Nutritional and Fertiliser Experiments on Young and Old Rubber

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INTRODUCTION

TN THE INDIAN UNION RUBBER *(Hevea brasiliensis)* is grown mainly in the State of Kerala. Out of a total area of nearly 300,000 acres under rubber in the country, more than 280,000 acres are in Kerala. Madras State has approximately 12000 acres most of which lie in the Cape District which was part of Kerala until 1956. Mysore State has about 4000 acres and the Andaman Islands, less than 1000 acres. Thus Kerala accounts for nearly 95 percent of the country's planted area under rubber and 91 percent of the total production of about 25,000 tons of rubber per year. In terms of money value, Kerala's rubber contribution is equivalent to Rs. 8.5 crores to the industrial economy of India every year. All rubber produced in India is consumed in the country itself and none is exported. On the contrary, very quantities of rubber are annually imported to meet the internal requirements. in 1960. the total consumption of rubber in India was more than double the country's production. The gap between production and consumption has been widening year after year. Greatly intensified efforts to step up production of rubber in the country have therefore to be made. It it in this context that the attempts of the Rubber Board of India and the Government of Kerala to develop the natural rubber plantation industry have to be viewed.

The ideal climatic conditions for the rubber tree to flourish are a more or less uniformly warm, humid tropical climate and a rainfall of about 100 inches, evenly distributed through out the year. In most of the planting districts of Kerala, the climatic conditions do not approximate to this. We have on the other hand a pronounced dry season as well as a wet season. During the dry season, the growth of the trees is retarded and yield depressed. Even though the rainfall is more than adequate in the planting districts, most of it falls during the south west monsoon in the months of June to August. The continuous heavy rains during this season interferes with tapping, resulting in considerable loss of the crop. The excessive humidity lends the rubber tree peculiarly succeptible to severe attack by *phytophthora palmivora* in all planting areas except the Cape District where the disease is almost non-existent. Nearly 80 percent of the total area under rubber consists of old low

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yielding trees. In more than half this area the trees have out-lived their economic life and are degenerating rapidly. in the case of many older plantations, the clones are unselected seedling material planted on unsuitable land several decades ago with no one anticipating the bright economic future in store for natural rubber in later years. Much of the rubber was planted on eroded, barren land, unfit for any other agricultural use.

All the above mentioned ecological and agronomic factors have contributed to the . very low yields of rubber being obtained in this country. While Malaya's average production of rubber is approaching 1500 lbs/acre, our average production is still of the order of less than 400 Ibs/acre; Phenomenal developments in the breeding of high yielding clones have taken place in Malaya during the last quarter of a century. Their RRIM 500 series and 600 series are reported to be capable of giving average yields of the order of 3000 to 4000 Ibs/acre. In Malaya and Ceylon, intensive efforts have been made to increase yields, not only though clonal breeding and improvement, but also through organised fertiliser practices and other agronomic measures. Our rubber plantation industry is considerably lagging behind in all these aspects of rubber research. The highest yield of rubber obtained in India is in the Cape District, where a combination of favourable climatic and soil factors and the quality of the planting material originally used, has made some ofthe plantations the very best in this country, giving yields of the order of 1500/lbs. per acre.

Review of literature:

There is a considerable volume of scientific literature on the manuring and nutrition of rubber accumulated during the last quarter of a century. Almost all such work has originated from the Rubber Research Institutes of Malaya, Ceylon, Indonesia and Indo China. Barring a small proportion of the work which related to fundamental studies on rubber nutrition, much of the researches that have been carried out are of an applied nature with special reference to the climatic and soil conditions obtaining in those counries. The applicability of the results from other countries, except of fundamental studies on rubber, to our rubber growing areas is thus somewhat limited. The rubber tree thrives well below elevations of 1000 feet. Although it can well adapt itself to widely varying soil conditions, the rubber tree responds to fertiliser treatments. Rubber can grow in soils with a pH range of 3.5 to 7.5 (17,20), although slightly acid soils may be more suitable. The early years of rubber, the first seven years from planting, is considered the critical stage when proper manuring has to be done (10) and it has been established that the effect of early manuring is sure to be seen in the trees reaching early tappability (17). Constable, (13) from carefully conducted studies concluded that up to 50 percent increase in growth can be expected over the control, if young rubber plants were manured with nitrogen, phosphoric acid and potash, by the time these reached the tapping stage. fn the first three years of manuring young rubber with NPK, he noted a 34 percent increase in girth in the NPK-treated plots compared to the control. Individual clones react differently to the supply of different nurient elements (7) so that responses to application of fertilisers may not necessarily follow the same pattern, It has been fairly well established that balanced NPK manuring of rubber gives an increased yield of latex (3, 6. 17, 20) and.

that such manuring builds up an increased resistance to plant diseases (3, 19). Extensive long term field experiments have clearly demonstrated the value of sound manuring programmes in the cultivation of rubber on virgin land and in replantings in Malaya (4, 6). The benefits of manuring modern high yielding rubber trees regularly with appropriate fertiliser mixtures have been established with confidence on practically all soils on which rubber is grown in Malaya (6).

