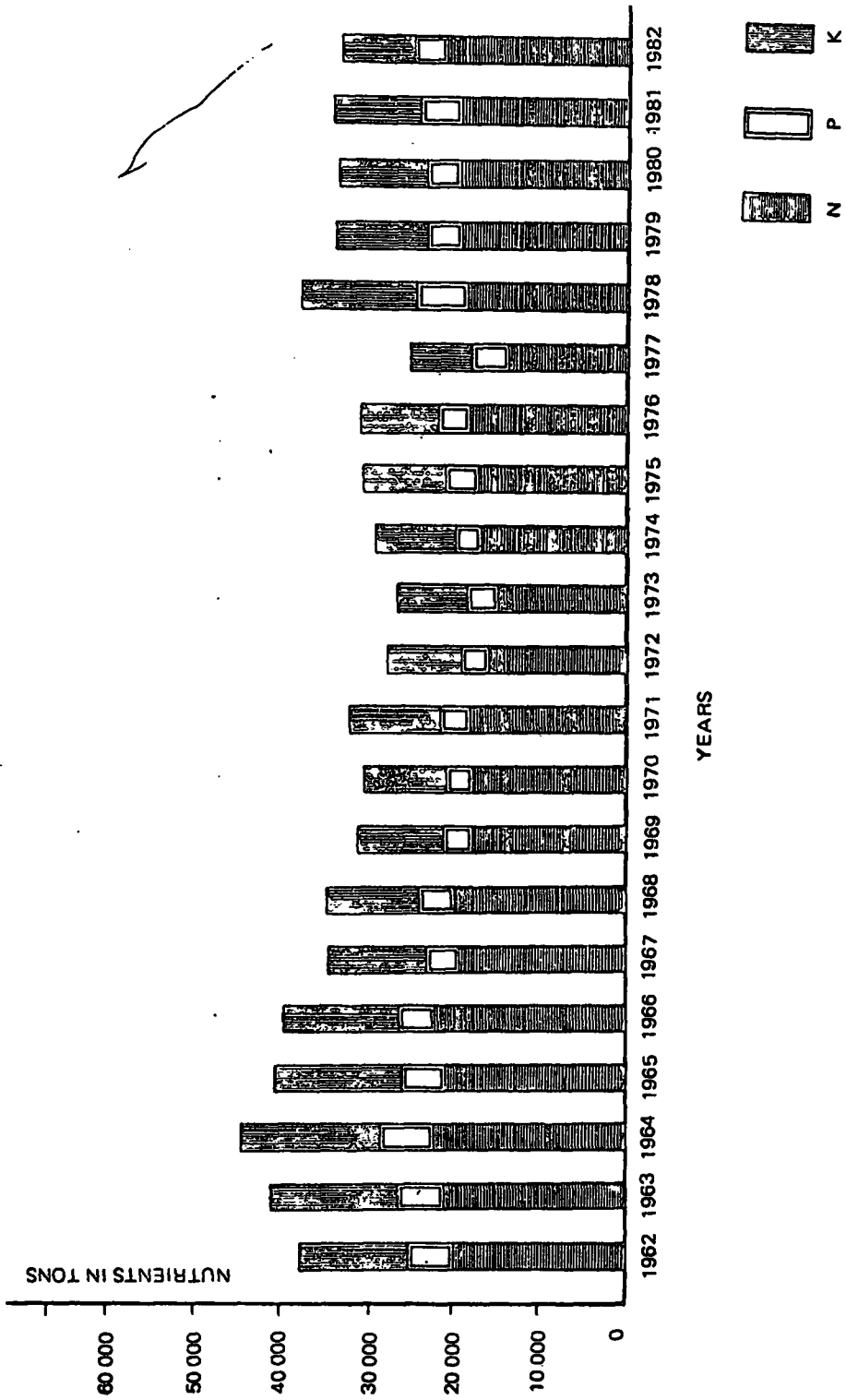


Fig. 1. Use of fertilizer nutrients in the tea sector 1962-1982

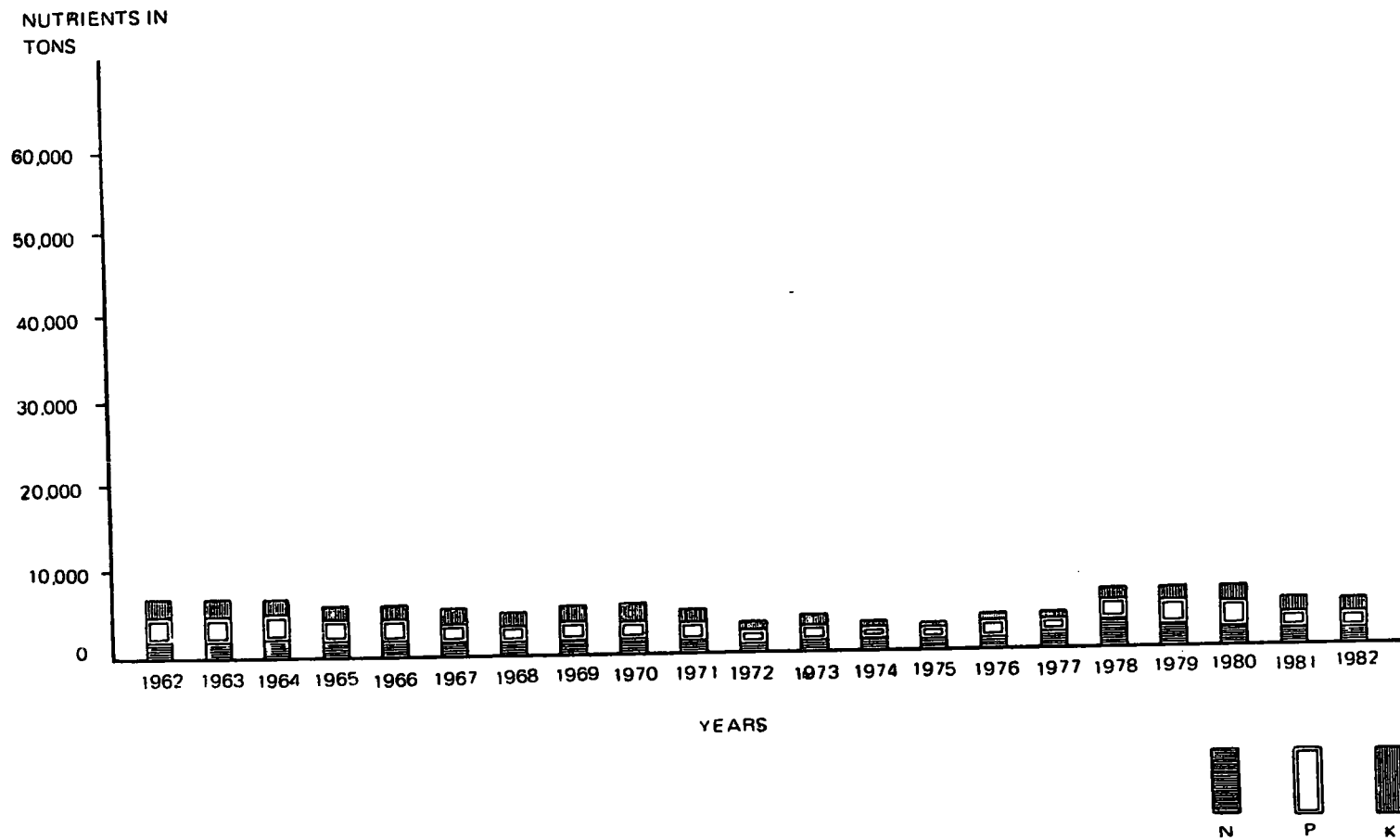


Fig 2 . Use of fertilizer nutrients in the rubber sector 1962 - 1982

