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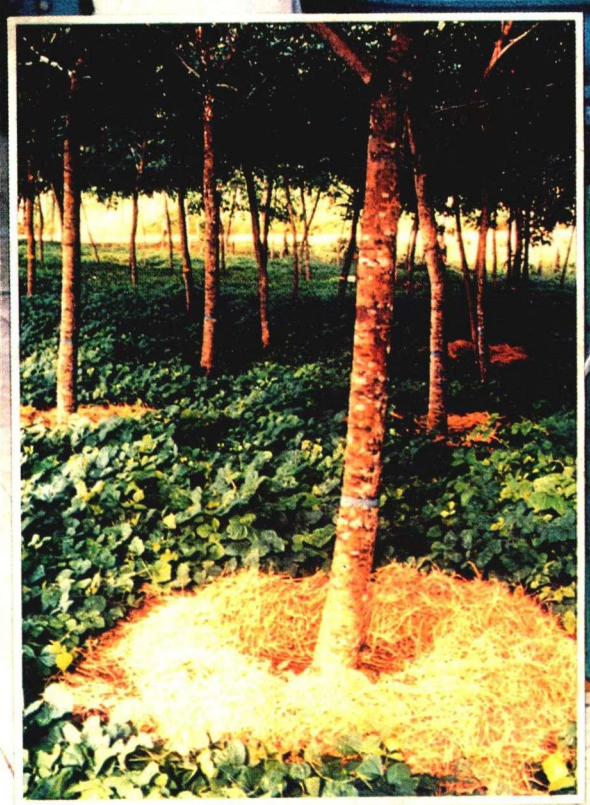
RUBBER RESEARCH INSTITUTE OF SRI LANKA



ANNUAL REVIEW 1995

RUBBER RESEARCH INSTITUTE OF SRI LANKA

ANNUAL REVIEW 1995

Cover:

Concentrated latex industry - shown best development in 1995 in Sri Lanka (Courtesy - Ansell Lanka (pvt.) Ltd.)

Insert:

Mulching with straw - towards shorter immaturity and improved yields .....

Photographed by - Wimal Amaratunga

Rubber Research Institute of Sri Lanka

Annual Review - 1995

1st January 1995 to 31st December 1995

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L M K Tillekeratne, PhD (Aston)
N Yogaratnam, PhD (Lond.)

Headquarters & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telawala Road
Ratmalana

CONTENTS

	Page
Board of Management	i
Staff	vi
REVIEWS	
Director *L M K Tillekeratne*	1
Genetics and Plant Breeding *N E M Jayasekera*	8
Plant Science *A Nugawela*	23
Plant Pathology and Microbiology *C K Jayasinghe*	53
Soils and Plant Nutrition *Lalani Samarappuli*	73
Biochemistry and Physiology *N Yogaratnam*	114
Rubber Technology and Development *N M V Kalyani Liyanage*	117
Polymer Chemistry *K G Karnika de Silva*	123
Raw Rubber and Chemical Analysis *L M K Tillekeratne*	133
Raw Rubber Process Development and Chemical Engineering *Upul Ratnayake*	138
Adaptive Research *N Yogaratnam*	147
Agricultural Economics *P H M U Herath and I N Samarappuli*	166
Biometry *Wasana Wijesuriya*	189
Library and Publications *Kamani Perera*	203
Dartonfield Group *A Nugawela*	206
List of Publications	215

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** On no pay leave overseas

*** On sabbatical leave overseas

PRESIDENTIAL AWARD FOR INVENTORS - 1995
FIRST PRIZE

The 1st prize of the presidential award in 1995 for inventors was awarded on the 27th November 1995 to Dr L M K Tillekeratne, Director, RRISL for the development of an environmental friendly, water soluble bleaching agent for the manufacture of latex crepe rubber.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

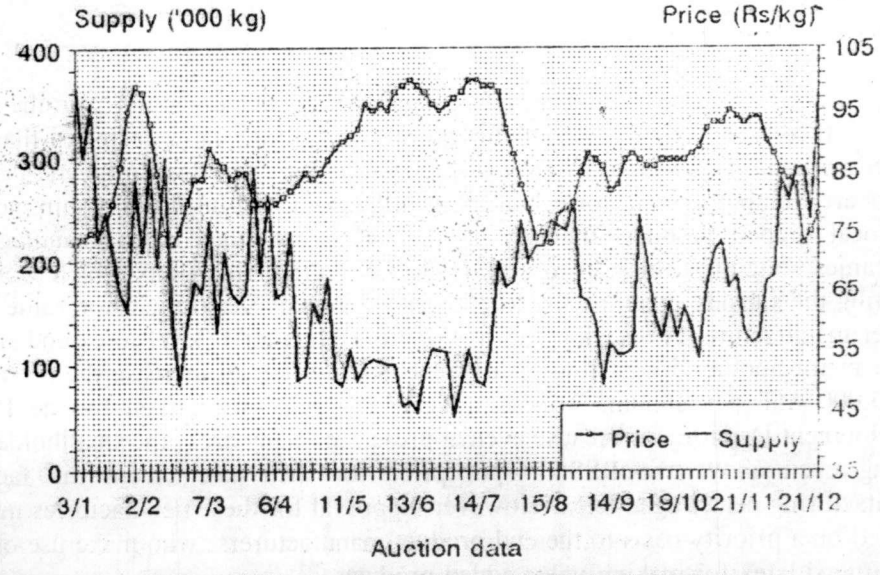
DIRECTOR'S REVIEW

L M K Tillekeratne

In 1995, the total rubber production in the country was 108,000 MT which is a marginal increase over the production of 106 000 MT in the previous year. The local consumption was in the region of 35% of the total production, with a marked development in the field of centrifuged latex. Centrifuged latex manufacture during 1995 was 15% of the total rubber production.

In 1995, out of the 4000 Ha expected to be replanted only 1750 Ha have been replanted. However, in the Matara and Hambantota districts there was a marked improvement in the replanting rate and also it was observed that most of the marginal tea lands have been replanted with rubber. This was purely due to the poor price paid for tea leaves in these areas during 1995. But the rubber prices remained fairly static and very attractive.

SUPPLY AND PRICE RELATIONSHIP FOR CREPE RUBBER (1995)



Source: With compliments from A.M. Rahim & Co. Ltd.

It is very clear from the graph given above, which was provided to us by A.M. Rahim & Co. Ltd. that there is a direct relationship between the top price quoted for latex crepe rubber at the auction and the quantity offered for auction. According to this graph, on the 24th of January, 150,000 kg of crepe rubber have been offered at the auction compared to the usual level of 300,000 - 350,000 kg and hence the price has arisen to Rs.110.00 per kg. But with the immediate improvement in production, on the 2nd of February itself, it has fallen down to Rs.85 to 90/- per Kg level again. Similarly, during the rainy period from 11th May - 25th July, the rubber presented at the auction has been in the region of 50,000 to 100,000 Kg and hence the price during this period has remained between Rs.95 to 100. This trend had been very clear throughout the year and on the 21st December, 350,000 Kg of crepe rubber has been presented at the auction thereby lowering the price to the lowest value of Rs.75/- per Kg. Based on these facts there is a possibility that the latex crepe rubber will sell below the RSS price in the dry months of March/April 1966, when the production may reach the maximum in most estates.

It has been reported in 1995 that Brokers withdrew rubber from the auction in may instances to sell them direct to buyers seated outside the auction room for the purpose of purchasing rubber from Brokers by offering them a small premium over the average price quoted on a particular day. Cost to the industry from such an exercise can be very high as it is possible that some may resort to some procedures which are unacceptable, in order to get ahead of the competition. In the long run, the rubber industry would suffer from this system as the competiting effects at the auction, which could establish true price levels, may not exist.

Centrifuged latex manufacture

At present, the centrifuged latex manufactured in the country is in the region of 15,000 MT per annum. Except for the few centrifuge latex factories that were started without proper plans as to what they were going to do with the end-product, others are running their factories almost at full capacity to fulfil the requirements of the local dipped products industry. Some such centrifuged latex manufacturing companies sought permission to set up further centrifuging units which would be enjoying the subsidy given by the Rubber Development Department for value added rubber manufacture. A decision was taken at the Ministerial level to extend subsidy payment for another 5 centrifuge latex factories in order to increase the production to 20,000 MT per annum. This is a very important step taken by the Rubber Development Department because even at present in many areas the smallholders are getting even above the RSS 1 spot price for their latex from the factories manufacturing centrifuged latex. However, approval for these new factories must be granted on a priority basis to the end-product manufacturers, who make use of their centrifuged latex for making value added products.

ISO 9002 Registration for crepe factories

Quality manuals for central crepe factories under the management of each plantation management company as well as for the Dartonfield Estate were completed according to the latest 1992 format. Application for accreditation to the Sri Lanka Standards Institute for all these factories will be done in the 1st quarter of 1996.

Effluent treatment

Work of the Pilot Plant to treat the effluent from Dartonfield Factory comprising of rubber trap, anaerobic digester, aerater, flocculation tank and the sand bed filter was commissioned during this year and this unit which is functioning satisfactorily is available for demonstration purposes to all interested parties. Meanwhile, the same system has been implemented in five Rubber Factories in the country and for the Oil Palm processing plant at Nakiyadeniya. In seven other factories, work has already been commenced to construct effluent treatment systems by this cost effective method developed by the RRI.

Clone recommendations

Rubber Research Institute recommend 3 clones *viz*. RRIC 100, 102 and 121 for planting in the smallholdings. However, it has been observed that the clone RRIC 100 is very popular among the smallholders and hence the percentage of RRIC 100 in the new plantings planted during the last 2 years have exceeded the expected 35% of the planted extent followed by RRIC 121. The demand for RRIC 102 has not been so high due to unknown reasons. Although RRIC 102 is known to give latex of slightly yellowish colour, which is even suitable for making latex crepe rubber, yieldwise, RRIC 102 clone is equally good compared to the other two clones.

It is believed that the situation in the estate sector is also the same and most of the planters select only either RRIC 100 or 121 for planting in the new clearings keeping aside the other 3 clones recommend for planting in the estates viz. RRIC 102, PB 28/59 and PB 217. It should be emphasised here that according to the policy decisions taken in 1985/86, maintaining a well balanced plantation with 20% from each of the above 5 clones in all the estates is important in order to protect the plantations from any epidemic that may cause devastation in any one or more clones as a result of infection by some new pathogens not isolated earlier. Hence all the plantations under public and private management should take care of this essential requirement in planting all the 5 recommended clones although PB 28/59 and PB 217 are known to be medium yielding clones. They have been found to be resistant to diseases and hence they should also be planted in equal proportions to meet the above requirement in all the estates throughout the country.

Biological and Technological Research

Two new genotypes from the 1981 hand pollination seedling progeny were registered under RRISL 200 series clones. With these two additions, now there are 28 clones under RRISL 200 series. Two foreign clones, PB 235 and PB 260 were promoted from Group IV to Group III of the clone recommendation for estate sector for planting up to 5 ha per estate. Two new germplasm clones which yielded more than 30 g per tree per tapping have also been identified for future evaluation. Studies on molecular biology were continued and a new, rapid method was developed to prepare extractions of DNA from *Hevea* leaf tissues.

Although, the low frequency tapping system, ½S d/3 with stimulation, gives the highest g/t/t yields, the annual total yields are however similar to that with the conventional ½S d/2 system. On the other hand, though the high intensity tapping, *i.e.* ½S d/1 on virgin panels, gives less yields per tree per tapping, the annual total yields are higher than from conventional ½S d/2 system. Commencement of tapping at lower girths continues to give less yields.

Clones and stimulation appear to have a significant effect on Tapping Panel Dryness. Further, there is a tendency for Tapping Panel Dryness to commence during the latter part of the year.

Different spatial arrangements tested for rubber, to facilitate intercropping, have not affected girthing of rubber plants. It appears that the presently recommended planting density for banana, as an intercrop, could be further increased with no adverse effect on rubber.

The incidence of leaf fall caused by *Gloeosporium* and *Oidium* was mild while phytophthora leaf fall during South West monsoon period was fairly heavy and the incidence of Bark rot remained insignificant.

The organism causing the irregular leaf spots and leaf fall on clone RRIM 712 was authenticated as *Fusarium palidoroseum*. The fungus *Thanatephorus cucumeris* was found to be the cause for the common leaf spots in *Mikania scandans* and *Pueraria phaseoloides* and it was found that these two, a common weed and a leguminous creeper in rubber plantations, were responsible for the spread of target leaf spot disease on *Hevea* in early 1990s.

VA mycorrhizal inoculum has been developed for use in commercial scale.

Residual effect of mulching with rice straw on girthing and latex production was seen throughout the virgin panel B)-1. Girth of rubber plants was higher under *Crotolaria anagyroides* and *Tephrosia vogellie* compared to trees under other species *viz. Pueraria phaseoloides, Sesbania aculeata* and *Gliricidia sepium. Crotolaria anagyroides, Tephrosia vogellie* and *Flemigia congesta* were identified as successful species that can be grown between the rows of rubber plants which would provide enough material for mulching also. It was also observed that by growing bush

legumes it is possible to reduce the cost of weeding during the immature phase of rubber by about 30%. It was further observed that the first lopping of these trees may be done 4 months after planting and it is also possible to do 3-4 loppings per year when climatic conditions are favourable.

Experiments on the possibility of using Eppawela rock phosphate (ERP) as a source of phosphate for immature rubber plants also, are being continued. Nevertheless, based on the initial results, arrangements have been made to recommend the use of this phosphate during the last two years of the immature period also, in addition to the current recommendation of its use in the mature phase.

The soil and foliar survey programme provided data for fertilizer recommendations for 4000 hectares in the estate sector. In general, as in the past, N and K fertilizers were recommended to most of the plantings. The soil and foliar survey programme was extended to the smallholder sector this year. Initially, Agalawatta Division of the Kalutara region was covered under this scheme. Eleven ranges *viz*. Agalawatta (1), Lathpandura (2), Palenda I(3), Morapitiya (4), Palenda II(5), Rathmale (6), Hedigalle, (7), Baduraliya (8), Kewitiyagala (9), Pelawatta II (10) and Athale (Hedigalle) (11), which consisted of more than 1000 holdings received fertilizer recommendations for the years 1966, 1997 and 1998. Three different fertilizer formulations were recommended for different RDO ranges and it was possible to reduce 50% of P fertilizers and 70% of Mg fertilizers during the mature phase.

Programmes on field establishment practices, clones, planting density, intercropping, rainguards, fertilizers and soil conservation practices were in progress in smallholder fields, under an adaptive research programme.

Membranes based on two types of natural rubber and coir dust to effect slow release action of fertilizers in the soil, in the presence of water, were developed. Further work is being done by testing them in the field with the appropriate dosage of fertilizers necessary for plant nurseries and immature rubber plantations.

Other developments are, the introduction of water proofing membranes based on bitumen and natural rubber latex for water tanks and concrete slabs which can also be used to produce self adhesive type rainguard sealant to fix polythene to rubber trees as rainguards, and a new formulation for wood-filling applications. A paper binding adhesive with good adhesive properties and a heat sensitive adhesive which could be used for garment stickers were also developed.

Work on latex bitumen emulsions indicated that stability characteristics of latex bitumen blends containing colloidal stabilizers were very high. However, the method of incorporation of latex with colloidal stabilizers to bitumen emulsions was also found to be important. A factory scale trial on the use of oil-extended natural rubber in tyre retreading industry was conducted.

Vision of the RRI to meet their clients needs by year 2010

A comprehensive research programme was planned to achieve the following in order to meet our clients' needs by year 2010:

* Increase the average national yields from the current level of 800 kg/ha to a higher level of 1,500 kg/ha.

* Extend the area under rubber cultivation, from the present maximum elevation of 1000 ft, upto 2000 ft.

* Reduce the cost of production (COP) in order to provide a higher profit margin to the grower.

* Development of transgenic rubber plants to improve the technological properties of Natural Rubber (NR).

* Develop appropriate rubber based farming system to suit the socio-economic needs of small rubber farmers and also that of the estate sector.

* Minimize environmental hazards caused by soil erosion and land degradation and also by pollution.

* Reduce cost of manufacture (COM) to minimum, in order to be competitive with other NR producers.

* Convert at least 65% of NR produced, into value added form.

* Convert at least 80% of annual rubber wood production into treated timber.

* Acquire ISO 9000 quality standards for all laboratories in the RRI and for all rubber processing factories in the Estate sector.

* Strengthen the process of disseminating economically viable research findings to the estate, the smallholder and the rubber products sectors.

OVERSEAS VISITORS

Mr Francois Bakou, Ivory Coast
Mr laureak Bosaquy, RCI
Mr George Brvn, Denmark
Mr Goh Kan Joo, Malaysia
Mr Hermon Garden, Netherlands
Mr Alexander H Delmen, United kingdom
Mr Lars Erik Elas, Sweden
Mr Perqusl sinclair, United Kingdom
Mr Ivan Aspunil, Sweden
Mr De Bie Yvan, Netherlands
Mr Peter J Bliss, Australia
Mr Wu Chesyzin, Chaina
Mr Zhow Pingchang, China

GENETICS AND PLANT BREEDING

N E M Jayasekera

SUMMARY

Studies on molecular biology were continued at the Biochemistry and Molecular Biology Department of the Colombo Medical Faculty. A new rapid method was developed to prepare extractions of DNA from *Hevea* leaf tissues. A bilateral clone exchange between India and Sri Lanka took place. Severe defoliation, due to infections of *Gleosporium* and *Corynespora* was detected on RRIC 110. Two new genotypes from 1981 hand pollination seedling progeny were registered under RRISL 200 series clones. With these two additions now there are 28 clones under RRISL 200 series.

Two foreign clones, PB 235 and PB 260 were, promoted from GP IV to GP III of the clone recommendation for estate sector. Each of the two clones could now be planted up to 5 ha per estate.

Observation plots of several RRISL 200 series clones, one unregistered selection and GPS 1 were established. The two promising germplasm selections GPS 1 and GPS 2 were test tapped. Two new germplasm clones which yielded more than 30g per tree per tapping have been identified for future evaluation.

DETAILED REVIEW

Staff

Dr N E M Jayasekera, the Head of the Department; Dr D P S T C Attanayake, Geneticist and Plant Breeder; Mr K B Karunasekera, Development Officer; Mr K W Rupatunga, Experimental Officer; Mr B M S G Peries, Senior Experimental Assistant and Messrs I D M J Sarath Kumara and R A S K Ranatunga Technical Officers, were on duty through out the year.

Mrs S Herath, Assistant Geneticist and Plant Breeder who was on maternity leave since November 1994 reported for work in April 1995.

Mr S T G C de Silva was appointed, for one year, as a temporary Technical Assistant under the CARP funded molecular biology project.

Mr W D Jinasena, Laboratory labourer and Mr A K M S Senarathna, Senior Experimental Assistant retired from service in April and August respectively. Mr W D Armon, Field attendant retired from service in November.

Dr D P S T G Attanayaka, was promoted to senior staff grade I and designated as the Geneticist and Plant Breeder.

Meetings

Head of the Department and Dr D P S T G Attanayaka attended the scientific committee meetings.

Head of the Department addressed Regional Scientific Committee Meetings organized by the Ceylon Planters Association of Avissawella, Galle and Ratnapura regions.

Workshops Seminars and Conferences

Dr D P S T G Attanayaka, as a resource person, conducted lectures in molecular biology for the participants in the Annual Training Course in Experimental designs, Quantitative Genetics and Breeding and Recombinant DNA Technology, conducted by the Faculty of Agriculture, University of Peradeniya.

Dr D P S T G Attanayakea attended the conference held in Vienna, Austria on the use of induced mutations and molecular technique for crop improvement.

Exchange of budwood

A bilateral exchange of clones, two from each country, between India and Sri Lanka took place in 1995.

Clones

Two new clones (RRISL 226 and RRISL 227) have been registered under RRISL 200 series. Two Malaysian clones, PB 235 and PB 260, were promoted from GP IV to GP III of the clone recommendation for the estates. Estate sector can now plant these 2 clones up to 5 ha per estate.

LABORATORY INVESTIGATIONS

Isozymes studies for clone identification (GPB/ISO/91/2)

Procurement of the chemicals needed for this project was not pursued and it was decided to divert the man power and the resources available for this project into the project on *Hevea* molecular biology since both three projects have same objectives.

Molecular biology of *Hevea* (CARP Project 12/192/165)

1. ***DNA Extractions***

DNA from 30 rubber clones were extracted using a simple method developed in this project. (see list of publications)

2. ***REF gene probe***

Southern blots were produced using an increased amount of DNA (10 μg) to probe with the REF gene probe. Only very faint bands were obtained and the hybridization conditions have to be further improved.

3. ***Repetitive DNA probes***

Construction of a genomic library

A genomic library from *Hevea* cultivar, GPS 1 containing 7 x 10^6 recombinant clones was constructed. Approximately 10,000 clones from this library were screened with 32p labelled total genomic DNA from GPS 1.

100 clones which gave strong signals were isolated as putative repetitive sequences. DNA fragments contained in two of these clones were excised invivo and used in hybridisation experiments. Others remain to be characterized.

4. ***PCR based DNA probes (DAF)***

In parallel with the RFLP work a new PCR based method with non radioactive detective on system was started.

Random amplifications of DNA was done using short Oligonucleotide primers on the genomic DNA from four different clones. Amplified DNA was then resolved in a 5% Polyacrylamide gel and bands were detected by staining with silver.

Preliminary results using M_{13} reverse primer and primer number 1 showed the possibility of detection of variation among the rubber clones (D P S T G Attanayaka, S Herath and E H Karunanayaka).

FIELD EXPERIMENTS

Hand pollination programme for 1995 (GPB/BST/HP/95/2)

This year the hand pollination programme was carried out at Dartonfield Group. The crosses attempted, the number of pollinations done in each cross, number of pods harvested and seedlings obtained in each cross are given in Table 1 (N E M Jayasekera and K B Karunasekera).

Table 1. *Details of 1995 hand pollination programme*

Cross	No. of pollinations	No. of pods harvested	No. of seedlings
RRIC 100 x GPS 1	2249	45	42
RRIC 121 x GPS 1	15	2	Nil

Evaluation of selections from 1974 hand pollinated (H.P.) Seedlings at Kuruwita Sub-station (GPB/BST/HPS/74/3)

Only promising genotypes (07) along with control clone, RRIC 121 were test tapped. Average yield based on 9 to 12 test tappings per year per tree and the mean girth are summarized in Table 2 for each promising clone and the control clone RRIC 121.

The control clone, RRIC 121 has given the highest yield of 113.79 (g/t/t) and registered the highest girth also. Out of the 7 promising clones RRISL 200 has given the highest yield of 87.34 (g/t/t) followed by RRISL 201. With respect to girth RRISL 201 registered the highest girth among promising genotypes (N E M Jayasekara, B M S G Peries and K B Karunasekera).

Table 2. *Mean yield in grams per tree per tapping (g/t/t) and mean girth of promising clones and the control (GPB/BST/HPS/74/3)*

Clone	Mean Yield (g/t/t)	Mean girth (cm)
74-12 (RRISL 200)	87.34	79.42
74-41 (RRISL 201)	86.39	84.3
74-135 (RRISL 202)	70.52	80.2
74-193 (RRISL 203)	61.45	65.5
74-130	45.49	61.2
74-180	48.34	65.4
74-205	62.94	65.4
RRIC 121 (control)	113.77	88.55

Evaluation of 1975 H.P. Selections - Clyde Estate (GPS/BST/HPS/1975/2)

Only four test tappings were carried out. Average yield of two RRISL clones, 205 and 204 recorded 47.84 and 43.64 (g/t/t) respectively.
With respect to girth RRISL 205 had a mean girth of 92.00 cm while RRISL 204 recorded a mean girth of 74.5 cm.

The best control clone RRIC 121 yielded 45.13 (g/t/t) and its mean girth was 79.75 cm (N E M Jayasekera and I D M J Sarathkumara).

Evaluation of 1976 H.P. Selections. Tempo Division, of Hillstream Estate. (GPB/BST/HPS/76/1)

In this trial, 32 clones, including the three control clones (RRIC 100, RRIC 102 and RRIC 121) are tested. Table 3 summerizes the results of the analysis of variance for girth and yield data collected from this trial.

Highly significant differences between clones were detected for both characters.

Duncan's Multiple Range Test (DMRT) was done on data collected for both traits. With respect to girth, DMRT grouped 32 clones into 19 groups. Group A and B did not over lap each other while there was considerable overlapping between other groups including group B.

DMRT analysis of yield data produced eight groups. Grouping of promising clones, according to DMRT on girth and yield, are presented in Table 4a and b (N E M Jayasekera and K W Rupatunge).

Table 3. *Analysis of variance of girth and yield data (GPB/BST/HPS/76/1)*

Girth				Yield		
		MS	P	DF	MS	P
Source	DF	584.35	***	31	1641.46	***
Block	3	280.29	***	3	1288.58	***
Error	363	53.20		369		

< Probability level
*** = < 0.001

Table 4. *Grouping of promising selections from 1976 H.P. seedling population, Tempo Division of Hillstream Estate (GPB/BST/HPS/76/1)*

4a-Girth

Clone	Mean girth cm	DMRT Grouping
76-8	88.33	A
76-82	82.28	B
RRIC 121	80.73	B C
76-52	77.45	B C D
76-182	76.53	B C D E
76-164	75.41	C D E F
76-10	75.20	C D E F G

LSD for 5% level = 5.86

4b-Yield

Clone	Mean yield (g/t/t)	DMRT Grouping
76-52	63.36	A
RRIC 121	57.52	A B
76-8	56.95	A B
76-82	46.84	B C
RRIC 100	46 06	B C
76-182	40.74	C D
76-158	37.88	C D E

LSD for 5% level = 11.27

1979 H.P. Seedlings - Eladuwa Estate (GPB/BST/HPS/79/1)

Average yield over previous 08 years, 1995 average yield and mean girth (1995) of this seedling population are given in Table 5.

Table 5. *Average yield of previous 8 years, including 1995 average yield and girth (GPB/BST/HPS/79/1)*

Clone	Average Yield Previous years g/t/t	Average Yield 1995 g/t/t	Mean Girth cm
79-347 (RRISL 207)	52.46	45.13	86.50
79-457	51.97	66.00	71.00
79-42	51.24	68.75	77.50
79-337	50.01	48.63	71.00
79-292	48.18	63.88	73.00
79-293	44.79	53.50	60.50
79-458	43.68	22.88	79.50
79-145	43.47	28.75	72.50
79-466(RRISL 209)	42.63	36.50	79.00
79-255	41.16	23.38	71.50
79-264	35.61	14.25	65.50
79-341	32.41	25.00	87.00

RRISL 207. had given the highest yield when averaged over previous 08 years. But its yield in 1995 was low when compared to unregistered clones such as 79-42 and 79-457. RRISL 207 also registered a high mean girth (N E M Jayasekera and I D M J Sarathkumara).

Evaluation of 1981 H.P. Seedlings - Eladuwa Estate (GPB/BST/HPS/81/2)

This progeny too has mother plants of some clones registered under RRISL 200 series. Mean girth for 1995, mean yield of first six years (including 1995) and 1995 mean yield are given in Table 7. RRISL 200 series clone numbers are given in parenthesis.

Table 7. *Mean yield and mean girth of promising H.P. Seedlings of 1981-Eladuwa Estate*

Clone	Mean yield first 5 years g/t/t	Mean yield 1995 g/t/t	Mean girth cm
81-8 (RRISL 217)	82.50	45.25	82.00
81-50 (RRISL 219)	81.39	82.08	76.50
81-192 (RRISL 222)	79.76	56.30	80.00
81-65	79.46	104.70	90.00
81-203	78.95	108.40	81.00
81-111 (RRISL 220)	78.09	86.50	86.50
81-207 (RRISL 224)	77.01	80.42	75.00
81-30 (RRISL 218)	76.43	85.58	95.50
81-178 (RRISL 221)	74.13	79.67	85.00
81-60	73.77	103.5	85.50
81-197	72.62	98.25	99.00

Two mother plants, 81-65 and 81-203 have given consistently high yields over the last six years and their yield trends indicate gradual increase over past few years. Considering these yields and very good girth it has been decided to register 81-65 and 81-203 as RRISL 226 and RRISL 227 respectively under RRISL 200 series (N E M Jayasekera, I D M J Sarathkumara and K B Karunasekera).

Evaluation of 1982 H.P. Selections -Clyde Estate (GPB/BST/HPS/82/2)

Analysis of girth data collected from 66 clones, including 5 control clones *viz.* RRIC 100, RRIC 102, RRIC 110, RRIC 121 and RRIM 600 indicated significant differences between clones (Table 8).

Table 8. *Analysis of girth data of 1982 H.P. selections-Clyde Estate (GPS/BST/HPS/82/2)*

Source	D.F.	MS	P
Clones	65	787.06	***
Blocks	3	95.70	*
Error	1141		

Probability - P
<0.001 = ***
0.01-0.5 = *

DMRT grouped the 66 clones in to 23 groups with considerable over lapping. Clones in group A and their over lappings with other groups are given in Table 9. Tapping of this trial commenced in 1995 and test tapping will be carried out in 1996.

Table 9. *Clones in group A and over lapping groups according to DMRT (GPB/BST/HPS/82/2)*

Clone	Mean girth cm	Group
82-163	64.78	A
82-132	64.65	A
82-110	64.45	A
82-51	64.40	A
82-140	63.55	A B
RRIC 102	63.30	A B
RRIC 110	62.75	A B C
82-15	62.56	A B C D
82-54	61.55	A B C D E
82-43	61.03	A B C D E F
82-152	60.66	A B C D E F

LSD for 5% level = 4.35

Evaluation of 1985 H.P. Selections - Tempo Division, Hillstream Estate. (GPB/BST/HPS/85/2)

In this field experiment, 55 clones including five control clones (RRIC 100, RRIC 102, RRIC 110, RRIC 121 and BPM 24) are tested. The results of the analysis of varience on girth data are presented in Table 10. Highly significant differences between clones were detected.

Table 10. *The analysis of variance results of girth data*

Source	D.F.	M.S.	P
Clones	54	557.03	***
Blocks	3	296.74	***
Error	878	43.03	

P = probability
<0.001 = ***

DMRT produced 21 groups with considerable over lapping. The 10 clones with highest mean girth and their DMRT grouping are given in Table 11 (N E M Jayasekera, K W Rupatunge and K B Karunasekera).

Table 11. *Ten clones with highest mean girth and their DMRT groups (GPB/BST/HPS/85/2)*

Clone	Mean girth cm	Group
85-82	59.75	A
85-60	58.17	A B
85.25	57.61	A B
RRIC 110	57.30	A B C
85-33	56.91	A B C D
85-26	56.20	A B C D E
85-13	55.92	A B C D E F
85-59	55.91	A B C D E F
85-28	55.52	A B C D E F G
RRIC 102	54.81	A B C D E F G

LSD for 5% level = 4.52

Evaluation of clones received under 1974 Multilateral Exchange Programme - Hewagam Estate (GPB/BST/ICT/79/2)

Mean girth and yield are of clones evaluated in this trial are given in Table 12.

Table 12. *Mean girth (cm) and yield (g/t/t) of clones evaluated under 1974 clone exchange programme (GPB/BST/79/2)*

Clone	Yield	Girth	No. of trees
RRIC 121	36.9	73.9	79-95
BPM 24	32.4	59.1	80-95
RRIC 100	32.2	65.3	48-111
RRIM 717	31.6	61.9	41-92
RRIC 117	31.3	59.8	69-78
RRIC 110	30.1	68.2	57-99
RRIM 712	30.0	57.0	96-108
PR 306	28.3	64.7	67-120
BPM 22	26.6	65.9	36-95
RRIM 722	25.4	69.4	42-48
RRIM 703	16.6	62.5	37-113

Statistical analysis of data wasn't possible as RRIC 103, RRIC 104 and RRIC 107 had to be uprooted in 1987 due to *Corynespora* leaf disease.

RRIC 121 was the best with respect to yield and girth. The second position was occupied by BPM 24 with respect to yield closely followed by RRIC 100.

With repect to girth RRIM 722 was the second best and the third place was occupied by RRIC 110 (N E M Jayasekera and R A S K Ranatunga).

Testing of proven foreign clones received under SRRP (GPB/FC/SRRP/91/2)

A girth measurement was taken from all the experimental sites. Mean girth of clones planted in large trials (Eladuwa and Salawa Estate) are given in Table 13. On Eladuwa one plot of each clone is planted and plot size is approximately 300 trees. On Salawa 2 such plots (P1 and P2) per clone have been planted.

Table 13. *Mean girth in cm*

Clone	Eladuwa	Salawa	
		P1	P2
PB 217	32.58	28.2	29.06
RRIC 110	39.14	33.88	33.06
PR 260	37.07	29.69	31.44
PR 255	28.42	26.72	26.74
PR 261	25.80	30.81	22.56
PB 235	39.54	32.01	31.68
RRIC 121	38.25	32.43	28.82
BPM 24	34.51	28.57	28.60
RRIC 100	37.39	32.87	29.25
RRIM 712	33.10	22.75	25.71

Mean girth of clones in four small experiments (Three 25 tree plots per clone per site) are given in Table 14.

Table 14. *Mean girth (cm) of clones in four experimental sites*

Clone	Yatawatta	Bentota	Kuruwita	Atale
RRIC 121	28.69	36.99	31.04	42.71
PB 260	26.86	39.61	31.55	42.69
PB 235	26.27	42.56	32.80	43.25
RRIM 712	23.95	27.75	22.19	39.86
PR 255	23.46	26.88	2 1.64	37.63
BPM 24	22.97	31.21	23.19	39.16
PR 261	15.26	27.68	18.80	39.17

An analysis of variance was done on data collected from four small exeperiments. Analysis showed significant differences between clones, blocks and sites. Clone x site interaction was also found to be highly significant indicating that the rank occupied by each clone varied over the experimental sites.

DMRT done on combined data of four small trials showed that PB 235 occupied the group A with the highest mean when averaged over all sites. Group B had two clones. RRIC 121 and PB 260. DMRT grouping is given in Table 15.

Table 15. *DMRT results for mean girth over all sites*

Clone	Mean girth (cm) over all sites	DMRT group
PB 235	36.26	A
PB 260	35.44	B
RRIC 121	34.85	B
BPM 24	29.29	C
RRIM 712	28.53	C
PR 255	27.44	D
PR 261	25.38	E

LSD for 5% level = 0.29

From the combine analysis it could be inferred that on the average, PB 235 is the most vigorous clone followed by PB 260 and RRIC 121.

PB 235 and PB 260 were promoted to group III of the clone recommendation for estate sector.

A small trial with three 25 tree plots per clone was planted on Kumarawatta Group in Monaragala District during 1995 North East planting season. This trial will replace the Bibile trial which was damaged by fire (N E M Jayasekera, K W Rupatunga, I D M J Sarathkumara, B M S G Peiris, R A S K Ranatunga and K B Karunasekara).

Evaluation of IRRDB germplasm collection (GPB/GP/85/2)

Evaluation of IRRDB germplasm collection continued. Test tapping of plants, so far, has led to identification of four genotypes which can yield more than 30 g per tree per tapping.

Test tapping yield, both average over first three years and the average for 1995, are given in Table 16. Number in parenthesis indicates the number of test-tapping on which the average is based.

Table 16. *Test tapping yield of promising IRRDB germplasm clones*

Clone	Average for first 3 years	Average for 1995
22-137	41.65(77)	33.41(156)
36-471 (GPS 2)	46.36(73)	42.72(151)
42-559 (GPS 1)	77.65(73)	99.85(156)
44-24	48.01(77)	46.83(153)

Considering the yield, it can be seen that the genotypes 42-559(GPS 1) is out standing and has a good potential as a high yielding clone (N E M Jayasekera and K B Karunasekera)

Observation plots of RRISL 200 series clones

Observation plots of some RRISL 200 series clones, RRIC 133, one promising unregistered clone and Germplasm selection one (GPS 1) were established in 1995. Details of the observation plots established are given in Table 17.

Table 17. *Details of observation plots established in 1995*

Clone	Estate/Site	No. of Tapping tasks
RRISL 205	Pallegoda Estate	01
RRISL 206	do	01
RRISL 218	do	01
76-52(unregistered)	do	01
RRISL 217	Kuruwita S.S	01
RRISL·222	do	01
RRIC 133	do	01
GPS 1	Dartonfield	01
RRISL 220	do	02

Studies on clonal response to different combinations of N P K and Mg (GPB/SPN/NUT/94/2)

A diameter measurement was recorded in this experiment. Some plants in the experiment on Paiyagala Estate were damaged by unknown persons (N E M Jayasekera, S Dharamakeerthi, K B Karunasekera, K W Rupatunge and I D M J Sarathkumara).