A very serious problem in fertiliser application to rubber is unbalanced nutrition. Considerable research work has been done on this subject in Malaya and Ceylon. In fact, it appears that much of the nutritional difficulties of the rubber tree, stem forth from nutrient imbalance in the soil. This is to be expected, as in the complex process of latex synthesis each nutrient element may have its own special role to play and the proportion in which each occurs in the plant may assume significance. Constable and Fairfield Smith (12, 18) have noted that the use of potash or nitrogen fertiliser alone caused a depressing effect on the yield of rubber. The same effect has been observed by Akhurst and Owen (1) Constable (14) has also established that one-sided treatment with potash will accentuate magnesium deficiency in rubber, Bolles-Jones (8, 9) who made a careful study of the interrelationship of magnesium, phosphorus and potassium in rubber nutrition. concluded that excess of phosphates or potassium caused magnesium deficiency in the rubber plant and that magnesium is mportant in the early stages of the growth of rubber, especially on sandy acid soils. The use of magnesium in addition to nitrogen, phosphorus potash is an accepted recommendation for rubber in Malaya (2). Deficiency of any major element or trace element may cause serious physiological disturbance in the rubber tree. Constable (16) believes that potash deficiencies and trace element deficiencies in rubber can be responsible for the "Die back", "Little Leaf" "Rosette" and "heart-rot" disease of the plant. Die back in rubber has been attributed to potash deficiency by other research workers as well (17). It has been further established that potash deficiency may seriously affect the uptake of nitrogen itself (15). In many unsatisfactory plantations in Ceylon, it was observed that the leaves had only one-fifth the potash content of normal healthy leaves. Deficiency of one mineral element or another renders the rubber tree increasingly susceptible to various diseases (5, 16, 17. 20).

While considerable research work has been done in other rubber growing countries during the last 30-40 years on the subject of rubber fertilisation, no work whatsoever was initiated in our country until about 1956. Research work on rubber was just beginning in India during the second Five Year Plan. Malaya and Ceylon had already their own fertiliser recommendations, evolved for their own soil types, from years of careful experimentation. These recommendations were in many cases most inapplicable to our rubber growing soils. The problems facing India's rubber plantation industry were peculiar and local, which had to be solved by local research (21). But the industry could not wait until the results of our own research work became available for application in the rubber plantations. An interim recommendation for fertiliser practices on rubber in this country was put forth (22) based on available information, applicable to the rubber growing areas in South India. Nutritional and fertiliser experiments on young and old rubber were started both in the Green House and in the field to obtain the requisite data 24, 25). This paper presents the results of these experiments up to the end of January 1959. The field experiments are being continued by the Rubber Board.

MATERIALS AND METHODS

The present investigations were on four separate problems (1) The nitrogen, phosphorus and potash balance as related to root and shoot development in young seedling rubber (2) Nitrogen, phosphorus and potash fertiliser requirements of young replanted rubber (3) Effect of manuring mature rubber trees in tapping with *nitrogen alone, nitrogen and phosphoric acid,* and *nitrogen, phosphoric acid and potash.* (4) Effect of potash manuring on die back of the rubber trees and yield of rubber.

1. Nitrogen, Phosphorus and Potash balance as related to root and shoot development in young seedling rubber.

The effect of balanced nutrition on the root and shoot development of young rubber was studied by growing rubber plants in acid-washed sand in pots. Specially made earthern ware pots 2¼ high and 1½ in diameter, were painted on the inside by black enamel paint. River sand, washed with cold hydrochloric and nitric acids, and leached by running tap water until all acidity was removed, was filled into the pots. Germinated Tjir-I, selected seeds were planted in the pots. The seedlings were given nutrient solutions at three levels of nitrogen, potassium and phosphorus each, as shown below:

Nitrogen as N	0, 3.5 & 7 m.e./litre of nutrient solution.
Phosphate as P	0, 2.0 & 4.0 m.e./litre
Potash as K	0, 2.0 & 4.0 m.e./litre •

One litre of nutrient solution was also made to contain the following concentrations of other elements:

Mn	0.002	mg. eqvt./litre.
Cu	0.002	
Zn)	0.002	
Ca	4.0	
Mg	3.0	
Na	0.5	
Fe	0.66	
Cl	5.16	
SO_4	3.02	
Mo	0.0002	m.mol/litre
B	0.033	