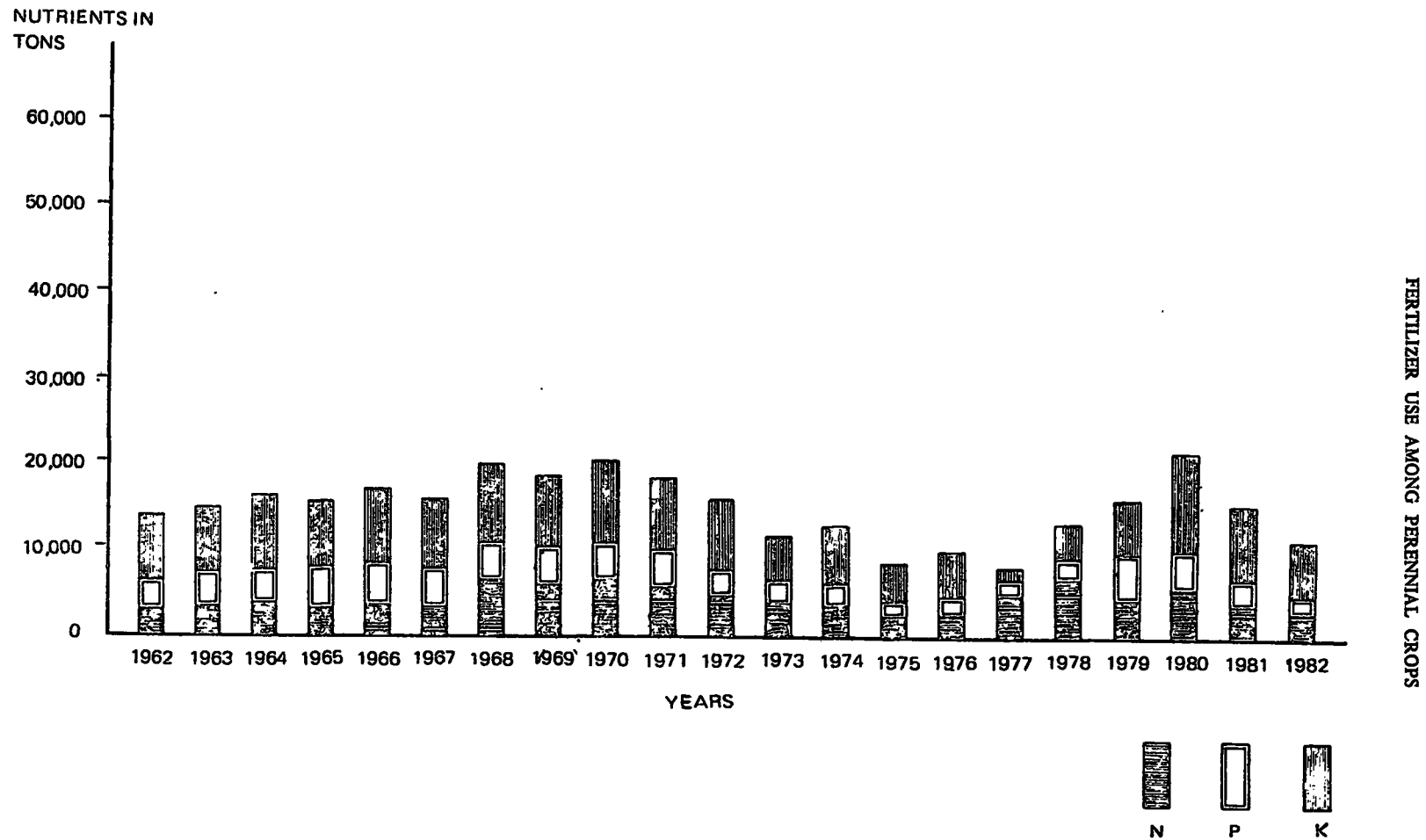


Fig. 3. Use of fertilizer nutrients in the coconut sector 1962 — 1982

Source: Review of the fertilizer year, 1980 — 1983.
National Fertilizer Secretariat of the Ministry of Plan Implementation.

coconut lands are owned by the smallholders, it is possible that they are more sensitive to fertilizer price increases. The drought in the latter part of 1981 and 1982 also would have affected this sector to a fair extent.