PLANT SCIENCE

A Nugawela

SUMMARY

Seed fall in relatively dry areas, is high and clonal differences are not apparent. Green bud-sticks harvested on previous day maintained the peeling quality and grafting success if stored correctly. In young buddings, cut back at time of grafting leaving a long snag accelerates sprouting with no adverse effect on grafting success.

In the low frequency tapping systems tested, ½S d/3 with stimulation continues to give the highest g/t/t yields. Nevertheless, the annual total yields are similar, marginally less than from conventional ½S d/2 system. High intensity tapping, *i.e.* ½S d/1 on virgin panels give less yields per tree per tapping. Anyhow, the annual total yields are higher than from conventional ½S d/2 system. Commencing of tapping at lower girths continue to give less yields. Once the virgin panels are tapped, continuing to tap the BI-I panel from the height of commencement of tapping is advantages than exploiting the upper virgin bark.

Clones and stimulation appear to have a significant effect on Tapping Panel Dryness. Further, there is a tendency for Tapping Panel Dryness to commence during the latter part of the year.

In high density planting, *i.e.* upto 900 plants/ha, competition is not apparent at the end of 3rd year in all clones tested. In mature areas though the g/t/t yields are less, YPH, increased with increasing planting density. Girth of mature rubber decreases with increasing planting density.

Different spatial arrangements tested for rubber, to facilitate intercropping, have not affected girthing of rubber plants. There is evidence that the presently recommended planting density of banana for intercropping could be further increased with no adverse effect to rubber.

DETAILED REVIEW

Staff

Dr A Nugawela, the Head of Department: Dr (Mrs) P Seneviratne, Botanist: Mr V H L Rodrigo, Research Officer (Intercropping); Mr R B Gunaratne and Mr L S Kariyawasam, Experimental Officers; Mr R P Karunasena, Mr K A G B

Amaratunge and Mrs G A S Wijesekera, Senior Technical Officers; Mr S Wilbert, Senior Experimental Assistant; Mrs C W Ranasinghe, Mr U S Weerakoon, Mrs R K Samarasekera, Mr M K P Perera, Mr T U K Silva, and Mr M de Alwis, Technical Officers, were on duty throughout the year.

Dr (Mrs) M S Ranasinghe, returned after successfully obtaining a PhD in Plant Physiology from the University of New England, Armidale, Australia. She was reinstated in the post of Assistant Botanist with effect from 8th May, but again vacated her post from 5th June.

Mr S M A Samarakoon was transferred to the Polymer Chemistry Department while Mr L P P Vitharana of the Polymer Chemistry Department was transferred to the Plant Science Department with effect from 11th September.

Mrs D E Jayawardena, Clerk/Typist was on maternity leave during the period. 10th February to 23rd June.

Mr L S S Pathiratna was promoted to Research Officer Grade II with effect from 28th September 1994.

Research students

Mr C Pasqual, an undergraduate student from the University of Ruhuna, completed his final year project on "Different methods of applying Ethrel for yield stimulation of *Hevea brasiliensis* Muell. Arg. plants" under the supervision of Dr A Nugawela.

Mr E P N Udayakumara, an undergraduate student from the University of Ruhuna, completed his final year project on "Effect of the position of the bud on the growth of the scion of *Hevea brasiliensis* Muell. Arg." under the supervision of Dr (Mrs) P Seneviratne.

Miss S S Gammanaliyanage, an undergraduate student from the University of Ruhuna, completed her final year project on "Effect of the height of the origin of explant on *in vitro* shoot growth *Hevea brasiliensis* Muell. Arg." under the supervision of Dr (Mrs) P Seneviratne.

Meetings and conferences

The Head of Department addressed at the following meetings and conferences:

* Scientific Committee Meetings. Dr (Mrs) P Seneviratne and Mr V H L Rodrigo also participated.
* Estate Committee Meetings.
* Regional Scientific Committee Meeting, Kegalle and Avissawella. Dr (Mrs) P Seneviratne and Mr V H L Rodrigo also participated.

* Seminar for Planting Executives, Namunukula Plantations Ltd.
* Planters Association Meeting at Galle, Kalutara and Ratnapura regions. Dr (Mrs) P Seneviratne and Mr V H L Rodrigo also participated.

The Departmental Staff also conducted the following programmes:

* Refresher course for Rubber Development Officers.
* Training programmes on Budgrafting, Young budding, Tapping and Rainguards.
* Seminars for mini-estate owners.

LABORATORY INVESTIGATIONS

Tissue culture

***Juvenile* Hevea**: Studies on individual variation in juvenile tissues showed a significant difference among the individuals with respect to axillary bud proliferation. Investigations to improve shoot proliferation rate of juvenile tissues are being continued (P Seneviratne and G A S Wijesekera).

FIELD EXPERIMENTS

Seedling nurseries

Seed production

A survey on seed production was carried out in Kegalle, Ratnapura and Kalutara regions. Region wise differences are apparent, *i.e.* more seeds in relatively dry Kegalle region. Clonal differences are not evident in regions with weather conditions not very conducive for diseases, *i.e.* Kegalle (Table 1).

Table 1. *The number of seeds collected per plot, percentages of good and inferior quality seeds and the estimated seed production per Hectare*

Region	Clone	No. of Seeds per plot	% number of seeds		Estimated no.seeds/hectare
			good	interior	
Kalutara (Dartonfield)	PB 86	131	4	96	5634
	RRIC 100	15	93	7	645
	RRIC 121	0	-	-	-
Kalutara (Perth)	PB 86	324	15	85	13932
	RRIC 100	130	100	0	5590
	RRIC 121	28	43	57	1204
Kegalle	PB 86	344	68	32	14792
	RRIC 100	244	56	44	10499
	RRIC 121	427	67	33	18361
Ratnapura	PB 86	311	60	40	13382
	RRIC 100	172	74	26	5462
	RRIC 121	0	-	-	-

This study shows that the current rate of seed production is sufficient to meet the countries requirement (P Seneviratne, K A G B Amaratunge, S Wilbert and R P Karunasena).

Seed germination

The germination percentage of seeds collected from Kegalle and Matale regions is 55 and 50 respectively. Germination of the seeds commenced 12-13 days after sowing. The percentage of usable seeds for stock nurseries, *i.e.* first four harvests, is 42 and 49 for seeds collected from Kegalle and Matale regions respectively.

Germinated seeds harvested on the 11th, 13th, 15th, and 17th day after sowing girthed significantly better than those harvested later (P Seneviratne).

Spacing

Two spacing systems, *i.e.* widely used 9" quincunx double row system with 2' between 2 double rows and 6"x2' single row, were tested for seedling nurseries. Spacing systems tested had no significant effect on the growth of stock plants (P Seneviratne and K A G B Amaratunge).

Planting material

Young budding

Sprouting: Cut back at time of grafting, leaving a long snag with leaves, accelerates sprouting with no adverse effect on grafting success. If cut back is done after either 2 or 4 weeks from grafting, the grafting successes is similar but time taken for sprouting is delayed. Spraying the bud patch with thiourea also accelerates sprouting (P Seneviratne, S M A Samarakoon and K A G B Amaratunge).

Bud sticks: Green bud sticks of clone RRIC 121, harvested on the previous day morning, previous day evening and the same day morning showed no difference either on the peeling quality of budwood or on the grafting success (P Seneviratne and S M A Samarakoon).

Tap root: In young buddings, the taproot often penetrates the polybag and this complicates field planting. If a folded piece of gauge 500 polythene is placed at the base of the polybag, penetration of the tap root can be minimized (P Seneviratne and S M A Samarakoon).

Rooted cuttings

Cuttings of seedlings, when treated with Rootone-F, rooted in 4-6 weeks under mist propagation. Without Rootone-F, rooting is delayed. Clonal cuttings of RRIC 100 failed to produce roots both under mist propagation and hydroponic system (P Seneviratne and S P Vithanage).

Polybagged buddings

Seedlings grown in polybags, as for young buddings, after successful grafting could be directly planted in the field. Time taken for sprouting, percentage of

sprouting and growth of the scion is significantly better than those of bare-roots (A Nugawela and P Seneviratne in collaboration with Genetics and Plant Breeding Department).

Planting techniques

The objective of these experiments is to compare the performance, *i.e.* establishment rate and early growth of different types of planting material, in different agroclimatic conditions where rubber is grown in Sri Lanka.

Padukka (PT/91/1)

This trial was established during SW 1991. The establishment rates and girth after 4 years of planting are given in Table 2.

Table 2. *The different types of planting material tested and their mean establishment success (%) and girth (cm) after 4 years of growth*

Planting material	Establishment Success (%)	Girth (cm)
Two whorled young buddings	100	36.4
Two whorled brown buddings	100	36.4
Bare root brown buddings	88	36.3
Green buddings in polybags	96	35.0

The growth and establishment rate are similar in young buddings and two whorled brown buddings and continue to be superior to other materials being tested (A Nugawela and S M A Samarakoon).

Mohamadi (PT/92/1)

This trial was established during SW 1992. Five types of planting material mentioned in Table 3 are being tested and the establishment rates and girth after 3 years of growth are given in the same Table.

Table 3. *The different types of planting material tested and their establishment success (%) and girth (cm) after 2 years of growth*

Planting material	Establishment Success (%)	Girth (cm)
Bare root green budding	93	18.9
Bare root brown budding	99	20.4
Green budding polybags	94	21.1
Young buddings	100	23.1
Brown budding polybags	98	22.2

The girth of young buddings and brown buddings in polybags is comparable and continue to be superior to other materials tested (A Nugawela and S M A Samarakoon).

Pallegama (PT/93/1)

The trial was established during SW 1993. The establishment success (%) of the different types of planting material and the mean girth after 2 years of growth are given in Table 4.

Table 4. *The different types of planting material tested and their establishment success and early growth*

Planting material	Establishment Success (%)	Diameter (cm)
Bare root green budding	91.0	12.8
Bare root brown budding	82.3	11.9
Green budding polybags	99.2	12.5
Young budding	100.0	13.4
Brown budding polybags	98.8	12.8

Young buddings are superior to other types tested both in establishment rate and growth (A Nugawela and K A G B Amaratunge).

Dartonfield (PT/92/2)

Girth values, 3 years after field planting, for the three types of planting materials, *i.e.* deep planted young buddings, shallow planted young buddings and bare root budded stumps of clone RRIC 121 were 29.8, 30.0 and 24.5 cm respectively (P Seneviratne, A Nugawela and S M A Samarakoon).

Girth at opening

The objective of this study is to find out the possibility of reducing the immature period by commencing tapping at lower girths than the presently recommended 50 cm or above.

RRIC 100, 1985 Replanting - Dalkeith (TG/91/1)
RRIC 100, 1985 Replanting - Kiriwanaketiya (TG/91/3)
RRIC 100, 1985 Replanting - Eladuwa (TG/91/4)
RRIC 121, 1984 Replanting - Perth (TG/91/2)

The mean dry rubber yield per tree per tapping (g/t/t), girth and girth increment for different treatments in both clones are summarized in Table 5.

Table 5. *The mean dry rubber yield per tree per tapping the girth and girth increment of RRIC 100 and RRIC 121 trees opened at different girths*

Girth Class	Yield (g/t/t)		Girth (Girth increment) cm.	
	RRIC 100	RRIC 121	RRIC 100	RRIC 121
T_1 40-44.9	22.6	19.8	57.2 (2.8)	49.9 (1.3)
T_2 45-49.9	29.9	29.8	59.0 (3.5)	57.7 (1.8)
T_3 50-54.4	35.1	37.8	61.4 (2.1)	63.9 (1.8)
T_4 55 and above	48.2	57.0	69.3 (2.4)	76.1 (3.1)

Trees opened at higher initial girths continue to give significantly high yields (A Nugawela, S Wilbert, T U K Silva and C W Ranasinghe).

RRIC 130, 1990 Replanting - Dartonfield (TG/95/1)
RRIC 121, 1990 Replanting - Dartonfield (TG/95/2)
RRIC 100, 1990 Replanting - Dartonfield (TG/95/3)

From each clone mentioned above, trees from girth classes 42-44 cm (GC1), 44-46 cm (GC2) and 49-51 cm (GC3) were selected. The following treatments were introduced randomly (single tree plots) for each clone. Twenty trees were assigned for each treatment per clone.

Treatments:

T_1 Commencing tapping at GC1
T_2 GC1 untapped trees
T_3 Commencing tapping at GC2
T_4 GC2 untapped trees
T_5 Commencing tapping at GC3
T_6 GC3 untapped trees
T_7 GC1 trees to be tapped when reach GC 2
T_8 GC 2 trees to be tapped when reach GC 3.

The mean g/t/t for different clones and girth classes are given in Table 6.

Table 6. *The mean yield, i.e. g/t/ when tapping commenced at different girths in different clones*

	Girth Class		
Clone	42-44 cm	44-46 cm	49-51 cm
RRIC 130	25.4	31.0	41.2
RRIC 121	15.0	16.6	18.9
RRIC 100	8.0	8.7	9.5
Mean	16.1	18.1	23.2

Generally, the yield increases with increasing girth in all 3 clones (A Nugawela, S Wilbert and R K Samarasekera).

Height of opening (TH)

The objective of these trials is to study the possibility of increasing the height of opening and reducing the tapping time with the use of Jebong knife. Increasing the height of opening will give more time for bark renewal.

RRIC 100, 1985 Replanting - Dalkeith (TH/91/1)
RRIC 100, 1985 Replanting - Kiriwanaketiya (TH/91/2)

Information on yield, bark consumption rate and girth increment for the different treatments during 1995 are summarized in Table 7.

Table 7: *Mean yield (Y,g/t/t), rate of bark consumption (BCR,cm/y) and girth increment (GI,cm/y) on trees opened at 60" using Jebong knife and 48" using Push knife.*

Treatment	TH/91/1			TH/91/2		
	Y	BCR	GI	Y	BCR	GI
T_1 - 60" Jebong knife	40.5	22.4	1.6	28.0	24.2	2.8
T_2 - 60" Jebong and 48" Push knife	39.0	22.4	2.0	30.2	24.3	3.1
T_3 - 48" Push knife	40.4	21.5	1.7	27.8	23.1	2.7

The yields and girthing of plants are similar with both Jebong and Push knives. The rate of bark consumption is marginally less with the push knife. Time taken to tap a tree is similar with both knives (A Nugawela and S Wilbert).

Low frequency tapping

The objective of these trials is to find out whether it is more economical to exploit newly introduced clones with low frequency tapping with stimulation than the presently recommended ½S d/2 system. Low frequency tapping systems can have the advantage of low tapping costs, low tapper requirement and longer tapping cycles.

RRIC 100, 1981 Replanting - Gallewatta (LFT/88/1)

The ½S d/3 + E system has given significantly higher dry rubber yields per tree per tapping (g/t/t), than the other low frequency systems tested and the conventional ½S d/2 system. Nevertheless, the total crop per tree per annum (Kg/t/year) is less in ½S d/3 + E system than in the conventional ½S d/2 method Table (8).

The treatment differences are not significant in either the girth or girth increment (Table 8).

Table 8. *Effect of tapping systems on dry rubber yields and growth of clone RRIC 100*

Tapping system	Yield		Growth	
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)
½S d/2	48.1	8.66	76.0	0.6
½S d/3 + E*	54.6	6.55	81.2	3.1
½S d/4 + E*	37.1	3.34	80.5	2.9
¼S d/2 + E*	37.0	6.66	83.3	1.6

E* 2.5% ET, Ba 0.8 (2.5) 4/y
(A Nugawela, S Wilbert and T U K Silva)

RRIC 121, 1985 Replanting - Kiriwanaketiya (LFT/91/1)

The dry rubber yield per tree per tapping (g/t/t) is high in ½S d/4 + E and ½S d/3 + E systems. Anyhow, the total annual yields are high in the conventional ½S d/2 system (Table 9).

The treatment differences are not significant in either the girth or girth increment.

Table 9. *Effect of tapping systems on dry rubber yields and growth of clone RRIC 121*

Tapping system	Yield		Growth	
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)
½S d/2	39.9	7.18	77.5	3.9
½S d 4 + E*	56.1	5.05	74.2	3.43
½S d/3	39.0	4.68	75.1	3.0
½S d/3 + E*	46.7	5.6	74.8	3.7

E* 2.5% ET, Ba 0.8(2.5) 4/Y

The tapping systems will be changed as follows from 1996 to enhance total annual yields (kg/t/annum) from low frequency tapping systems to those of conventional tapping.

Tapping Systems	
Present	New
½S d/2	½S d/2 (unchanged)
½S d/4 + E* (4/y)	½S d/4 + E* (6/y)
½S d/3	½S d/3 + E* (6/y)
½S d/3 + E* (4/y)	½S d/3 + E* (4/y) (unchanged)

E* 2.5% ET, Ba 1.6(2.5)
(A Nugawela and S Wilbert)

RRIC 102, 1981 Replanting - Neuchatle (LFT/88/2)

The annual mean dry rubber yield per tree per tapping (g/t/t) is highest in tapping system ½S d/3 + E*. Nevertheless, the estimated total annual yield based on the maximum number of possible tappings per tree per year is highest in the conventional ½S d/2 system (Table 10). The treatment differences in girth are not significant. Incidence of dry trees (TPD) is highest in conventional ½S d/2 system.

Table 10. *Effect of tapping systems on dry rubber yields, growth and mean number of dry trees (TPD) per plot of clone RRIC 102.*

Tapping system	Yield		Girth	TPD
	g/t/t	kg/t/year	cm	(%)
½S d/2	44.01	7.92	62.0	16.7
½S d/3	51.0	6.12	71.0	7.0
½S d/3 + E*	58.2	6.98	71.1	8.4
½S d/4 + E*	51.1	4.6	71.4	13.0
¼S d/2 + E*	43.1	6.14	71.5	3.4

*E 2.5% ET. Ba 0.8(2.5) 4/y.

The low frequency tapping treatments of this trial will be changed as follows to improve the total annual yields upto the levels of conventional tapping.

Tapping Systems	
Present	New
½S d/2	½S d/2 (unchanged)
½S d/3	½S d/3 (unchanged)
½S d/3 +E* (4/y)	½S d/3 + E* (4/y) (unchanged)
½S d/4 + E* (4/y)	½S d/4 + E* (6/y)
¼S d/2 + E* (4/y)	½S d/3 + E* (6/y)

E* 2.5% ET. Ba 1.6 (2.5)

(A Nugawela and K A G B Amaratunge)

Low frequency tapping systems and clones - Eladuwa (F/76/5)

Three tapping systems tested on three different genotypes *i.e.* RRIC 100, RRIC 101 and PB 86 were changed as follows during the year.

Treatments	
Old	New
½S d/2	½S d/2 (unchanged)
½S d/3	½S d/3 + E*
½S d/4	½S d/3 + E**

The yields recorded on the new tapping systems introduced are given in Table 11.

Table 11. *Effect of different tapping systems on the yield per tree per tapping (g/t/t) and estimated yield per tree per year (kg/t/annum) in 3 clones tested.*

Tapping System	Clones and Yield					
	RRIC 100		PB 86		RRIC 101	
	g/t/t	kg/t/year	g/t/t	kg/t/year	g/t/t	kg/t/year
½S d/2	29.2	5.26	21.0	3.78	23.3	4.19
½S d/3 + E*	51.5	6.20	43.7	5.24	49.4	5.93
½S d/3 + E**	38.2	4.58	33.7	4.04	44.3	5.32

E* 2.5% ET.Ba 0.8(2.5) 4/y
E** 2.5% ET.Ba 0.8(2.5)6/y

The yield per tree per tapping (g/t/t) and the estimated yield per tree per year are both high in low frequency tapping system. Differences between 4 and 6 rounds of stimulation per year are not apparent to-date (A Nugawela and C W Ranasinghe).

Low frequency tapping systems and frequency of stimulation (LFT/95/1)

½S d/3 tapping system with different frequencies of stimulation, i.e. monthly with 1% ethrel, once every 2 months with 2.5% ethrel, once every 3 months with 2.5% ethrel is tested on clones RRIC 100,102,121 and 130.

The mean grammes per tree per tapping yields recorded during 1995 for the 4 clones tested are given in Table 12.

Table 12. *Annual mean grammes per tree per tapping (g/t/t) for different frequencies of stimulation in clones RRIC 100, RRIC 102, RRIC 121 and RRIC 130*

	Clone and Yield (g/t/t)			
Treatment	RRIC 100	RRIC 102	RRIC 121	RRIC 130
1% ET,Ba 0.8(2.5)12/y	40.1	31.6	40.7	2.1
2.5%ET,Ba 0.8(2.5)6/y	41.2	26.9	44.1	64.7
2.5%ET,Ba 0.8(2.5)4/y	38.9	26.6	31.4	52.2

Treatment differences vary with the clone. Nevertheless, it appears 2.5%ET, Ba 0.8 (2.5)6/y will give the highest yield per tree per annum (A Nugawela and R P Karunasena).

High intensity tapping of virgin panels

Trials on the above were initiated during 1993 with the objective of finding out whether total yields obtained during the presently recommended 24 year tapping cycle could be realized during a shorter tapping cycle and if so, whether such tapping systems are more economical.

RRIC 100, 102, 121 and 130, 1988 Replanting - Dartonfield (HIT/93/1)

The experimental details are given in Annual Review 1993. Mean yields per tree per tapping (g/t/t) and the annual girth increment (cm) are given in Table 13.

The yields from ½S d/1 tapping is low in all clones. The girth increment per year appears not to vary with the tapping system in all clones tested. In clone RRIC 130 the ½S d/2 and ½S d/3 + E* appears to give similar dry rubber yields per tree per annum (A Nugawela and R P Karunasena in collaboration with the soils and Plant Nutrition Department).

Table 13. *Effect tapping systems at different fertilizer levels on dry rubber yields of different clones*

Tapping system	Fertilizer level	Yield (g/t/t)			
		RRIC 100	RRIC 102	RRIC 121	RRIC 130
½S d/1	Level -1	27.1 (2.9)	22.2 (3.3)	31.4 (3.2)	26.3 (1.2)
	Level -2	22.4 (2.9)	19.3 (3.3)	31.7 (3.3)	26.1 (3.0)
½S d/2	Level -1	31.6 (3.6)	31.2 (3.4)	37.8 (3.1)	57.9 (3.1)
	Level -2	36.7 (3.7)	26.3 (2.9)	42.3 (3.9)	48.0 (2.7)
½S d/2 +E*	Level -1	43.2 (3.6)	32.4 (3.9)	42.9 (2.9)	49.3 (3.0)
	Level -2	39.8 (3.0)	31.1 (3.3)	40.9 (3.7)	47.1 (2.4)
½S d/3+E*	Level -1	40.6 (3.5)	37.2 (3.4)	40.9 (3.5)	75.8 (2.6)
	Level -2	50.9 (2.9)	26.0 (2.1)	56.2 (3.8)	74.0 (3.0)

E* 2.5% ET, Ba 0.8(2.5) 4/y.

Exploitation of renewed bark

The objective of this trial is to identify suitable bark for tapping once the virgin panels, *i.e.* BO-1 and BO-2 are tapped.

PB 86, 1971 Replanting - Payagala Estate (ERB/93/1)
PB 86, 1971 Replanting - Perth Estate (ERB/93/2)

The annual mean yield, *i.e.* g/t/t for each year since the commencement of the two trials for different tapping treatments are given in Table 14.

Table 14. *The dry rubber yield (g/t/t) of the different treatments in trials ERB/93/1 and ERB/93/2.*

	Year and mean annual yield (g/t/t)					
	ERB 93/1			ERB 93/2		
Treatment	1993	1994	1995	1993	1994	1995
T_1 Panel BI-1	38.4	38.7	45.9	49.6	35.1	48.3
T_2 6" above BI-1	27.3	30.8	37.0	32.8	30.7	41.0
T_3 Upper Virgin Bark (↑)	37.3	27.8	27.3	58.7	42.0	45.9
T_4 Upper Virgin Bark (↓)	30.8	29.9	36.2	45.4	33.3	39.5
T_5 Upper Virgin Bark (Puncture Tapping)	14.2	24.3	36.2	21.2	31.5	38.6

The above data clearly indicates tapping panel BI-1 commencing from the original height of opening gives highest yields. The mean annual bark consumption for treatments T_1, T_2, T_3 and T_4 above are 19.9, 20.1, 31.5 and 19 cm respectively. The bark consumption rate of upward cuts is significantly high (A Nugawela and R P Karunasena).

Tapping panel dryness

The objective of this study is to identify factors that may be associated with the incidence of tapping panel dryness.

RRIC 100, 1986 Replanting - Eladuwa Estate (TPD/93/1)
RRIC 110, 1986 Replanting - Eladuwa Estate (TPD/93/2)

The experimental details are given in the Annual Review 1994. The mean annual yield per tree per tapping (g/t/t), girth increment and % incidence of tapping panel dryness for different treatments and clones are given in Table 15.

Table 15. *Effect of different agronomic practices on yield (g/t/t), girth increment (GI, cm) and incidence of tapping panel dryness (% TPD) in clones RRIC 100 and RRIC 110*

Treatment	Fert. Level	RRIC 100			RRIC 110		
		g/t/t	GI (cm)	% TPD	g/t/t	GI (cm)	% TPD
Rainguarding	1	32.6	4.8	6.7	40.4	3.1	-
	2	36.2	5.5	-	38.5	4.0	-
Rainguarding and Stimulation	1	33.1	3.9	-	53.3	3.3	13.3
	2	36.5	5.0	13.3	55.0	3.2	20.0
Stimulation	1	30.9	3.3	13.3	51.1	3.8	6.7
	2	33.8	4.2	-	50.7	2.8	6.7
Control	1	26.5	4.4	-	42.1	3.2	20.0
	2	30.8	5.2	6.7	35.2	3.5	-

Data in Table 15 are further summarised in Table 16 to study the effect of different agronomic practices on the percentage incidence of TPD.

Table 16. *Effect of different agronomic practices on the percentage incidence of TPD*

Practice	Treatment	TPD (%)
Rainguarding	With	6.7
	Without	6.7
Stimulation	With	9.2
	Without	4.2
Fertilizer	Normal	7.5
	Double	5.8
Clone	RRIC 100	5.0
	RRIC 110	8.3

The effect of clone and stimulation appear to be significant with regard to the incidence of TPD (Table 16). The mean annual yield per tree tapping with and without stimulation is 43.1 and 35.3 g respectively (A Nugawela and C W Ranasinghe in collaboration with Soils and Plant Nutrition Department).

During the year 1995, six (06) trees have fallen dry (TPD). The monthly variation in latex volume, dry rubber content and dry rubber yield are given in Table 17.

Table 17. *Monthly variation in dry rubber yields and latex volume in trees fallen dry during the year.*

Tree No.	Parameters	Month											
		J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D
1	Vol.(ml)	102	63	75	70	160	-	20	40	-	20	10	50
	DRC(%)	28	34	32	37	32	-	30	25	-	30	36	35
	Yield(g)	29	21	24	26	51	-	6	12	-	6	4	17
2	Vol.(ml)	84	84	48	30	50	-	20	30	-	30	0	0
	DRC(%)	28	30	30	37	32	-	33	28	-	31	0	0
	Yield(g)	24	26	14	11	16	-	7	8	-	9	0	0
3	Vol.(ml)	107	190	32*	190	40	-*	120	40	-8	100	0	0*
	DRC(%)	36	40	40	37	34	-	37	37	-	37	0	0
	Yield(g)	39	75	13	71	14	-	45	15	-	37	0	0
4	Vol.(ml)	50	40	34	40	40	-	90	40	-	30	20	50
	DRC(%)	35	30	38	31	32	-	31	35	-	33	33	33
	Yield(g)	18	12	13	13	13	-	28	14	-	10	7	16
5	Vol.(ml)	195	140	69*	140	110	-*	0	0	-*	0	0	0*
	DRC(%)	39	39	31	34	32	-	0	0	-	0	0	0
	Yield(g)	76	55	21	48	35	-	0	0	-	0	0	0
6	Vol.(ml)	113	130	27*	30	15	-*	20	0	-*	0	0	0*
	DRC(%)	39	38	39	35	33	-	33	0	-	0	0	0
	Yield(g)	44	49	10	11	5	-	7	0	-	0	0	0

Trees appear to dry during the latter part of the year, *i.e.* during peak yielding months. Similar observations were made last year. In trees falling dry there is a gradual decline in latex volume and dry rubber yield. The dry rubber content in latex remains unchanged (Table 17) (A Nugawela and C W Ranasinghe in collaboration with Soils and Plant Nutrition Department)

Planting density

The objective of these trials is to examine the possibility of increasing the planting density of rubber to increase productivity and profitability per unit area of land.

Millewa, 1977 Replanting - CD/77/1

The mean annual yield per tree per tapping for different density treatments in both clones are given in Table 18.

Table 18. *The yield of clones RRIC 101 and PB 86 planted at different densities.*

Spacing (m)	Density (trees/ha)	Yield (g/t/t)		Girth (cm)	
		RRIC 101	PB 86	RRIC 101	PB 86
1. 2.5 x 10	400	27.2	21.8	75.8	71.3
2. 2.5 x 7.5	533	17.7	22.1	69.8	71.5
3. 2.5 x 6	666	15.9	18.2	61.2	64.5
4. 2.5 x 5	800	16.9	14.6	61.3	64.3
5. 3.87 (Triangular)	771	19.1	17.0	63.1	65.2
6. 3.54 (Triangular)	920	13.4	14.5	60.5	60.0

The mean annual yield per tree per tapping (g/t/t) and girthing of trees appear to decline with increasing density. The yield per hectare when calculated assuming a complete stand and 150 tappings per tree per annum increases with increasing density (Table 19).

Table 19. *The yield per hectare (YPH,kg) for different planting densities of clones RRIC 101 and PB 86*

Spacing (m)	Density(trees/ha)	YPH (kg)	
		RRIC 101	PB 86
1. 2.5 x 10	400	1631	1310
2. 2.5 x 75	533	1418	1763
3. 2.5 x 6	666	1590	1822
4. 2.5 x 5	800	2030	1751
5. 3.87 (Triangular)	771	2209	1960
6. 3.54 (Triangular)	920	1849	2001

At similar densities, triangular spacing appears to be advantageous (Tables 18 and 19) (A Nugawela and K A G B Amaratunge).

Kuruwita 1992 Replanting - PD/92/1

Experimental details were reported in Annual Review 1992.

Statistical analysis of girth measurements made at 90 cm height from union indicates that plant growth has not so far been affected by the increase in plant density in all clones tested. Growth of clone RRIC 121 continues to be superior than the other clones (Table 20).

Table 20. *Girth of rubber plants at a) different planting densities and b) in different clones*

a).

Density (plants/ha)	Girth (cm)	SD
500	26.5	2.78
600	28.26	2.15
700	28.75	2.30
800	28.17	2.35

b).

Clone	Girth(cm)	SD
RRIC 121	28.85[A]	1.92
RRIC 100	27.08[B]	2.88
RRIC 110	27.85[B]	2.33

(Means with same letter are not significantly different).

(V H L Rodrigo. A Nugawela and L S Kariyawasam in collaboration with the Genetics and Plant Breeding Department)

Rainguards

Gutter type rainguards were fixed in seven smallholdings in the Kalutara region.

The number of extra tapping days recorded, *i.e.* per tapping block is given in Table 21.

Table 21. *Monthly distribution of extra tapping days recorded in holdings fixed with rainguards*

	Month and No. of extra days tapped									
Holding	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1	-	1	1	3	3	3	2	2	1	13
2	-	5	5	2	5	2	2	1	2	24
3	1	3	3	-	3	5	2	1	0	14
4	-	-	-	-	-	-	-	-	-	-
5	-	0	3	7	3	2	1	1	1	18
6		Tapper absent		2	3	3	3	2	2	15
7		Tapper absent		1	4	2	0	0	0	7

Number of extra tapping days recorded per tree varies from zero to 24. This variation is attributed to the interest shown by the tapper and the land owner.
The number of extra tapping days needed to recover the cost of the rainguard depends on rubber prices, tapping and manufacture costs and yield potential of trees and can be estimated using the following equation.

$$T_{extra} = \frac{1000}{NSA - (T_{cost} + M_{cost})} \times \frac{RG_{cost}}{Y_{pot}}$$

Where,

T_{extra} = Number of additional tappings per tree needed to recover the cost of rainguard.

NSA = Net Sale Average (Rs/kg).

T_{cost} = Tapping Cost (Rs./kg).

M_{cost} = Manufacture Cost (Rs./kg).

RG_{cost} = Cost of rainguard (Rs.).

Y_{pot} = The yield potential of a tree (g/t/t).

The average values for the above variables in the smallholder sector are NSA = Rs.60/kg, T_{cost} = Rs.16/kg, M_{cost} = Rs.3/kg, RG_{cost} =Rs.8/tree and Y_{pot} = 20g/t/t. Accordingly T_{extra} will be around 10 days.

Data in Table 21 indicate that it is possible to achieve much more than 10 additional tapping days with both Gutter and Skirt type rainguards provided that the tapper and land owner has the interest to do so (A Nugawela and R P Karunasena. The project is funded by CARP Research Grant 12/176/150).

Nursery Inspection Unit

Inspections

Fifty four (54) private commercial nurseries were inspected and reports were submitted to the Rubber Development Department for the issue of permits.
Budwood nurseries of estates managed by 5 (five) management companies were inspected and reports were submitted (A Nugawela, R B Gunaratna, U S Weerakoon and M Alwis).

Intercropping

Spatial arrangements

Different spacing systems for the rubber crop are tested to identify systems that will provide more light for a longer period to facilitate intercropping.

Usk Valley, 1992 Replanting - IC/S/92/1

Experimental details are reported in the Annual Review 1992. Analysis based on girth at 90 cm from the union, shows there is no significant difference in the growth of rubber in different spatial arrangements being tested. However, system 4 appears to be better than system 2 and 3 as far as the growth of rubber is concerned (Table 22).

Table 22. *The mean girth of different spacial systems in 1995*

System	Mean girth (cm)	SD
1	24.09^{AB}	1.87
2	21.71^{B}	1.37
3	21.98^{B}	1.87
4	25.03^{A}	0.29
5	23.08^{AB}	1.56

(Mean with same letter are not significantly different).
(V H L Rodrigo and L S Kariyawasam).

Perth, 1992 Replanting - IC/S/92/2

The experiment was established in 1992 and the experimental details are described in the annual review of the same year.

The growth of the rubber trees are not significantly affected by the spacial arrangements *i.e.* row or contour plantings and by the intercrops. The growth of Coffee is also not affected by the spacial arrangement of rubber. Grass was harvested every 60 days and Cinnamon was harvested for the first time in June. Yield of both intercrops are unaffected by the spacial arrangement of rubber plants at this stage (Table 23).

Table 23. *The growth Rubber and Coffee plants and the yield of grass and cinnamon in different treatments*

Treatments	Girth rubber (cm)	Stem diameter of Coffee (cm)	Bark yield of Cinnamon (g)	Yield of grass kg/ha
Row planting -Rubber + Grass	15.6	-	-	723.6
Row planting - Rubber + Cinnamon	20.0	-	36.0	-
Row planting - Rubber + Coffee	20.0	1.9	-	-
Row planting - Rubber only	19.0	-	-	-
Contour planting - Rubber + Grass	16.7	-	-	699.5
Contour planting - Rubber + Cinnamon	16.5	-	23.6	-
Contour planting - Rubber + Coffee	16.0	1.6	-	-
Contour planting - Rubber only	18.5	-	-	-

(L S S Pathiratna and M K P Perera)

Rubber and Timber

Usk Valley, 1992 Replanting - IC/RT/92/1
Ambatenna, 1992 Replanting - IC/RT/92/2

Experimental detail appears in the Annual Review 1992. The growth of rubber has not been adversely affected by the timber crops (Table 24). The performance of Halmilla and Mahogani is poor.