Four litres of the nutrient solution were applied to each pot in a week, in two applications of 2 litres each, with four recyclings a day or 28 recyclings a week. Recyclings were done by drawing the nutrient solution through the bottom of the earthern ware pot provided with a half-inch hole which remained closed with a rubber stopper and pinch-cock arrangement when the nutrient solution was applied. By releasing the pinch-cock, the nutrient solution could be drawn out any time for recycling. At the time of recycling, volume losses were made up by additions of water. The nutrient solutions were, renewed every two weeks. pH determinations using glass electrode showed that the recycled nutrient solutions underwent change in pH of less than one unit during the course of two weeks. The stock solutions of nutrients were prepared in such a way that 1 ml. diluted to 1 litre corresponded to the second level and 2 ml. diluted to 1 litre corresponded to the third level. The diluted nutrient solutions had a pH between 5 & 6. Salts were selected in such a way as to avoid mutual precipitation. Elements other than N, P and K were applied to all pots to correspond to the appropriate concentration indicated. There were three replications in each treatment, to take care of possible damage to any pot. The levels of NPK were labelled 0,1 and 2 respectively (eg. 201, meaning nitrogen at third level or 7 me/1, phosphorus at zero level and potash at second level or 2 me/1). These experiments were laid out not to prodnce deficiency symptoms (only ordinary tap water was used), but to study root and shoot development of seedling rubber as a function of nutrient imbalance with respect to N, P, and K.

2. NPK Factorial experiments on Young Rubber: (October 1956 to January 1959)

NPK factorial experiments ($3 \times 3 \times 3$) were laid out on young replanted rubber in September-October 1956. Four different planting districts were selected for this purpose. The estates selected for the experiments were:

(1) Pudukad Estate, Trichur District (Peirce, Leslie & Co. Ltd).

(2) Manikkal Estate, Mundakayam, Kottayam District (Travancore Rubber & Tea Co. Ltd.)

(3) Malankara Estate, Thodupuzha, Ernakulam District (John Sons Estates & Agencies Ltd).

(4) Vaikundam Estate, Kulasekharam, Cape Comorin District (Harrisons & Crosfield Ltd; now under the management of Sharma Brothers).

The soils in these areas, although all lateritic in origin, had acquired varying degrees of fertility as a result of different cultural and manurial practices lasting for several years before the areas were replanted. In general, they are depleted, eroded soils of poor fertility where no replanting would thrive unless properly manured and cared for. In all the areas, thick ground cover of *pueraria phaseoloides* was established by the managements in the first year of planting itself. These estates were selected for the experiments in view of the fact that their reputed Managements could be depended upon to leave the experimental areas undisturbed for a period of 15 or 20 years until the experiments were completed.

The clones, plot-size, and other particulars of the experimental areas are given below.

Place	*Clone*	*Year of replanting*	*Plot-size*	*No. of replications*
Pudukad (Trichur)	PB-86 (budded)	1956	40 trees	2
Malankara (Thodupuzha)	Tjir-1 (clonal seedlings)	1956	20 trees ($16' \times 16'$)	2
Manikkal (Mundakayam)	PB-5/139 (budded)	1956	30 trees	
Vaikundam (Kulasekharam)	PB-5/139 (budded)	1955	20 trees (contour planting)	

Levels of nitrogen, phosphus and potash and materials used:

Nitrogen:	0,30,60	Ibs/acre of 160 mature trees. (Ammonium Sulphate-Nitrate).
Phosphorus: (P_2O_5)	0,40,80	Ibs/acre of 160 mature trees. (Jordan Rock Phosphate)
Potash: (K_2O)	0,40,80	Ibs/acre of 160 mature trees. (Muriate of Potash).

Method and time of application:

1st year:	1956 at -j- full dose (one application in September-October).
2nd year :	1957 at 1 full dose (one application in September-October).
3rd year :	1958 at \ full dose (in two equal instalments in March-April and September-October).
4th year	1959 at f full dose (in two equal instalments).
5th year	1960 at ' full dose (in two equal instalments).
6th year	1961 at full dose (in two equal instalments).

7th and subsequent years: at full dose (in two equal instalments).

During the first three years, fertilisers were applied around the base of each plant in annular bands to the extent of root development, and forked into the soil. Six months after planting this area will be a circle of 18 inches or more in diameter and progressively increases to about 4 feet when the plants are three years old (4). The fertiliser is lightly forked into the top, 2 or 3 inches of soil, several inches away from the base of the stem. (Application in the case of trees older than three years is done by spreading the fertilizer in square or rectangular patches, in between rows, each patch serving four trees). The two annual applications are done during March-May, soon after the pre-monsoon showers, and in September-October during a temporary break in the monsoon when a dry interval of 4 to 5 weeks will be usually available (22). In the case of contour-planted rubber, appropriate 'pocket application of fertilisers, or trench application, has to be followed from the fourth year onwards.

3. Manuring of mature trees **in tapping.**

The view was generally held by some planters that manuring mature rubber did not result in economic increase in yield. This view was arbitrary and unscientific and was not supported by any experimental evidence in this country. Some demonstration trials were therefore laid out on the manuring of mature rubber in October 1956. The treatments were.