In general, the potential for yield increases in the plantation crop sector by the application of fertilizer on a large scale could be judged from the fact that the present rate of fertilizer consumption in this sector is far from satisfactory as seen (Table 2) from the rough estimates of fertilizer use in relation to the dosage recommended by the relevant research institutes.

Table 2. *Rough estimates of fertilizer use in relation to the dosage recommended by the relevant research institutes (1979 — 1982)*

Crop	Fertilizer use (%)			
	1979	1980	1981	1982
Tea	75	63	72	73
Rubber	35	37	35	40
Coconut	20	31	22	18

Agronomic responses to fertilizer application

For perennial crops it is impossible and would, in any case, be meaningless to base fertilizer recommendations on trials carried out for one year. The nutrient supply at the nursery stage and during the immaturity period has a strong influence on the future production level. Also mature trees may respond to different fertilizer treatments only after several years. Coconuts for example, need about 7–8 years for the young palms to come into production, about 3 years from flower initiation until harvest and in the case of rubber it take 5–6 years for the tree to come into production. Fertilizer experiments for perennial crops, therefore, have always been carried out on a long-term basis.

Tea

Like any other crop, in tea, the response to fertilizer application follows the principle of diminishing returns (Table 3). As fertilizer consumption is increased, the output is also increased but at a diminishing rate (Krishnapillai, 1983).

Table 3. *Effect of increasing rates of N and K on yield of made tea*

Levels of nutrients (kg/ha/annum)	Yield of made tea (kg/ha/annum)	Relative yield as affected by fertilizers (%)
90 N, 30 K ₂ °	1570	100
180 N, 60 K ₂ °	2050	131
270 N, 90 K ₂ °	2318	148
360 N, 120 K ₂ .	2374	151

Source : Krishnapillai (1983)

Rubber

Long and medium term fertilizer experiments have been carried out in Sri Lanka. Even at present fertilizer trials are being conducted in many forms and designs. Growth analyses of immature plants from one experiment, where the effect of application of

nitrogen and potash to young immature rubber is being studied (Table 4), indicate a significant curvilinear response (diminishing returns) to application of nitrogen and potassium (Yogarathnam, 1983).

Table 4. *Effect of three levels of nitrogen and potash on tree girth at the end of 6 years*

Levels of nutrients (kg/ha)	Mean girth (cm)	Relative girth as affected by fertilizer (%)
N ₀	46.22	100
N ₁₈₅	49.19*	106
N ₃₇₀	50.57*	109
K ₀	43.98	100
K ₁₇₅	50.55**	115
K ₃₅₀	51.43**	117

* and ** treatments significantly different from the control at $p=0.05$ and 0.001 level respectively.

Source : Yogarathnam (1983)

Yield data obtained from several field experiments showed variable results, thus emphasizing the importance of the use of fertilizers for mature rubber plants on a discriminatory basis, taking into consideration such variable factors as soil type, clone, age of the plants and management practises. Nevertheless, an overall assessment of the results so far obtained (Jeevarathnam, 1970), no doubt shows that application of fertilizer is beneficial (Table 5).

Table 5. *Effect of continuous application of NPK on yield of made rubber (average of 8 years)*

Fertilizer treatments	Mean yield (kg/ha/yr)	Relative yield as affected by fertilizers (%)
0	990	100
NPK	1184	122

Source : Jeevarathnam (1970)

Data from another experiment (Yogarathnam, 1982) where the effect of nitrogen fertilizers on yield of rubber (PB 86) was studied, stressed the importance of the correct method of application of nitrogen fertilizers, in particular urea (Table 6).