Table 24. *The girth of rubber plants measured at 90 cm from the union*

Intercropping System		Usk Valley IC/RT/92/1	Ambatenna IS/RT/92/2
1. Rubber (8'x27')	No Timber	24.9	22.62
	Halmilla	25.43	21.44
	Alstonia	24.15	22.01
	Teak	22.23	21.44
	Mahogani	25.6	22.21
2. Rubber planted in double rows	No Timber	22.9	22.63
	Halmilla	22.66	25.69
	Alstonia	24.77	24.06
	Teak	23.39	23.87
	Mahogani	25.26	24.37
3. High density rubber (8'x17')		26.83	21.88
4. High density rubber (8'x15')		26.67	22.12

(V H L Rodrigo and L S Kariyawasam).

Rubber and Sugarcane

Details of the experiment are given in Annual Review 1992.

The upkeep of the eight experimental sites, *i.e.* 4 planted in NE 1992 and 4 planted in NE 1993 were monitored.

Harvesting of sugarcane in all 8 sites were undertaken during the period. The yield, *i.e.* kg m^{-1}, for different varieties under different planting densities are given in Table 25.

Table 25. *Sugarcane yield for different varieties under different planting densities in both 1992 and 1993 planted sites*

Variety	Density (Rows)	Crop (kg/meter) and year	
		1992	1993
SL 7103	4	8.3	9.8
	5	7.9	8.4
CO 775	4	6.3	11.7
	5	9.9	11.5
SL 38/2915	4	8.8	10.9
	5	8.8	10.8
SL 8306	4	8.3	12.1
	5	10.0	9.2

Sugarcane yield, (kg m^{-1}) appear to be similar in all varieties. Further sugarcane yields are similar at both planting densities, i.e. 4 and 5 row systems.

The growth measurements of rubber plants in the 1992 sites, *i.e.* girth at 3' and 5' are given in Table 26. The data show that growing of sugarcane, at both densities have not retarded the growth of main crop.

Table 26. *Growth measurements of rubber plants, i.e. girth at 3 feet - 3G(cm) and 5 feet - 5G(cm) under two densities of sugarcane, i.e. S_1 (4 rows), S_2 (5 rows) and C (with no intercrop)*

Density	S_1		S_2		C	
Growth	3G	5G	3G	5G	3G	5G
Site No.1	13.6	12.2	12.1	10.5	-	-
2	15.6	14.3	16.1	14.5	13.9	12.6
3	15.8	13.6	15.7	13.8	11.0	10.0
4	12.2	11.0	14.6	13.2	15.1	13.5
Mean	14.3	12.8	14.6	13.0	13.3	12.5

(A Nugawela, V H L Rodrigo in collaboration with SRI, Udawalawe and Rubber Development Department. This project is funded by the CARP Research Grant 12/106/95).

Rubber and Grass/Legume - Neuchetal IC/GL/91/1

The trial was started in 1991 and the experimental details are reported in the Annual Review of the same year.

There is a further decline in the yield of grasses this year probably due to the shade from rubber trees. The yield of *Paincum maximum* (PM) is generally higher than of *Brachiaria brizantha* (BB). Treatment effect on growth of rubber is apparent but at this stage it is not clear as to whether it is due to presence of the grass or the type of grass (Table 27).

Table 27. *Effect of cropping system on the growth of rubber and yield of grasses.*

Treatment	Growth of rubber (cm)	Grass fresh weight (kg/ha)
1. Rubber	38.7 A B	-
2. Rubber + PM	41.7 A	2733.3 A B
3. Rubber + BB	34.6 C B	2497.9 B
4. Rubber + Gliricidia	38.7 A B	-
5. Rubber + Ipil Ipil	40.1 A	-
6. Rubber + PM+Gliricidia	40.9 A	3276.4 A
7. Rubber + PM + Ipil Ipil	38.6 A B	3120.9 A
8. Rubber + BB+ Gliricidia	39.4 A	2333.8 B
9. Rubber + BB+ Ipil Ipil	33.4 C	2841.0 A B

(Means with the same letter are not significantly different)
(L S S Pathiratna and M K P Perera).

Rubber and Cocoa/Cinnamon

Dartonfield - IC/CC/91/2

This trial was established in 1991 to investigate the possibility of intercropping Cinnamon and Cocoa with rubber.

The growth of rubber is not affected by the intercrops at this stage (Table 28)

Cinnamon was harvested in July and treatments difference in bark yield were not observed (Table 28). The growth of Cocoa plants is satisfactory.

Table 28. *Effect of intercrops on the growth of rubber (cm) and the yield of dry Cinnamon bark per bush (g)*

Treatments	Girth of rubber (cm)	Cinnamon bark yield (g/bush)
1.Rubber only	27.6	-
2.Rubber + Cinnamon (spacing 1)	29.3	117.1
3.Rubber + Cinnamon (Spacing 2)	27.0	90.3
4.Rubber + Cinnamon (Spacing 3)	32.4	99.5
5.Rubber + Cocoa (Spacing 1)	25.8	-
6.Rubber + Cocoa (Spacing 2)	23.2	-
7.Rubber + Cocoa (Spacing 3)	28.9	-

(L S S Pathiratna and M K P Perera).

Cocoa Trials - Perth, Neuchetal, Tempo and Miriswatta

The pods were harvested in June and the bean dry weight was estimated. The growth of rubber is not affected by Cocoa in these trials (Table 29).

Table 29. *The effect of intercrop on the girth of rubber (cm) and the yield cocoa beans (g) in different sites*

Treatment	Parameter	Perth	Neuchatal	Tempo	Miriswatta
Rubber and Cocoa double row	Girth(cm)	64.8	60.0	64.2	68.2
	Been yield(g)	3450.0	425.0	610.0	1700.0
Rubber and Cocoa single row	Girth(cm)	65.7	60.4	65.9	67.8
	Been yield (g)	925.0	235.0	315.0	600.0
Rubber only	Girth (cm)	63.5	61.4	65.8	62.3

(L S S Pathiratna and M K P Perera).

Rubber Banana

Experimental details appear in Annual Review 1993. Results obtained so far from this experiment indicate that the presently recommended banana density in the rubber x banana intercroping system is sub optimal. Growth analysis of both crops indicate that up to threefold increase in banana density in the rubber x banana intercroping system has no deleterious effect on either rubber or banana crop. Also, growth of banana, as an intercrop appeared to be better than that of sole crop in the later stages. The increase in banana density has resulted in improved light and water use systems leading to increase in land use efficiency.

This project is jointly funded by the Council for Agricultural Research Policy and Overseas Development Administration (V H L Rodrigo, R K Samarasekera and L S Kariyawasam).

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

The incidence of leaf falls caused by *Gloeosporium* and *Oidium* remained mild while phytophthora leaf fall during South West monsoon period was fairly heavy. However. Bark rot remained insignificant.

The organism causing the irregular leaf spots and leaf fall of the clone RRIM 712 was authenticated as *Fusarium pallidoroseum*. The fungus *Thanatephorus cucumeris* was proved to be the cause for the common leaf spots in *Mikania scandans* and *Pueraria phaseoloides* and it was shown that these two common weeds and a leguminous creeper in rubber plantations were responsible for the spread of target leaf spot disease on *Hevea* is early 1990s.

There was no effect of the prophylactic application of recommended fungicides (to prevent bark rot) on cumulative yields of rubber plants.

Cultural characteristics and the morphology of the reproductive structures of *Cylindrocladium quinqueseptatum*, a fungus identified as a potential pathogen of *Hevea* in Eastern Hemisphere, were described using photomicrographs and it was shown that IMI 342173 from Sri Lanka resembles the isolates of *C. quinqueseptatum* obtained from different hosts in other parts of the world. The fungus was capable of producing a host specific toxin and significant differences in lesion sizes were observed when filtrates of different isolates were assayed. Most of the *C. quinqueseptatum* isolates were not capable of producing pectolytic enzymes, the enzyme complex important for the digestion of pectin.

Results of routine screening trials showed that though there are site to site variations, clones RRIC 114, RRIC 120, PB 86, RRIC 112, RRIC 110 and RRIC 130 are susceptible to bark rot.

VA mycorrhizal inoculum to be used in commercial scale has been developed.

DETAILED REVIEW

Staff

Mr C K Jayasinghe, Head of Plant Pathology and Microbiology Dept, Dr R Jayaratne, Plant Pathologist, Mr K E Jayasuriya, Asst. Plant Pathologist, Mr W Amaratunge, Audio Visual Aids Production Officer were on duty throughout the

year. Miss W P K Silva, Asst. Plant Pathologist continued working on her post-graduate programme at the University of Sydney, Australia.

Experimental Officers Messers D S Wettasinghe and E B Fernando were on duty throughout the year. Mrs J L P C Wettasinghe, Senior Technical Officer left for India on 14th September 1995 for a special training on diseases of *Hevea* at Rubber Research Institute of India. Technical Officers, Mrs B I Fernando, Misses T H P S Fernando, D Siriwardane, U M S Priyanka., and Clerk Typist Mrs P Amarasekara were continued to work in the Department.

Mr C Jayalath and Mr C A Nanayakkara, Temporary Technical Assistants participated in research projects funded by CARP.

Visits

The Department Staff made 29 visits for advisory purposes, 165 for experimental and 56 for other purposes.

Training/Lectures/Seminars

Mr C K Jayasinghe, Dr R Jayaratne and Mr K E Jayasuriya were involved in training Superintendents and Asst. Superintendents on Management of *Hevea* diseases.

Mr C K Jayasinghe addressed the Directors and Estate Managers of Kegalle/Awissawella District Planters Association, Namunukula Plantations Ltd. and Kotagala Plantations Ltd. on "Phytophthora Epidemics and Management Strategies".

Committees

Mr C K Jayasinghe served as a member of Pesticides Technical and Advisory Committee and National Plant Quarantine Committee (NPQC). The main duty of the NPQC for the year 1995 was the revision of the Plant Protection Ordinance.

Mr C K Jayasinghe and Dr R Jayaratne attended the Scientific Committee Meetings of the Rubber Research Board.

GENERAL

The weather conditions throughout the refoliation period were unfavourable for the development of the fungus *Oidium heveae*. The incidence of the oidium leaf fall thus remained mild in all rubber growing districts except in higher elevations. The incidence of phytophthora leaf disease during the South West monsoon season was fairly heavy, especially in the humid districts. The bark rot, second phase of the

disease, however, remained mild or even insignificant. Unusual disease symptoms detected on the clone RRIM 712 in Bentota and Eladuwa estates in the international clone trials were proved to be caused by *Fusarium pallidoroseum* (Cooke) Sacc. Clone RRIC 110 was found to be highly susceptible to *Colletotrichum gloeosporioides* and *Corynespora cassiicola*. Observations of the subsequent surveys conducted by the Plant Pathology and Microbiology Dept. revealed that severely affected clearings are limited to localities where the microclimate is highly favourable for the development and spread of the fungal diseases. A severe infection of corynespora leaf fall was detected in polybag nurseries (regardless of the clone) and seedling nurseries in Moneragala district. Director General, Rubber Development Dept. was informed regarding the disease incidence and was requested to take necessary action regarding the mature RRIC 103 clearings which have still not been replaced with tolerant clones.

The series of "grass root" level training classes initiated in 1995 on the management of white root disease was continued. Rubber Development Officers of all the regions and estate managers of Kegalle/Awissawella District Planters Association, Namunukula Plantations and Kotagala Plantations were addressed on "Phytophthora Epidemics - History, Management Strategies and Possible Threat to Future Rubber Industry in Sri Lanka". A series of discussions was held with all executive directors of Rubber Development Department on all aspects of *Hevea* diseases. Special attention was drawn to educate them on new diseases discovered during the recent past.

Country Committee on South American Leaf Blight was established and the first meeting was held on 11th January 1995.

LABORATORY AND FIELD INVESTIGATIONS

Chemical Control of Economically Important Diseases of *Hevea* (CC/89/1)

A. *Screening of fungicides against Rigidoporus lignosus*

A_1 *Screening of 2 - Furaldehyde (Furfural) against* R. lignosus. Poisoned food technique was used to test the effect of 2-furaldehyde against *R. lignosus* and found that it has a potential to control the pathogen *in vitro*. Hence field experiments were initiated. Experiments are in progress (K E Jayasuriya and B I Tennakoon).

A_3. A field experiment was carried out to establish the effectiveness of the systemic fungicides, Bayleton and Bayfidan at five different agroclimatic regions of the Island. These estates were Madeniya estate, Warakapola, Peenkanda estate, Ratnapura, Dartonfield estate, Agalawatta and Yatadola estate, Matugama. Plants were artificially inoculated with *Rigidoporus lignosus* in the first 4 sites and a naturally infected field plants at Yatadola estate were treated with the above fungicides as a drench application. Fungicides were applied at the rate of 20 ml/1 litre of water/tree/treatment. Second application was done at 6 months after the 1st application. Recovery of the trees was assessed at 3 monthly intervals by examining the collar region of the plants (Table 1) (R Jayaratne, C K Jayasinghe, P C Wettasinghe and Chaminda Jayalath).

Table 1. *Effectivity of Bayleton and Bayfidan against white root disease of rubber at different locations*

Site	Fungicide	Pre-treatment assessment No. of trees with disease scores* 1	2	3	4	% recovery after 12 months
Madeniya (Panana Div)	Bayleton	-	9	5	1	93%
	Bayfidan	-	8	8	1	75%
	PCP 2%	-	10	7	-	41%
Peenkanda (Parawatta Div)	Bayleton	2	8	6	1	81%
	Bayfidan	-	10	6	-	94%
	PCP 2%	-	8	6	-	57%
Dartonfield	Bayleton	1	5	17	1	83%
	Bayfidan	-	2	21	2	76%
	PCP 2%	1	8	9	2	35%
Yatadola	Bayleton	1	3	2	3	33%
	Bayfidan	2	5	7	9	42%
	PCP 2%	1	-	7	-	50%

* Disease scores

1. Collar slightly affected with no foliar symptoms
2. Collar half circumference rotted with light foliar symptoms
3. Collar badly rotted with severe foliar symptoms
4. Collar completely rotted with fully withered leaves

Plants with disease score 4 were not considered for % recovery as these plants were beyond recovery at the time of treatment.
From the above results it is confirmed that these two systemic fungicides are quite effective in managing the white root disease of rubber if the treatment is carried out at a fairly early stage.

The following chemicals were also tested against *Rigidoporus lignosus* to find out a suitable cheap chemical to control white root disease.

In vitro studies, it was found that fungicide Tilt (Propeconazole) is effective at concentrations 0.08% *a.i.* where as fungicide Bavistin was ineffective. Opus (Eposiconazole) was found to be effective at concentration above 0.16% *a.i.* (Table 2 and 3) (R Jayaratne, C K Jayasinghe, P C Wettasinghe and Chaminda Jayalath).

Brunolinum plantarium (mixture of xylenols) and Mergal S 96 was tested using painting of root pieces technique. The concentrations tested were, 10, 15 and 20% of the ready mixture. Brunolinum was found to be effective at 20% concentrations while mergal S 96 was effective at 2%.

A_3 A field trial was laid out at Arappolakanda estate with naturally infected plants and at Dartonfield estate with artificially inoculated plants to ascertain the efficacy of Anvil under field conditions (Table 4) (R Jayaratne, C K Jayasinghe, P C Wettasinghe and Chaminda Jayalath).

A_4. Although the fungicide Benlate gave high inhibitory effects under vitro conditions (see Annual Review 1994) the field trial carried out at Padukka estate with naturally infected plants did not show any effectiveness at the rate of 20 g/plant under these conditions as a drench application (R Jayaratne and P C Wettasinghe).

B. Evaluation of Prophylactic spraying of copper fungicides against Phytophthora leaf fall disease

B_1. Spraying of CuOCl at the rate of 3.5 kg/*a.i.*/25 litres of oil (30-40l/ha) were repeated this year too at Neuchatel and Halwatura estates, just before the onset of south west monsoon rains. The carrier spray oil used was diesolene. However this year too, as the Phytophthora leaf fall in these areas were mild (Table 5), it was not possible to observe any significant difference in yield (R Jayaratne, C K Jayasinghe, S Wettasinghe and D Siriwardane).

Table 2. *Colony diameter in (mm) of mycelial growth of* Rigidoporus lignosus *using SFST (mean of 5 replicates)*

Fungicide	Cont.	Concentrations in plates (*a.i.%*)							
		0.005	0.01	0.02	0.04	0.08	0.16	0.32	0.64
Anvil	80.00 ±0.00 (fully grown)	65.12 ±2.73	62.35 ±4.79	41.62 ±6.80	25.25 ±1.82	24.32 ±3.03	23.87 ±4.18	16.40 ±0.56	15.10 ±0.52
Tilt	85.00 ±0.00 (fully grown)	82.00 ±0.58	74.90 ±1.23	63.40 ±4.40	41.90 ±2.91	- -	- -	- -	- -
Opus	85.00 ±0.00	40.40 ±2.41	40.00 ±3.74	14.70 ±1.89	8.70 ±2.47	7.90 ±0.64	5.50 ±0.42	3.90 ±0.77	0.50 ±0.53

± - Std. Error of the mean.

Table 3. *Colony diameter (mm) of mycelial growth of* Rigidoporus lignosus *using Poison Food Technique (mean of 5 replicates)*

Fungicide	Cont.	Concentrations *a.i.%*							
		0.005	0.01	0.02	0.04	0.08	0.16	0.32	0.64
Anvil	80.00 (mm) (Fully grown)	Not grown	Not grown	Not grown	Not grown	Not grown	Not grown	Not grown	Not grown
Tilt	80.00 (mm) (Fully grown)	Showed thin ring	Showed thin ring	Not grown	Not grown	Not grown	Not grown	Not grown	Not grown
Bavistin	80.00 (mm) (Fully grown)	80.00 (mm)	80.00 (mm)	80.00 (mm)	80.00 (mm)	80.00 (mm)	80.00 (mm)	80.00 (mm)	80.00 (mm)

Table 4. *Efficacy of Anvil under field condition*

Site	Pre-treatment assessment. Disease score*				% recovery after 7 months
	1	2	3	4	
Arappoiakanda (1991 R.P.)	1	1	6	4	37%
Dartonfield (Artificially inoculated plants)	7	4	2	1	73%

* Disease score

1. Collar slightly affected with no foliar symptoms.
2. Collar half circumference rotted with light foliar symptoms.
3. Collar badly rotted with severe foliar symptoms.
4. Collar completely rotted with fully withered leaves.

** Chemicals were applied at the rate of 20 ml/tree
2 - applications at 6 monthly intervals.

Table 5. *Comparison of leaf fall figures collected in Sq.m/area/week. Mean value for 4 tapping blocks*

Neuchatel Estate

Time	Sprayed	Unsprayed
1st week	294 ± 75.04	445 ± 41.49
2nd week	92 ± 12.94	278 ± 106.46
3rd week	34 ± 3.72	49 ± 10.27
4th week	12 ± 2.56	25 ± 1.04
5th week	6 ± 2.14	8 ± 3.01
6th week	3 ± 1.11	7 ± 1.32

Halwatura Estate

Time	Sprayed	Unsprayed
1st week	19 ± 1.60	15 ± 9.36
2nd week	70 ± 16.89	71 ± 38.31
3rd week	71 ± 16.01	63 ± 24.80
4th week	34 ± 5.82	31 ± 6.59
5th week	16 ± 3.07	9 ± 0.946
6th week	2 ± 1.22	2 ± 1.03

± Std. Error of the mean.

Micro-organisms and Pests (MP/89/1)

A. *Leaf spots and defoliation of the clone RRIM 712*

Plants of the clone RRIM 712 established under the multilateral clone exchange programme at Bentota and Eladuwa estates were found to be affected with unknown fungal pathogen during latter part of the year 1994. Irregular leaf spots were seen on leaves and defoliation occurred repeatedly due to the infection. Isolates made from the affected leaves consistently yielded the fungus *Fusarium* sp. The causal organism was authenticated as *Fusarium pallidoroseum* (Cooke) Sacc. (IMI 364286 and 367503) with the collaboration of IMI, UK and pathogenicity was confirmed by fulfilling Koch's postulates (C K Jayasinghe and D S Wettasinghe).

B. *Occurrence of* **Colletotrichum acutatum**

The fungus *Colletotrichum gloeosporioides* is believed to be the causative agent of gloeosporium leaf disease of rubber in Sri Lanka. A report from Indonesian workers appeared in 1994 stating that *C. acutatum* is also present in rubber plantations of Sri Lanka after studying a culture sent to Indonesia from Sri Lanka. Hence, a survey was initiated to find the occurrence of *C. acutatum* in our plantations in the 3rd Quarter of 1995. Single spore isolates were obtained from affected *Hevea* leaves and sent to IMI, UK for authentication purposes (C K Jayasinghe, T H P S Fernando and U M S Priyanka).

C. Thanatephorus cucumeris *infections of* Mikania scandens *and* Pueraria phaseoloides

Target leaf spot disease detected in 1993-1994 in *Hevea* seedling nurseries and field plants was suspected to have spread from common weed soil leguminous creepers given rubber plantations. Hence, a survey was launched to find the occurrence of *T. cucumeris* on common weeds and isolates were obtained from the diseased leaves. The fungus *T. cucumeris* was found to be the causative agent for most of the lesions present on leaves of *Mikania scandens* and *Pueraria phaseoloides*. Fungus was authenticated with the collaboration of IMI, UK (IMI 367590 and 367591) and Koch's postulates were proved (C K Jayasinghe and E B Fernando).

Screening for Leaf and Panel Diseases (SC/89/1)

A. *Screening against bark rot caused by* Phytophthora meadii

Results of the screening programmes carried out in December, 1994 and January, 1995 were statistically analysed. The observations are presented in Table 6. Though there are site to site variations, it could be concluded that the clones RRIC 114, RRIC 120, PB 86, RRIC 112, RRIC 110, RRIC 119, RRIC 133 and RRIC 130 are highly susceptible to bark rot whereas clones such as RRIC 116, RRIM 717, PB 260, PB 235, RRIC 121, RRIC 102 and PR 255 are resistant to the same disease.

Another series of experiments was conducted to screen the clones in the International clone exchange programme. The results are presented in table 7. It seems that PR 261 and PB 217 are highly susceptible to bark rot while PB 235 and BPM 24 are resistant to the same disease (Table 7) (C K Jayasinghe and D S Wettasinghe).

Biological control of White root disease (BC/89/1)

a. Basidiomycetes fungi (*Trametes* spp. and *Schizophillum commune*) antagonistic against *Rigidoporus lignosus* were tested in a pot experiment for pathogenicity on rubber seedlings. None of the above fungi colonised on roots of rubber seedlings. Effects on their antagonism against *R. lignosus* in naturally colonised roots will be studied by artificial inoculation of freshly felled rubber tree logs with the inocula of antagonistists.

Table 6. *Susceptibility of different clones to bark rot at five different localities (lesion area is given in cm²)*

CLONE	MADENIYA	BENTOTA	FROCESTER	PADUKKA	RILHENA
RRIC 130	14.93 b	10.85 bcd	13.30 bcde	11.86 b	19.55 a
RRIC 133	15.34 b	-	17.87 a	10.92 bcd	8.59 jkl
RRIC 119	14.68 bc	14.66 a	13.90 bcd	8.53 efghij	16.09 bc
RRIC 110	15.35 b	8.92 cdefghi	-	10.75 bcd	19.06 ab
RRIC 112	12.83 bcde	11.49 b	10.30 fghij	11.046 bcd	20.20 a
PB 86	14.19 bcd	8.12 ghij	14.02 bcd	10.42 bcde	15.81 c
RRIC 120	11.44 defg	8.13 ghij	10.61 efghij	8.07 ghij	12.00 efghij
RRIC 114	22.52 a	9.47 bcdefgh	9.10 ghijk	11.68 bc	14.15 cdef
RRIC 132	13.80 bcd	7.96 ghij	-	-	13.03 cdefgh
HP 74-181	10.48 efgh	8.46 fghij	11.65 defghi	9.36 defghi	12.16 defghij
RRIC 117	12.84 bcde	10.66 bcdef	15.39 b	11.07 bcd	11.36 fghijk
RRIC 115	9.29 fgh	8.61 defghij	10.00 fghij	9.45 defghi	12.16 defghij
RRIC 101	11.65 cdef	9.29 bcdefgh	10.58 efghij	9.23 defghi	9.45 ijkl
HP 74-193	10.01 efgh	9.88 bcdefg	9.55 hgij	10.49 bcde	9.36 ijkl
HP 74-194	15.80 b	6.50 jk	-	-	15.60 cd
RRIC 109	11.48 defg	9.47 bcdefgh	12.84 bcdef	9.78 bcdefgh	13.05 cdefgh
RRIC 111	10.92 defg	7.33 ijkh	10.91 efghij	8.23 fghij	11.33 fghijk

CLONE	MADENIYA	BENTOTA	FROCESTER	PADUKKA	RILHENA
RRIC 113	8.10 gh	7.94 ghij	9.78 ghij	10.28 bcdef	11.61 fghijk
PB 28/59	10.88 efgh	9.37 bcdefgh	11.84 defgh	9.42 defghi	11.92 efghij
RRIM 600	14.73 bc	10.69 bc	-	10.40 bcdef	21.72 a
RRIM 712	10.93 defg	8.01 ghij	9.55 ghij	7.59 hij	15.23 cde
RRII 105	14.91 b	5.81 k	12.00 cdefg	9.13 defghij	9.34 ijklm
PR 261	10.93 defg	10.78 bcde	14.68 bc	10.58 bcde	11.25 fghijk
RRIC 100	9.27 fgh	8.58 efghij	8.74 ijkl	9.23 defghi	11.07 fghijk
HP 74-213	9.78 efgh	8.19 ghij	11.33 defghi	13.70 a	14.13 cdefg
BPM 24	7.28 h	5.67 k	8.87 ijk	8.46 efghij	7.46 l
PR 255	8.29 fgh	10.11 bcdefg	-	10.00 bcdefg	10.56 ghijkl
RRIC 102	8.69 fgh	9.26 bcdefgh	8.94 hijk	9.53 cdefghi	16.18 bc
RRIC 121	9.93 efgh	6.54 jk	8.07 jkl	7.03 j	10.78 fghijkl
PB 260	9.28 fgh	6.83 ijk	10.45 efghij	7.76 hij	8.14 kl
PB 235	9.23 fgh	-	-	9.42 defghi	12.92 cdefghi
RRIM 717	8.08 gh	5.69 k	6.13 l	7.48 ij	7.49 l
RRIC 116	9.31 fgh	9.04 cdefghi	6.67 kl	7.07 j	9.36 ijkl

Means with the same letter are not significantly different at 0.05% level according to DMRT

Table 7. *Testing of proven foreign clones under SRRP 2: Clonal susceptibility to bark rot caused by* Phytophthora meadii

Hevea clone	Locality				
	Salawa	Malaboda	Atale	Kuruwita	Bentota
PR 261	9.742 a	13.072 a	13.323 a	6.155 a	8.426 abc
PB 217	7.478 a	6.833 ed	-	-	-
PB 260	6.974 ab	11.594 b	12.226 a	6.323 a	8.774 ab
PR 255	6.968 ab	9.833 c	12.620 a	5.445 ab	9.439 a
RRIC 110	6.949 ab	12.220 ab	-	-	-
RRIC 121	6.587 abc	6.871 ed	11.697 ab	6.148 a	8.110 abc
RRIC 100	6.187 bc	7.820 d	-	-	-
RRIM 712	6.162 bc	6.878 ed	12.568 a	5.742 ab	7.632 bc
PB 235	6.104 bc	6.168 e	10.103 b	5.735 ab	6.955 dc
BPM 24	5.729 c	6.181 e	10.439 b	4.922 b	5.780 d

Trichoderma spp. isolated from Sri Lankan soil were exposed to high concentrations of furfuraldehyde (0.1 - 1%) to produce furfural resistant isolates. It was assumed that furfuraldehyde resistant *Trichoderma* spp. could be incorporated to soil after a treatment with furfuraldehyde on *R. lignosus* infected plants, thus reducing the chemical dose. Meanwhile, furfuraldehyde resistant *Trichoderma* isolates were tested for their *in vitro* antagonism against *R. lignosus* to note any variation in the antagonistic properties.

Few species of fungi antagonistic against *R. lignosus in vitro* were isolated from decaying woods, specialised habitats such as on decaying straws and dung. Initial studies on their *in vitro* antagonism were carried out. *Pycnoporus* sp. (wood decay fungus) and few *Coprinus* spp. (on specialised habitats) were found to be antagonistic against *R. lignosus in vitro*.

Different *Trichoderma* spp. were tested for productivity of conidio-spores on cheaper liquid medium such as molasses solution. *T. harzianum* (strain P 41, 12) produced significantly a large number of spores on sterile molasses solution (30 g/lit) (K E Jayasuriya, B I Tennakoon and E B Fernando).

a_1. The pot experiment carried out with *Trichoderma harzianum* to evaluate the best media to use as an artificial inoculum to be used under field conditions was completed (Details are given in Annual Review 1994) (Table 8) (R Jayaratne, C K Jayasinghe and D Siriwardane).

From these results it is evident that sulphur amendment technique is quite effective in checking the white root infection in seedlings. Although there is no direct impact by introducing *Trichoderma harzinum* to these pots. it is clear that rice bran and straw are equally good media to introduce *Trichoderma* to soil. There is no direct relationship between introduced *Trichoderma* pollution and the white root incidence of seedlings.

b. *Biological control of nursery diseases (BC/89/1)*

Fungi antagonistic against *C. cassiicola, Phytophthora* spp., and *Bipoloris hevea* were isolated from the Phylloplane of different plants. Their antagonism against the pathogen were studied on dual membered plates.
(K E Jayasuriya and B I Tennakoon)

VA mycorrhizal studies (M/86/1)

1. A glasshouse pot experiment was carried out with the collaboration of Soils and Plant Nutrition Dept to evaluate the effect of VA mycorrhizal associations on uptake of Phosphorus from different sources of rock phosphate (R Jayaratne, A Dissanayake, D Siriwardene and C Jayalath).

2. The same experiment was repeated with *Hevea* seedlings using a pure culture of VA mycorrhizal (*Gigaspora margarita*) inoculum to inoculate the mycorrhizal plants to over-come the problem faced in the above experiment with Pueraria plants due to the involvement of a pathogenic fungi in mycorrhizal roots. This experiment is in progress (R Jayaratne, A Dissanayake, D Siriwardane and C Jayalath).

3. *Production of VA/mycorrhizal/Rhizobium inoculum for commercial use*

A suitable media was found to be used on a VA mycorrhizal/Rhizobia for commercial use. Results of the ability to storage for a long time is not available yet. However from the results so far obtained this product is highly infective even after 6 months of storage under low temperature (R Jayaratne, C K Jayasinghe and D Siriwardane).

Table 8. *Incidence of* Rigidoporus lignosus *on seedlings after 30 weeks from inoculation*

Treatment	Pot No.	Severity of R.L. infection	Trichoderma population per/g of soil(No.of colonies)
F + c.d Trichoderma	1	++	
	2	++	6450
	3	+	
	4	++	
F + c.d Trichoderma + S	5	+	
	6	++	10,200
	7	Nil	
	8	Nil	
	9	Nil	
F + S	10	Nil	8,500
	11	++	
	12	++	
F + R.b.Trichoderma	13	+	
	14	++	41,600
	15	dead(10 weeks)	
	16	++	
F + R.b + S Tricho.	17	dead(28 weeks)	
	18	+	39,000
	19	++	
	20	++	
F + St. Tricho.	21	dead(16 weeks)	
	22	dead(12 weeks)	49,800
	23	dead(12 weeks)	
	24	+++	
F + St.Tricho.+S	25	+	
	26	+	46,700
	27	+	
	28	+	
	29	dead(16 weeks)	
F - only	30	dead(13 weeks)	2,500
	31	dead(14 weeks)	
	32	dead(26 weeks)	

Nil - No infection
\+ - very mild infection on laterals.
++ - slightly more infection on laterals as well as in the collar region.
+++ - severe infection covering the whole root system.
F - *Rigidoporus lignosus* inoculum
S - Sulphur
R.b - Rice bran
St - Straw
c.d - coir dust

4. A field experiment was laid out to ascertain the effects of two mycorrhizal fungi namely *Gigaspora margarita* and *Acaulospora* sp. in competition with the natural population of VAM fungi on *Hevea* seedlings under stock seedling nursery conditions. This experiment is in progress and the growth measurements will be taken at 2 monthly intervals. Budding success and growth of the plants after polybagging will also be monitored (R Jayaratne, C K Jayasinghe and D Siriwardane).

5. From a repeat glass-house experiment carried out in wooden trays lined with thick polythene, it was confirmed that *Pueraria* plants under VA mycorrhizal condition do not permit the spread of *Rigidoporus* rhizomorphs through soil where as non-mycorrhizal conditions helps to spread for considerable distances through the root network in soil (R Jayaratne and D Siriwardene).

MISCELLANEOUS

(A) The effect of prophylactic fungicide application on yield of rubber

A series of experiments has been initiated at two sites namely Neuchatel Estate and Dartonfield Estate to find the effect of prophylactic application of recommended fungicides on tapping panels. This experiment was conducted as a response to a request made by Estate Managers. The fungicides tested were Brunolinum, Dithane and Ridomil. Experiment was conducted for four months and chemicals were applied at two frequencies *viz*. once in two day and once in four days using recommended concentrations. The observations on the cumulative yields (Table 9) revealed that there is no marked influence on yield with the application of different fungicides (C K Jayasinghe and E B Fernando).

(B) Effect of rainguards on the development of Bark Rot

Experiments conducted to find the effect of rainguards on the development of bark rot was terminated as bark rot symptoms were not developed even on control plots due to dry weather that prevailed during bark rot season (C K Jayasinghe and E B Fernando).

(C) Morphological, cultural and pathogenic variation among the isolates of *C. quinqueseptatum*

Cylindrocladium quinqueseptatum Boedijn and Reitsma causes seedling blight and extensive defoliation on a wide variety of plants and the fungus is widely distributed in the humid tropics.

Table 9. *Effect of application of different fungicides on yield*

	Cumulative yield (g/tree)	
Fungicide	Neuchatel Estate	Gallewatte Estate
Brunolinum every other day	569.20	438.59
Brunolinum every 4th day	614.07	442.82
Dithane M 45 every other day	681.38	451.45
Dithane M 45 every 4th day	553.61	420.82
Ridomil MZ 72 every other day	646.15	395.71
Ridomil MZ 72 every 4th day	505.50	458.61
Control	578.11	440.98
LSD 5%	84.82	50.666

Morphological, cultural and pathogenic variations were studied in four isolates of the fungus obtained from *Eugenia caryophyllata* in Sri Lanka. Further, twenty one *Hevea brasiliensis* clones grown in eastern hemisphere were screened against these isolates as *C. quinqueseptatum* is identified as a potential pathogen of *H. brasiliensis* in South and South East Asia.

This study clearly showed that distinct variations exist among *C. quinqueseptatum* isolates in colony colour, colony annulation, mycelial form, rate of growth and spore production, and these characters provide a very useful method of separating isolates from each other (C K Jayasinghe, T H P S Fernando, U M S Priyanka).

(D) Culture characteristics and reproductive morphogenic is of *C. quinqueseptatum*

Cultural characteristics and the morphology of the reproductive structures: conidia, vesicle, stipe, phialides, chlamydospores and microsclerotia of clove isolate IMI 342173 were studied using the photomicrographs. Our investigations demonstrated that the isolate IMI 342173 from Sri Lanka resembles the isolates of *C. quinqueseptatum* obtained from different hosts in other parts of the world (C K Jayasinghe, T H P S Fernando, and U M S Priyanka).

(E) Variation in toxin production among *C. quinqueseptatum* isolates

Though significant differences were observed in lesion sizes when filtrates of different isolates were assayed for crude toxin production, all clove isolates (Rt, Kp, Aw and Rw) were found to be capable of secreting toxic substances to the growing medium. But the size of the lesions produced by different isolates varied markedly. These observations suggest that a marked variation in toxin production exist among four isolates.

Temperatures upto 100°C had no effect on the crude toxin when activity was assessed on detached *Hevea* leaves of two clones, Tjir 1 and RRIC 100. However, the activity decreased significantly when the toxin was heated to 110°C and above for 10 minutes.

When crude toxin was tested on different hosts, intense lesions were observed on the leaves of *Eucalyptus grandis, Eugenia caryophyllata, Hevea brasiliensis* and *Polyanthia* sp. within 72 hours while no lesions were produced on *Cocos nucifera, Desmodium ovalifolium, Ipomea batatas, Oryza sativa, Psophocarpus tetragonolobus, Pueraria phaseoloides* and *Saccharum officinarum* even with incubation periods upto nine days.