Control (no manuring).
2. Nitrogen alone.
3. Nitrogen and phosphoric acid.
4. Nitrogen, phosphoric acid and potash.

The quantity of N, P and K applied corresponded to 4 lbs of 8-10-12 per tree per year. Each treatment had 40 trees and was carried out in duplicate. The experiments were laid out in all the four estates where the NPK factorial experiments were being conducted. The areas selected were all planted prior to 1940. The clones were :

Manikkal, Mundakayam—BD-10.
Malankara, Thodupuzha—PB-86.
Pudukad, Trichur—Tjir-16 (clonal seedlings).
Vaikundam, Kulasekharam—Unselected seedlings.

The fertilisers were applied in two annual instalments, one in September-October and the other in March-April. The first application was made in October 1956 (full dose) (Nitrogen as Ammonium Sulphate-Nitrate, phosphorus as Jordan Rock Phosphate and potash as Muriate of Potash). Yield measurements were recorded only from the inner trees in the 40-tree plots, the border trees being left out. The inner trees were ring marked with enamel paint and the quantity of latex obtained from them separately measured. Measurements were made for two tapping days only per month, the days being selected at wide intervals. The measurements were made by the Managements of the estates themselves and recorded in the books kept by them. Systematic results were not recorded in the case of Vaikundam estate on account of frequent labour unrest. Results for this estate are therefore not presented in this paper.

4. Manuring for Potash deficiency.

In a replanted area in Chemoni Estate (Pudukad, Trichur), severe die-back was noticed in clone Tjir-16, planted in 1941. The area consisted of depleted and eroded laterite soil, deficient in potash, nitrogen and organic matter. The 28 acre area was divided into two halves. One half was manured with 2 lbs. of ammonium sulphate and 2 lbs. of muriate of potash per tree per year while the other half was left as an unmanured control. The first application of fertilisers was made in April 1957. The yield data up to June 1958 are recorded in this paper.

DISCUSSION OF RESULTS

(a) *Root and shoot development young rubber as a function of nutrient imbalance.*

Figures 1 to 5 persent the photographs of the root and shoot systems of young rubber plants grown in different nutrient media. The photographs were taken 15 months after the germinated seeds were planted in the pots *Fig. (a)* and *(b)* are photographs of the root systems of plants growing in nutrient media from which one or other of the three elements, nitrogen, phosphorus or potassium, had been withheld. These plants received only the nitrogen, phosphorus or potassium that might have been contained in the tap water. It can be seen from Fig 1 a to f, that withholding of any one of these major elements has a very adverse effect on root and shoot development in young rubber. There *is* no noticeable difference in the root-growth of the control (000) receiving all other nutrient elements other than, N, P and K, and the root growth in treatments 001,002, (potash only), 010 (phosphorus only) and 100 (nitrogen only). Treatment 010 has a better developed root system than 020, indicating that a higher concentration of phosphorus alone, in the absence of nitrogen and potash has a depressing effect on root development in rubber. Phosphorus, in combination with either nitrogen or potash contributes to a better development of the root system than phosphorus alone. In all cases where phosphorus has been withheld, the plants had extremely poor root systems (Fig. 1 >. treatments 200.201 and 202). Withholding of Potash also suppressed root development, although the effect was not as pronounced as in the case of nitrogen and phosphorus. (Fig. II, treatments 110 and 210: Fig. III-a, treatment 120 and Fig. III-b, treatment 220). The best developed root systems were of those plants receiving nitrogen, phosphorus and potash. (Fig. III a and b). In general, the effect of a properly developed root system, is well reflected in shoot growth. (Fig. IV-a, b, and c; Fig. V-a, and b).

No attempt was made to quantitatively measure the extent of root and shoot development in the experiment. The growth characteristics were sufficiently prominent to provide treatment comparisons. The need for balanced manuring of rubber nurseries is quite apparent from the results of these studies. It had been the practice of Indian rubber growers to fertilise rubber nurseries only with phosphates. Occasionally, nitrogen and phosphates both were used but seldom any potash in rubber nurseries. The need for balanced manuring of nurseries as well as young rubber plants in the field, with proper proportions of nitrogen, phosphates and potash is well brought out from the photographs of the root and shoot systems of 15-month old rubber plants reproduced in this paper.

(b) *NPK-factorial experiments on young rubber*

The first set of girth measurements were made from NPK factorial experiments in January 1958, for all experimental areas except Vaikundam Estate, where thinning out had not been done at the time. The second set of girth measurements were made for all the areas in January 1959. The average increase in girths of plants during the period January 1958 to January 1959 according to treatments is given in Table I for three experimental areas.