Table 6. *Effect of nitrogen fertilizers on yield of rubber*
Mean yield (kg/ha)

	1977	1978	1979	1980	1981	1977	Relative to 81 increase (%)
Control (nil nitrogen)	2340	1861	1492	1666	1645	9004	100
Ammonium sulphate forked in (35kgN/ha/yr)	2494	2086*	1717*	1974*	1852	10123	112
Urea-forked in (35kg N/ha/ yr)	2463	2144*	1703*	2014*	1876	10200	113
Urea-broadcast (35kg N/ha/yr)	2346	1969	1619	1976*	1702	9612	106
LSD	NS	189	131	203	NS	—	—

* denotes treatments significantly different from the control at $P=0.05$

Source : Yogarathnam (1982)

It is also possible to improve the efficiency of fertilizer utilization in tree crops by some soil management practices such as establishment of leguminous covers during the early stages of the planting and fertilizing them with appropriate fertilizers (Yogaratnam, 1983) as seen in Table 7. This experiment was started in 1970 and phosphate was applied according to the experimental treatments from 1970 to 1974 (for 5 years). Results obtained at the end of 1982 *i.e.* 8 years after phosphate application was discontinued, showed that application of P to legume covers still has a residual effect beneficial to the growth and yield of rubber in comparison with P application direct to the rubber tree.

Table 7. *Effect of phosphate application on growth and yield of made rubber*

Treatments	Mean trunk girth (cm)	Mean yield (kg/ha)
Nil phosphate	64.28	1418
P to rubber	65.98	1565
P to cover	68.33	1753*
P to rubber and cover	68.24	1760*

* Treatments significantly different from the control at P = 0.05 level.

Source : Yogaratnam (1983)

Coconut

As in the case of tea and rubber, researching on the use of fertilizers for coconut had been the responsibility of the Coconut Research Institute of Sri Lanka. Data from an experiment carried out by the CRI are discussed in this paper (Jeevaratnam, 1970). Like for tea and rubber, the response to fertilizer is expressed as the difference between the plots given the treatment $N_0 P_0 K_0$ (no fertilizer) and the plots given the treatment $N_2 P_1 K_2$ which gave the best yield. The treatment $N_2 P_1 K_2$ consisted of a mixture containing 1.10 kg of sulphate of ammonia, 0.83 kg of saphos phosphate and 0.57 kg of muriate of potash calculated on an yearly basis. The progressive responses to fertilizer over time was obtained (Fig. 4) by deducting from each such difference the initial (*i.e.* pre-manurial) difference between the two sets of plots. Adjustment was however made to eliminate the masking effects of weather on response to fertilizer through a regression analysis. It is apparent that the response builds up in two well defined phases. The first phase shows a large response after one year of manuring. This builds up according to the law of "diminishing returns" and reaches a plateau somewhere after 3-4 years. Then commences the second phase which constitutes at first an "increasing returns" phase followed by yet another "diminishing returns" phase, apparently ending up in an asymptote by about the 8th year of manuring.

Economics of fertilizer application

Considerations about the necessary fertilizer application to maintain the optimum nutrient status of the soil for the production of high crop yields are of practical value only if the fertilizer rates involved are profitable to the grower. In this connection it is more important to look at the economics of fertilizer application in the long run than at the profitability in the initial phase of an experiment. In a given year the results can be obscured by weather and other influences. But the yield data of medium-trials, where the effects of climate, soil fertility, and agronomic practices, are more balanced and responses to the fertilizer treatments more reliable, form a suitable basis.