With regard to reaction of *Hevea brasiliensis* populations towards the toxin, three main clusters were distinguished (Fig.1). The clones which showed an extremely severe reaction were RRIC 105, RRIC 36, Tjir 1, RRIC 121 and RRIC 100 represent cluster I. Eleven clones were found to be in cluster 2 while RRIC 131 and RRIC 102 formed cluster 3 which were the least sensitive to the toxin. These observations confirmed that a marked variation exist among the *Hevea* clones grown in eastern hemisphere in sensitivity to the crude toxin produced by *C. quinqueseptatum* (C K Jayasinghe, T H P S Fernando and U M S Priyanka).

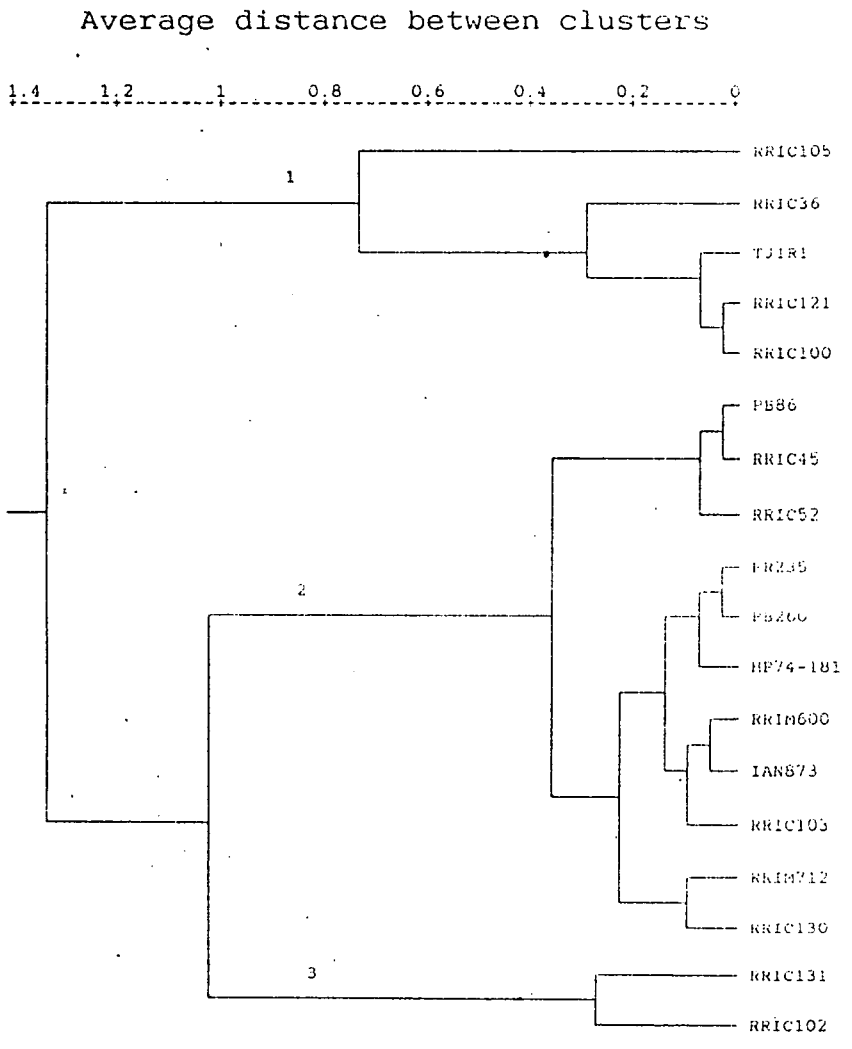


Fig. 1 Dendrogram showing the grouping of 18 *Hevea* clones grown in Eastern Hemisphere based on sensitivity to crude toxin produced by *Cylindrocladium quinqueseptatum*. The average linkage method of clusterint was applied to Euclidean distances

(F) Cellulolytic and pectiolytic enzyme production by *C. quinqueseptatum* isolates

A series of experiments was designed to study the production of different enzymes by *C. quinqueseptatum* isolates to understand the disease development process in diseases caused by *Cylindrocladium* sp. Initial observations showed that most of the isolates are not capable of producing PG.-an enzyme important for the digestion of pectin, Experiments are in progress (C K Jayasinghe, T H P S Fernando and U M S Priyanka).

(G) Cellulolytic and pectiolytic enzyme production by common pathogens of *Hevea*

Experiments on *in vitro* and *in vivo* cell wall degrading enzyme production of *Corynespora cassiicola, Phytophthora* spp. and *Bipolaris heaveae* are in progress (C K Jayasinghe, T H P S Fernando and U M S Priyanka).

Biology of common pathogens (BCP/95/1)

A. A study was initiated to identify the different isolates/strains of the fungus *Rigidoporus lignosus*. Isolation of fungus from 10 sites covering all rubber growing areas were carried out. Growth rate studies under two different culture media were carried out to identify the possible strains (Table 10 and 11). Genetic variation of the isolates will be confirmed by comparing the gene band pattens using RFLP (Restriction Fragment length Polymorphysm) studies. These studies are in progress with the collaboration of the Dept. of Botany, University of Colombo.

From these results it is clear that there are at least 4-strains of *Rigidoporus lignosus* existing between these 10 isolates (R Jayaratne, C K Jayasinghe, P C Wettasinghe and Chaminda Jayalath).

Table 10. *Mean colony diameter (mm) of different isolates on PDA with temperature (mean of 6 replicates)*

Isolate	28°C	15°C	20°C	25°C	30°C	37°C
1	44.02 c	0.00 d	13.45 c	36.27 c	46.17 c	7.78 e
2	35.95 e	7.77 a	12.33 d	26.56 g	33.88 g	8.25 e
3	60.55 a	0.00 d	21.33 a	58.50 a	65.68 a	17.63 a
4	43.12 c	2.23 c	14.32 bc	28.79 f	45.30 c	8.24 e
5	35.57 e	0.00 d	11.40 d	35.70 c	42.92 d	13.62 b
6	30.00 g	0.00 d	9.35 e	31.62 e	36.07 f	12.15 c
7	35.86 e	0.00 d	8.43 e	34.28 d	45.90 c	13.52 b
8	32.84 f	0.00 d	14.65 b	31.18 e	38.33 e	9.70 d
9	50.98 b	4.30 b	20.47 a	31.40 b	53.87 b	8.17 e
10	39.96 d	0.00 d	12.12 d	31.83 e	43.17 d	0.90 f

Means with the some letter are not significantly different, by Duncan's Multiple Range Test.

Table 11. *Mean colony diameter (mm) of different isolates on PDA with time (mean of 6 replicates)*

Isolate	3rd day	4th day	5th day	6th day	7th day
1	5.97 b	14.57 d	25.79 c	32.03 ef	44.32 c
2	3.31 cd	12.46 e	21.97 e	28.97 hi	37.94 e
3	11.60 a	31.74 a	42.66 a	48.61 a	50.22 a
4	3.94 c	14.17 d	24.18 d	32.63 de	43.93 c
5	0.00 f	12.15 e	23.99 d	33.93 d	45.93 b
6	0.00 f	10.01 f	19.96 f	28.51 i	41.10 d
7	0.00 f	15.76 c	21.58 e	36.24 c	41.57 d
8	3.14 d	i3.00 e	21.83 e	30.08 gh	37.51 e
9	6.22 b	18.75 b	30.40 b	44.10 b	49.85 a
10	1.28 e	10.56 f	22.51 e	30.91 fg	41.09 d

Means with the same letter are not significantly different by Duncan's Multiple Range Test.

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

Research on improvement in soil fertility, increasing efficiency of nutrient uptake, economizing on fertilizer use, improved methods of soil, water and nutrient conservation and weed control have been the main objectives of this Department.

Residual effect of mulching with rice straw on girthing and latex production was seen throughout the virgin panel BO-1. Girth of rubber plants was higher under *Crotolaria anagyroides* and *Tephrosia vogellie* compared to trees under other species *viz. Pueraria phaseoloides*, *Sesbania aculeata* and *Gliricidia sepium*. *Crotolaria anagyroides*, *Tephrosia vogellie* and *Flemingia congesta* were identified as successful species that can be grown between the rows of rubber plants which would provide enough material for mulching. It was also observed that by growing bush legumes it is possible to reduce the cost of weeding during the immature phase of rubber by about 30%. It was further observed that the first lopping of these trees may be done 4 months after planting depending on the weather conditions. It may be possible to do 3-4 loppings per year when climatic conditions are favourable.

The possibility of using Eppawela rock phosphate (ERP) as a source of phosphate for immature rubber plants during the last two years of immature period was explored.

The soil and foliar survey programme provided data for fertilizer recommendations for 4000 hectares in the estate sector. In general, as in the past, N and K fertilizers were recommended to most of the plantings. The soil and foliar survey programme was extended to the smallholder sector this year. Initially, Agalawatte Division of the Kalutara Region was covered under this scheme. Eleven ranges *viz.* Agalawatta(1), Lathpandura(2), Palenda I(3), Morapitiya(4), Palenda II(5), Rathmale (6), Hedigalle (7), Baduraliya (8), Kewitiyagala (9), Pelawatta II (10) and Athale (Hedigalle) (11), which consisted of more than 1000 holdings received fertilizer recommendations for the years 1996, 1997 and 1998. Three different fertilizer formulations were recommended for different RDO ranges and it was possible to reduce 50% of P fertilizers and 70% of Mg fertilizers during the mature phase.

An assessment of the effectiveness of the discriminative fertilizer application to mature rubber in relation to yield was done for the Avissawella region. According to this investigation, it is clear, that the soil and foliar survey based fertilizer recommendation could be further improved to give site specific recommendations

according to the soil in the locality, clone, slope of the land, land quality and number of replanting cycles.

DETAILED REVIEW

Staff

Dr (Mrs) Lalani Samarappuli, Head of the Department; Dr D M A P Dissanayake, Soils Chemist and Mr S Dharmakeerthi, Assistant Soils Chemist were on duty throughout the year.

The Experimental Officers Messrs A M A Perera, H D S P Perera, G de Mel and Mrs R Hettiarachchi were on duty throughout the year.

Senior Technical Officer Mr S N Silva was on duty throughout the year and Mrs C Maheepala was on maternity leave from 5th August 1995. Technical Officers Messrs P Karunadasa, U Mitrasena, T B Dissanayake, A N Yakandawela, C Jayalath, V Edirimanne and D Senaratne; Senior Testing Officer Mr T M Ahamadeen and the English Stenographer Mrs L Rupasinghe were on duty.

Technical Officers Messrs R Gunasekara and H P Dhammika resigned from the services of the RRI in May.

Research Students

Mr E A J Rupasinghe, an undergraduate student from the University of Peradeniya, completed his final year project on "An assessment of discriminative fertilizer application to mature rubber in relation to yield in Avissawella region." under the supervision of Dr (Mrs) Lalani Samarappuli.

Mr G W Rajapaksa, an undergraduate student from the University of Ruhuna, completed his final year project on "Micronutrient status of the rubber plantations in Sri Lanka in relation to soil type and management practices" under the supervision of Dr (Mrs) Lalani Samarappuli.

Mr K G J P Mahindapala, an undergraduate student from the University of Peradeniya, completed his final year project on "Soil and leaf nutrient changes in relation to fertilizer application for mature rubber" under the supervision of Dr D M A P Dissanayake.

Miss D D Weerakoon, an undergraduate student from the University of Ruhuna, completed her final year project on "Some aspects of locally available rock phosphate fertilizers from deposits at Eppawala and Ridigama" under the supervision of Dr D M A P Dissanayake.

Visits

Dr D M A P Dissanayake participated in the training programme on "Use of isotope and radiation techniques in studies of soil/plant relationships with emphasis on crop production on acid soils organized by the IAEA from 6th March to 7th April, in the Dept. of Agriculture, Bangkok, Thailand.

He also attended the International Conference on "Soil resources and sustainable agriculture" organized by the Malaysian Soil Science Society held in Malaysia in September and presented a paper entitled "Recent development in the use of root bioassay technique for assessing the phosphate requirements of annual and perennial crop species".

The Departmental staff paid advisory visits to plantations and smallholdings and routine visits to experimental areas where necessary.

Seminars, Meetings, Workshops and Trainings

Dr (Mrs) Lalani Samarappuli addressed the following seminars:

Seminar on the Recent Advances in the Knowledge of the Secondary and Micronutrients in Agriculture, on "Micronutrient status of the rubber plantations in Sri Lanka".

Seminar on the Rubber Cultivation and Process organized by the Kegalle/Avissawella District Planters Association on "Soil Management and Fertilizer Use".

Galle and Ratnapura Regional Scientific Committee Meetings on "Soil Management and Fertilizer Use".

Namunukula and Kotagala Plantations Ltd. Directors and Executive Managers on "Fertilizer Use and Soil Management".

Seminar on Fertilizer Use organized by the National Fertilizer Secretariat on "Fertilizer to Rubber".

Dr D M A P Dissanayake delivered the key note address at the International workshop on "Direct application of phosphate rock and appropriate technology fertilizers in Asia: What hinders acceptance and growth" organized by the International Fertilizer Development Center (IFDC) in cosponsorship with Institute of Fundamental Studies, Sri Lanka, 20-24th February.

Dr (Mrs) Lalani Samarappuli[1], Dr D M A P Dissanayake[2] and Mr S Dharmakeerthi[3] attended the following seminars, meetings workshops and trainings:

* Fertilizer Advisory Committee[1].

* The Working Group on Fertilizer Mixtures of the Sri Lanka Standards Institution[1].

* Central Scientific Committee[1,2].

* Assessor Training Programme organized by the Sri Lanka Standards Institution with the assistance of the Central Environmental Authority[3].

Training Programmes

Lalani Samarappuli, D M A P Dissanayake and S Dharmakeerthi were involved in the following training programmes as trainers:

* Rubber Development officers of the Rubber Development Department.

* Owners and Managers of middle level estates.

* Assistant Superintendents of Plantation Management Companies.

* Field officers of Plantation Management Companies.

* Superintendents/Assistant Superintendents for the Diploma Course in Plantation Management.

* University Students/NDT Trainees.

LABORATORY AND FIELD INVESTIGATIONS

1. Agronomic practices in relation to moisture conservation

1.1 *Use of live and dead mulch*

1.1.1 *Comparison of different management practices*

Study on the residual effect of, mulching during the immature period, on latex production and girthing of trees was continued in experiment SM/82/5. The residual effect of treatments on average yield in the virgin panel BO-1 and girth increment during the last year are given in Table 1 and 2, respectively. Yield of latex and girth increment were higher in mulched plots compared to other soil management practices.

Table 1. *Residual effect of different soil management practices on average yield in the panel BO-1*

Treatment	Average Yield (panel BO-1)		Relative Increase (%)
	(g/t/t)	(kg/ha/yr)	
Legumes	18.94[a]	1193[a]	100
Naturals	18.51[a]	1166[a]	98
Dead mulch	22.52[b]	1419[b]	119

Table 2. *Residual effect of different soil management practices on girthing of Hevea*

Treatment	Girth (cm)	Girth Increment (cm)
Legumes	60.97[a]	0.82[a]
Naturals	61.12[a]	0.87[a]
Dead mulch	67.17[b]	1.02[b]

1.1.2 *Optimum N P K levels for rubber mulched with rice straw*

In this experiment (SM/83/1), the N,P,K requirements for rubber, mulched with rice straw, was studied in a 3x3x3 factorial design in which three levels of N,P and K were applied with and without mulching in the sub-plots.

Yield data obtained were used to assess the optimum N P K levels under different management practices (with and without straw) using response surface analysis technique. The results indicate that the optimum N and K levels varied according to the management practice (Table 3). The yield under different management practices is given in table 4.

Table 3. *Optimum levels of N, P and K under different management practices obtained by response surface analysis*

Nutrient	Currently recommended level (g/tree/yr)	Without Straw (g/tree/yr)	With Straw (g/tree/yr)
N	99	46.5	21.8
P	51	44.9	46.4
K	99	123.8	105.9

Table 4. *Predicted and observed yield under different management practices*

	Without straw		With straw	
	(g/tree/yr)	(kg/ha/yr)	(g/tree/yr)	(kg/ha/yr)
Predicted value at maximum point	24.19	1524	26.69	1682
Observed mean yield	20.06	1264	22.07	1390
Difference in yield	4.13	260	4.62	291

This indicates that it is possible to obtain higher yields in the region of 158 kg/ha/yr by application of straw at optimum N,P,K levels (L Samarappuli, P Karunadasa and U Mitrasena).

1.2 *Fertilizer practices for overcoming moisture stress*

A field experiment (SM/88/3) is in progress at Nalanda Estate, Ulpotha to study the effect of different levels of potassium on growth of *Hevea* plants in a comparatively drier area. The effect of treatments on girth and girth increment during the last year and leaf nutrient contents are given in Table 5 and 6, respectively.

In experiment SM/88/1, with and without K, girth and yield data indicated higher girthing and higher yield (Table 7) with potassium at K1 level. The effect of K levels on leaf nutrient contents is given in Table 8.

In another field experiment (SM/95/1), the effect of both potassium and mulching on moisture stress, growth and latex production of *Hevea* was studied. Treatments consisted of three mulching techniques; no mulch (M0), surface mulching (M1) and sub surface mulching (incorporation) (M2) and four potassium levels; half the recommended level (K1), recommended level (K2), one and half the recommended level (K3) and double the recommended level (K4). Girth measurements at six months after planting are given in Table 9 (L Samarappuli, P Karunadasa and U Mitrasena).

Table 5. *Effect of different K levels on girth and girth increment of rubber plants*

K Level*	Girth (cm)	Girth Increment (cm)
K_0k_0	40.00	3.16
K_0k_1	44.80	7.22
K_0k_2	42.15	7.75
K_1k_0	38.82	5.32
K_1k_1	37.32	6.22
K_1k_2	41.73	6.93

* K_0 and K_1 refer to levels of potassium application up to year 5
k_0, k_1 and k_2 refer to levels of potassium application from year 6

Table 6. *Effect of different K levels on leaf nutrient content of rubber*

K Level*	N (%)	P (%)	K (%)
K_0k_0	3.64	0.326	1.25
K_0k_1	3.56	0.309	1.23
K_0k_2	3.48	0.327	1.38
K_1k_0	3.60	0.329	1.32
K_1k_1	3.35	0.324	1.47
K_1k_2	3.47	0.304	1.38

* K_0 and K_1 refer to levels of potassium application up to year 5
k_0, k_1 and k_2 refer to levels of potassium application from year 6

Table 7. *Effect of potassium on girth and yield of rubber plants*

K levels	Girth (cm)	Yield (g/t/t)	Yield (kg/ha/yr)
K_0	46.2	13.7	863
K_1	50.9*	15.4*	970*
LSD	2.7	1.4	88

Table 8. *Effect of potassium on leaf nutrient contents of rubber*

K levels	N (%)	P(%)	K (%)	Mg (%)	Ca (%)
K_0	3.28	0.367	1.12	0.34	0.64
K_1	3.35	0.334	1.41*	0.27*	0.58
LSD	ns	ns	0.14	0.32	ns

Rubber based cropping systems to increase water use efficiency of rubber plants

Access tubes were installed at 4 points in each plot in the experimental area multicropping of rubber with tea at the RRI Sub Station in Kuruwita (SM/93/1) monitoring of soil moisture content using Neutron Probe and Leaf Water ential (LWP) using Pressure Bomb was done. There was a significant difference soil moisture content between the different spacings of rubber, different agement practices of tea and between positions of rubber and tea plants (Table 11 and 12 respectively). Leaf water potential also showed a significant difference ween the different times of the day, the planting practices and positions of tea and ber plants (Table 13, 14 and 15 respectively), (L Samarappuli, N Yogaratnam, S M Iqbal, P Karunadasa and U Mitrasena).

Table 9. *Effect of potassium and mulching on girth of rubber plants*

Treatment	Girth (mm)
K_1M_0	21.50[a]
K_2M_0	21.25[a]
K_3M_0	20.75[a]
K_4M_0	20.50[a]
K_1M_1	20.00[a]
K_2M_1	20.75[a]
K_3M_1	21.00[a]
K_4M_1	20.75[a]
K_1M_2	21.00[a]
K_2M_2	20.00[a]
K_3M_2	19.50[a]
K_4M_2	20.75[a]

Table 10. *Effect of different spacings of rubber on soil moisture content under tea & rubber multicropping system*

Treatment	Moisture content (kg/M^3)			
	January	February	March	April
Tea & rubber (8'x27')	542.0[a]	461.7[a]	438.6[a]	494.7[a]
Tea & rubber (8'x40')	480.6[b]	425.9[b]	412.9[b]	482.5[b]

Table 11. *Effect of different planting practices of tea on soil moisture content under tea and rubber multicropping system*

Treatment	Moisture content (kg/M^3)			
	January	February	March	April
Tea (rehabilitated) & rubber	510.5	458.0[a]	428.0[a]	494.8
Tea (unrehabilitated) & rubber	507.0	429.6[b]	413.5[b]	482.4

Table 12. *Effect of different positions of tea and rubber plants on soil moisture content under tea and rubber multicropping system*

Position	Moisture content (kg/M^3)			
	January	February	March	April
Rubber planting row	500.9	439.3	418.8	481.4[a]
Between rubber & tea plants	497.9	435.9	420.3	477.1[a]
1st row of tea plants	497.6	442.0	418.8	485.2[a]
Middle row of tea plants	538.6	458.1	444.9	510.6[b]

Table 13. *Effect of time of the day on Leaf Water Potential (LWP) under tea and rubber multicropping system*

Treatment	LWP (-bars)	
	Rubber	Tea
8.00 - 10.00 a.m.	3.29[a]	2.58[a]
1.00 - 3.00 p.m.	8.19[b]	6.15[b]

Table 14. *Effect of different planting practices of tea and rubber on Leaf Water Potential (LWP)*

Treatment	LWP (-bars)	
	Rubber	Tea
Tea only (rehabilitated)	-	8.23[a]
Rubber only	10.1[a]	-
Tea and rubber (rehab.)(8'x27')	9.9[a]	8.38[ab]
Tea and rubber (unrehab.)(8'x27')	9.3[a]	8.02[a]
Tea and rubber (rehab.)(8'x40')	10.0[a]	7.83[a]
Tea and rubber (unrehab.)(8'x40')	9.2[a]	8.95[b]

Table 15. *Effect of different positions of tea plants on Leaf Water Potential (LWP).*

Position	LWP (-bars)
1st row of tea plants	5.43[a]
Middle row of tea plants	5.42[a]

2. Land degradation, ground cover management and nutrient recycling

2.1 *Assessment of land degradation in rubber plantations*

In a field experiment (SM/82/5), with two slopes *viz.* 6% and 12%, the soil degradation and development aspects were studied. In the 12% slope, soil degradation is greater compared to 6% slope. Soil degradation and development effects were further confirmed by girth and yield data collected during the year 1995 (Table 16), (L Samarappuli, P Karunadasa and U Mitrasena).

Table 16. *Effect of different slopes on girth and yield of rubber plants*

Slope	Girth (cm)	Yield	
		(g/t/t)	(kg/ha/yr)
6%	64.21[a]	27.56[a]	1736[a]
12%	61.11[b]	21.75[b]	1370[b]

2.2 *Ground cover management*

2.2.1 *Comparison of different cover types*

Experiment, SM/88/1, was started to study the influence of creeping, bush and tree legumes on some soil characteristics and their effects on the performance of rubber in *Boralu* series soils. Effect of different types of legumes on girth and yield of rubber is given in Table 17 (L Samarappuli, P Karunadasa and U Mitrasena).

Table 17. *Effect of different types of legumes on girth and yield of* Hevea

Treatment	Girth (cm)	Yield (g/t/t)	Yield (kg/ha/yr)
Pueraria (creeping type)	51.17[a]	14.02[a]	883[a]
Desmodium (bush type)	46.27[b]	13.75[a]	866[a]
Stylosanthus (bush type)	47.18[b]	13.63[a]	859[a]
Tephrosia (tree type)	46.32[b]	13.39[a]	844[a]

2.2.2 *Comparison of different tree legumes*

Experiments C/92/1 and C/93/1, were started to study the performance of leguminous trees and their effect on soil and moisture conservation , growth and yield of *Hevea* plants. Girth of rubber plants under different management practices are presented in Table 18. Girth was higher in trees under *Crotolaria anagyroides* and *Tephrosia vogellie* compared to trees under other species *viz. Pueraria phaseoloides*, *Sesbania aculeata* and *Gliricidia sepium*. It was also observed that by growing bush legumes it is possible to reduce the cost of weeding during the immature phase of rubber (Table 19). (L Samarappuli, P Karunadasa, U Mitrasena and E A T Senadeera).

Table 18. *Effect of different tree legume species on girth of rubber plants*

Treatment	Girth (cm)
Crotolaria anagyroides	20.95[a]
Tephrosia vogellie	20.38[ab]
Pueraria phaseoloides	19.20[b]
Sesbania aculeata	16.83[c]
Gliricidia sepium	14.88[d]

Table 19. *Effect of growing tree legumes on cost of weeding during the 1st two years of planting*

Treatment	No. of labours/ha		Cost (Rs)/ha
	Weeding	Establishment and pruning of tree legumes	
Growing tree legumes		23	1886.00
Growing conventional legumes	32		2624.00
Saving			738.00

Another field experiment (C/94/1), was started to study the effectiveness of Eppawela rock phosphate as a source of P for leguminous ground covers, both creeping and bush/tree types. Treatments consisted of three P sources: no P, ERP and IRP and four cover types: *Pueraria phaseoloides, Tephrosia vogellie, Crotolaria anagroiydes and Flemingia congesta*. Effect of different sources of P and cover types on girth of rubber plants at the end of 18 months from planting is presented in Table 20 (L Samarappuli, A Dissanayake, N Yogaratnam G de Mel and E A T Senadeera).

Table 20. *Effect of different sources of P and cover types on girth of rubber plants*

Treatments	Girth (cm)
Crotolaria anagyroides	14.76[a]
Pueraria phaseoloides	14.54[a]
Tephrosia vogellie	14.01[a]
Flemingia congesta	13.66[a]
No P	13.75[a]
ERP	14.41[a]
IRP	14.57[a]

2.2.3 *New cover crop species*

A field experiment (C/94/2), was started to study the comparative efficiency of *Mucuna bracteata*, a fast growing legume introduced from the North Eastern States of India, in nutrient enrichment and other desirable characteristics in comparison with *Pueraria* and on seed production under Sri Lankan conditions. Visual observations on growth rate of this cover crop during both dry and wet periods appear to indicate higher rate than *Pueraria*.

A site was selected at Perth Estate, Horana for another experiment (C/96/1), to study the efficiency of *Mucuna bracteata*, in growth, nutrient enrichment and other desirable characteristics in comparison with *Pueraria* and three other tree legumes (L Samarappuli, P Karunadasa and U Mitrasena).

2.3 *Nutrient recycling in rubber plantations*

2.3.1 *Organic materials*

2.3.1.1 Use of organic materials in poly bagged nursery plants

An experiment (OM/95/1), is in progress to study the possibility of using organic materials as a substitute for top soil in poly bagged nursery plants. Treatments consisted of (a) top soil (control), (b) top soil and sub soil (1:1), (c) sub soil and coir dust (1:1), (d) sub soil and paddy husk (1:1), (e) sub soil and poultry litter (2:1), (f) sub soil and saw dust (1:1), (g) sub soil, saw dust and poultry litter (1:1:1), (h) sub soil, paddy husk and poultry litter (1:1:1) and (i) sub soil, coir dust and poultry litter (1:1:1). Soil organic carbon content under different treatments are given in the Table 21. No. of leaves of rubber plants under different treatments are presented in Table 22. Growth was higher in plants under most of the treatments compared to the control treatment (top soil) (L Samarappuli and R Hettiarachchi).

Table 21. *Soil organic carbon content of different treatments*

Treatment	Organic C (%)
Top soil (control)	2.00
Top soil & sub soil (1:1)	2.00
Sub soil & coir dust (1:1)	4.00
Sub soil & paddy husk (1:1)	13.65
Sub soil & poultry litter (2:1)	5.85
Sub soil & saw dust (1:1)	9.50
Sub soil, saw dust & poultry litter (1:1:1)	10.60
Sub soil, paddy husk & poultry litter (1:1:1)	12.25
Sub soil, coir dust & poultry litter (1:1:1)	8.35

Table 22. *Effect of different organic material substitutes on no. of leaves of rubber plants*

Treatment	No. of leaves	
	3 months after planting	4 months after planting
Top soil (control)	5.00^{cde}	7.64^{c}
Top soil & sub soil (1:1)	4.86^{de}	7.29^{c}
Sub soil & coir dust (1:1)	5.07^{cde}	6.79^{c}
Sub soil & paddy husk (1:1)	5.14^{cde}	7.93^{c}
Sub soil & poultry litter (2:1)	6.00^{bcd}	8.64^{bc}
Sub soil & saw dust (1:1)	4.39^{e}	6.85^{c}
Sub soil, saw dust & poultry litter (1:1:1)	7.07^{ab}	10.08^{ab}
Sub soil, paddy husk & poultry litter (1:1:1)	6.5^{abc}	8.67^{bc}
Sub soil, coir dust & poultry litter (1:1:1)	7.86^{a}	10.79^{a}

2.3.1.2 Nutrient release pattern of organic materials

A laboratory incubation study (OM/95/2), was carried out to evaluate the nutrient release pattern over a period of time by paddy straw, poultry litter, green matter and sludge. Changes in pH, organic carbon and soil N with time are given in the Table 23, 24 and 25, respectively (L Samarappuli and R Hettiarachchi).

2.3.2 *Organic manure*

2.3.2.1 Use of animal wastes in rubber cultivations

The use of cow dung in *Hevea* plantations is being studied (OM/88/1), at three different sites (estates). Results obtained show an improved yield from trees that received organic manure supplement (Table 26) (L Samarappuli, N Yogaratnam and J de Mel).

Table 23. *Effect of different organic materials on soil pH*

Treatment	Weeks									
	2	4	6	8	10	12	14	16	18	20
Control	4.9^{a}	4.7^{c}	4.8^{cd}	4.8^{a}	4.7^{cd}	4.2^{de}	4.1^{b}	4.9^{bc}	4.9^{bc}	4.9^{bc}
Straw	4.9^{a}	4.9^{c}	4.9^{cd}	4.8^{a}	4.8^{cd}	4.4^{cd}	4.1^{b}	4.9^{bc}	5.1^{bc}	5.1^{b}
Poultry litter	7.0^{a}	6.4^{a}	5.5^{b}	5.5^{a}	5.3^{b}	4.8^{bc}	4.5^{b}	5.3^{b}	5.2^{b}	5.2^{b}
Green matter	5.2^{a}	6.2^{ab}	5.2^{bc}	5.0^{a}	4.9^{c}	4.2^{de}	4.0^{b}	4.8^{bc}	5.0^{bc}	4.6^{cd}
Sludge	5.5^{a}	6.7^{a}	6.5^{a}	6.3^{a}	5.8^{a}	5.8^{a}	5.5^{a}	6.1^{a}	5.7^{a}	5.9^{a}

Table 24. *Effect of different organic materials on soil organic carbon content (%)*

Treatment	Weeks									
	2	4	6	8	10	12	14	16	18	20
Control	1.17^{a}	1.15^{d}	1.21^{c}	1.24^{bc}	-	1.31^{a}	1.24^{b}	1.26^{d}	1.27^{bc}	1.25^{c}
Straw	1.20^{a}	1.25^{c}	1.28^{bc}	1.37^{b}	-	1.44^{a}	1.4^{ab}	1.37^{bcd}	1.45^{bc}	1.42^{bc}
Poultry litter	-	1.68^{a}	1.66^{a}	1.75^{a}	-	1.65^{a}	1.64^{a}	2.00^{a}	1.95^{a}	1.99^{a}
Green matter	1.23^{a}	1.24^{c}	1.23^{c}	1.31^{bc}	-	1.42^{a}	1.4^{ab}	1.53^{bc}	1.36^{bc}	1.36^{c}
Sludge	1.27^{a}	1.33^{b}	1.25^{bc}	1.29^{bc}	-	1.32^{a}	1.26^{b}	1.35^{cd}	1.28^{bc}	1.32^{c}

Another field experiment (OM/95/3), is in progress at Dorset Division, Clyde Estate, Tebuwana to study the effect of poultry litter as an organic manure for rubber. Treatments consisted of (a) Inorganic fertilizer (recommended level), (b) Inorganic fertilizer (½ recommended level) + poultry litter, (c) Inorganic fertilizer (¼ recommended level) + poultry litter, (d) Poultry litter only, (e) Poultry litter + IRP + MOP, (f) Poultry litter + IRP + paddy straw and (g) Poultry litter only with natural cover. It is too early to make any comments on the data obtained (L Samarappuli, P Karunadasa and U Mitrasena).

Table 25. *Effect of different organic materials on soil N content (%)*

Treatment	Weeks									
	2	4	6	8	10	12	14	16	18	20
Control	0.28^{b}	0.29^{bc}	0.46^{cd}	0.22^{c}	0.25^{dc}	0.19^{cdc}	0.16^{a}	0.13^{d}	0.12^{bc}	0.11d
Straw	0.34^{b}	0.34^{bc}	0.38^{d}	0.29^{c}	0.28^{cd}	0.20^{cdc}	0.27^{a}	0.14^{d}	0.13^{bc}	0.12d
Poultry litter	0.55^{a}	0.56^{a}	0.61^{ad}	0.54^{a}	0.54^{a}	0.38^{b}	0.21^{a}	0.34^{a}	0.23^{a}	0.25a
Green matter	0.30^{b}	0.30^{bc}	0.40^{d}	0.32^{bc}	0.26^{dc}	0.22^{cd}	0.17^{a}	0.17^{cd}	0.13^{bc}	0.13cd
Sludge	0.52^{a}	0.54^{a}	0.65^{a}	0.46^{ad}	0.36^{b}	0.30^{b}	0.27^{a}	0.27^{b}	0.24^{a}	0.24ab

Table 26. *Effect of different fertilizer practices on yield of rubber*

Treatment	Yield (g/t/t)	Yield (kg/ha/yr)
Inorganic fertilizer (½ normal)	20.41^{a}	1286^{a}
Inorganic fertilizer (½ normal) + organic manure	24.72^{b}	1557^{b}
Inorganic fertilizer (normal)	21.55^{ab}	1358^{ab}
Inorganic fertilizer (normal) + organic manure	23.99^{ab}	1511^{ab}

2.3.2.2 Use of green manure in rubber cultivation

A field experiment (OM/94/1), is in progress at Culloden Estate, Neboda to study the effect of legume cover material as an organic manure for rubber. Treatments consisted of (a) Bare root plants with fertilizer (recommended level), (b) Bare root plants with fertilizer (recommended level) + green manure, (c) Bare root plants with fertilizer (substitute level) + green manure, (d) Poly bag plants with fertilizer (recommended level), (e) Poly bag plants with fertilizer (recommended level) + green manure, (f) Poly bag plants with fertilizer (substitute level) + green manure. Girth of rubber plants under different treatments are presented in Table 27 (L Samarappuli and G de Mel).

Table 27. *Effect of application of green manure and fertilizers on girth of rubber plants*

Treatment	Girth (cm)
Bare root plants with fertilizer (recommended level)	9.15[a]
Bare root plants with fertilizer (recommended level) + green manure	9.49[a]
Bare root plants with fertilizer (substitute level) + green manure	8.32[b]
Poly bag plants with fertilizer (recommended level)	9.51[a]
Poly bag plants with fertilizer (recommended level) + green manure	9.79[a]
Poly bag plants with fertilizer (substitute level) + green manure	9.02[a]

2.3.2.3 Sludge as a potential fertilizer for *Hevea*

Three experiments were started at Payagala estate to evaluate sludge as a fertilizer for immature rubber (OM/93/2 & OM/93/3), and for legume covers (OM/93/1). Different levels of fertilizers and sludge were applied according to the design. Effects of treatments on girth of rubber plants are given in Tables 28, 29 and 30. Girth measurements done at one and a half years after planting showed that there is no significant difference between different treatments (L Samarappuli, A M A Perera and H P Dhammika).