TABLE I

Summary of girth data from NPK-factorial (3x3x3) experiments

(increase in girth in inches during the period January 1958–January 1959)

(Data from inner trees only)

average increase

Treatment	MUNDAKAYAM (PB-5/139; 1956 replanting)	PUDUKAD (PB-86; 1956 replanting)	THODUPUZHA (Tjir-1 Clonal seedlins: 1956 replanting
$N_0P_0K_0$	3.1	3.1	1.6
$N_0P_0K_1$	3.3	3.1	1.9
$N_0P_0K_2$	3.3	3.6	1.7
$N_0P_1K_0$	2.5	3.1	2.8
$N_0P_2K_0$	3.4	3.0	1.7
$N_0P_1K_1$	3.8	2.9	3.0
$N_0P_1K_2$	3.8	2.7	3.0
$N_0P_2K_1$	3.5	2.8	2.1

$N_0P_2K_2$	3.3	2.4	2.5
$N_1P_0K_0$	2.7	2.9	3.0
$N_1P_0K_1$	3.1	2.8	2.4
$N_1P_0K_2$	3.4	3.2	1.7
$N_1P_1K_0$	3.4	2.8	2.1
$N_1P_1K_1$	3.8	2.8	2.4
$N_1P_1K_2$	3.7	3.2	3.0
$N_1P_2K_0$	3.8	3.1	2.2
$N_1P_2K_1$	3.6	2.8	3.2
$N_1P_2K_2$	4.2	3.4	2.1
$N_2P_0K_0$	3.2	3.4	2.2
$N_2P_0K_1$	3.2	3.3	2.4
$N_2P_0K_2$	3.5	3.0	3.0
$N_2P_1K_0$	3.5	3.0	3.0
$N_2P_1K_1$	3.7	3.2	2.9
$N_2P_1K_2$	3.4	2.9	3.1
$N_2P_2K_0$	3.4	2.9	2.5
$N_2P_2K_1$	3.6	2.8	2.3
$N_2P_2K_2$	4.4	3.5	2.8

It is seen from the Table that a maximum of 42 percent increase in girth has been observed at Mundakayam over the control, in the case of plants receiving NPK at the highest level. This compares well with the 34 percent increase noted by Constable (13) during the initial three years in the case of NPK-manured plots over the control, in Ceylon. A 13 to 16 percent increase in girth is noted at Pudukad, in the case of plants receiving the highest level of Potash (treatments 222, 002) and nearly 100 percent increase at Malankara estate, Thodupuzha, for plants receiving phosphoric acid and potash (treatments 012, 112, 121, 202 and 212).

The analysis of variance shows that in the case of Pudukad, P was approaching the significance limit. A notable feature of the Thodupuzha experiment is the high error variance, signifying the heterogeneity between the plots within replicates. The analysis of variance for the Mundakayam Estate reveals extremely high significance for P. The error of variance at Mundakayam is very small, as can be seen from Taele II below.

TABLE II.

Average increase in girth in inches on the applications of N, P, & K.

Treatment	Malankara Estate	(Response)	Pudukad Estate	(Response)	Manikal Estate	(Response)
N_0	2.07		2.86		3.35	
N_1	2.44	+0.37	2.90	+0.04	3.48	+0.13
N_2	2.47	+0.03	3.03	+0.13	3.63	+0.15
P_0	2.11		3.03		3.13	
P_1	2.63	+0.52	3.23	+0.21	3.57	+0.44
P_2	2.76	+0.13	3.61	+0·37	3.64	+0.07
K_0	2.26		2.96		3.47	
K_1	2.46	+0.20	2.79	-0.17	3,47	
K_2	2.57	+0.11	3.03	+0.24	3.61	+0.14
S. E. of response		0.46		0.16		0.11

It is to be expected that the response trends would continue and that the main effects and their interation would approach significance limit in all estates as the experiments progress.

(c) *Manuring of mature in tapping :*

The yield data obtained from the fertiliser trials on mature rubber are tabulated in Table III. The data indicate that significant increase in yield are recorded in all cases over the controls, during the period April 1957 to May 1958. The average increase in the yield of latex per tapping for NPK-treated plots was 55 percent for clone [illegible] (Mundakayam), 63 percent for clone [illegible] (Pudukad) and 31 percent for clone PB-86 (Thodupuzha) over the controls. The plots receiving nitrogen alone, and nitrogen and phosphoric acid also showed significant increases in yield over the controls, but less than in the case of plots receiving nitrogen, phosphoric acid and potash.

These results with all their limitations would serve to indicate the degree of response of old rubber standing on nutrient-depleted soils, to balanced manuring with NPK. In the of an area yielding 500 of dry rubber per acre pee year, the increases recorded in the case of the NPK-treated plots represent 275 315 and

155 lbs. of additional dry rubber per acre per year. In terms of money value, the increases may represent approximately, Rs. 415, Rs. 475 and Rs. 225 per acre per year respectively. The cost of manuring with 4 lbs. of 8-10-12 per tree per year will not exceed Rs. 100 per acre with 120 trees in tapping. The manuring of mature trees in tapping is thus, beyond question, highly economical, besides contributing to the increased production of rubber in the country.