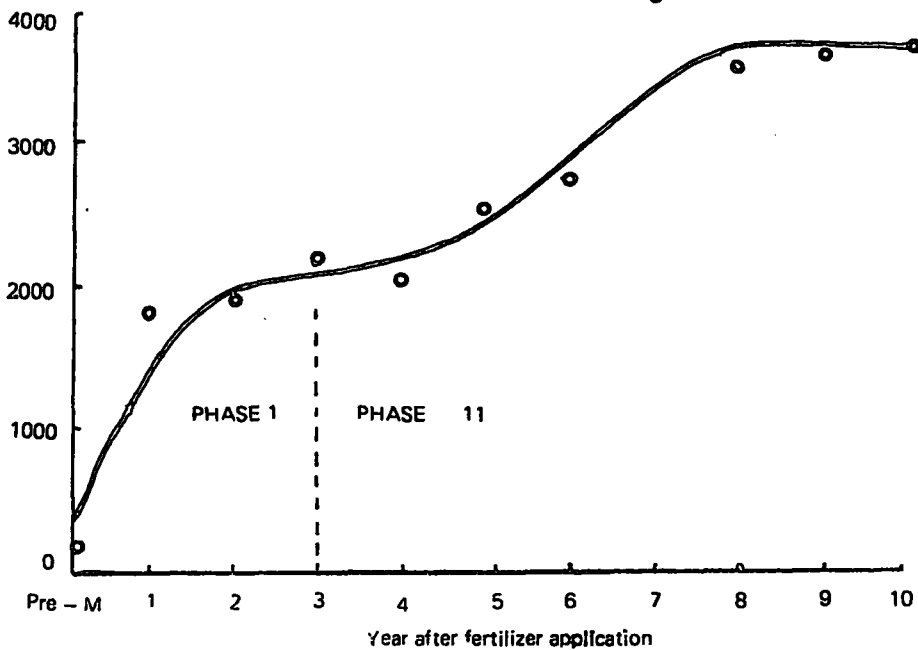


Fig 4: Response to fertilizer application with time.

Source : Abeyawardena (1978)

Tea

The data on profitability of fertilizer use in relation to N and K fertilizer input, obtained from a few fertilizer trials at St. Coombs, Talawakele (Ann. Rep. Central Bank, 1982) is given in Table 8. Like any other crop, the most profitable level of fertilizer use may be below the amount required to achieve the highest yield. Benefits would be obtained for both urea and the mixture "50% urea - 50% sulphate of ammonia" for levels up to 270N and 90 K.

Table 8. *Profitability of fertilizer use in tea*

Levels of fertilizer nutrients (kg)		Total yield (kg/ha)	Yield increase per unit fertilizer (kg/ha)	Value of yield increase (Rs. /-)	Fertilizer Cost N as 50% U \pm 50% A	Fertilizer Cost Value/ cost ratio	Fertilizer Cost N as 100 %U	Fertilizer Cost Value/ cost ratio
N	K							
90	30	1570						
180	60	2050	480	2,400	1330	1.9	690	3.4
270	90	2318	268	1,340	1330	1.0	690	2.0
360	120	2374	56	280	1330	0.2	690	0.4

Source : Krishnapillai (1983)

Rubber

In the case of rubber where fertilizer effects on yield become apparent only after several years, profitability calculations are more difficult than for crops like tea, notably when fertilizers have been applied also in the immature phase of the trees. As an example, data from an experiment (Kemmler and Malicornet 1976) comparing the effects of three levels of potash (0, 150 or 300 g K₂O/tree/year from 1961 to 1968) with and without stimulation (stimulation from 1969) on the performance of *Hevea*, is being discussed. The result of the profitability calculation for the years 1961 to 1972 is summarised in Table 9, including 4 years of immaturity, with fertilizer application but no production, and the first 8 years of increasing latex production. For the sake of easier comparison with data from different rubber producing countries, the net return has been expressed in terms of kg dry rubber equivalents. On this basis 1 kg dry rubber was equivalent to 2.67 kg K₂O (cost of fertilizer, transport and application included). The expenses for fertilizers and their application and for latex stimulation corresponded to the following quantities of dry rubber in the basis year :

150g K ₂ O/tree	=	22	kg rubber/ha
300g K ₂ O/tree	=	44	kg rubber/ha
Stimulation cost/ha	=	43.75	kg rubber/ha

The graphical presentation of the results in Fig. 5 illustrates the accumulation of costs during the immature phase, their gradual diminution after the start of tapping and the subsequent accumulation of profits, notably in the treatments with high K application and stimulation.

Economics of nitrogen fertilization with particular reference to the use of urea are shown in Table 10. The return per unit investment with the use of urea by forking into soil is 190% as against a return of 130% with sulphate of ammonia (Yogarathnam, 1982).