Table 28. *Effect of application of sludge on girth of rubber plants*

Treatment	Girth (cm)
Without sludge	14.4[a]
With sludge	15.2[a]

Table 29. *Effect of application of sludge and fertilizers on girth of rubber plants*

Treatment	Girth (cm)
No fertilizer + sludge (½ kg/plant)	19.71[a]
No fertilizer + sludge (1 kg/plant)	18.28[a]
Fertilizer (½ level) + sludge (½ kg/plant)	15.69[a]
Fertilizer (½ level) + sludge (1 kg/plant)	19.78[a]
Fertilizer (normal level) + sludge (½ kg/plant)	15.49[a]
Fertilizer (normal level) + sludge (1 kg/plant)	17.42[a]

Table 30. *Effect of application of sludge to covers on girth of rubber plants*

Treatment	Girth (cm)
Nó P fertilizer	17.61[a]
IRP (recommended level)	17.71[a]
Sludge (normal level)	18.08[a]
Sludge (double level)	17.24[a]

3. Fertilizer recommendations and soil and foliar survey programme

3.1 *Soil and foliar survey programme*

3.1.1 *Assessment of soil and foliar survey programme*

An assessment (F/SF/95/1), of the effectiveness of the discriminative fertilizer application to mature rubber in relation to yield was done for the Avissawella region. Yield data of the last 15 years collected from different locations in the Avissawella region showed an increasing trend with the time (Fig 1). This clearly shows the appropriateness of the soil and foliar survey based fertilizer recommendations for mature rubber. Clone RRIC 102 showed a higher positive gradient of 27.91 compared to PB86 which showed a positive gradient of 15.25 (Fig 2). Lands with

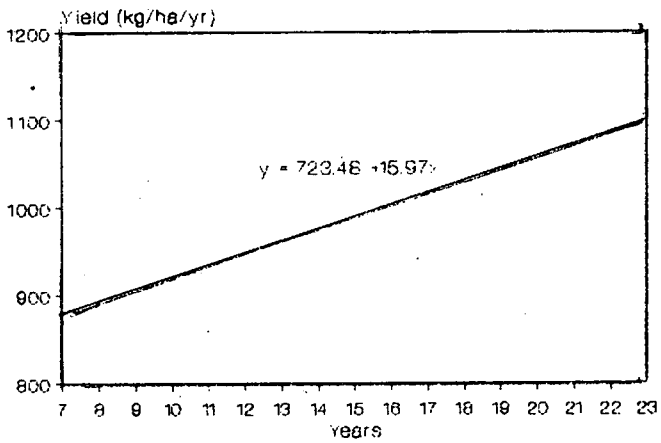


Fig. 1 Effect of soil and foliar survey based fertilizer recommendation on yield of rubber

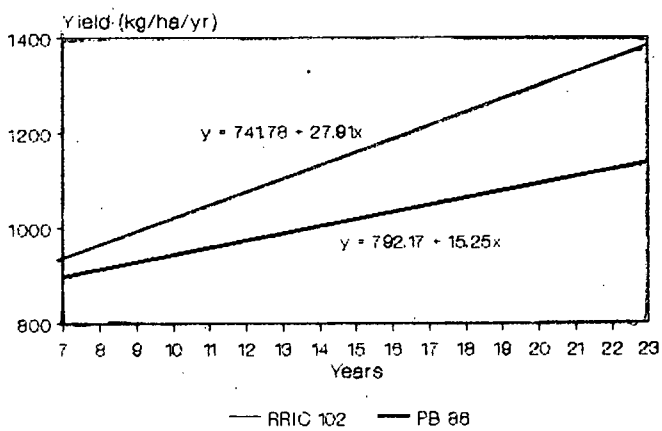


Fig. 2 Effect of soil and foliar survey based fertilizer recommendation on yield of two different clones

different slopes and land qualities showed different positive gradients for yield (Fig 3 & Fig 4). Soil N, P, K and Mg contents of different locations were in the ranges of 0.11%-0.63%, 4 ppm-33ppm, 4 ppm-109 ppm and 10 ppm-43 ppm, respectively. Slope class <50% showed a higher soil N, P, K and Mg contents compared to slope class >50% (Table 31). Soil P and Mg were higher in <25% rockiness compared to >25% (Table 32).

According to this investigation, it is clear that the soil and foliar survey based fertilizer recommendation could be further improved to give site specific recommendations according to the soil in the locality, clone, slope of the land, land quality and number of replanting cycles. However, further studies in other regions should also be done before any conclusions are made (L Samarappuli, J Rupasinghe and V Edirimanne).

Table 31. *Soil nutrient status in two different slope classes*

Soil Nutrient	Slope Class	
	<50%	>50%
N [%]	0.354[a]	0.270[b]
P [ppm]	22.38[a]	11.68[b]
K [ppm]	48.51[a]	26.32[b]
Mg [ppm]	21.61[a]	14.22[b]

3.1.2 *Improvements to soil and foliar survey programme*

An experiment (F/SF/95/2), is in progress to further substantiate the early findings of sampling intensity for formulation of appropriate practices in sampling technique for soil and foliar survey programme. Fourteen different sampling intensities are being evaluated and this experiment further examines the sub sampling procedures and leaf nutrient variation pattern of different clones of rubber with the time (L Samarappuli, N Yogaratnam, W Wijesuriya, V Edirimanne, P Karunadasa and U Mitrasena).

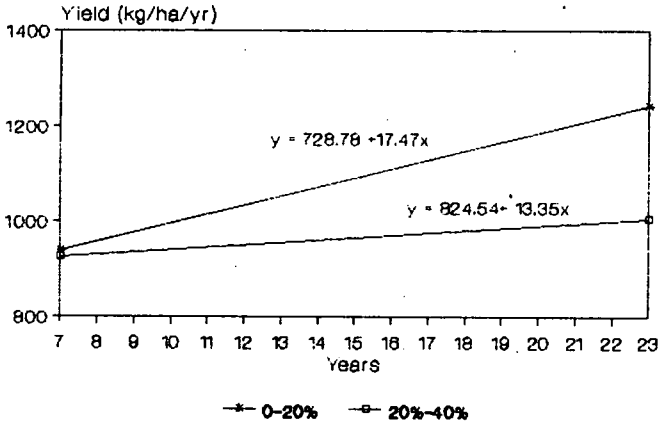


Fig. 3 Effect of soil and foliar survey based fertilizer recommendation on yield under two different slopes

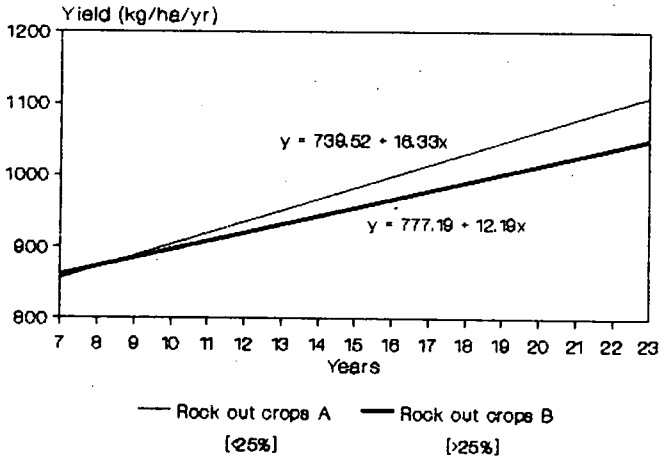


Fig. 4 Effect of soil and foliar survey based fertilizer recommendation on yield under two different land qualities

Table 32. *Soil nutrient status in two different land quality classes*

Soil Nutrient	Land Quality Class	
	<25% of Rockiness	>25% of Rockiness
N [%]	0.36[a]	0.36[a]
P [ppm]	18.06[a]	16.38[b]
K [ppm]	37.53[a]	36.49[a]
Mg [ppm]	20.27[a]	14.86[b]

3.1.3 *Soil and foliar survey programme - Fertilizer recommendation*

Estate sector

The soil and foliar survey programme for 1995 commenced in July and approximately 4000 ha were surveyed this year. Fertilizer recommendations based on this survey were sent to all the estates in December. In general, as in the past, N and K fertilizers were recommended to most of the plantings (L Samarappuli, V Edirimanne, A M A Perera and T M Ahamadeen).

Smallholder sector

The soil and foliar survey programme was extended to the small holder sector. Initially, Agalawatte Division of the Kalutara Region was covered under this scheme. 11 ranges *viz.* Agalawatta(1), Lathpandura(2), Palenda I(3), Morapitiya(4), Palenda II(5), Rathmale (6), Hedigalle (7), Baduraliya (8), Kewitiyagala (9), Pelawatta II (10) and Athale (Hedigalle) (11), which consisted of more than 1000 holdings, received fertilizer recommendations for the years 1996, 1997 and 1998. Three different fertilizer formulations recommended for different RDO ranges are given in Table 33, 34 and 35 (L Samarappuli, V Edirimanne, A M A Perera and G de Mel).

Table 33. *Recommended Fertilizer Schedule for 1996, 1997, 1998 for ranges 1,2,3, 4,5 and 6*

Year	Fertilizer Quantity (gram/tree/year)			
	Urea	Muriate of Potash	Eppawela Rock phosphate	Kieserite
1996	200	200	200	-
1997	200	200	200	-
1998	200	200	200	-

Table 34. *Recommended Fertilizer Schedule for 1996, 1997, 1998 for ranges 7,8,9 and 10*

Year	Fertilizer Quantity (gram/tree/year)			
	Urea	Muriate of Potash	Eppawela Rock phosphate	Kieserite
1996	200	200	200	150
1997	200	200	200	150
1998	200	200	200	150

Table 35. *Recommended Fertilizer Schedule for 1996, 1997, 1998 for range 11*

Year	Fertilizer Quantity (gram/tree/year)			
	Urea	Muriate of Potash	Eppawela Rock phosphate	Kieserite
1996	200	200	200	200
1997	200	200	200	200
1998	200	200	200	200

3.2 *Economics of fertilizer use in mature rubber*

Economics of fertilizer utilization by mature rubber is being investigated in an experiment (F/EC/92/1), at Clyde estate, Dorset Division. Following treatments were allocated to each plot in a randomized complete block design with five replicates. Yield data obtained during the last year is given in Table 36 (L Samarappuli, N Yogaratnam, P Karunadasa and U Mitrasena).

T_1 No fertilizer from the first year of panel C
T_2 No fertilizer from the second year of panel C
T_3 No fertilizer from the third year of panel C
T_4 No fertilizer from the fourth year of panel C
T_5 Fertilizing throughout the panel C

3.3 *Dolomite as a source of Mg for mature rubber*

An experiment (F/Mg/94/1), is in progress in Dorset Division, Clyde Estate to study the feasibility of using Dolomite even during the mature stage. Treatments consisted of kieserite throughout the immature and mature period, kieserite in immature period and dolomite in mature period, dolomite throughout the immature and mature period, dolomite in immature period and kieserite in mature period. Girth and yield data obtained during the last year are given in Table 37 (L Samarappuli, S M M Iqbal and U Mitrasena).

Table 36. *Effect of different fertilizer treatments on the yield of Hevea*

Treatment	Yield	
	(g/t/t)	(kg/ha/yr)
T1	28.28[a]	1782[a]
T2	27.32[a]	1721[a]
T3	27.03[a]	1703[a]
T4	27.02[a]	1702[a]
T5	29.72[a]	1872[a]

Table 37. *Effect of different sources of Mg fertilizer on girth and yield of rubber plants*

Treatment	Girth (cm)	Yield		Relative yield (%)
		(g/tree/tapping)	(kg/ha/yr)	
Kieserite	52.98[a]	19.61[a]	1235[a]	100
Dolomite	52.93[a]	18.28[a]	1152[a]	93

3.4 *SUL-PO-MAG based fertilizer mixtures*

An experiment (F/SPMg/94/1), was started in Culloden Estate, Neboda to study the effectiveness of SUL-PO-MAG based mixtures in comparison with the conventional mixtures 12:14:14 and 7:9:9:3 in immature rubber. SUL-PO-MAG based treatment was formulated by adding urea, rock phosphate and muriate of potash to SUL-PO-MAG to meet the nutrient ratios of N,P,K and Mg recommended for rubber in conventional mixtures. Growth was significantly higher in plants that received fertilizers compared to no fertilizer treatment. However, there was no significant difference in girth between the three fertilizer treatments (Table 38) (L Samarappuli, N Yogaratnam, J G de Mel and P Karunadasa).

Table 38. *Effect of different fertilizer mixtures on girth of rubber plants*

Treatment	Girth (cm)
Control (no fertilizer)	8.00[a]
Urea based	10.56[b]
SA based	10.00[b]
Sulpomag based	10.40[b]

3.5 *Fertilizer and soil moisture requirement of rubber under different densities*

A site was selected at Mucalana Division, Sirikandura Estate for an experiment (F/D/96/1), to study the fertilizer and soil moisture requirement of rubber under different densities. Treatments consisted of (a) Four different densities; (i) 500 trees/ha [4.5 m x 4.5 m], (ii) 600 trees/ha [4.2 m x 4.2 m], (iii) 700 trees/ha [3.8m x 3.8m] and (iv) 800 trees/ha [3.5 m x 3.5 m] (b) Three fertilizer treatments; (i) recommended level, (ii) reduced level and (iii) 1st three years recommended level and thereafter reduced level (L Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

3.6 *Reduced frequency of fertilizer applications*

A field experiment (F/Ap/95/1), is in progress to the study the effect of reduced frequency of fertilizer applications during the immature priod on the growth of rubber plants. Treatments consisted of (a) 25 applications/immature six year period (urea based), (b) 20 applications/immature six year period (SA based), (c) 19 applications/immature six year period (urea based), (d) 14 applications/immature six year period (SA based) and (e) 14 applications/immature six year period (urea based). Fertilizers were applied according to the experimental design (L Samarappuli, P Karunadasa and U Mitrasena).

3.7 *Slow Release Fertilizers*

Polymer Chemistry Department was successful in developing fertilizer encapsulated coir blocks. A joint project (F/SR/95/1) with Polymer Chemistry Department was commenced to study the possibility of using these fertilizer encapsulated coir blocks for poly bagged nursery plants. Effect of different quantities of encapsulated fertilizers on the growth of poly bagged plants is presented in Table 39 (L Samarappuli, K G K de Silva, R Hettiarachchi and M Wijesekera).

Table 39. *Effect of different fertilizer treatments on the growth of rubber plants*

Treatment	Plant diameter (mm)	Plant height (cm)	No. of leaves
Normal application of fertilizer only	53.7[a]	25.9[a]	12[a]
Normal application of fertilizer + coir block	53.2[a]	26.3[a]	12[a]
Normal application of basal fertilizers + coir block encapsulated with higher dose of NPKMg fertilizers	45.5[a]	20.1[a]	11[a]
100g IRP + coir block encapsulated with higher dose of NPKMg fertilizers	47.3[a]	21.0[a]	11[a]
All fertilizers encapsulated in the coir block	46.2[a]	20.3[a]	11[a]

4. Micro nutrients

Micronutrient status under different soil management practices was studied (M/95/1), by collecting and analysing soil and leaf samples from existing field experiments. Effect of different soil management practices on ammonium acetate extractable soil Mn and Zn contents are presented in Table 40. There were significant differences ($P < 0.001$) between different soil management practices, highest value being recorded with straw mulch for soil exchangable Mn and Zn contents. Effect of poultry litter application on soil exchangable Mn and Zn contents are presented in Table 41. There were significant differences between two treatments for soil exchangable Mn and Zn contents.

Effect of straw application on some micronutrient contents of soil and leaf micronutrient composition of different cover species are presented in Tables 42 and 43, respectively.

Effect of continuous application of different nitrogen fertilizers on soil and leaf S content of rubber is given in Table 44 (L Samarappuli and W Rajapakse).

Table 40. *Effect of different soil management practices on ammonium acetate extractable soil Mn and Zn contents*

Treatment	Mn (ppm)	Zn (ppm)
Bare	0.673[b]	0.646[b]
Naturals	0.656[b]	0.541[b]
Straw mulch	2.782[a]	1.203[a]
Pueraria	0.717[b]	0.572[b]
Desmodium	0.780[b]	0.455[b]
Tephrosia	0.626[b]	0.450[b]
Stylosanthus	0.530[b]	0.318[b]

Table 41 *Effect of poultry litter application on soil exchangable Mn and Zn contents*

Treatment	Mn (ppm)	Zn (ppm)
With poultry litter	2.568[a]	0.690[a]
Without poultry litter	1.040[b]	0.580[b]

Table 42. *Effect of straw application on some micronutrient contents of soil*

Treatment	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
Nil straw	1.36	1.50	9.4	0.32
Straw (incorporation)	3.92	3.20	6.0	0.65
Straw (surface mulching)	3.71	3.10	6.4	0.62

Table 43. *Leaf micronutrient composition of different cover species*

Nutrient	Amount		
	Pueraria	*Centrocema*	*Calopogonium*
S (%)	0.65	0.68	0.64
Mn (ppm)	75.00	76.00	54.00
Fe (ppm)	400.00	100.00	200.00
B (ppm)	42.00	26.00	40.00
Mo (ppm)	0.61	0.45	0.55
Zn (ppm)	30.00	22.00	33.00
Cu (ppm)	14.00	19.00	9.00

Table 44. *Effect of continuous application of different nitrogen fertilizers on soil and leaf S content of rubber*

Treatment	Soil S content (mg/kg)		Leaf S content (%)	
	After 8 yrs	After 18 yrs	After 8 yrs	After 18 yrs
Ammonium sulphate	409.7	403.2	0.26	0.25
Urea	388.1	326.8	0.24	0.22

5. Phosphate nutrition

5.1 *Rubber soils*

5.1.1 *P fixation in rubber soils*

Arrangements were made to analyze soils collected to represent all the rubber growing areas for the clay and organic matter contents (A Dissanayake, T Dissanayake, C Maheepala and C Jayalath).

5.1.2 *Reactivity of rock phosphates in rubber soils*

Behavior of rock phosphate fertilizers in rubber growing soils was studied by conducting a laboratory incubation experiment. The reactivity of IRP in rubber soils was superior than locally available P fertilizers from Eppawela but dissolution of locally available Ridigama rock phosphate (RRP) was similar to that of imported rock phosphate throughout the experimental period.

Although, commercially available rock phosphate (CERP) was inferior to both IRP and RRP at the early stages, it's reactivity increased with the increase in time. At this stage there was no significant difference between high phosphate Eppawela rock phosphate (HERP) and selectively mixed ERP (SERP) in respect to P availability. But the reactivity of partially acidulated ERP (PAERP) was significantly lower ($P<0.05$) than that of all the other P fertilizers from Eppawela (Table 45).

Table 45. *Effect of different P fertilizers on acetic acid extractable P (AAE- P)*

Sources of P	Time (Days)	
	10	60
Nil P	2.81^{D}	2.13^{D}
CERP	146.91^{B}	187.05^{A}
HERP	137.10^{B}	131.36^{B}
SERP	140.37^{B}	126.58^{B}
PAERP	47.58^{C}	70.60^{C}
RRP	199.30^{A}	183.46^{A}
IRP	216.62^{A}	191.41^{A}

(Means with the same letters are not significantly different at 5% level)

5.2 *Nursery Plants*

A new experiment was started at Nivitigalakele Sub Station to study the suitability of different P fertilizers from Eppawela *viz.* (CERP, HERP, SERP and PAERP) in comparison with that of IRP and Ridigama rock phosphate (RRP) for nursery plants. Girth measurements were made at the age of 4 months. No significant

effect of the P fertilizer treatments on girthing of rubber plants was observed. This experiment is being continued (A Dissanayake, T Dissanayake and Peter Perera).

5.3 *Immature rubber*

5.3.1 *Effect of different sources and levels of P*

This experiment (P/IM/87) was continued. Assessments of yield was started in November 1994 as the plantation is now under exploitation. The yield was not significantly influenced by either the source or rate of phosphorus (Table 46 and 47).

Table 46. *Effect of different sources of P on yield of rubber*

Source	Yield	
	(g/t/t)	(kg/ha/yr)
IRP	15.560[a]	980[a]
ERP	15.499[a]	976[a]
TSP	14.648[a]	922[a]

Table 47. *Effect of different levels of P on yield of rubber*

P level	Yield	
	(g/t/t)	(kg/ha/yr)
P0	16.284[a]	1025[a]
P1	15.132[a]	953[a]
P2	14.291[a]	900[a]

Leaf samples were collected and analyzed for P. Although there were no marked effects on leaf P content due to different sources and levels of P at the early stages, a significant influence of P levels on leaf P content was observed during the mature stage. Leaf phosphate levels was significantly increased ($P<0.05$) with the application of phosphate fertilizers, although significant differences were not observed between the recommended level (L1) and double the recommended level (L2) (Table 48).

Table 48. *Effect of different levels of P on leaf P content*

P level	Leaf P (%)
P0	0.254
P1	0.292*
P2	0.302*
LSD	0.034

Experimental plots were sub divided into two sub plots to study the residual effects of rock phosphates applied during the immature period on yield and fertilizer treatments were applied according to the new arrangement (A Dissanayake, T Dissanayake and Peter Perera).

5.3.2 *Ability of different clones to utilize ERP*

Experiment P/IM/93-01

This experiment started at Devalakanda Estate was continued. Fertilizers (ERP,IRP and ERP and IRP mixture) were applied according to the experimental treatments to supply phosphate at zero, normal and double the recommended level.

Girth measurements made after the completion of one year showed that there is no significant difference between rock phosphate sources and between P levels. But at the age of 2 years plants were responded positively to phosphate application.

A significant increase ($P<0.05$) in girth was recorded when plants received P fertilizers. But, no significant differences were observed in plant girth between the recommended level and double the recommended level at this stage (Table 49).

Although there had been significant increase in girth to application of phosphate, yet different sources of P did not show any significant differences on the performance of rubber plants. All the sources behaved in a similar manner showing that the effect of ERP was similar to that of IRP and IRP/ERP mixture (50:50) on plant girthing (Table 50).

Table 49. *Effect of different P levels on plant girth (cm)*

P level	1st year	2nd year
P0 (no P fertilizer)	8.40	10.88
P1 (rec.level)	8.80	11.92*
P2 (doub. rec. level)	8.87	11.75*
LSD	ns	0.85

Table 50. *Effect of different source of P on plant girth (cm)*

Sources	1st year	2nd year
IRP	8.63[a]	11.65[a]
ERP	8.45[a]	10.90[a]
IRP + ERP (50:50)	8.89[a]	11.90[a]

Experiment P/IM/94

This experiment started at Lagos Division, Payagala Estate to study the ability of different RRIC clones (RRIC 110 & 121) in utilization of ERP was continued for the 2nd year. Fertilizer treatments, ERP, IRP and IRP+ERP (50:50) mixture were applied according to the experimental design. Girth measurements were made after completion of 2 years. Leaf and soil samples were also collected and analysis of leaf samples were completed (A Dissanayake, T Dissanayake, Peter Perera, C Maheepala and C Jayalath).

Experiment P/IM/93-02

The experiment started at Vogan Estate to study the possibility of using both Eppawela and imported rock phosphates was continued. Fertilizer treatments were applied at the beginning of 3rd year in September, 1994.

Girth measurements made after completion of 3 years showed that there is no significant difference between fertilizer treatments. Leaf and soil samples also collected and chemical analysis of leaf samples were completed (A Dissanayake, T Dissanayake and Peter Perera).

5.4 *Mature rubber*

5.4.1 *Residual effect of added rock phosphates*

This experiment (P/M/76) was continued for a further period of one year. Assessments of yield were done but not regularly due to interference by rain. Soil and leaf samples were collected. No P fertilizer was applied during this year also. But, uniform application of N,K and Mg fertilizers were made. Chemical analyses of leaf samples were completed (A Dissanayake, T Dissanayake and Peter Perera and C Maheepala).

5.4.2 *Evaluation of clonal differences in rock phosphate utilization*

The experiment (P/M/93) on clonal effects during the mature phase on P utilization was continued at Sorana, Perth,and Clyde estates. Fertilizers were applied according to the experimental treatments. Yield, assessments were made. Soil and leaf samples were collected. Chemical analysis of leaf samples were completed (A Dissanayake, T Dissanayake and Peter Perera).

5.5 *Agronomic practices to increase the availability of P from ERP*

5.5.1 *Mulching and liming*

The experiment (P/Ag/93) started at Culloden Estate to study the effect of different agronomic practices on availability of P from ERP was continued. Fertilizer treatments were applied according to the experimental design. Rice straw and lime were also applied around the base of the rubber trees. Girth measurements were made at the age of 2 years. Soil and leaf samples were also collected at this stage (A Dissanayake, L Samarappuli, T Dissanayake and Peter Perera).

5.5.2 *ERP with coir dust*

This experiment started to study the effect of coir dust on dissolution of ERP and its uptake by poly bagged rubber plants was terminated due to the death of large number of rubber plants for unknown reasons. However, arrangements will be made to repeat the experiment in the year 1996 (A Dissanayake, T Dissanayake, C Maheepala and C Jayalath).

5.5.3 *Use of rubber factory effluent*

The effect of rubber factory effluent on the solubility of grades of P fertilizers from Eppawela was evaluated in a simple laboratory experiment.

Initially, solubility of high phosphate Eppawela rock phosphate (HERP) and partially acidulated ERP (PAERP) was significantly higher ($P<0.05$) than that of other fertilizers. But, solubilities of all the Eppawela fertilizers increased after 8-10 days of treatment with rubber factory effluent. Nevertheless, it appears that their rates of solubility were decreasing with the increase in the time of reaction with effluent (Table 51). The citric acid solubility of HERP was significantly higher ($P<0.001$) than that of other fertilizers. The highest values for solubility for HERP, PAERP and selectively mixed ERP (SERP) was observed at the 10th day of the experiment. But, it required more time for commercially available rock phosphate (CERP) to reach the maximum solubility than the other P fertilizers from Eppawela (Fig. 5).

Table 51. *Effect of rubber factory effluent on the citric acid solubility (%) of rock phosphates*

Fertilizers	Time (Days)							
	0	2	4	6	8	10	12	14
CERP	1.88^{b}	1.68^{b}	1.86^{a}	1.88^{b}	2.14^{b}	2.35^{b}	2.48^{b}	2.31^{b}
HERP	2.22^{a}	2.14^{a}	2.04^{a}	2.01^{a}	3.06^{a}	3.11^{a}	2.96^{a}	2.80^{a}
SERP	1.75^{c}	1.53^{c}	2.04^{a}	1.57^{c}	2.26^{b}	2.52^{b}	2.28^{b}	2.13^{c}
RAERP	2.24^{a}	1.56^{c}	1.52^{a}	1.59^{c}	2.14^{b}	2.30^{b}	2.01^{c}	2.07^{c}

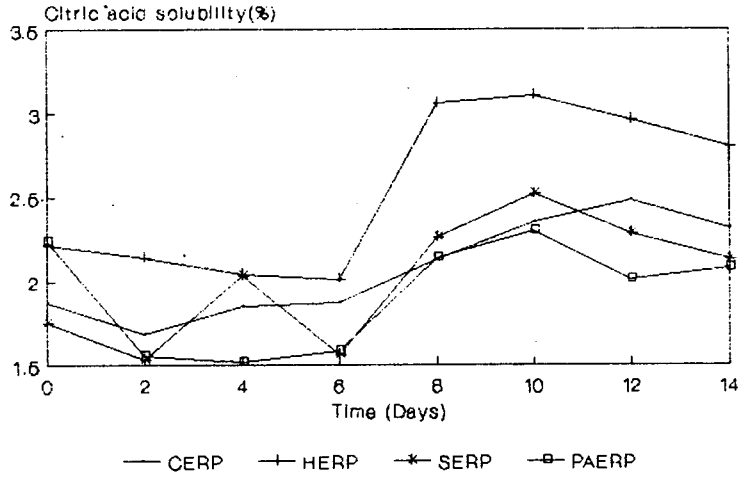


Fig. 5 Effect of rubber factory effluent on the solubility of rock phosphates

5.6 *Suitability of ERP to cover crops:*

Mycorrhizal aspect

i. Pueraria plants were raised in Boralu series soils to study the effect of mychorrizae on dissolutions of Eppawela rock phosphate and on the uptake of phosphorus. The growth of the plants were poor irrespective of the treatments. Plants were harvested and separated into shoots and roots. Dry matter yield were recorded and number of root nodules were counted. Chemical analysis of plant samples were completed (A Dissanayake, T Dissanayake, C Jayalath and C Maheepala).

ii. A new experiment was started to study the effect of mycorrizae on the efficiency of P uptake from Eppawela rock phosphate by rubber plants grown in poly bags. The effect of rubber factory effluent on dissolution of ERP will also be evaluated

in this experiment (A Dissanayake, R Jayaratne, T Dissanayake, C Jayalath and C Maheepala).

6. Nutrient requirement of new clones

The field experiment at Lagos Division, Payagala estate was continued for the 3rd year to evaluate the nutrient requirements of vigorously growing high yielding clones. There were significant differences among levels of fertilizers ($P < 0.001$) and among clones ($P < 0.01$). However, no significant difference was observed in clone x fertilizer level interaction. Application of fertilizer significantly increased the girth when compared to the no fertilizer control (Table 52). Increasing the fertilizer level from ½ the currently recommended level to currently recommended level increased the girth significantly. Further increase up to 1½ times the currently recommended level did not show significant increase in girth. Girthing of PB 260 and RRIC 110 were significantly higher than that of clones RRIC 121, RRIM 712 and 74-193 (Table 53) (R S Dharmakeerthi, S N Silva, A Yakandawela and D Senaratne).

7. Chemical Analysis

Routine chemical analysis of soil, leaf, latex and fertilizer samples collected for experimental and advisory purposes were carried out. Samples from other Departments and Organizations were also analysed (L Samarappuli, A M A Perera and V Edirimanne).

Table 52. *Effect of fertilizer on girth of clones RRIC 121, RRIC 110, PB 260, 74-193 and RRIM 712 after 3 years of planting*

Treatment	Mean girth (cm)
Control (no fertilizer)	18.62
½ Current recommendation	24.36***
Current recommendation	26.31***
1½ current recommendation	27.68***
LSD	1.428

Table 53. *Clonal difference on girthing after 3 years planting*

Clone	Girth (cm)
PB 260	25.91[a]
RRIC 110	25.32[ab]
RRIC 121	23.96[bc]
RRIM 712	23.08[c]
74-193	22.95[c]

8. Adaptive Research Programme

8.1 *Effectiveness of bush/tree legumes*

Experiments were started to compare the effectiveness of growing bush/tree legumes with the current practice of growing creeping legumes on soil and moisture conservation in smallholdings in Kalutara and Kegalle Districts (L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

8.2 *Use of poultry manure*

Use of poultry manure as a substitute for inorganic fertilizer in immature and mature rubber smallholdings is also being studied under Adaptive Research Programme (L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

8.3 *Mulching with rice straw*

A new set of experiments was started to evaluate the effectiveness of mulching with rice straw in smallholdings (L Samarappuli, F P W Silva, W C Dayaratne and E A T Senadeera).

8.4 *Use of* Vetiver *grass*

A site was selected to grow *Vetiver* grass as hedges in inter row area as a substitution for drains and stone terraces (L Samarappuli, W C Dayaratne and E A T Senadeera).

8.5 *Evaluation of ERP*

A new set of experiments was started in smallholdings to evaluate the effectiveness of ERP and IRP mixture (50:50) on the performance of immature rubber (A Dissanayake and F P W Silva).

Experimental details and results of the above experiments are discussed in the Review of the Adaptive Research Unit.

BIOCHEMISTRY AND PLANT PHYSIOLOGY

N Yogaratnam

SUMMARY

Studies on the effectiveness of biological systems in the treatment of rubber factory effluent, the effectiveness of rubber factory effluent as a source of nutrients to mature rubber and the influence of soil/plant nutritional status on the incidence of tapping panel dryness have been the main research programmes of this department.

DETAILED REVIEW

Staff

Mrs Neelamanie Yapa, Asst. Biochemist resigned from the services of the Institute with effect from 03.04.1995. Mr M T Warnakula, Asst. Biochemist returned to the department from Australia on 20.06.1995. Mr D Ramawickrema and Miss S Kudaligama, Technical Officers were transferred back to the department. Mr P D J Rodrigo, Specification Assistant was on duty throughout the year. Mr W A Themis Laboratory Attendant retired from duty with effect from 04.01.1995.

LABORATORY AND FIELD EXPERIMENTS

Effluent utilization

Rubber factory effluent (serum) is known to be rich in several important nutrients. The nutrients that are likely to be added to the soil by the effluent under Sri Lankan conditions are Nitrogen - 217 Phosphorous - 224, Potassium - 258, Magnesium - 127, Calcium - 29 and Sodium - 35, metric tons/year. When used as a source of nutrients to plants, it can also help in minimizing environmental pollution. This study is therefore in progress at Culloden Estate, Neboda to investigate the effectiveness of rubber factory effluent as a source of nutrients to rubber with special reference to N,P and K. This is being conducted in an area of about 6 acres on clone PB 86 in 1986 replanting. Following treatments are being tested:

Treatments:

T_1 : Normal fertilizer mixture (12:14:14) recommended for mature rubber
T_2 : Half the normal fertilizer + 1:1 diluted serum
T_3 : 1:1 diluted serum
T_4 : Undiluted serum
T_5 : Control (water)

The analyses that were done are; Latex yield per tree and DRC per 50 ml of latex, soil pH, moisture contents and N,P,K,Mg and Ca contents of soil and leaf samples (Neelamanie Yapa, S Dharmakeerthi, N Yogaratnam, M D C Seneviratne and P D J Rodrigo).

Tapping panel dryness

Studies were in progress at Eladuwa Estate on the incidence of tapping panel dryness in relation to Soil/Plant nutritional status of mature rubber using a complete randomized design. One hundred and forty trees of clone RRIC 100 which were affected by brown bast were selected and twenty healthy trees from the same location were also selected for comparison.

Treatments:

T_1 : Control (no fertilizer application)
T_2 : 800 g of appropriate N,P,K mixture/plant/year + 150 g of kieserite
T_3 : 1200 g of appropriate N,P,K mixture/plant/year + 150 g of kieserite
T_4 : 1600 of appropriate N,P,K mixture/plant/year + 150 g of kieserite
T_5 : 2400 g of appropriate N,P,K mixture/plant/year + 150 g of kieserite
T_6 : 1:1 diluted serum, weekly, 2 gallons/application

The assessments that were done are; Leaf analysis for N,P,K,Mg and Ca Dry rubber content in latex, Latex bark and leaf analysis for proline, sugars and sugar alcohols, Density of active latex vessels in the bark and trunk girth (Neelamanie Yapa, A Nugawela, M D C Seneviratne, S Kudaligama and D Ramawickrema).

Effluent treatment

A new research scale model of an effluent treatment plant was installed at Dartonfield to study the effectiveness of biological process in the treatment of rubber factory effluent. A new method, aerating bio - brush system was used in this process.

The analytical tests that were done on the biologically treated serum are: COD, BOD, Total N, suspended solid content, volatile suspended solid content, K,P, Ca and Mg content (M T Warnakula, S Kudaligama, P D J Rodrigo and D Ramawickrema).

RUBBER TECHNOLOGY AND DEVELOPMENT

N M V Kalyani Liyanage

SUMMARY

Work on latex bitumen emulsions indicated that stability characteristics of latex bitumen blends containing colloidal stabilizers were very high. However, the method of incorporation of latex with colloidal stabilizers to bitumen emulsions was also found to be important.

A paper binding adhesive with good adhesive properties was developed at the request of Sarvodaya Economic Enterprises. A heat sensitive adhesive which could be used for garment stickers was also developed.

Work on Radiation prevulcanisation of NR latex was continued. Factors which would contribute to the inferior technological properties of irradiated latex were looked into.

Effects of the method of dilution on the technological properties of epoxidised natural rubber were investigated.

A factory scale trial on the use of oil-extended natural rubber in tyre retreading industry was conducted with the assistance of Associated Motorways Limited.

Preliminary discussions were held with a leading Retreader in the country on the possible commercial implementation of new latex - based cement.

A research project was commenced to evaluate the effects of intensity of smoking on the cure characteristics of sheet rubber.