TABLE III.

Monthwise Yield of Latex in lbs. per Tapping from Manured Mature Trees

(yield of 18 trees)

(Figure for each month is average of two recordings from two plots)

Year & Month	*Mundakayam (clone, BD-10)* Contr.	*N*		*NPK*	*Pudukad (clone, Tjir-16)* Contr.	N	NP	NPK	*Thodupuzha (clone PB 86)* Contr.	N	NP	NPK
1957 April	4.1	4.7	5.0	5.9	2.2	2.2	2.4	3.1				
May	2.6	4.0	3.5	4.3	1.2	1.7	1.3	2.1	2.0	3.2	3.3	3.5
June												
July	4.0	5.2	5.9	5.9								
Aug.	3.9	5.9	6.5	7.0	1.3	[illegible]	1.3	1.9	4.0	4.0	4.5	4.8
Sept.	4.1	5.7	5.4	6.4	1.8	2.4	2.1	3.2	3.9	4.4	4.5	5.1
Octo.	3.7	5.8	5.6	6.3	1.8	2.4	2.2	2.7	4.0	5.0	4.7	4.0
Nov.	4,3	4.6	4.7	5.3	2.5	3.0	3.1	4.0	3.9	5.4	5.0	5.2
Dec.	3.6	4.2	5.4	5.5	2.3	2.6	2.7	3.7	4.2	4.8	4.9	5.5
1958 Jan.					2.1	2.3	2.8	3.6	3.6	4.4	4.0	5.2
April	4.1	4.7	6.5	6.8	2.1	2.6	2.8	3.6	3.7	3.7	3.5	4.7
Average yield of latex per tapping from [illegible] trees, in one year (lbs.)	3.8	4.9	5.4	5.9	1.9	2.3	2.3	3.1	3.2	3.9	3.8	4.2

Dosage : N, NP & NPK at rates corresponding to 4 lbs of 8-10-12 per tree peryear.
First application : October 1956 (full dose)
Second application : March-April 1957 (half dose)
Third application : October 1957 (half dose)
Fourth application March-April 1958 (half dose)
Plot size : 40 trees (18 recordable) trees).

(d) *Manuring for potash deficiency :*

The results of manuring rubber trees in the area in Chemoni Estate where serious die-back was noticed, are presented in Table "IV.

Within a period of six months from the first application, the trees in the manured area began to recover from the die-back disease and yields began to rise. Besides saving the trees in the manured area from further damage caused by die-back, a 15 percent increase in the yield oT rubber had been obtained by the Management from the manured area. The trees in the unmanured 14 acres showed no improvement in the matter of resistance to die-back and yield of rubber.

TABLE IV.

* * **Yield data of potash manured plots on chemoni** estate (1941 replanting)

(Tjir-16)

(6 blocks manured and 6 blocks control; 2 lbs. of Ammonium Sulphate and 2 lbs. of Muriate of Potash per tree per year; first manuring April 1957.

Month		Manured area		Unmanured area	
		Total yield (lbs. of dry rubber)	Yield/tapper (lbs. of latex)	Total yield (lbs. of dry rubber	Yield/tapper (lbs. of latex).
1957	April	474	9.29	491	9.63
	May	399	8.49	362	7.70
	June	142	5.91	123	5.12
	July	13	2.17	11	2.22
	August	558	10.35	477	8.83
	September	955	17.68	804	14.88
	October	991	16.50	884	14.73
	November	1244	17.27	1110	15.41
	December	1063	17.71	929	15.48
1958	January	1152	18.00	971	14.94
	February	165	3.75	202	4.92
	March	411	7.90	326	6.52
	April	641	13.64	542	10.42
	May	680	13.07	593	11.40
	June	325	13.54	279	12.13
Yield/acre/year (lbs. of dry rubber)		552.43		481.50	

* * These data were recorded and supplied by J. S. M. Barnett, Manager, Chemoni-Pudukad Estates (Peirce, Leslie & Co. Ltd.) from the potash-manured and contro! areas, totalling approximately 28 acres).

SUMMARY AND CONCLUSIONS

Results of studies on root and shoot development in young seedling rubber as a function of nutrient imblance with respect to nitrogen, phosphorus and potasium; preliminary results from NPK factorial experiments in three different estates and the effects of NPK manuring of young replanted rubber as indicated by girth measurements; results from three experimental areas on the manuring of mature rubber trees in tapping and the results of potash manuring on trees suffering from die-back disease are separately presented in this paper.

The studies on root and shoot development in yound seeding rubber were conducted on selected Tjir-I seedlings grown in acid-washed sand in pots of approximately 2.75 cubic feet capacity. Different levels of NPK were applied through nutrient solutions, which were renewed every two weeks. The nutrient solutions were recycled through the pots four times a day or 28 times a week. Photographs of root and shoot syetems were taken 15 months after planting.