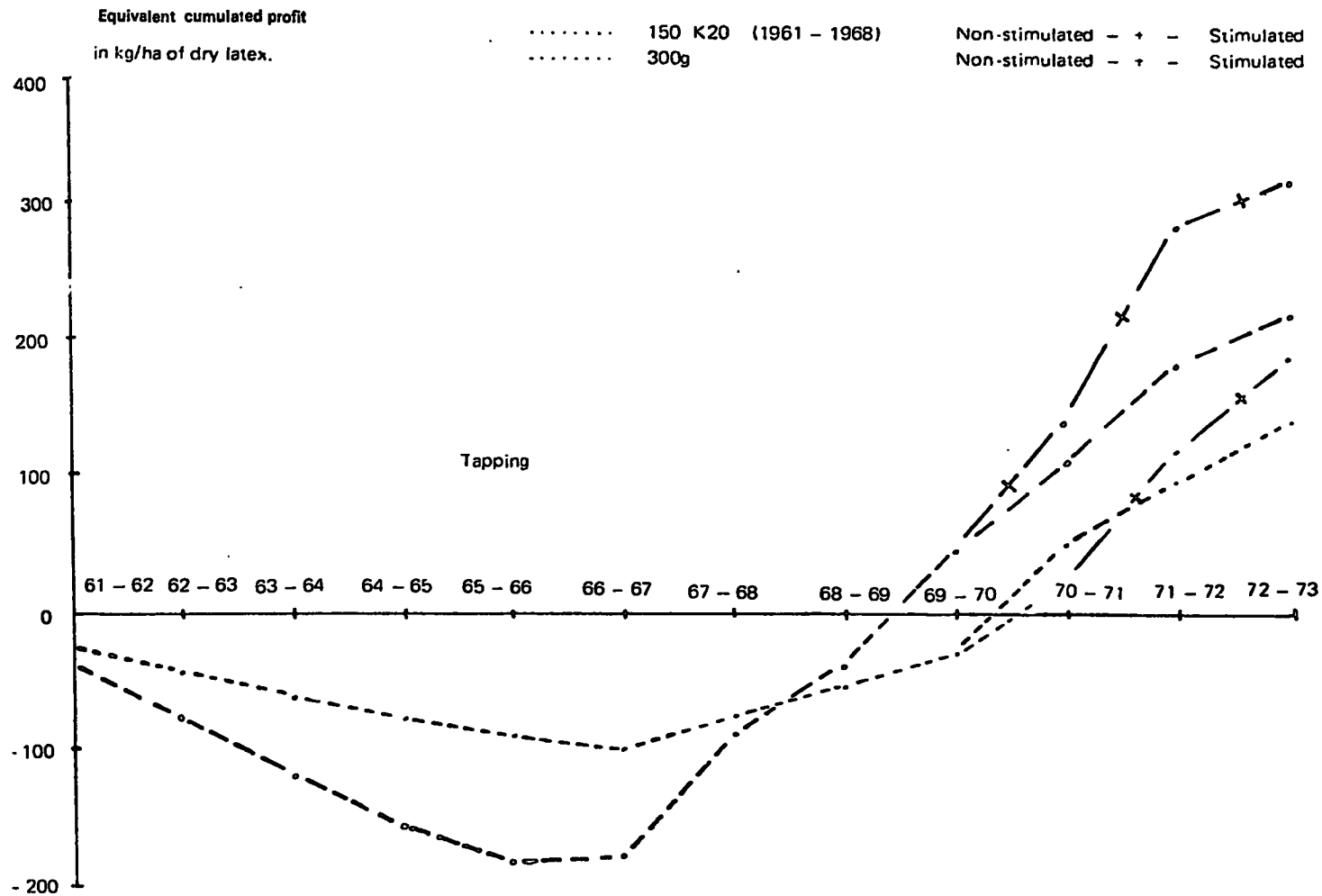


Fig. 5 . Effect of K application on the development of profits per year.