DETAILED REVIEW

Staff

Dr. (Mrs) N M V Kalyani Liyanage, Head, Rubber Technology and Development Department; Mrs Madhupani Jayasuriya, Assistant Rubber Chemist; Mrs Manel Mahanama, Senior Technical Officer; Mr K M U Mithrananda and Mrs Sriyani Yapa, Technical Officers were on duty throughout the year.

Research students

Miss M S Bandara, NDT student and Mrs Anoma Ratnayake, MSc student, University of Sri Jayawardenepura, were trained under various research projects.

Meetings, seminars and lectures

Dr (Mrs) N M V Kalyani Liyanage[1] and Mrs Madhupani Jayasuriya[2] participated in the following:

* Progress Control meeting of the Road Development Authority to discuss the latex/bitumen project[1,2]

* Central Scientific Committee meetings of the RRI[1].

* Committee meeting of "Working group in Tyres" held at the Sri Lanka Standards Institution[1]

* Committee meetings of "Working group on Bicycle Tyres" held at the Sri Lanka Standards Institution[1]

* Committee meeting of the "Polymers and Polymer products" held at the Sri Lanka Standards Institution[1].

* Committee meetings of the Sri Lankan group on "Radiation Prevulcanisation of Natural Rubber Latex" held at the Atomic Energy Authority[1]

* Work shop on "Rubber based adhesives" organized by the Industrial Development Board[1,2]

* The Diploma course in Rubber Technology organized by the Plastics and Rubber Institute and the MSc course in Polymer Science & Technology conducted by the Sri Jayawardenapura University[1]

* Practical assessments for the students of National Diploma in Technology of the University of Moratuwa[1]

* A seminar on "Chemical Sciences for Utilization of renewable resources" held at the SLAAS auditorium[1]

* Factory visit and a discussion with Officers of D Samson Industries[1]

LABORATORY INVESTIGATION

1. Latex Technology

1.1 *Latex bitumen emulsions in road construction*

A set of laboratory trials were carried out to improve the stability of latex bitumen blends by using some inorganic salts and colloidal stabilizers. It was evident that inorganic salts and colloidal stabilizers are not only capable of improving the stability of latex bitumen blends but also in improving the physical properties such as softening point, productivity and penetration of the resultant blends. However, as expected, colloidal stabilizers were found to impart much higher stability.

A few plant trials were conducted at the emulsion plant of Road construction and Development Company by using positex modified either with an inorganic salt or with a colloidal stabilizer. It was noted that the method of incorporation of latex into bitumen emulsion is a very important factor to be taken into consideration since it affects the stability and the physical properties especially penetration values of the bitumen emulsion. A sand sealing of a road surface was carried out in small sale at Maharagama by using a positex modified with a colloidal stabilizer and its performance is under observation (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Manel Mahanama and Sriyani I Yapa).

1.2 *Paper binding adhesives*

Several trials have been carried out to develop a stable adhesive compound for paper binding at the request of Sarvodaya Economic Enterprises. An adhesive compound of high bond strength has been developed (N M V Kalyani Liyanage and M M Jayasuriya).

1.3 *Heat sensitive adhesive for garment stickers*

Preliminary trials have been carried out to develop a NR latex based adhesive to replace a synthetic rubber based adhesive known as a "hot melt" used in garment stickers. A stable latex compound with much higher bond strength has been developed. However, further trials are to be done to improve the handling properties (N M V Kalyani Liyanage, Madhupani M Jayasuriya and Manel Mahanama).

1.4 *Radiation prevulcanization*

Few batches of special types of LA centrifuged latex were prepared at Dartonfield. Some of them were prevulcanized using the irradiation facility at the Eye bank. Technical properties of the irradiated samples were found to be inferior to those of sulphur prevulcanized films. It was evident that this is the cause of improper incorporation of sensitiser *i.e.* n-BA into the latex. A new set of trials were performed by giving due consideration to the method of incorporation of the sensitiser. Technical properties of the resultant latices are being studied (N M V Kalyani Liyanage, Manel Mahanama, S Gajanayake (MSc Student, University of Jayawardenapura, S S Kulathunga (Atomic Energy Authority).

1.5 *Pink discoloration of latex form*

A request was made by Mal Lanka Ltd., to analyze a pink discoloration occurred in their foam product. Solubility tests and FTIR analysis indicated that the discoloration was due to blooming of a phenolic antioxidant and a remedial measure was recommended (N M V Kalyani Liyanage, Pushpa Goonatilaka and Sriyani Yapa).

2. Dry rubber technology

2.1 *Epoxidised natural rubber*

A few types of epoxidised natural rubber (ENR) were prepared by varying the extent of dilution of latex. These ENR types were used in preparing ENR/NR blends. ENR/NR blends were then compounded according to a tyre tread formula and the physical properties of the vulcanizates were evaluated. It was evident that the extent of dilution of latex prior to epoxidation reaction, has no significant effect on physical properties such as hardness, abrasion resistance, resilience, and compression set. How ever, the effect of dilution of latex on resilience was found to be some what significant. The method of coagulation of ENR latex was found to affect the compression set of vulcanisates to a greater extent (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Sriyani Yapa, Manel Mahanama and K M U Mithrananda).

2.2 *Oil extended natural rubber*

More compounds based on rubber seed oil (RSO) and Natural Rubber Processing Oil (PO) were prepared. In both cases, oil extension was carried out in the latex stage. Rheological and technological properties of both types of compounds were evaluated. Significant improvements in certain properties such as resilience and abrasion resistance have been observed.

A factory scale trial was also conducted by using both RSO & PO based compounds prepared at the University of Moratuwa. Preparation of retreads were done at the Associated Motorways Ltd. The wear performance of the retreads so prepared is being evaluated (N M V Kalyani Liyanage, Madhupani Jayasuriya, Manel Mahanama and Anoma Ratnayake (MSc Student, University of Sri Jayawardenapura)

2.3 *Latex based cement for tyre retreading industry*

Preliminary discussions were held with a leading tyre retreader in the country to investigate the applicability of the latex based cement commercially as a replacement for currently used solvent based cement (N M V Kalyani Liyanage, Manel Mahanama and S Weeraman).

2.4 *Cure behaviour of sheet rubber*

A research project was commenced to evaluate the effect of intensity of smoking on the cure characteristic of gum compounds of sheet rubber which were prepared by drying in sunlight or smoke house and by varying the intensity of smoking process. Cure characteristics of the gum compounds of RSS were studied by Brabender Plasticorder as well as by Monsanto Rheometer. It was evident that smoked RSS sheets cured at a much faster rate than unsmoked sheet and crepe grades at low curing temperatures and this may be due to the presence of phenolic creosotic substances and volatile aldehydes which are deposited on sheet during smoking process. A paper titled as "Effects of intensity of smoking on rate of cure of RSS rubber" will be published in the near future (L M K Tillekeratne, Madhupani M Jayasuriya, Manel Mahanama, K M U Mithrananda and Sriyani I Yapa).

Industrial extension

The following industrialists obtained the services of this Department in product development and testing:

Lanka tyre Retreaders	Testing of tread and cushion gum compounds
Midland Retreads (Pvt.) Ltd.	Testing of tread compounds
Kandy Tyre House (Pvt.) Ltd.	Testing of antioxidants
Sri Lanka Standards Institution	Testing of garden hoses
Road Development Authority	Testing of latex/bitumen emulsions
Ceyesta	Testing of latex and chemical dispersions
Associated Motorways Ltd.	Testing of tread compounds
Mal Lanka	Testing of rubber chemicals
Central Industries	Testing of PVC compounds
Plymouth Industries	Testing of shoe soles
Microcells	Testing of rubber compounds

POLYMER CHEMISTRY

K G Karnika de Silva

SUMMARY

Two types of membranes based on natural rubber and coir dust and coir dust and natural rubber latex to affect slow release action of fertilizers to soil in the presence of water was developed in collaboration with the Soils and Plant Nutrition Department. Further work is being done by testing them in the field with the appropriate to dosage of fertilizers necessary for plant nurseries and mature rubber plantations.

Another development is the introduction of water proofing membranes based on bitumen and natural rubber latex for water tanks and concrete slabs. The same sealant can be used to produce self adhesive type rain guard sealant to fix polythene to rubber trees as rain guards.

A new formulation for wood-filling applications developed in the department has been commercially implemented by Sinwa Holdings (Pvt) Ltd, during this year.

Latex proteins in rubber products from various industries were analyzed using Bradford Assay.

Experiments on adhesives, sealants, NR/NBR blends with compatibilizers, epoxidised natural rubber, cyclised rubber, positex, superior processing rubbers, MG rubber and CV rubbers were conducted and samples were handed over to the requested parties. Studies on gel content on storage, blooming, elastomer analysis, PVC/PU blends were conducted throughout the year.

Fabrication of pilot plant for the manufacture of speciality grades of natural rubber was completed. This will be used to conduct research and development work and manufacture speciality grades of natural rubber in semi commercial scale. The funds required for the fabrication work has been granted by the Council for Agricultural Research Policy, CARP.

A lot of attention has been paid to solve industrial trouble shooting during this year. These include discolouration of examination gloves, blooming in shoe soles and finished rubber products rubber-metals sealants, ply separation in rollers out of nitrile rubber.

DETAILED REVIEW

Staff

Dr K G Karnika de Silva, Head of the Polymer Chemistry Department was on duty throughout the year. She was promoted to the Principal Research Officer grade with effect from March 1995. Dr Pushpa Goonetilleke, Rubber Chemist was on duty throughout the year. Mr S M C E Silva, Assistant Rubber Chemist continued his post graduate studies at the University of North London, UK.

Mrs Indra Denawaka, Experimental Officer; Mr S S Warnapura, Senior Technical Officer and Miss Medhavi Wijesekera, Technical Officer were on duty throughout the year.

Mr H N K K Chandralal, Experimental Officer was on no pay leave in Saudi Arabia until November' 95 which was extended by the Rubber Research Board until November' 96 at his request.

Mrs Chitra Kuruppu left for India in December' 95 on a party funded IRRDB training at RRI, India.

Mr S L G Ranjith, Technical Officer left for Saudi Arabia on no-pay leave in September' 95.

Mr L P Vitharana, Technical Officer was transferred to Dartonfield on his request and Mr S M A Samarakoon was transferred to Polymer Chemistry Department on mutual agreement.

Mrs Renuka Wijayaratna, Clerk/Typist was on duty throughout the year.

Messrs S Weerasiri, P R Sigera, Laboratory Attendants and Messrs L L Piyasena and W D S Dharmawardene, Laboratory Labourers were on duty throughout the year. Mr J Dayaratne Laboratory Labourer was temporarily transferred to the Raw Rubber and Chemical Analysis Department.

Visits

Dr Karnika de Silva visited Penang, Malaysia from 31st October - 9th November to present a paper at the follow up workshop on NR Blends. This visit was sponsored by the IRRDB UK, INRO and CFC.

Dr Karnika de Silva visited Nakiadeniya Estate. Hanwella Rubber Products and Lankem Developments on advisory visits.

Dr Pushpa Goonetilleke visited Ceylon Sports Wear (Pvt) Ltd to solve a blooming problem.

Seminars, Meetings programmes and workshops

Dr Karnika de silva participated in the following:

* Central Scientific Committee meetings. Dr Pushpa Goonetilleke also participated.

* Workshop on adhesives at Galadari Hotel organized by IDB and served as a lecturer.

* Seminar on recycled waste at the University of Colombo.

* Seminar af current developments in Rubber at Hotel Taj organised by PRI. Dr Pushpa Goonetilleke also participated.

*. Meeting at Hotel Taj with Investor's Commission.

* Meeting at Tourist Board on R/D activities at RRISL on a request by Dhoordharshan TV, India.

* Served as a member of drafting committee for Standards of PP sacks at SLSI.

* Children's radio programme on R/D activities.

* Seminar on rubber plantations and processing at Sugathadasa Auditorium.

* Seminar organised by the EDB on markets for rubber in USA and Europe at Export Trade Centre.

* Served as a lecturer at the University of colombo and delivered lecturers on industrial polymers

* Served as a moderator for Kotalawala Defence Academy. Dr Pushpa Goonetilleke also served as a moderator, for Kotalawela Defence Academy.

* Meeting with officials of small and medium scale Industrial Development Authority. Dr Pushpa Goonetilleke also participated.

* Seminar on Blooming and Nitrosoamine in Rubber Products organised by Polysar (Malaysia) held in Kuala Lumpur, Malaysia.

* Work shop held on NR blends, held in penang, Malaysia and presented a paper on NR\NBR blends with compatibilizers.

* Dr Pushpa Goonetilleke served as a visiting lecturer at the University of Colombo for the MSc course in Analytical Chemistry. In addition to some of the meetings and programmes listed above.

* In addition the Institute staff assisted two international schools and two government schools to hold science exhibitions.

Messers Thusitha Kariyawasam, Piyal Wickramasinghe from the University of Sri Jayawardenepura and Miss Swarna Perera and Miss Manel Gunaratne NDT students were trained in the department.

1. Blends with NR

A. *NR/NBR Blends*

Trials have been conducted to explore the suitability of using NR/NBR blends with compatibilizers such as chloroprene rubber for the manufacture of bottle holders used in the bottling plant at the coco-cola company. These holders are used in the final stage in picking up bottles with metal caps for packaging and they need good compression set, flexibility, high tear strength and hardness. The properties have shown acceptable results but need further improvements.

A few printing rollers used in textile and printing industries have been turned out with NR/NBR blends. Since these rollers are subjected to frequent washings with Kerosene oil rollers out of NR alone make the rollers swell in Kerosene oil. Rollers out of NBR alone make them harder which is not a good property for printing rollers. The blends have shown good results and a few companies such as polymer products, Richard Peiris and Companies and IDB have been requested to implement the project and transfer the technology to the industry. IDB has recommended NR/NBR blends in steering couplings to overcome the problem of ply separation (K G Karnika de Silva and S S Warnapura).

B. *NR/Grafted rubber blends*

NR/MG rubber blends have also been tried out in the manufacture of bottle holders mentioned in (A). These have shown improved transparency and high tear strength when compared to NR/NBR blends.

NR/MG rubber blends were also used in the manufacture of roller squeegees used in screen/printing industry. The customer has accepted the properties of the rollers turned out of NR/MG blends and a semi-commercial scale production of MG rubber will be carried out using the pilot plant at DF in January next year (K G Karnika de Silva, S S Warnapura, Chitra Kuruppu and S M Samarakoon).

C. *Polymer/PVC blends*

This project was continued throughout the 1st quarter of the year and following investigations were carried out.

a. It was observed that the calibration curve for MDI, depends on the type of PVC. Therefore, experiments were carried out to obtain separate calibration curves for each PVC type available.

b. Effect of Stoichiometric imbalance (presence of excess polycaprolactonediol) was investigated.

c. To study the effect on PVC on the PU/formation kinetics, an investigation was carried out by replacing PVC powder in the mix with powder which can be treated as an inert filler. This project is being continued at the University of North London, UK (M S M Alger, and Laleen Karunanayaka).

D. *NR/Polypropylene blends - Thermoplastic Natural Rubber (TPNR)*

This project had been adversely affected due to the current high prices of rubbers in the local market. The manufacture of TPNR coagulating pans has led to making plastic pans out of only recycled polypropylene and even though the properties of these pans are inferior to TPNR pans the small holders find it difficult to identify them. Since it is convenient and economical to produce plastic pans, even though the properties are not upto the standards, the main manufacturer prefers to turn out pans out of recycled polypropylene alone. As a result only a limited number of pans out TPNR has been distributed during this quarter.

Possibilities of turning out crates out of TPNR to export perishables have been studied. CISIR, Phoenix Co. Ltd. and Department of Perennial Crops have been involved in this study. A report on this has been submitted to the appropriate authorities (K G Karnika de Silva, S S Warnapura and S L G Ranjith).

2. Discolouration of gloves

Hanwella rubber products limited have experienced an orangish discolouration of about 50% of the manufactured gloves on storage. RRISL assistance was requested to overcome this problem.

A visit to the factory was made and it was observed that there are possibilities of iron contamination due to some corrosion in metal parts in the plant. The gloves and water used in the production line were analysed for iron content in the elemental analyzer which were found to be a little higher than the normal. Also the sludge remaining in the leaching tank found to contain a higher percentage of iron. Use of higher percentage of antioxidant was also recommended as a precaution against this problem.

A comprehensive report has been submitted on this matter and further assistance will be given to them to overcome this problem completely (K G Karnika de Silva and N M V Kalyani Liyanage).

3. Slow release fertilizer

The experiments conducted during the past quarter has shown effective release of 60% of the fertilizers within the first three months, to the soil. Out of the nutrients from the two types matrix device (based on coir dust and natural rubber latex) and reservoir device (microcellular network based on dry rubber-ball type), the matrix device was find to have a faster releasing effect than the reservoir device.

The experiments were conducted in both soil and water media and the rates were calculated based on different variables. Further work on the project is in progress (K G Karnika de Silva, Lalani Samarappuli, Medhavi Wijesekera, and T Kariawasam (MSc student).

4. Cyclised rubber as a reinforcing filler

During the first quarter, cyclised rubber (CR) samples were prepared for some trials to be conducted at Elastometric Engineering Company in shoe soles as a reinforcing filler. The results were not reported. A MSc research project has been started in the second quarter to investigate the reinforcing action in CR in place of high styrene resin (HSR). HSR and CR were blended with RSS in various proportions and compounded using formulation for shoe soles. Cyclised rubber compound shows

superior physical properties at the optimum concentration of 40% in comparison to HSR as a reinforcing filler. The physical properties of CR powder were also determined. The particle size of CR as determined by the Anderson-Pipette method at Ceramics Research and Development Centre is 20 microns which is very small compared to other fillers (Pushpa Goonetilleke, Piyal Wickramasinghe, (MSc student) L P Vitharana and Indra Denawaka).

5. Epoxidised Natural Rubber (ENR)

ENR 25 and 50 prepared using DRC latex were characterised by FTIR and NMR. Physical properties such as mooney viscosity, gel content and colour of the dry rubber were determined. ENR was compounded using a semi EV formulation and oil resistance, abrasion resistance, tear strength, compression set and rebound resilience were evaluated.

ENR exhibits higher abrasion and oil resistance, lower compression and re - bound resilience as compared to NBR vulcanizates. Use of ENR in footwear adhesives has also been looked into. The gum adhesives were prepared by resolving the ENR and RSS in a mixture of MEK and Toluene. The adhesives were applied to paste rubber to rubber, rubber to PVC and rubber to cotton. The evaluation of peel strength is underway (Pushpa Goonetilleke, Swarna Perera (NDT student) and L P Vitharana).

6. a. *Water proofing Membranes*

A new self adhesive type membrane based on natural rubber and bitumen has been developed to be used on concrete slabs and water tanks.

These products developed by us have been tested by Lankem and System Contractors and Engineering (Pvt) Ltd and found to be comparable to the costly imported product from the middle east.

The process will be patented before giving the technical know how to interested parties (K G Karnika de Silva, Chitra Kuruppu and S M A Samarakoon).

b. *Positex/Bitumen for water proofing*

Positex/bitumen samples were supplied to TRI to apply on pruned tea bushes for water proofing. Same samples were given to a firm which undertake water proofing applications. The performance of the material was reported to be promising and more samples have been requested (Pushpa Goonetilleke, Chitra Kuruppu, S L G Ranjith).

7. Constant Viscosity Rubber (CV Rubber)

Several samples of CV rubber were prepared by the latex in which hydroxyl amine neutral sulphate is added to the latex. Drying time was corrected after several trials to minimize over drying problem. Analysis of samples included measurement of V in comparison to a CV rubber sample obtained from C W Mackies. However, their CV 60 rubber sample was with higher mooney viscosity and higher v than the sample (CV 60) prepared by our method (Pushpa Goonetilleke and Chitra Kuruppu).

8. Adhesives

a). Adhesives based on depolymerized rubber and acrylics were tested on cellophane films used in different industries such as in textile and tea packaging bags. The imported materials based on acrylics seem to form separate layers when stored for longer periods causing problems in film properties and the high cost of the material have been found to be disadvantageous.

b) Acrylic based materials including methymethacrylate grafted latex have been tested as suitable adhesives for cellophane. Depolymerized latex with acrylic blends were also tested. Trials have not been successful so far due to poor strength between the two surfaces (K G Karnika de Silva and S S Warnapura).

9. Effect of gel content on prevulcanisation of latex during storage

a. *Study of variations of gel content with storage*

The property variations of centrifuged latex during storage is a problem which is not yet solved in the latex product industry. In order to explore the possibilities of controlling these changes occurring in the latex concentrate, LATZ samples obtained from Vincit Estate, Waharaka were stored for five to six months during which the gel content, viscosity and film properties were evaluated after storage. The changes that had been occurred in the latex will be monitored by taking IR spectras of each latex film (Pushpa Gonnetilleke and Indra Denawaka).

b. ***Study of variations of gel content in latex***

Data has been collected over a period of one year to investigate the seasonal effect on gel content in centrifuged latex. The results show that gel content follows an irregular pattern of change depending on the season (Pushpa Goonetilleke and S L G Ranjith).

10. Blooming in rubber products

a. ***In rubber rings***

VorWerk and Sons Asia (Pvt) Ltd has requested RRISL to analyze blooms appear on bead surfaces and solid tyres produce in the factory. The blooms were identified as true blooms and spot tests were carried out to see if the bloom contained free sulphur. The bloom was scraped and subjected to FTIR analysis. The presence of zinc stearates was identified. The formulation used in compounding contained higher percentage of ZnO and recommendations were made to adjust the formulations to avoid any blooming on surface due to chemicals (K G Karnika de Silva and Indra Denawaka).

b. ***In rubber shoe soles***

An analysis was carried out to identify a bloom which appeared on shoe soles and of a boot as requested by Ceylon Sports Wear Manufacturers. The bloom which appeared on the surface after sending to UK were not soluble in any solvent and were difficult to separate to identification. Hence different compounding formulations were suggested to rectify the problem and some compounds have been prepared in our laboratories as well. Further investigations are underway (Pushpa Goonetilleke and Indra Denawaka).

11. Use of waste materials in product manufacture

Waste materials such as saw dust, glove and foam rubber waste and buffing dust have been used in NR formulations to turn out useful materials such as partitioning boards, safety mats for children's playgrounds, tiles *etc.*

Further improvements on this project are underway (K G Karnika de Silva, Indra Denawaka, S S Warnapura, Medhavi Wijesekera and Manel Gunaratne (NDT student).

Industrial Extensions

Mal Lanka	Recycling of foam rubber
Sinwa Holdings	Wood fillers, Adhesives, Solvent extractions
IDB	TPNR, Speciality Rubbers, NR/Blends, NR Rubbers
Korea Ceylon Footwear	Bloom Analysis
AMW	Toxicity Analysis of seals
Hanwella Rubber Products	Latex Stability Discolouration of Gloves
Vorwerk Asia (Pvt) Ltd Dipped Products, Textrip (Pvt) Ltd Lankem	Bloom Analysis Latex protein Analysis Water proofing membrane
Lalan Rubbers	Analysis of latex protein in rubber products
Associated Speciality Rubbers	SP Rubber
Associated Polymers & Allied Products	SP Rubber
Hemas Drugs	Analysis of toothpaste of FTIR
System Contractors & Engineers (Pvt) Ltd	Water proofing membranes
TRI	Water proofing latex based sealants
Associated Components	Chalk mould, Adhesives
Eastern Merchants	SP Rubber

RAW RUBBER AND CHEMICAL ANALYSIS

L M K Tillekeratne

SUMMARY

This department was engaged in the following activities during the year:

a. Analysis, grading and issuing shipping certificates for all TSR produced in the country.

b. Analysis and issuing quality certificates for sheet and crepe rubber.

c. Analysis and certification of concentrated latex manufactured in the country for local industries and for exports.

d. Analysis of chemicals and water used in the NR industry.

e. Testing of finished products such as absence of SPP in rubber gloves, and rubber content in vulcanized products for export.

f. Analysis and certification of master batch and reclaimed rubber for export.

g. Participation in Round robin crosscheck for regional laboratories conducted by the Rubber Research Institute of Malaysia.

h. Organizing demonstrations on preparation of rain guard sealant for RDOs of the Rubber Development department and smallholders.

i. Assistance was rendered to other departments in their research and extension work by analysing dry rubber, latex, chemicals and water samples.

j. The following research projects were in progress:

* Development of sealant for rainguards.
* Evaluating the raw rubber and latex properties of currently recommend clones.
* Effect of intensity of smoking on cure rate of RSS rubber.

* Use of solar energy for drying rubber.
* Alternate by products for coagulation of rubber.
* Use of Nutmeg skin extract for coagulation of sheet rubber.
* Use of coconut water for coagulation of sheet and crepe rubber.

k. Solved the problems of skim adulteration for local companies and RMIT polymer technology center, Australia.

DETAILED REVIEW

Staff

Dr L M K Tillekeratne, Director, overlooked the work of this Department. Mr L Karunanayake, Assistant Specifications Officer proceeded to UK on 20th September 1995 to continue his post graduate training at the University of North London. Mrs Anoma Silva, Assistant Rubber Chemist, left for the University of Loughborough UK for her post graduate training on 28th October 1994.

Mrs Sriyanthi Weeraman, Experimental Officer and Mrs Leela Wanigatunga, Senior Technical Officer were on duty throughout the year.

Technical Officers, Mrs Nanda Baduge, Mrs Vasantha Gamage, Mr R S Wijesundara, Mrs Geethani Rajapakse, Mr Gamini Wanigatunga, Mr Lional Perera and Instrument Technician Mr P Lelwala were on duty throughout the year.

Mrs C Lokuge, Technical Officer, left for Malaysia for a period of 2 years on no-pay leave, commencing 4th August, 1994.

Specifications Assistants, Messrs B Gunasiri, K R N Karunatilleke, Wimaladasa Vithanage and Sarath Chandrasiri were on duty throughout the year.

Mr Mahesh Gamage, was on duty as a temporary Specifications Assistant with effect from 12th April 1995 and was confirmed in the post with effect from 1st November 1995.

Mrs Indranie Wijesinghe, Clerk/Typist, was on duty throughout the year.

Mr Sirisena Gallage, the Laboratory Attendant and Messrs G H Somasiri and J A Dayaratne, Laboratory Labourers were on duty throughout the year.

Workshop

Mr P L Perera attend a 2 weeks workshop on the repair of scientific instruments organized by the University of Peradeniya.

Training

The following Officers were trained on latex and raw rubber testing:

Delan Industries	- Miss N W Veena
	- Miss Nimal Kanthi
	- Mr R Wickremaratne
Ansell Lanka (Pvt) Ltd.	- Miss N A N R K Senaratne
Kegalle Plantation	- Miss Shamali Jayathilaka
	- Miss Dhammika Illankoon
	- Mr M T S Krishntha
Vandale Estate	- Mr G U Upananda
Mal Lanka (pvt) Ltd.	- Mr J A Bulankulama

LABORATORY INVESTIGATION

Development of sealant for rainguards

Islandwide educational and demonstrational campaign was launched to educate the farmers on the method of making rainguard sealant developed by this department. The cost of fixing a rainguard will be reduced to between Rs.2.50 - 4.00 per tree when the smallholders themselves make the sealant. Experiments are now in progress to develop a sticker type rainguard for the convenience of fixing (L Karunanayake, Nimal Karunatilleke and Wimaladasa Vithanage).

Evaluating the raw rubber and latex properties of the currently recommended clones

Experiments and surveys carried out with clones such as RRIC 100, RRIC 102, RRIC 121, RRIC 130, RRIM 600, RRIC 160, PB 217, PB 28/59 and the properties of their latex were studied in detail. Out of these clones, RRIC 121 shows some remarkable properties. The project is being continued with these clones and with some other RRIC clones newly introduced by the RRI (L M K Tillekeratne, Mrs L Wanigatunga, Mr Lional Perera and Mr C Senanayake).

Effect of intensity of smoking on cure rate of RSS rubber

The results indicate that the intensity of smoking increase the cure rate. Hence there is a tremendous processing safety when unsmoked crepe and ADS are used in products manufacture (L M K Tillekeratne and Madhupani Jayasooriya).

Materials for coagulation of latex

a. ***Use of Nutmeg skin extract for coagulation of latex in RSS manufacture***

Attempts were made to use sadikka skins, which are wasted in large quantities in Matale area, to make a coagulant for rubber latex. Different type extracts of the materials were used in making RSS and the properties of the RSS produced were then tested and compared with the RSS made by the usual process. Results obtained so far has been very attractive. Work is in progress (L M K Tillekeratne, Nimal Karunatilleke and Sarath Chandrasiri).

b. ***Use of coconut water for coagulation of latex in sheet and crepe rubber manufacture***

Attempts were made to use, domestically used coconut water as a coagulant for latex which would enable the Smallholders to use the coconut water wasted by them in day to day life for the coagulation of rubber and to cut down the cost. As a result of this type of bacterial assisted coagulation, vulcanized properties of the rubber are expected to improve (L M K Tillekeratne, N Karunatilleke and S Weeraman).

Analytical service

Table 1. *Number of samples tested from each TSR factory*

Code	Producer	No. of samples
AD	Statcon Block Rubber Factory, Getahetta	1157
AE	Sherman Block Rubber Factory, Ingiriya	2161
AF	Ceymac Block Rubber Factory, Horana	3647
AI	Associated Traders Ltd., Colombo 13	212
	Total	7177

Table 2. *Miscellaneous samples tested*

Samples	No. tested
Rubber	260
Latex	279
Chemicals	142
Masterbatches	177
Gloves	31
Reclaimed rubber	369
Polythene	08
Total	1266

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Upul Ratnayake

SUMMARY

A comprehensive evaluation was made on the blends of skim rubber and natural rubber on the basis of physical properties and dynamic physical properties. This reveals that the blends are superior in rebound resilience and abrasion resistance than the individual values shown by each polymer itself. The Tensile Strength of natural rubber alone and the blends are far superior to the individual strength values of skim rubbers.

Investigations on sun drying of sheet rubber indicated that it is possible to use sunlight for drying. The surface acidity of smoked sheet rubber is higher than that of sun dried sheet rubber which would be a crucial factor in the vulcanisation process.

Studies were undertaken on effluent treatment using the plant installed at the Dartonfield rubber factory. The results of the experiments indicate that the effluent quality parameters of the final discharge from the treatment plant could be brought down to CEA standards with this treatment system.

A large number of requests were made seeking assistance to control environmental pollution created by rubber factory waste water. Suitable proposals were submitted to the relevant rubber factories after studying the quality of effluent, factory location, available land space. Some of these proposals have already been implemented.

Work on ISO 9000 Quality Assurance scheme was in progress and the manuals have been prepared for twelve crepe rubber factories and one centrifuged latex factory.

As one of the main function of this department, services were extended to raw rubber manufacturing industries to help them to overcome their problems related to quality of their products.

DETAILED REVIEW

Staff

Dr W M G Seneviratne, Head of the Department left for Australia on 10th July on sabbatical leave for a period of 6 months.

Mr Susantha Siriwardena, Assistant Rubber Chemist continued his Post graduate studies at the University of Melbourne, in Australia.

Mr R M U N Ratnayake, Trainee Development Programme Assistant under the Graduate Training Scheme, was recruited to the permanent staff and appointed as Research Assistant with effect from 03rd August.

Mr P P Jayasinghe, Development Officer was on duty throughout the year.

Mr P H Sarath Kumara, Experimental Officer was on duty throughout the year.

Messrs C D Senanayake, T A S Siriwardena Technical Officers were on duty throughout the year. Mrs W K C Nalini was on maternity leave from 14th October.

Mr H P P S Somasiri joined as a temporary Research Assistant in April to work on the project on 'Cost Effective Treatment System for Rubber Factory Effluents' funded by CARP. Miss Malkanthie Tenabadu who was recruited as a temporary Technical Officer to work on the project, vacated her post in March. Miss S W Wijesooriya joined as a temporary Technical Officer on 23rd August to work on the same project.

Mrs Anusha Paranavitane, Clerk/Typist and Mrs L Rukmani, Stores Assistant were on duty throughout the year.

Mr U R Weeratunge, Laboratory Labourer vacated his post in May. Mr U Dharmasena was on duty throughout the year. Mr H A Ariyaratne was transferred to Plant Science Department with effect from 02nd October and Mr N L D Priyantha Chandrasiri joined as a Laboratory Labourer on 02nd October.

Research students

Miss K K W P Priyangi, an NDT student from the University of Moratuwa was trained under the National Apprenticeship Board Training Scheme.

Meetings, seminars and lectures

The Head of the Department participated in the following:-

* A workshop on'Rubber Products Manufacture'organised by the Plastics and Rubber Institute in January.

* Two committee meetings of the National Laboratory Accreditation Committee of the Sri Lanka Standards Institution.

* Two NIPM Technical Committee Meetings during the year.

* Garbage Disposal committee meeting at the Ministry of Environment.

* Scientific Committee meeting of RRB held at SLAAS.

* Several committee meetings of the Plastics and Rubber Institute (PRI) and also its education sub committee as the course co-odinator of the Rubber Diploma course.

* Delivered a lecture on ISO 9000, Effluent Treatment in the seminar organized by the Planters' Association, Awissawella region.

* Delivered a talk on rubber manufacture and effluent disposal at a seminar organized by the Rubber Development Department for rubber Development Officers.

Dr W M G Seneviratne[1], Lalin Karunanayake[2], Upul Ratnayake[3], P P Jayasinghe[4], P H Sarath Kumara[5] and T A S Siriwardane[6] participated in the following;

* One day workshop on 'Rubber Processing and Manufacture' for the staff of the Maha Oya and Udabage estates belonging to the Metropolitan Plantations Management Company at Maha Oya Estate, Dehiowita.[1,5 & 6.]

* Discussion with the staff of the Mal Lanka Rubber Coir & Foam Rubber factory on ISO 9000 Quality Assurance Scheme.[1,4 & 5.] W M G Seneviratne delivered a talk on this subject.

* Seminar on "Reclaimed Rubber" organised by Plastics and Rubber Institute held at Hilton Hotel.[1 & 5.]

* One day seminar on "Environmental Pollution control organised by Biotech Corporation (Lanka) Limited held in Colombo.[1 & 4.]

* Seminar on "Industry related research" held at the University of Moratuwa which was organised by the Engineering Research Unit of the University[5]

* Delivered lectures for seven groups of Rubber Development Officers of the Rubber Development Department, at the Training centre, Matugama[5]

* Delivered lectures at a two day seminar held at Mawanella SRMEC, for the staff of the SRMEC.[1,2 & 5.]

* Delivered lectures for one group of small scale rubber manufacturers and for 3 groups of medium scale rubber manufacturers at the Training Centre, Matugama.[3 & 5.]

* Served in an assessment panel for NDT trainees, at the University of Moratuwa.[5]

* Delivered lectures and held demonstrations at two workshops on latex based rubber products manufacture organised by Mr Sugath Wijesekera, Senior Testing Officer jointly with the Rubber Development Department at Matara.[3 & 5.]

* Seminar organised by Galle Planters' Association at Galle.[5]

* Special meeting of NLAC representing the Head of the Department.[5]

* Delivered a talk on 'Effluent Treatment and Disposal' for Planters at a seminar organised by the Ratnapura Planters Assooiation and held at Palm Garden Auditorium, Ratnapura.[5]

* Delivered lectures on 'Metrolac weighing of latex' and 'Chemical usage' for Planters at a seminar organised by Balangoda Plantations Limited and held at Palm Garden Auditorium in Ratnapura.[2 & 5.]

* Attended a 2 weeks training course on Energy and Environmental management organised by Sri Lanka Energy Managers Association and held at Agrarian Research Training Institute and Embilipitiya paper mill. [3]

* Delivered lectures for field staff at Bentota estate on 'Preservation of latex' and 'metrolac weighing of latex'. [3 & 5]

* Delivered lectures for Managers, Asst. Managers, Field Officers and Factory Officers of Elpitiya Plantation Limited at Igalkanda Estate, organised by the Superintendent, Igalkanda estate on 'preservation of latex and metrolac weighing of latex.[3 & 5]

* Delivered lectures on Rubber manufacture and Processing and effluent disposal at Dartonfield and held demonstrations at TSR factory Nartupana for Kuliyapitiya Affiliated university students. [3 & 5.]