The results of these studies indicate that contrary to popular belief young seedling rubber requires a well-balanced proportion of N, P & K for proper root and shoot development. The application of phosphates alone or phosphates and nitrogen to rubber nurseries is likely to cause poor development of nursery plants, Nursery fertilisers have necessarily to include potash in sufficient quantities. Excess of phosphates, or phosphates alone, has a depressing effect on root and shoot development in young rubber.

NPK-factorial experiments on young replanted rubber were laid out in four different estates. Preliminary results from three expermental areas are presented in this paper. Three levels of nitrogen, three levels of phosphorus and three levels of potassium, were used in the experiments. The total area of these experiments was approximately 40 acres in all the four estates together. The Summary of girth data presented in this paper has been prepared from approximately 10,000 girth-measurements.

Three years of manuring young replanted rubber has indicated that the rate of growth ofNPK-manured plots is significantly greater than plots manured differently and that the main effects and their interactions are approaching significance in all the experimental areas. It is too early to draw broader conclusions from this first set of data of experiments, which are expected to continue for a period of 15 to 20 years. Up to 42 percent increase in girth has been observed in one experimental area for plants receiving NPK at the highest level, over control, during the first three years. In the same experimental area, extremely high significance for p has been observed.

Results of manuring mature rubber trees in tapping, from three experimental areas indicate that NPK-manuring has greatly increased yield of latex in all the treated areas. The average increase in the yield of latex per tapping for NPK-treated plots was 31 percent for clone PB-86, 55 percent for clone BD-10 and 63 percent for clone Tjir-16, over the controls. The N and NP plots also showed significant increases in yield over the cantrols, but less than in the case of plots receiving NPK. The data indicate that manuring mature trees with NPK gives highly economic returns, besides contributing to increased production of rubber in the country. The data summarised in this paper were gathered from 432 measurements in latex yields, spread over a

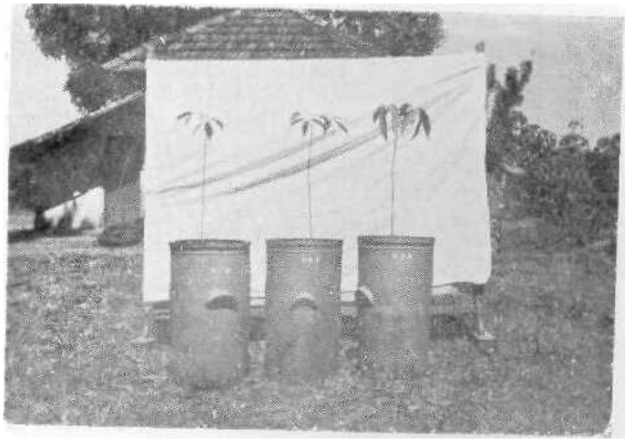

Fig. V a
(200, 201, 202)

Fig. V b
(111, 110, 210)

Shoot development in young rubber plants receiving different levels of nitrogen, phosphorus and potassium, alone and in various combinations.

Fig. IV a
(120, 121, 122)

Fig. IV b
(112, 211, 212)

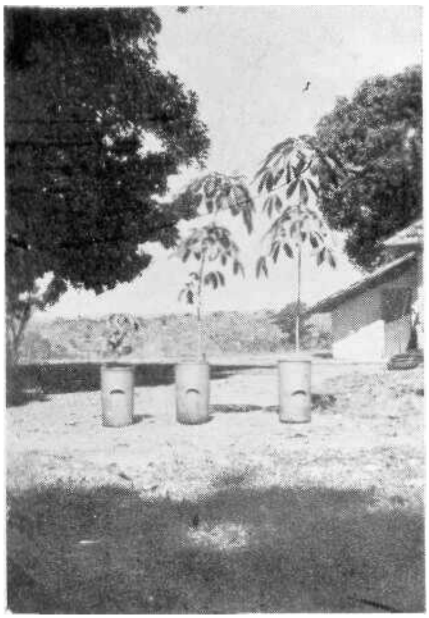

Fig. IV c
(220, 221 222)

Shoot development in young rubber plants receiving different levels of nitrogen, phosphorus and potassium in various combinations.