Table 9. *Cumulative net return due to K application and stimulation, expressed in equivalent quantities of dry rubber, basis year 1961 (kg/ha)*

Years		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
No stimulation	K 150	-22	-42	-60	-76	-91	-103	-78	-60	-39	+47	-88	+122
	K 300	-44	-84	-120	-153	-183	-179	-92	-45	+30	+107	+173	+202
With stimulation	K 150										+24	+104	+166
	K 300										+129	+291	+356

Source : Kemmler and Malicornet (1976)

Table 10. *Economics of nitrogen fertilization in rubber*

*Economic criterion	Ammonium sulphate	Urea forked	Urea broadcast
<i>Output</i>			
Yield increase due to N (kg/ha/yr)	225	240	122
Value of rubber @ Rs. 10/- per kg.	2250/-	2400/-	1220/-
<i>Input</i>			
Quantity of N fertilizer (kg/ha/yr)	208	104	104
Cost of N (Rs)	888/-	761/-	761/-
Cost of application @ Rs. 22,50 per worker (Rs)	90 (4 per ha)	67.50 (3 per ha)	45 (2 per ha)
Total cost;	978/-	828.50	806/-
<i>Profit</i>			
Net return (Rs/ha/yr)	1272/-	1572.50	414/-
% return per unit investment	130%	190%	51%
V/C ratio	2.3	2.9	1.5

Cost of handling, storage and transport have not been considered.

(Source; Yogaratnam 1982)

Coconut

The economics of fertilizer use based on the results of the experiment already discussed, are shown in Table 11. It is clear that it would be possible to obtain a return per unit investment of 174% in the first year of manuring. This builds up progressively to 624% by about the 10th year after manuring.

Table 11. *Economics of fertilizer application in coconut*

Year after application	Yield increase nuts per ha	Total income kgs. copra per ha	Rs.	Cost of fertilizer per ha	Rs.	Profit per ha	Rs.	%profit per unit investment	Rs.	Value/cost ratio
1st	1400	284	1048	383	665	174	2.7			
2nd	1975	401	1479	383	1096	286	3.9			
3rd	2110	429	1582	383	1199	313	4.1			
4th	2200	447	1648	383	1265	330	4.2			
5th	2450	498	1836	383	1453	379	4.8			
6th	2890	587	2164	383	1781	465	5.7			
7th	3400	691	2548	383	2165	565	6.7			
8th	3660	744	2743	383	2360	616	7.2			
9th	3700	752	2772	383	2389	624	7.2			
10th	3700	752	2772	383	2389	624	7.2			
10 year	27467	5585	20592	3830	16762	4376	5.4			

Source ; Abeyawardena (1976)

In general, the commercial or plantation sector with capital intensive infra-structure with high overheads aim at maximising the crop production in order to obtain the maximum net profits with the minimum investment in inputs. In the smallholder sector on the other hand, with little or no capital investment and still less overheads, the approach is a search for the highest returns with minimum of risk. Consequently, fertilizer use in this sector is dependent on several external factors. Therefore, quantifying these situations in terms of the concept of value/cost ratios by including not only application cost of the input, but also the additional labour and processing costs as a result of higher crop production, would mean a labour inclusive V/C ratio as opposed to a labour exclusive V/C ratio. Rough estimates of the V/C ratios (10) that have been worked out for 1977 and 1985 are given in Table 12. From these figures one may be able to conclude that the perennial crops have good incentive for using fertilizers.

Table 12. *Rough estimate of value/cost ratios for the tea, rubber and coconut sectors*

Crop	Labour inclusive		Labour exclusive	
	V/C		V/C	
	1977	1985	1977	1985
Tea	2.5	2.2	11.9	8.8
Rubber	3.9	4.5	5.1	5.5
Coconut	6.0	5.7	8.2	7.3

Source : Masterplan on promotion of fertilizer distribution and consumption 1978

In conclusion, it should be emphasised that it may be a sound agricultural policy to provide a greater support and encouragement in the areas of agro-chemical supplies in general and even extension services, thus concentrating on a total package to the end-user.

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