* Seminar on 'Environmental and Sanatory problems' at Sausiripaya organised by Charted Institute of water and Environmental Management Sri Lanka branch. [3, 5]

* NIPM Technical Committee meeting[5]

* Delivered lectures on 'Plantation Rubber' for part-time Polymer Technology students throughout the year at the University of Moratuwa[5]

Advisory visits

The following rubber factories and other industries were visited during the year in order to investigate into their problems with regard to processing and manufacturing of raw rubber, factory development work and waste water disposal problems:

1. *Raw Rubber processing and manufacturing*:

* Pallegoda estate, Matugama
* Latex collecting centres- Kegalle, Mawanalla regions
* Bibile group, Monaragala
* Hatnagala estate, Godagampola
* Substation of RRISL and SRMEC Rubber factory, Kuruwita
* Vogan estate, Matugama
* SRMEC factory, Mawanela

2. ***Factory Development:***

* Sirikandura estate, Matugama
* Pallegoda estate, Matugama
* Kumarawatte estate, Moneragala

3. ***Following rubber factories and industries were visited to look into their waste water disposal problems and suitable treatment systems were suggested:***

* Sena Textile Washing plant, Moratuwa
* Halpe Group, Tummodera
* Atale Rubber Factory, Kegalle
* Pimbura Rubber factory, Agalawatta
* Haltota proposed scrap crepe factory
* Baduraliya Lak Latex centrifuge latex factory, Baduraliya
* Pelmadulla Rubber Factory, Pelmadulla
* Maha Oya Group, Avissawella
* Kumarawatte Estate, Monaragala
* SRMEC Baduraliya Rubber factory, Baduraliya

4. ***Following waste water treatment plants, which are already in operation were visited for monitoring the quality of waste water and further advice was given to them to get the existing treatment system in order***

* Nakiadeniya oil palm factory.
* Elkanda estate, Horana.
* Mackwoods weedicide and insecticide factory - Ekala.
* Mal Lanka Rubberized coir and foam rubber factory.
* Carnival and Busan latex ko-lanka rubber factory.
* Busan and Daisen Ko -lanka Limited.
* Langsland rubber factory, Neboda.

5. ***Factory of the united rubber industries (Pvt) Ltd.*** was inspected and a detailed report given on the extent of environment pollution enabling them to carry on their manufacture.

6. *Industrial support work*:

The exhaust air velocity of the fume cupboard at the Union Carbide Lanka Limited at Ekala, Ja-Ela was measured and report was provided.

LABORATORY AND FIELD INVESTIGATIONS

ISO 9000 Quality Assurance Scheme

Work in connection with ISO 9000 standard certification scheme was in progress throughout the year. Quality and Procedure Manuals and the Work Instructions were completed in respect of twelve estates and one centrifuge latex factory. The estates are Dartonfield, Padukka, Peenkande, Panawatte, Dewalakanda, Madampe, Frocester, Nakiadeniya, Elston, Elpitiya, Kahawatte and Rambukkanda. Subsequent visits were made to familiarise the estate management and factory staff on the purpose and implementation of this scheme.

The centrifuge latex factory reviewed under the scheme is Vincit at waharaka.

A workshop was held in the Ratmalana premises for the Estate Superintendents of Galle district to enlighten them on the scheme. After a series of discussions and familiarisation work on ISO 9000 Quality Assurance Scheme was started at Dartonfield and Elpitiya rubber factories.

Evaluation of physical and raw rubber properties of skim rubber/NR blends

Completed the evaluation on skim rubber and Natural rubber blends, which was carried out as a research project for an MSc dissertation. This work was carried out in collaboration with the University of Moratuwa, Sri Lanka.

Various types of skim rubber (sorted and unsorted)was blended with natural rubber and Deprotenized natural rubber (DPNR) in different compositions were tested. Physical properties of some of the blends revealed that some of the properties were comparable to pure NR compounds hence could be used in certain applications of the rubber industry. These are yet to be tried out in industrial scale (W M G Seneviratne, P P Jayasinghe, K H T Nanadalal, T A S Siriwardane and C Senanayake).

Studies on Blends of BR and LNNR

A research project on the study of the physical properties of blends and Butadiene and Low Nitrogen Natural Rubber was started. The compounding of samples was done at the University of Moratuwa and Rheological studies on the compounds were done at the Industrial Development Board. This work is still in progress (W. M G Seneviratne, P P Jayasinghe and W K C Nalini).

Sun drying of rubber

Initial investigations, confirm the earlier finding that drying of rubber under direct sunlight is possible. Sheet rubber can initially be sun dried for 3 - 4 days and finally be smoked for one day to obtain the honey colour. Investigations also reveal that unfractionated unbleached crepe rubber also can be dried under the sun within two days.

The work on this project was extended to study the vulcanisation characteristics of sun dried rubber. Tests carried out revealed that the surface acidity of smoked sheet rubber was higher than that of sun dried RSS, while the acidity increased with time of smoking. It is believed that the high acidity of smoked RSS is due to the presence of creosotic substances which are deposited on sheets during smoking. It was also observed that the acidity was more in sun dried lace crepe than in air dried lace crepe. More details are given under Rubber Technology and Raw Rubber & Chemical Analysis (L M K Tillekaratne, W M G Seneviratne, P H Sarath Kumara, T A S Siriwardane, H M M de S Jayasuriya and D S K Ranaweera).

Raw Rubber properties of clonal latices

A project was started to study the raw rubber and latex properties of different clonal latices. 14 samples of 8 different clones collected from Dartonfield, Neuchatel, Ambettenne and Sorana Estates have already been analysed. The clones for this study were selected in consultation with the Plant Breeding department of RRISL. Testings for all raw rubber properties including Mooney viscosity , Lovibond colour and the gel content were carried out on the collected samples. Molecular weights of rubber samples have yet to be analysed (Lalin Karunanayake, L Wanigatunga, C D Senanayake and P L Perera).

Effluent treatment and disposal

Construction of the Pilot Plant at Dartonfield rubber factory which was funded by the Council of Agricultural Research policy was completed and studies commenced on the treatment system based on anaerobic/aerobic principle. The work on the project was initially hampered due to non-availability of effluent to feed the tanks.

The results of the experiments so far carried out show that the final discharge of the treatment system conforms to the CEA regulatory Standards. However, further trials have to be carried out with the plant operated at full capacity.

The treatment plant based on anaerobic/RBC aeration process at Ellakanda Rubber Factory, Horana was officially commissioned by the Hon. Minister of Environmental and Women Affairs Mrs Shrimani Athulathmudali. The plant is functioning satisfactorily.

Energy consumption study programme at Dartonfield Rubber Factory

This programme was initiated in collaboration with the Demand side Managenent Unit of Ceylon Electricity Board.

The pprogramme includes the power factor correction of 12 rubber mills at Dartonfield Rubber Factory and taking necessary remedial action to save energy (Upul Ratnayake, P P Jayasinghe, Ramya Wanniarachchi).

Detail Study on Skim Serum

Seven centrifuged latex factories were selected for this study. The programme is aimed to develop a cost effective treatment system or modify the existing anaerobic/aerobic coupled treatment system to treat the skim serum. The project work includes the analysis of sludge and investigation of the possibility of using it as a fertilizer and analysis of the gas emanated from anaerobic digester to complete the possibility of using it as an energy source (Upul Ratnayake, T A S Siriwardena and H P P S Somasiri).

ADAPTIVE RESEARCH

N Yogaratnam

SUMMARY

Programmes on field establishment practices, clones, planting density, intercropping, rainguards, fertilizers and soil moisture conservation practices were in progress in smallholder fields.

DETAILED REVIEW

Staff

The Deputy Director (Research), Dr N Yogaratnam coordinated the activities of this unit. The following officers were on duty throughout the year:

Research Assistant in Agronomy	:	Mr S M M Iqbal
Development Officers	:	Mr F P W Silva
		Mr W C Dayaratne
Senior Technical Officer	:	Mr E A T Senadeera (Kegalle Region)
Senior Testing Officer	:	Mr S Wijesekera (Galle Region)

Other Scientists and Extension personnel involved in this programme are:

(A) SCIENTISTS :

Dr N E M Jayasekera	:	Head, Genetics and Plant Breeding
Dr A Nugawela	:	Head, Plant Science
Dr (Mrs) L Samarappuli	:	Head, Soils and Plant Nutrition
Mr C K Jayasinghe	:	Head, Plant Pathology and Microbiology
Dr (Mrs) K de Silva	:	Head, Polymer Chemistry
Mr V H L Rodrigo	:	Research Officer in Intercropping
Mr P H M U Herath	:	Asst. Agricultural Economist

(B) EXTENSION PERSONNEL: (Rubber Development Dept.)

Mr K Meegahawatta	:	Director (Development).
Mr P Samaranayake	:	Provisional Deputy Director, Homagama.
Mr B Nagasinghe	:	Provisional Deputy Director, Kegalle.
Mrs J Jayatunga	:	Provisional Deputy Director, Ratnapura.
Mr K D W Piyasiri	:	Provisional Deputy Director, Kalutara.
Mr N M Wijesinghe	:	Asst. Director, Galle/Matara.
Mr A Kalubowila	:	Asst. Director, Galle.
Mr D D Dasanayake	:	Asst. Director, Kegalle.
Mr A H Kularatne	:	Asst. Director, Ratnapura.
Mrs G Gunawardena	:	Asst. Director, Homagama.
Mrs A D R Sriyalatha	:	Asst. Director, Gampaha.

Temporary worker

Mr L D Soyza assumed duties as a Temporary Technical Assistant in a programme funded by the Council for Agricultural Research Policy on 1st April 1995.

Visits

The External Review Team of the Council for Agricultural Research Policy and the Auditors from the Auditor General Department visited the Adaptive Research experimental areas in Kegalle and Kalutara and Ratnapura regions respectively.

Meetings and Conferences

The Adaptive Research Unit Staff participated in the following:

* Review Meeting of the Adaptive Research Unit and the Rubber Development Department.
* Monthly conferences of the Regional Rubber Development Departments.
* Young budding nurseries and intercropping programmes - organized by the Rubber Development Department, Matara Region.
* Rubber smallholder seminar and exhibition organized by the Rubber Development Department, Galle Region.
* Rubber with tea smallholding, IRDB, Kalutara. Programme organized by the Rubber Development Department.

Training Programmes

S M M Iqbal delivered a lecture on Interplanting rubber with tea at the refresher training programme for Rubber Development Officers organized by the Rubber Development Department and for the students of the Affiliated University, Makandura, conducted by the NIPM.

Mr E A T Senadeera, Senior Technical Officer, was involved in the following programmes in the Kegalle region :

* Demonstration programme on rainguard fixing for the Rubber Development Officers and smallholders.
* Rubber leaf diseases.

FIELD INVESTIGATIONS

1989 Integrated Programme

(1) Field establishment practices : Young Budding/bare root/poly bag.
(2) Clones : PB 86/RRIC 100/RRIC 102/RRIC 121.
(3) Planting distances : 12'x18'/9'x27'/14'x14'/8'x27'.
(4) Intercropping.

The following trials were continued:

Regions	Number of Plots
Ratnapura	16
Kegalle	22
Kalutara	59
Colombo	21
Galle	19

The 1994 girth data of rubber plants in this programme was analyzed. (Table 1 and 2).

Table 1. *Comparison of mean girth between the regions after 5 years of growth*

Region	No. of Plots	Mean girth (m)
Kegalle	20	41.69A
Colomob	21	40.00A
Ratnapura	16	39.71A
Kalutara	59	38.88A
Galle	19	31.85B

Means with same letters are not significantly different.

Percentage of rubber trees which reached 40 cm of girth was also included in each plots. No. of plots that reached more than 60%, of rubber trees with 40 cm of girth, in each region are given in Table 2.

Table 2. *Comparison of No. of plants that reached 40 cm girth after 5 years of growth*

Regions	No. of plots	No of plots with more than 60% of rubber trees at 40 cm of girth
Ratnapura	16	05
Kegalle	23	24
Kalutara	59	24
Colombo	23	10
Galle	19	05

Girth census reports were collected during the month of November 1995. Tappability percentage of each site was calculated. Details are as follows :

Regions	No. of plots	No. of sites where girth census was recorded	No. of sites that reach tappable girth at 50 cm girth at 120 cm of height
Ratnapura	10	10	03
Kegalle	12	08	03
Kalutara	24	22	06
Colombo	13	12	05
Galle	10	10	01

Tapping was also recommended on all trees having a girth of lesser than 45 cm (A Nugawela, S M M Iqbal, F P W Silva and W C Dayaratne).

1990 - 1995 Programme

Clone evaluation (1990 Programme)

Programme on clone evaluation in the Kegalle and Kalutara regions were in progress. Girth of rubber plants in each region are given in Table 3.

Leaf disease in the 1990 clone evaluation Programme

It was noticed that the rubber plants of clone RRIC 110 in a site at Kegalle and in another site at Kalutara region were severely affected with *Gleosporium* leaf disease. *Corynespora* infection was also noticed in some instances.

These two clearings are situated in a high humid area. The microclimate of these sites are considered to be highly favorable for the spread of the disease. Results of survey and observation made by the P.P. & M.B.D. over the last six years, also reveals that RRIC 110 is susceptible to both *Gleosporium* and *Corynespora* leaf diseases. The microclimate of the locality is known to play a significant role in the development of these diseases. This clone does extremely well in drier areas (N E M Jayaseker, C K Jayasinghe, S M M Iqbal, F P W Silva and W C Dayaratne).

Table 3. *Mean girth of the rubber plants after 3 years of growth in Kegalle and Kalutara regions*

Region	Site	Treatments	Mean girth (cm)
Kegalle	1	RRIC 100; SHP	23.07
	2	RRIC 100; RRI	34.17
	3	RRIC 102; SHP	26.15
	4	RRIC 102; RRI	44.56
	5	RRIC 110; SHP	31.44
	6	RRIC 110; RRI	40.15
	7	RRIC 121; SHP	30.31
	8	RRIC 121; RRI	35.62
	9	RRIC 110; SHP	24.54
		RRI	27.80
	10	RRIC 121; SHP	31.54
		RRI	33.21
Kalutara	1	RRIC 100; RRI	33.00
	2	RRIC 102; SMP	36.99
	3	RRIC 102; RRI	28.68
	4	RRIC 110; SMP	36.89
	5	RRIC 110; RRI	31.17
	6	RRIC 121; SHP	34.98
	7	RRIC 121; RRI	38.87
	8	RRIC 100; SHP	39.27
		RRI	35.64
	9	RRIC 110; SHP	39.06
		RRI	38.76
	10	RRIC 121; SHP	29.12
		RRI	28.75

(N E M Jayasekera, S M M Iqbal, F P W Silva and W C Dayaratne).

Use of Rainguards

Gutter type rainguards were fixed in seven smallholdings (Table 4). Materials were provided by this unit. Sealant was also prepared at the RRISL.

Table 4. *Details of the rainguard programme*

	Smallholder & Address	Extent	Treatment	Remarks
Location : Ratnapura Region				
01.	Mr D D Gunaratne, Ekneligoda, Kuruwita.	Two tapping blocks	With rainguard/ Without rainguards	Gutter type
Location : Kegalle Region				
01.	Mr U M Gunasekera banda, Udainguwatte, Mawathagama	- do -	- do -	- do -
02.	Mr R P A Somasiri 'Mahawatta'	- do -	- do -	- do -
Location : Colombo Region				
01.	Mr P Weerakoon, Malaguduwatta, Udumulla, Padukka.	- do -	- do -	- do -
Location : Galle/Matara Region				
01.	Mr K G Piyadasa, Gonagaswatta, Lenabatuwa, Kamburupitiya.	- do -	- do-	- do -
02.	Mr K K Dharmadasa, Labugodakanda Estate, Mapalana, Kamburupitiya.	- do -	- do -	- do -
03.	Mr W W Wijesinghe, 'Asiri', Pallewela, Padawala.	- do -	- do -	- do -

The number of extra tapping days recorded in a tapping block is given in Table 5.

Table 5. *Number of extra tapping days with the use of rainguards*

Region	Site No.	Periods	No. of extra tapping days
Ratnapura	1	Jan. - Oct. (10)	49
Kegalle	1	Sept.- Nov. (03)	08
	2	June - Dec. (07)	33
Colombo	1	April- Sept.(06)	15
Galle/Matara	1	June - Nov. (06)	37
	2	June - Nov. (06)	38
	3	June - Sept.(04)	09

(A Nugawela, L M K Tillekeratne, S M M Iqbal, F P W Silva and W C Dayaratne).

Rainguard sealant preparation and demonstration

A demonstration was organized in the preparation of rainguards for smallholders in the Galle Region (L M K Tillekeratne, S M M Iqbal and S Wijesekera).

Intercropping

Rubber with Banana/Pineapple

Girth of rubber plants was recorded in the Kalutara region (Table 6).

Table 6. *Mean girth of rubber plants in the plots intercropped and not intercropped in the Kalutara region*

Treatment	Mean girth (cm) Rubber		
	Site 1 (1990 - RP)	Site 2 (1991 - RP)	Site 3 (1990)
With intercropping	38.11	48.79	41.0
Without intercropping	30.76	46.13	41.4

Programmes on rubber with pineapple in the Ratnapura region and rubber with cinnamon in the Galle region were continued.

Rubber with Cinnamon

A new trial was started in the Kalutara region (L Rodrigo, S M M Iqbal, F P W Silva and W C Dayaratne).

Soil Moisture Conservation/Organic Fertilizer

Trials on the effectiveness of bush/tree legumes, use of poultry manure and mulching with paddy straw were continued. Details of these programmes were reported in the Annual Review of 1994.

Girth of the rubber plants were recorded. Details are as follows (Table 7).

Table 7. *Mean girth of rubber plants in the plots treated with poultry litter and without poultry litter/with paddy straw and without paddy straw*

Region	Site	Mean girth (cm) 1995	
		With Poultry litter	Without Poultry litter
Colombo	1 (1992 RP)	26.19	23.63
Kalutara	1 (1990 RP)	46.13	45.0
Galle	1 (1986 RP)	64.00	58.9
		Mean girth (cm) 1994	
		With Paddy Straw	Without Paddy Straw
Kalutara	1 (1986 RP)	52.31	53.15

The following trials were discontinued due to negligence by the growers.

Region	No of Sites
Ratnapura	1
Kegalle	1
Galle	4
Kalutara	1

(L Samarappuli, S M M Iqbal, F P W Silva, W C Dayaratne and E A T Senadeera)

Planting Techniques

Trials on young budding were continued. Details were presented in the Annual Review of 1994. More trials were also started during this period. Details are given in Table 8.

Casualties were recorded (Table 9). It was noted that the establishment rate of young buddings were superior to that of the bare root plants.

Table 8. *Details of planting technique programme in 1995*

Year of commencement	Smallholder name & address	Extent	Treatments
Location	: **Kalutara Region**		
1995	Mrs P P Sumanawathi. Palawatta Road. Morapitiya.	1 ac	Young budding Bare root RRIC 121
1995	Mrs Karuna Walpita. Kandana. Horana.	1 ac	- do -
1995	Mr W A Karunaratne. Diggoda. Baduraliya.	1 ac	- do -
Location	: **Galle Region**		
1995	Mr W A Sesor de Silva. Wehihena. Mattaka.	1 ac	Young budding. Bare root. RRIC 121
1995	Mr C Liyanage. Walpita. Akuressa.	1 ac	- do -
Location	: **Kegalle Region**		
1995	Mr M L Premaratne. Ihattillawala. Kotiyakumbura.	1 ac	Young budding. Bare root. RRIC 100/RRIC 121
	Mr D M S Bandara. Shakerly Estate. Ambekote.	1 ac	- do -
Location	: **Ratnapura Region**		
1995	Mr P M E Gankanda. Pahagankanda Gedara. Pelmadulla.	1 ac	Young budding. Bare root. RRIC 121
Location	: **Colombo Region**		
1995	Mrs W Warusapperuma. Mudungoda. Gampaha.	1 ac	Young Budding. Bare root. RRIC 100/RRIC 121
	Mr B M C Abeysinghe. Ambalangoda. Polgaslovita.	1 ac	- do -

Table 9. *Casualties in the Planting Techniques Programme*

Region	Year of planting	Site	Casualties (%)		
			Young budding	Bare root	Remarks
Kalutara	1994	1	3	7	In progress
	1995	1	1	15	- do -
		2	2	15	- do -
		3	1	20	- do -
Galle	1994	1	7	7	- do -
	1995	1	5	5	- do -
		2	2	9	- do -
Kegalle	1994	1	10	4	Casualties due to extragenious factors
	1995	1	1	40	Casualties due to dry weather condition
Ratnapura	1994	1	7	8	Casualties due to extragenious factors
	1995	1	2	16	In progress

(A Nugawela, S M M Ibqbal, F P W Silva and W C Dayaratna).

Inorganic Fertilizer

Trials started in the smallholdings to evaluate the effectiveness of Eppawela rock phosphate and imported rock phosphate mixture (50:50) on the performance of immature rubber area were in progress. Fertilizers were proyided by this Unit. Fertilizer application was also done under the supervision of the RRI (A Dissanayake and F P W Silva).

The adaptive Research Progrmmes were partially funded by the CARP under their contract research programme (12/43/34) (N Yogaratnam).

Interplanting of rubber with tea

Economics of interplanting rubber with tea

This study examined the economic viability of interplanting rubber with tea in the low country wet zone, where cultivation of both these crops is agronomically feasible. In analysis, apart from the Net Present Value (NPV), other measurements of project worth have also been used to determine the retains on investment.

Economic lifespan of a 25 - year period was is considered for discontinued cashflow analysis. The results reveal the profitability of these integrated farm activity, which generated a NPV of nearly Rs.162,000 at 15% discount rate. The B/C ratio, net benefit investment ratio and IRR are 1.24, 3.73 and 31% respectively. The pay back period of 5 years also, emphasized the economic feasibility of the investment. Sensitivity Analysis on certain parameters have been done to ascertain the economic viability. Commencement of interplanting rubber with tea in the low country wet zone, at least on a limited scale is therefore, economically desirable (N Yogaratnam, I N Samarappuli and S M M Iqbal).

State Sector I (1985)

Observation trials at 6 commercial estates were in progress. In these trials which were started in 1985, the effect of interplanting rubber with tea with spacing of 2.4m x 9m (8' x 30') and 2.4 m x 12 m (8' x 40') for rubber had been tested.

Girth of the rubber plants were recorded in December 1994 and 1995 (Table 10).

Significant differences between treatments were seen on girthing of rubber where the plots in rubber interplanted with tea were found to be superior to plots with rubber only in Panawatta and Kiriporuwa estates.

Table 10. *Girth of rubber in the rubber with tea interplanting experiments (State Sector 1)*

Estate Spacing	Year	Mean rubber girth (cm)		
		Rubber only plot	Rubber x Tea plot	Remarks
Neuchatel 8'x 30'	1994	60.13	62.20	N.S.
	1995	62.81	66.08	N.S.
Perth 8' x 30'	1994	68.03	66.03	N.S.
	1995	69.71	68.05	N.S.
Miriswatta 8'x 30'	1994	64.43	61.40	N.S.
	1995	65.73	63.89	N.S.
Panawatta 8'x40'	1994	64.60	58.16	xx
	1995	69.92	59.38	xxx
Kiriporuwa 8'x40'	1994	63.70	61.55	x
	1995	68.56	63.80	x
Ambadeniya 8'x40'	1994	71.84	76.02	N.S.
	1995	75.98	78.73	N.S.

N.S. : Not significant
x : Significant at 5% level.
xx : Significant at 1% level.
xxx : Significant at 0.1% level.

Yield figures of made tea in Panawatta Estate is presented in Table 11.

Table 11. *Made tea yield in rubber with tea interplanting experiment (Panawatta Estate)*

Year		Mean tea yield kg/ha		
		RubberxTea plot	100% calculated	Tea only plot 100%
1988	1st cycle	494	705	13
1989	- do -	995	1421	198
1990	- do -	544	777	790
1991	2nd cycle	1138	1627	433
1992	- do -	1072	1531	381
1993	- do -	543	776	371
1994	3rd cycle	1254	1791	465
1995	- do -	1189	1699	843

It is noted that the made tea yield was higher in plots with rubber interplanted with tea than in plots that were planted with tea only. Heavy casualties were also found in tea only plots as these plots were affected by severe drought in 1992 (N Yogaratnam and S M M Iqbal).

State Sector II

Two experiments were in progress in Dartonfield, Agalawatta and RRISL substation, Kuruwita.

EXPERIMENT 1 (RRISL substation, Kuruwita)

Details were reported in the earlier annual review. Yield of tea in the rehabilitated and unrehabilitated plots were recorded (Table 12 and Table 13).

Table 12. *The effect of multicropping of rubber lands with tea on yield of tea in the unrehabilitated plots*

Treatments	Average made tea yield (kg/ha) Jan. 1995 - Dec. 1995	
	2nd cycle	100% calculated
Tea(unrehab) + Rubber 8'x27'	947	1460 A
Tea(unrehab) + Rubber 8'x40'	1689	2413 B

Means with same letter are not significantly different.

Table 13. *The effect of multicropping of rubber lands with tea on yield of tea in rehabilitated plots*

Treatments	Average made tea yield (kg/ha) Jan. 94 - Dec. 94		Jan. 95 - Dec. 95	
	1st cycle	100%	1st cycle	100%
Tea Only (rehab)	2560	2560 A	4647	4647 A
Tea(rehab) + Rubber 8'x27'	1136	1748 B	1670	2570 B
Tea(rehab) + Rubber 8'x40'	1346	1922 B	1964	2806 B

Means with the same letters are not significantly different.

Yield of tea in the rehabilitated plot, showed a significant difference between treatments, where the plots with the spacing for rubber 8' x 40' is found to be superior. But in the rehabilitated plots, tea only treatments showed the highest yield.

Light intensity measurements were made in the month of March and April 1995 (Table 14).

Table 14. *% of light intensity in the plots with rubber and tea - 1995*

Treatments	March 1995 (Day 1)	April 1995 (Day 1)
Rubber 8'x27' + Tea	0.2558 A	0.1081 A
Rubber 8'x40' + Tea	0.5576 B	0.4000 B

Means with same letters are not significantly different.

As there had been excessive shade on Tea, 15% to 20% of rubber foliage were removed in ½ of the plots with the rubber spacing of 8' x 27'.

Leaf and soil samples were collected. Girth of rubber plants was also recorded. 60% of the rubber plants reached the tappable girth in December 1995 (N Yogaratnam, S M M Iqbal in collaboration with the Plant Science Dept. and the TRI).

EXPERIMENT II (RRISL Agalawatta)

The following activities were in progress:

* Centering of tea at 9" and 18" height
* Growth assessments of tea and rubber
* Collection of soil and leaf samples
* Infilling of tea.

Mr N H D Nihal Weerasekera, Tea Inspector cum Extension Officer/ TSHDA, Agalawatta, also participated in this programme (N Yogaratnam, S M M Iqbal and C Seneviratne).

A new experiment (Exp. III) was also planned to be started in May/June 1996 at Perth Estate, Horana with the following treatments, in plots ½ acre in size using a randomized block design replicated 3 times.

Treatments:

(a) Rubber only 12' x 18' (100%)
(b) Tea only 2' x 4' (100%)
(c) Rubber 8'x 60' (single row)(45%) + Tea (12 rows)(86%)
(d) Rubber 8'x 8' x 46' (double row)(100%) + Tea (8 rows)(66%)
(e) Rubber 8'x 8' x 60' (double row)(80%) + Tea (12 rows)(76%)
(f) Rubber 8'x 8' x 70' (double row)(70%) + Tea (14 rows) (78%)

(N Yogaratnam and S M M Iqbal)

Experiment I and II were partially funded by the CARP under their Contract Research Programme 12/30/21 (N Yogaratnam).

Smallholder Sector

Two trials were in progress. Girth after 3 years of growth of rubber and Tea yields are presented in Table 15.

Table 15. *Effect of interplanting rubber with tea on girthing of rubber and yield of tea*

Site	Mean girth	Fresh tea yield Jan. 1995 to July 1995
1. Mr Higgoda, Undugoda	34.16	768 kg
2. Mr Premaratne Kotiyakumbura	24.77	796 kg

(N Yogaratnam, S M M Iqbal and E A T Senadeera).

Interplanting of Rubber with Tea - Smallholdings under the IRRDB Programme, Kalutara

Tea yield data (Table 16) indicated that in a few smallholding sites, tea yields are low due to poor management practices.

Table 16. *Made tea yield and other details of the interplanting of rubber with tea programme at the Kalutara region (N.E. = North East, S.W. = South West)*

Smallholder site	Year of planting	Made tea yield kg/ha Jan '95 - July '95 (1st cycle)
1	NE 1991	1071
2	NE 1991	1161
3	SW 1992	1904
4	SW 1992	1304
5	SW 1992	941
6	SW 1992	924
7	SW 1992	1046
8	SW 1992	641
9	SW 1992	720
10	NE 1991	993
11	SW 1992	2054
12	SW 1992	2159
13	SW 1992	1777
14	NE 1992	2750
15	SW 1993	621

[N Yogaratnam, S M M Iqbal and K Meegahawatta (RDD)].

AGRICULTURAL ECONOMICS

P H M U Herath and I N Samarappuli

SUMMARY

A study on micro-economic aspects of rubber smallholders under different farming systems showed that diversification improved the land use intensity and productivity but this imposes a constraint on hired labour usage. Further, an economic efficiency index was computed which indicates that nearly half of the total smallholdings were inefficient and a low level of labour use efficiency in all districts.

Mathematical relationships between run-off and soil loss were developed for environmental impact assessment using replacement cost technique.

Development of a user friendly computer programme is in progress based on climatic and edaphic factors to provide a package for managerial decision making.

A conceptual model was developed to estimate the rubber wood production in Sri Lanka.

A study conducted on replanting in smallholder sector shows that the subsidy has no significant impact but the two year moving average of rubber price has a significant effect.

Developed a mathematical relationship to decide optimum double tapping wage rate base on financial aspects of estates.

Preliminary analysis on crop diversification of rubber sector shows that except in Gampaha and Colombo the performance of the other major rubber growing districts is very poor.

DETAILED REVIEW

Staff

Mr P H M U Herath was promoted to senior staff grade II with effect from 02nd February 1995. Assistant Agricultural Economists, Mr I N Samarappulli and Mr A K B Naranpanawa, were on duty throughout the year.

Research Students

Two undergraduate students from Ruhuna University successfully completed their final year research projects under the supervision of I N Samarappuli. The titles of their research projects are as follows.

Miss N H K D Nimali :	"Socio-Economic conditions of rubber smallholders in the Kegalle District".
Miss N P Jayasinghe :	"Economic analysis of replanting of rubber in the Kegalle District"

Meetings and Seminars

A K B Naranpanawa Addressed the following workshops conducted by the Industrial Development Board on product costing aspects:

22nd February	-	Workshop on adhesive industry at Hotel Galadari Meridian, Colombo.
30th March	-	Technology transfer workshop on processing of natural mineral water for drinking purpose at Central Training Institute, Bank of Ceylon, Maharagama.
2nd June	-	Technology transfer workshop on processing of natural mineral water for drinking purpose at the Youth Center, Maharagama.

Mr A K B Naranpanawa Delivered the following lectures.

1st August	-	On local rubber market for the 1st year management students of the Sri Lanka Technical College, Maradana, at the Training Center Nivitigalakele.
25th October	-	On cost of production of rubber and the rubber statistics for the 2nd year affiliated university students in plantation management at the RRI auditorium.

P H M U Herath addressed the Planters Association meeting at Rathnapura region on some economics aspect of rubber industry in Sri Lanka.

I N Samarappuli addressed the following: Seminar on "Land Degradation" organized by the Ministry of Plantation Industries in collaboration with University of La Trobe on "Economic Impact of Land degradation in Rubber Lands".

The Kalutara District Planters' Association on "Present scenario in the rubber industry" at the Annual General Meeting.

P H M U Herath and I N Samarappulli attended the Scientific committee meetings of the Rubber Research Institute of Sri Lanka.

RESEARCH

Comparative study of Sri Lankan NR auction and FOB prices with other major producing countries

Data on Auction and F.O.B prices of Sri Lanka, Malaysian and Thailand since 1970, were gathered. The study is in progress (A K B Naranpanawa).

Economic analysis of interplanting rubber with tea

An economic analysis carried out at the request of the Adaptive Research Unit, on the economic viability of interplanting Rubber with Tea using experimental data provided by the Adaptive Research Unit indicates that this would be a profitable program. A scientific paper was published (N Yogaratnam, I N Samarappuli and S M M Iqbal).

A study of the factors affecting replanting in the smallholder rubber sector in Sri Lanka

Scope of the study

Many development plans, policies and programs adopted by the governments recognize the problem pertaining to replanting. The success or failure of the plans and policies depends on different factors which are versatile.

However, very few studies have been conducted in understanding the replanting process of smallholders. Further, these studies have been limited only to an analysis of smallholder decision making process.

Therefore, as a prerequisite for successful formulation of a program of replanting for smallholders, quantifying the factors affecting replanting in smallholder sector was considered in this study.

Progress in replanting

According to the Rubber Development Department figures the rate of replanting amongst the different groups has been far below the targets. The backlog has been about 25% in all three type of growers (large, medium and smallholdings). The target of 3% of the acreage expected to be replanted every year is never achieved.

Data collection

The data used in this analysis was collected mainly from the Annual Administrative Report of the Rubber Controller. Various aspects of data on area, production and prices are published in this report. Data on age specific area and area supposed to be replanted are not readily available due to non maintenance of such records. Moreover, in the available data there are errors and discrepancies. The other main source of data was the Central Bank Annual Report.

In order to obtain accurate estimations, both the above main sources of data have been used in this analysis and the similarities between these two and other sources of data like Commodity Purchasing Department and Census and Statistics Department publications have also been taken into account.

The theoretical model

Possible factors determining the replanting area in smallholder rubber sector is decided based on the following facts:.

Due to the time required for replanting and uprooting and to a short resting time for the uprooted land as given by some cultivators, available area for replanting depends on the current years uprooted area as well as on the area uprooted but not replanted during at least the last 2 years. Profits from the rubber are assumed to be part of the funds available for replanting. Moving averages of the current and last year prices were also included in the model assuming that it has immediate impact on

replanting. Annual average yield variation at the smallholder level was included in the model considering the possible effects on replanting with newly bred high yielding clones. The final variable expected to affect replanting is government subsidy payments. All the above variables are assumed to have positive effects on replanting. Hence, the rubber replanting (RPRU) equation could be written as below.

$$RPRU = a_{10} + a_{11}\,URA + a_{12}(URA\text{-}1 - RPRU\text{-}1 + URA\text{-}2 - RPRU\text{-}2) + a_{13}\{(PR/CPI) + (PR/CPI)\text{-}1)/2\} + a_{14}AY + a_{15}(SUR/CPI) + a_{16}(PRO/CPI)$$

Estimation of the model

The time series data specified in the above were used in the estimation of the above specified replanting model. In the determination of the best fitting line, proportion of area replanted out of the total area due to be replanted was used as the dependent variable. Subsidy rates, Rs./ha (SUR), total area due to be replanted in hectares (TRP), uprooted area in hectares (URA), moving average of RSS 3 rubber prices Rs./Kg, (MAP), average annual profit per kilogram of rubber (PRO) and average yield in Kg per hectare (YA) were used as explanatory variables. SAS, procedure; PROC REGG was used to find the best fiting model. The final model developed is as follows with an explanatory power of around 70%

$$RE = 0.1 + .25\,LMP - .000063\,TRP + .000021\,LTRP$$

The study indicates that the moving average of the rubber prices has significant ($p = .05$) positive effect on replanting. The total area due to be replanted annually has significant ($p = .05$) negative effect on replanting. The subsidy plays non significant role. Profit variable indicates negative impact on replanting, which shows that with higher profit, the rubber growers tends to rely more on the existing plantations. However, the impact is not significant. Although the research level studies indicated that there is very high yield potential in newly bred clones, the average yield performance at the smallholder level has no significant effects on replanting.

Conclusions

(1) Subsidy has no significant impact on replanting.

(2) Tax imposed on rubber exports and any further increase in subsidy rates might cause negative impacts on replanting as the taxes cause lower level rubber prices. The negative impact of taxes on price is considerable at smallholder level due to the inefficiency in the smallholder rubber marketing system.

(3) Improvements in the smallholder sector marketing system to certify high and stable prices would be more useful to enhance replanting rather than increasing subsidy rates.

(4) Although research level studies showed promising high yield levels of newly breed clones, the yield expectation of these clones has not contributed significantly on replanting. Intensive extension practices on this aspect would be very useful to encourage replanting with high yielding clones.