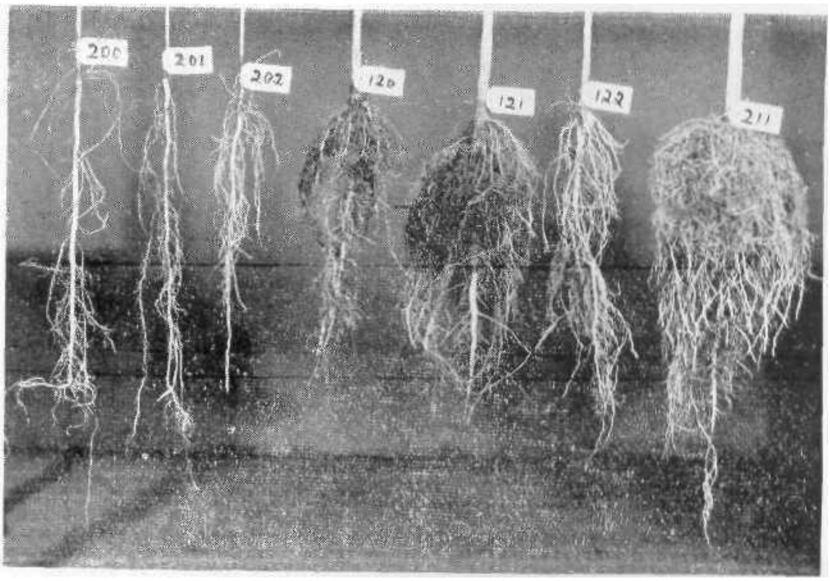

Fig. III a
(200, 201, 202, 120, 121, 122, 211)

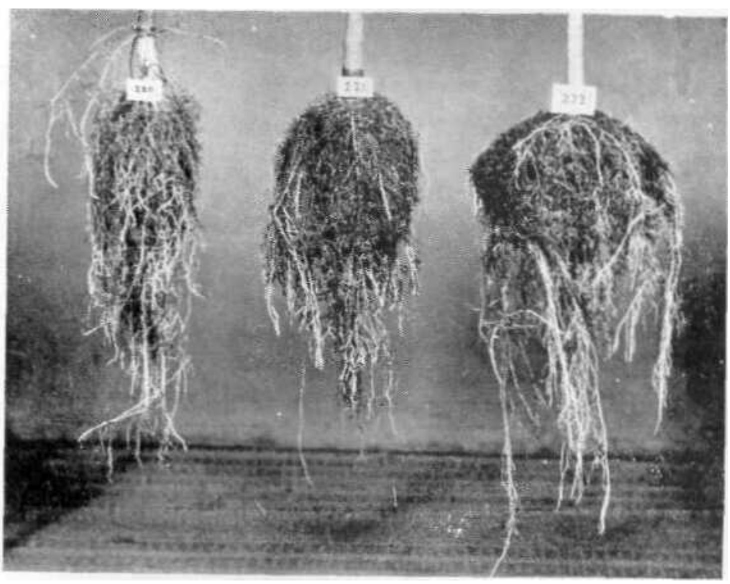

Fig. III b
(220, 221, 222)

Root systems of young rubber plants receiving different levels of nitrogen, phosphorus and potassium, alone and in various combinations.

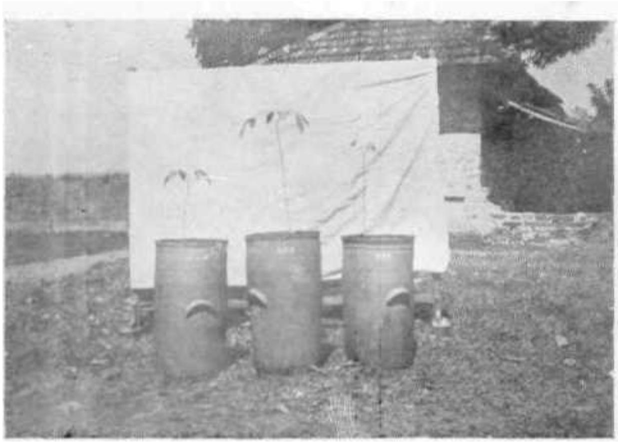

Fig. I e
(010, 011, 012)

Fig. I f
(002, 001, 000)

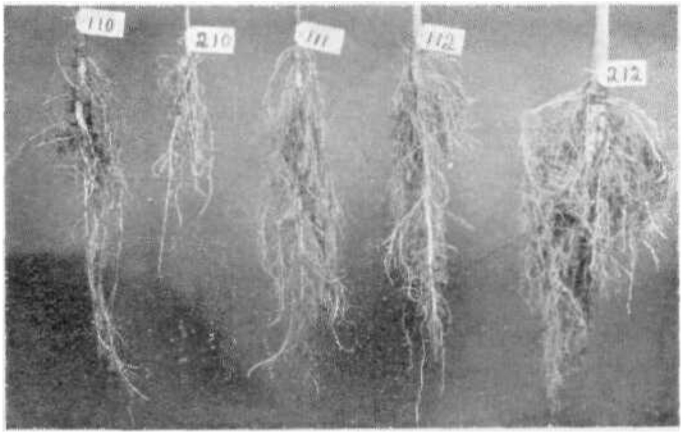

Fig. II
(110, 210, 111, 112, 212)

Root and shoot systems of young rubber plants receiving different levels of nitrogen, phosphorus and potassium, alone and in various combinations.

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