(5) Moving average of the prices has significant ($p = .05$) positive impact on replanting. This indicates that the high and stable rubber prices encourage replanting (P H M U Herath).

Economics of rubber based farming systems

The general objective of this study was to evaluate micro-economic aspects of rubber smallholders under different farming systems practiced in the rubber growing districts of Kalutara, Kegalle, Ratnapura and Gampaha. A field survey was conducted using a pre-tested questionnaire to gather information from a sample of 230 rubber smallholders. Regression and tabular analysis were used to analyze the data. The data were also used to estimate the frontier efficient profit function and optimal input demand for labour. A summary of some important findings derived from this study and their policy implications are given below.

Demographic, educational and employment characteristics

The average family size of the rubber smallholders was 4-5 per family with equal female to male ratio. About 60% of the households were within working ages of 15-60 years. Approximately 60% of the households had a minimum of secondary level education indicating a fairly high level of literacy. This can be considered as an incentive in transfer of technology and technology adoption among smallholders.

The variation of the households in full time farming ranged from 7.5% in Gampaha to 21.5% in Kalutara district. This indicates that majority were either employed (temporary or permanent) in the private or public sectors. For instance, nearly 63% of smallholder households in Gampaha district were serving in the public sector. This is strongly related (positively) to the degree of urbanization and availability of employment opportunities in this district.

Land use pattern and tenancy

The land use pattern was classified in terms of home gardens, lowland and highland cultivations. The land use intensity ranged from 58 in Kalutara to 89 in Kegalle district in all type of holdings.

The average farm size (cultivated with rubber) varied from 0.32 ha in Gampaha to 1.3 ha in Kegalle District. In each district, majority of the smallholders (76-91%) owned their high lands. Tenancy was therefore not a major constraint.

Farming system

The variation of the types of cropping systems practiced with rubber differed by the agro-ecology of the respective districts. For example, rubber and pineapple were grown only in Gampaha district. The other type of crops grown in the highlands of rubber farmers included tea, coconut and mixed crops. In addition to the highland crops, majority of rubber smallholders in each district (42-65%) cultivated lowland paddy. The average extent of lowland paddy in the districts ranged from 0.26-0.36 ha per farm.

The types of livestock raised by rubber smallholders included cattle, buffaloes and poultry. Cattle rearing was common among 30% of rubber smallholders in Gampaha district.

The diversified cropping systems adopted by smallholders indicated their physical and price risk averseness. However, rubber continued to dominate the farm economics in terms of their contribution to household income. Diversification improved the land use intensity and productivity of the smallholdings but impose a constraint on hired labour usage.

Management practices of rubber

Varietal use

Over 93% of smallholders adopted budded varieties. The district wise distribution of RRIC 100 series clones ranged from 25-42% whereas PB-86 ranged from 55-68%.

Fertilizer use

More than 59% of smallholders used fertilizers for rubber. The fertilizer demand function for rubber was estimated for each district.

Labour use

The average daily wage per hired labour ranged from Rs 70/= in Ratnapura district to Rs.98/= in Kegalle district. The high cost of production is unavoidable due to growing demand for hired labour for planting and tapping operations in particular.

Contract Labour was more common for land preparation practices. Labour on daily wage basis was less expansive than contract labour.

The results suggest that policy emphases should be focused on producer pricing policies rather than on lowering the prices for inputs. Labour availability require changes in labour wage policies adopted for plantation workers to be in par with competitive wages offered to other industries. However, all adjustments in wage rates should be linked to labour use efficiency of the respective farms.

Tapping practices

The average number of tapping days in the districts varied from 127-162 days per year. Moreover, it also differed by seasons of dry, wet and wintering months.

Credit

Less than 13% of the rubber smallholders obtained any from of credit to invest on rubber cultivation. The average amount of credit ranged from Rs.650 to 2650 per farm. Repayment was lowest in Ratnapura District. Factors such as repayment rates, duration of credit and extent of rubber holdings significantly affected the demand for credit.

The unsatisfactory utilization of credit has adversely affected the adoption of improved cultural practices in small rubber holdings. The results indicate the requirement for an effective and dynamic long-term credit policy with fair interest rates. The demand functions for institutional credit were estimated for each district.

Rubber yields

The district wise average productivity of rubber in all districts was higher in plots close to (within 2 Km) their homesteads (708-1640 Kg/ha) compared to those located away from the residence (552-1030 Kg/ha). Better management and supervision would have contributed to higher productivity in rubber plots located close to farm houses. The average productivity equations were fitted for each district and estimated.

Processing and marketing

Majority of smallholders coagulated their rubber latex in their own farms with the cost of processing ranging from Rs.0.75-1.00/Kg. Few practiced rolling of coagulated rubber in Group Processing centers. Most farmers smoked the rolled rubber sheets in their own smoke house or at outside sources for an average fee of Rs.0.58-1.07/Kg.

Nearly 80-96% of farmers produced smoke sheets. Yet, 15% of smallholders in Kalutara district marketed unprocessed rubber. The average daily output of smoked sheets (per tapping day) in the four districts ranged from Kg 5.0-8.5/farm.

Smallholders market their rubber to different sources. The private shops were a common source of marketing in all the districts. The major reasons for selecting these market sources included higher price, instant payments, ability to obtain consumer goods on credit and closer distance. Majority of the farmers supplied rubber to markets within 10 Km from their farms once a month for spot cash.

Local rubber traders generally offer a low price for higher grades of rubber sheets marketed by smallholders. Hence, many farmers are compelled to produce low quality rubber due to lack of financial advantage. The visual grading system practiced in the markets therefore needs improvement and constant supervision to ensure consistency and a fair price for processed rubber at the farm gate level.

The market price equation for RSS rubber was fitted for each district and estimated by OLS method.

Cost of production and income

The annual cost of mature rubber upkeep ranged from Rs.4,728-17,206/ha. Nearly 70% of the total cost constitutes of labour. The average net income earned by rubber smallholders ranged from Rs.11,725 to 43,885 per ha per year.

$$X_i = \frac{\beta_0 \; p_i \; (W_i, Z_i)}{W_i}$$

Where:

W_i = Vector of input prices

Z_i = Vector of fixed inputs

The comparison of average labour use and optimal demand for hired labour use per farm and the efficiency index for hired labour according to districts is shown in Table 2.

Table 2. *Average labour use, optimal demand for hired labour and Efficiency index for hired labour*

District	Labour Use (Man days/Farm)		Efficiency Index
	Observed	Optimal	
Kegalle	14.5	49.5	0.29
Kalutara	13.6	29.5	0.46
Ratnapura	16.7	71.5	0.23
Gampaha	14.9	45.7	0.33

In general, the labour use efficiency of rubber was relatively low in all districts with the highest level of 46% in Kalutara district (I N Samarappuli with C Bogahawatta of the University of Peradeniya).

A study on tapping wage rate

At present, tapping wage rate has become an important factor due to severe scarcity of the tapping labour. Therefore, deciding optimum wage rate to attract labour while maintaining the financial viability of the industry is very important.

In economic terms, marginal value product criterion gives the maximum paying capacity, while the poverty line criterion gives the minimum level of wage needed. Therefore, to estimate marginal products of labour a study was initiated to develop production functions at different estates and smallholder sector. Necessary data collection at estate and smallholder level was planned on this aspect.

Technical efficiency of smallholdings

A Cobb-Douglass production function and the respective logarithmic profit function were computed and the results of the profit function and coefficients of the production function for respective districts are given in Table 2.

All estimated coefficients have the expected signs except for variable W (wage rate) and C (cost of inputs : weeding + pest control) in the Ratnapura district. Most of the estimated coefficients were statistically significant. However, the fit of the models were generally poor.

The frontier efficient profits over observed profit was estimated for each farm and the Economic Efficiency Index was computed. The distribution of Economic Efficiencies for all farms by district is shown in Table 1.

Table 1. *Distribution of Efficiency Index of rubber smallholder farms by district*

Efficiency Index	No. of farms per District			Ave. farm size (ha) per District		
	Keg.	Kalu.	Ratna.	Keg.	Kalu.	Ratna.
0.00 - 0.50	47	36	30	2.22	3.95	1.66
0.51 - 0.99	8	15	9	4.71	4.62	2.83
1.00 - 1.49	14	8	15	2.84	3.30	3.87
1.50 <	10	10	10	2.24	2.86	2.24

The results show that nearly 59%, 52% and 47% of total rubber smallholder farms were inefficient producers in Kegalle, Kalutara and Ratnapura districts respectively. Contrary to results of other districts the relation of farm efficiency and farm size was some what evident in the Ratnapura district with larger farms being more efficient than smaller farms.

Labour use efficiency

The optimal demand for labour of the i^{th} farm (X_i) is calculated from the computed profit function. The frontier efficient demand [X_i] is equal to the ratio of frontier efficient profit [$p_i (W_i, Z_i)$] and wage rate [W_i]. *i.e*:

The proposed production function to be developed is trascendental logarithmic with a single output and two inputs as indicated below.

$$\log y = \log a_0 + a_k \log k + a_l \log l + \tfrac{1}{2} a_{kk} (\log k)^2 + \tfrac{1}{2} a_{ll} (\log l)^2 + a_{kl} (\log l)(\log k) + e$$

where, y = production level

k = capital and other production costs

l = person days worked per hectare.

According to the preliminary studies conducted the following factors were observed.

(a) The share of the plantation sector in the gross domestic products has declined but the share of labour force depending on plantation sector maintained more or less constant.

(b) It appears possible that the tapping wage rate in the plantation sector is systematically below the marginal product of labour.

(c) The gap between the wage rate and productivity tends to widen whenever labour productivity goes up.

(d) The introduction of improved crop varieties and practices tends to drive the labour productivity far above wage rate (P H M U Herath).

Double tapping wage rate

A study on double tapping wage rate focused only on financial aspects of wage determination. Accordingly, there are several factors to be considered to decide the double tapping wage rate, namely Net Sale Average (NSA), Cost of Manufacture (COM), general charges, mature area upkeep cost and the profit margin retained by the producer. A financial analysis has been conducted encompassing all the above variables in the form of a sensitivity analysis under different situations. A mathematical relationship is developed by this analysis. Relationship developed is as follows:

$$DTW = NSA(1-RR) - C$$

where.

DTW - Double tapping wage rate
NSA - net sale averae
RR - Rate of return
C - cost of production except tapping cost component

Conclusions

1. It is evident that the double tapping wage rate is affected by several factors. namely NSA. COM. general charges cost of mature area upkeep and the magnitude of the profit margin retained by the producer.

2. Therefore. any decision to increase wage rate should be determined subjected to the above factors and within a feasible limit.

3. It is important to note that, although it is feasible to increase wages. in some instances. it may lead to practical problems such as non declaring of the real quantity of latex collected during normal tapping while showing that with double tapped latex to gain higher salary

4. The study indicates the possibility of changing the current double tapping wage rate. Accordingly, under the present price level it is desirable to pay more than Rs. 10 per Kg (P H M U Herath and A K B Naranpanawa).

Statistical modelling on run-off studies using econometric procedures

The data for this particular analysis was obtained from a run-off experiment conducted in the Kalutara district in the early 1980s (Samarappuli and Yogaratnam). A time series data set collected over a period of 3 years was transformed into a cross sectional database (with the aid of appropriate dummy variables) comprising of 72 observations *viz*. Management practices (4) * Replicates (3) * Slopes (2) * Years (3). The variables considered for the subsequent analysis are as follows:

Run-off (litres/ha/year)	X_1
Soil loss (tons/ha/year)	X_2
Plant Girth (cm)	X_3
Soil P (ppm)	X_4
Soil N (%)	X_5
Soil K (me/100g)	X_6

Management practices (Dummy's)	X_7 - X_9
Bare	
Legumes	
Naturals	
Mulch	
Age (Dummy's)	X_{10},X_{11}
Year 1	
Year 2	
Year 3	
Soil Organic C (%)	X_{12}
Bulk Density (g/cm^3)	X_{13}
Slope (Dummy's)	X_{14}
Slope 1 (10-15%)	
Slope 2 (35-40%)	
Average Slope (%)	X_{15}

The data were analyzed using standard statistical and econometric procedures with particular reference to factor analysis and regression procedures.

Factor analysis

Three distinct factors were identified with regard to variables X_1, X_2, X_4, X_5, X_6 and X_{13} based on the eigen values (using the >1 criterion). The variance explained by these 3 factors was 74%; 35, 24 and 15 percent respectively by each factor. The causal relationship between hypothetical factors and variables associated with run-off is shown in figure 01. It appears that variable X_{12} (organic C %) and X_{13} (bulk density) are unique for factors 2 and 1 respectively. Moreover, variables X_1, X_6; X_2, X_4; and X_5 are common for factors 1 and 3; 1 and 2; 2 and 3 respectively. The variables X_1, X_{12} and X_6 showed the highest factor loading with respect to factors 1, 2 and 3 respectively. This implies that soil loss may be explained by variables X_1 (run-off), X_{12} (soil organic C %) and X_6 (soil K). The correlation coefficients (upper triangular values) and the P values (lower triangular values) signified the absence of correlation among the variables with highest factor loading (table 03).

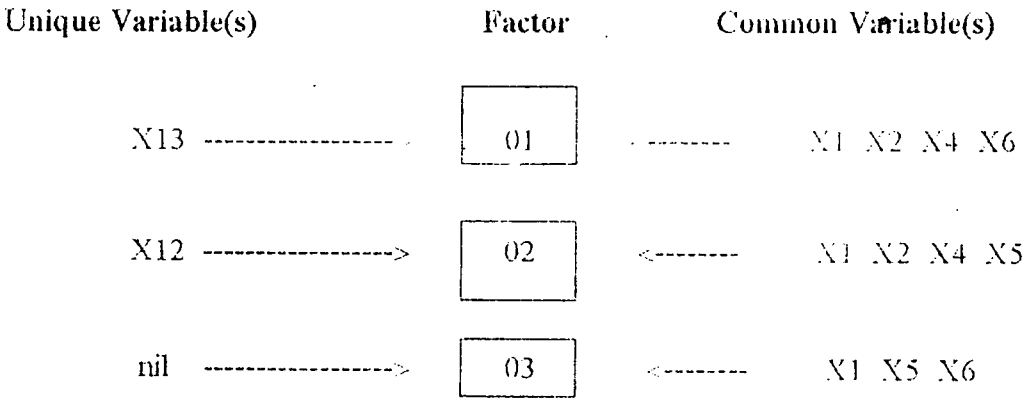


Fig 1. Casual relationship between hypothetical factors and variables associated with land degradation

Table 3. *Correlation matrix among highest loading variables governing each factor*

	X_1	X_{12}	X_6
X_1	1	0.0416	-0.1302
X_{12}	0.7288	1	0.2067
X_6	0.2752	0.0815	1

(Upper and lower triangular values are Pearson correlation coefficients and prob > |R| under H_0 : Rho=0/N=72)

Sequence of model fitting approach

The following models were fitted to explore the relationship between run-off and soil loss under different management practices, age of plantation and different slopes. Initially the classificative variable were included in the model one at a time. The variables to be included in the models were selected according to the magnitude of factor loadings in each identified hypothetical factors. The GLM procedure was used to estimate the run-off models.

These models can be used to describe the relationship between run-off and soil loss under different management practices, age of classificative variables by giving values to other quantitative variables in models.

Finally, these derived run-off levels will form the basis to assess the environmental impact in immature rubber holdings. The "Replacement Cost Technique" which is based on intended behaviour will be used as the criterion to value the damage done to the environment under different management practices.

This particular technique calculates the future cost of replacing the eroded soil or nutrients by an equivalent asset subject to a specific condition *i.e.* value of the original resource has to be equal or greater than the replacement cost (I N Samarappuli, W Wijesuriya, L Samarappuli and N Yogaratnam).

A computer model to assess agro-climatic feasibility for rubber cultivation in Sri Lanka

The objective of this study is to develop a user friendly computer package to assess the agro-climatic suitability for cultivation of rubber.

The programme enables the user to understand the climatic and edaphic limitations of a particular land. The programme also suggests appropriate remedial measures to be undertaken and their respective cost, labour and material based on the current RRI recommendations.

A schematic diagram showing the basic structure of the proposed computer model is given in figure 2. Preliminary data were collected on some important meteorological observations in several rubber growing districts. Data related to physiographic and soil factors were obtained from the Soils and Plant Nutrition Department. The recent information available in advisory circulars complied by the respective Research Departments were also incorporated to the model to suggest relevant action to be undertaken by the former under each situation.

The initial programme segments were developed and further refinements are in progress.

Future Directions of the rubber wood industry in Sri Lanka

The main objectives of this study are as follows

(a) To review and analyse the supply and demand potential, technology, constraints and investment opportunities of the rubber wood industry.

(b) To develop a conceptual and analytical model of the existing rubber wood industry.

A conceptual model of rubber wood production (Figure 03) was developed to design an appropriate methodology for the estimation of wood production (I N Samarappuli, L M K Tillekeratne and K G K de Silva).

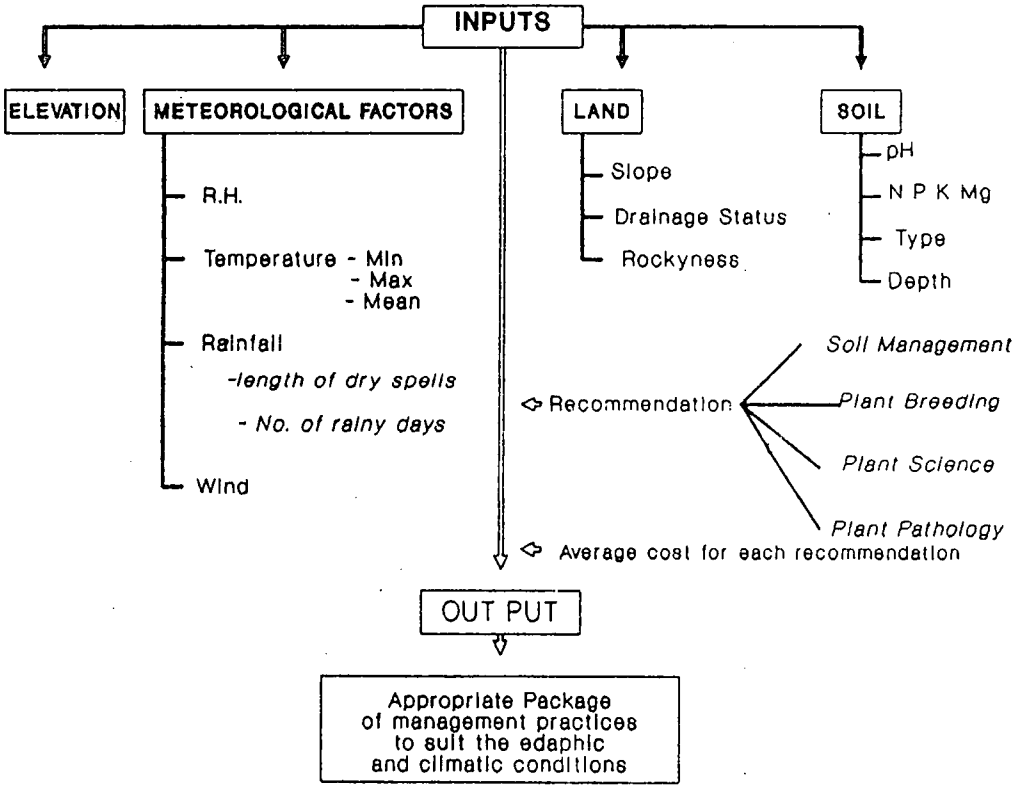


Fig. 2 Schematic presentation of the computer programme

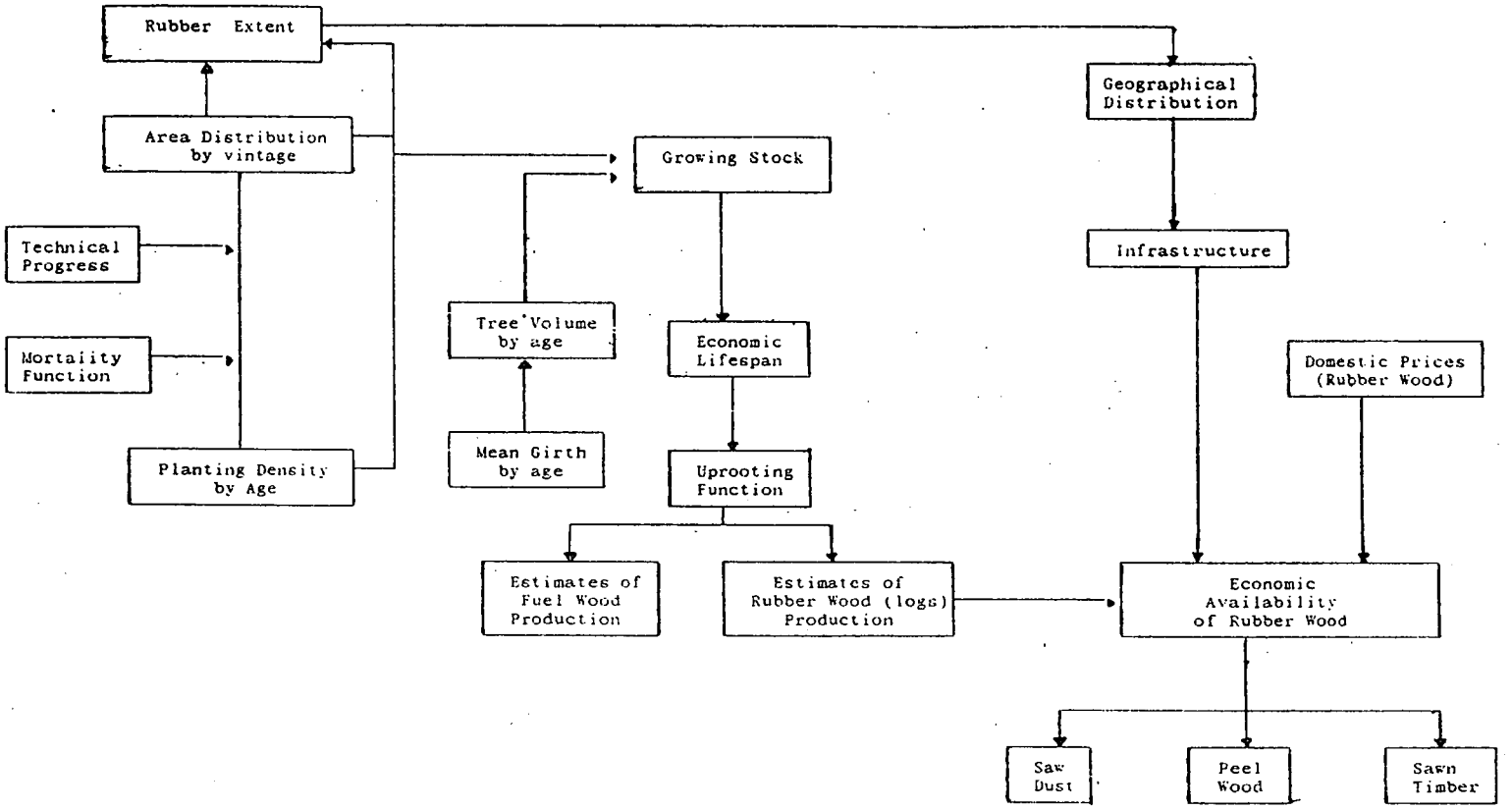


Fig. 3 Rubber wood production model

Study on crop diversification in rubber sector in Sri Lanka

Objectives of the study

(a). to study the present situation of the crop diversification in the rubber sector.
(b). to study and quantify the factors affecting crop diversification.
(c). to make necessary recommendations to improve the crop diversification.

Sampling procedure

To estimate optimum sample size for the survey stratified random sampling procedures was employed.

Differentiation of strata for the study population.

The survey was confined to 5 main rubber growing districts, ie the total immature rubber growers were divided into 5 main strata. In each district different RDO ranges were considered as sub strata of the main strata (districts). The immature rubber growers of the sub strata were selected according to land sizes as final strata to be sampled.

Sample size

According to the Rubber Control Department administration procedure Ratnapura, Kalutara, Kegalle, Colombo and Gampaha districts were divided to 31, 45, 54, 24 and 15 RDO ranges respectively. Therefore, to select the optimum number of RDO ranges out of the 156 ranges the following formula was used.

$$n = \frac{\sum_{i=1}^{L} N^2 \sigma^2{}_i / Wi}{N^2 + \sum_{i=1}^{L} N_i \sigma_i^2} \quad \text{---------(1)}$$

where,
N - total number of RDO ranges
N_i - number of RDO ranges of each district
σ_i^2 = Population variance (approximated by sample variance from previous experiments)
W_i = fraction of total sample size to be allocated into i^{th} stratum
B = specified amount by experimenter to lie the estimates within that unit of population mean with probability equal to .95.

There was no previous information of intercropping studies on rubber. Therefore, to estimate the parameters specified for the above equation, the information of the previous studies on some other aspects is used. This procedure was justified because the final objective was to differentiate the concerned population into homogenous groups. Therefore, a study on yield performances was used as a base to estimate the parameters specified in the above equation.
Accordingly
$\sigma = 50$
$B = 1000$ (in the case of estimating total yield figure)

The W_i the fraction of total ranges to be allocated to each district was estimated by the following formula,

$$Wi = \frac{N_i \sigma_i / \sqrt{C_i}}{\sum_{i=1}^{L} N_i \sigma_i / \sqrt{C_i}} \quad \text{-------(2)}$$

where,
N_i = number of RDO ranges in relevant districts.
C_i = cost of obtaining information from a farmer.

The W_i values were estimated by the formular 2 and substituted to the formula 1 to estimate the optimum number of RDO ranges to be selected. This number was estimated as 96 RDO ranges.

Optimum number of RDO ranges for each district was estimated by the following formula.

$$n_i = n \frac{N_i \sigma_i / \sqrt{C_i}}{\sum_{i=1}^{L} N_i \sigma_i / C_i}$$

where, n = 96

Sample sizes for selected RDO ranges

The total number of farmers to be interviewed from each district was decided by considering the cost factor. Calculations showed an average cost of Rs. 125 per farmer in Kalutara and Rs.150 per farmer in the rest of the districts. The total budget available was estimated as Rs.100,000. Therefore, number of farmers from Kalutara district was 200 and 168 farmers from each of the other district.

Assuming equal cost for each RDO range and the variances are equal in each RDO range of a given district the formula 2 was simplify as follows to estimate allocation fractions for each RDO range.

$n_{RDO} = n * N_i / N$

where,

N = total number of immature rubber holders in a particular district
N_i = number of immature rubber holders in a particular RDO range
n = number of farmers to be interviewed in a district

The above method of estimating sample sizes to a strata is called proportional allocation. The same procedure was employed for further categorization of the number of farmers to be included to different holding size.

Data collection

Necessary data were gathered by a questionnare. The questionnaire was pre tested in Agalawatta range in Kalutara district by interviewing 10 farmers. The field survey was initiated on month of June 1995. The survey was conducted in 5 major rubber growing districts namely, Kalutara, Kegalle, Rathnapura, Colombo and Gampaha.

Analysis of the data

To verify the present situation of the crop diversification a simple mean, variance, covariance analysis was planned by frequency and tabulation test procedures (V H L Rodrigo, P H M U Herath and A K B Naranpanawa).

As dependent variable is binary a probit model to be fitted to quantify the factors affecting on crop diversification. The study is inprogress (P H M U Herath and A K B Naranpanawa).

Developing a simulation model for rubber industry in Sri Lanka.

An explanatory model was designed as a pre requsite to develop a simulation model. The process of developing a simulation model to whole sector is copmplicated. Therefore, model devlopment was seggregated according to the main aspect of the production. Initialy the biological aspects of the production was studied and an explanatory flow chart was developed (fig. 4). The following abbreviations were used to explain the chart (P H M U Herath).

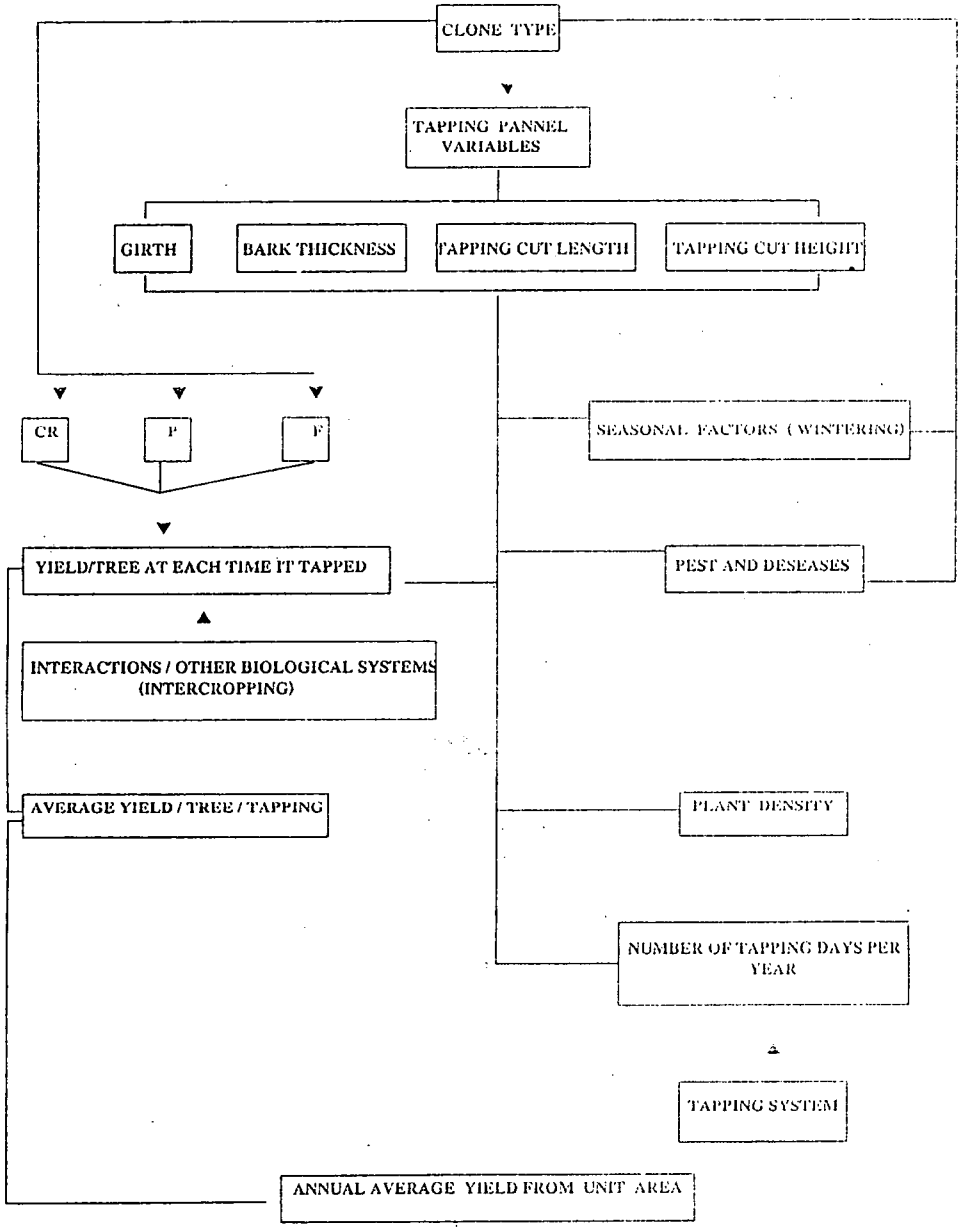


Fig. 4 Explanatory diagram on biological factors of production

CR - rubber content
P - plugging index
F - average initial flow rate of tapping cut during the first 5 minutes.

Macro and micro economic policies and their impact on the plantation sector of Sri Lanka

A study was planned to quantify the impact of different policy measures on the Efficiency index for hired labour.plantation sector development. The necessary data collection since 1948, on different policy measures and the sector performances in terms of land and labour productivity, contribution to the gross national production, employment generation, foreign exchange earnings and land utilization was initiated (P H M U Herath).

BIOMETRY

Wasana Wijesuriya

SUMMARY

The Biometry Section attended to regular services, including experimental design, statistical analysis and interpretation of results of experiments done by the Research Departments. The services also include, development of computer programs, devising graphical methods for presenting complex results in assimilable manner, providing assistance in effective usage of word processing and graphic software in preparation of audio visuals and reports and database management.

Studies carried out by the Biometry section during 1995 were on ways and means of increasing precision of experiments, studies on variation of meteorological factors in different rubber growing areas, sampling procedures and time series analysis of natural rubber prices. Several collaborative research were also initiated on sampling methods, development of computer programs for assessing edaphic and climatic suitability for commercial rubber plantations and modelling of runoff-soil loss relationships under different management practices.

DETAILED REVIEW

Staff

Ms Wasana Wijesuriya, Assistant Biometrician continued to be in charge of the Biometry Section while continuing her postgraduate programme at the PGIA. Senior Technical Officer, Ms Nandani Wanigatunga and Technical Officer, Ms Chintha Munasinghe were on duty throughout the year. Mr M A Bodhiwansa who served as a Technical Officer since 01st January 1993, resigned on 29th July in order to continue with his graduate studies. Ms Sagari Kudaligama was transferred back to the Biochemistry Department on 28th June.

Seminars, Meetings and Workshops

Ms Wijesuriya presented a paper on "An effective sampling procedure to Estimate Annual Yield of Rubber" at the 07th Congress of PGIA at the Plant Genetic Resource Centre, Gannoruwa, Peradeniya.

Services

Statistical

Assistance was provided in designing of experiments, analysis and interpretation of results to Research Departments and University students on specialized training.The areas of statistical analyses include; analysis of variance and covariance, linear and non-linear regression, multivariate methods, categorical and non-parametric methods.

Computer Programming

The computer programs written by the Biometry Section for routine work of the Institute have been restructured according to the requirements of the Research Departments.

Database Management

Daily meteorological observations of the Dartonfield Station were recorded and maintained successfully.

RESEARCH

1. Inter-relationships of Natural Rubber (NR) Prices between Colombo and other Terminal Markets*

The relationship of NR prices between Colombo and other markets reveals the efficiency of information flow that describe the transparency of the market structure for natural rubber. Therefore, this study attempts to compare the FOB prices in Colombo with different terminal NR markets, namely Singapore, Indonesia, Malaysia, New York and London.

The cross correlation function (CCF) is generally used for examining the relationship between two series in the same time domain. Hence, cross correlations of Colombo versus other markets were computed on monthly and quarterly basis. The cyclic behaviour of prices were also studied to compare different NR markets. The study of cyclical movement aims at removing seasonal, irregular and trend components from time series data leaving only the cyclic component of prices in different markets. Further, since the data were in different currency units, they were standerized by dividing each cyclical indicator by its standard deviation.

The prices of markets lead the Colombo FOB prices by a quarter. The relationship between FOB prices of Colombo and other countries was always highest at the first lag and positively related. The order of magnitude of the relationship followed was; Singapore, London, New York, Malaysia and Indonesia with r_k values of 0.649, 0.648, 0.596, 0.478 and 0.419 respectively. The monthly relationships observed were less prominent when compared to quarterly prices. Out of the major overseas markets studied, prices of New York and London lead Colombo prices by 3 months and Singapore leads by 2 months.

The study of cyclical indicators is not a substitute for but complementary to econometric model building. However, they provide information on the direction of change. Table 1 lists different markets, their classification, leads/lags and coefficients of correlation. A graphical presentation of cyclic behaviour in major NR markets is given in figure 1.

Table 1. *Characteristics of Cyclical Indicators.*

Market	Sri Lanka	Singapore	London	New York	Malaysia
Sri Lanka		0.861	0.740	0.843	0.747
Singapore	-1		0.753	0.920	0.855
London	-1	0		0.691	0.649
New York	-1	0	0		0.848
Malaysia	-1	0	0	0	

* Upper triangular values are correlation coefficients.
* Lower triangular values: zeros, negative and positive values indicate coincident, leading or lagging behaviour when columns are taken as reference cycles.

These results signify that, the Sri Lankan market always follow the prices of other terminal markets. As a consequence, Sri Lanka can be regarded as a 'price taker' in the global rubber economy. This may be due to Sri Lanka's position, presently 6th in the NR market, exporting only around 1.82 percent of the total NR exports (ANRPC, 1995).

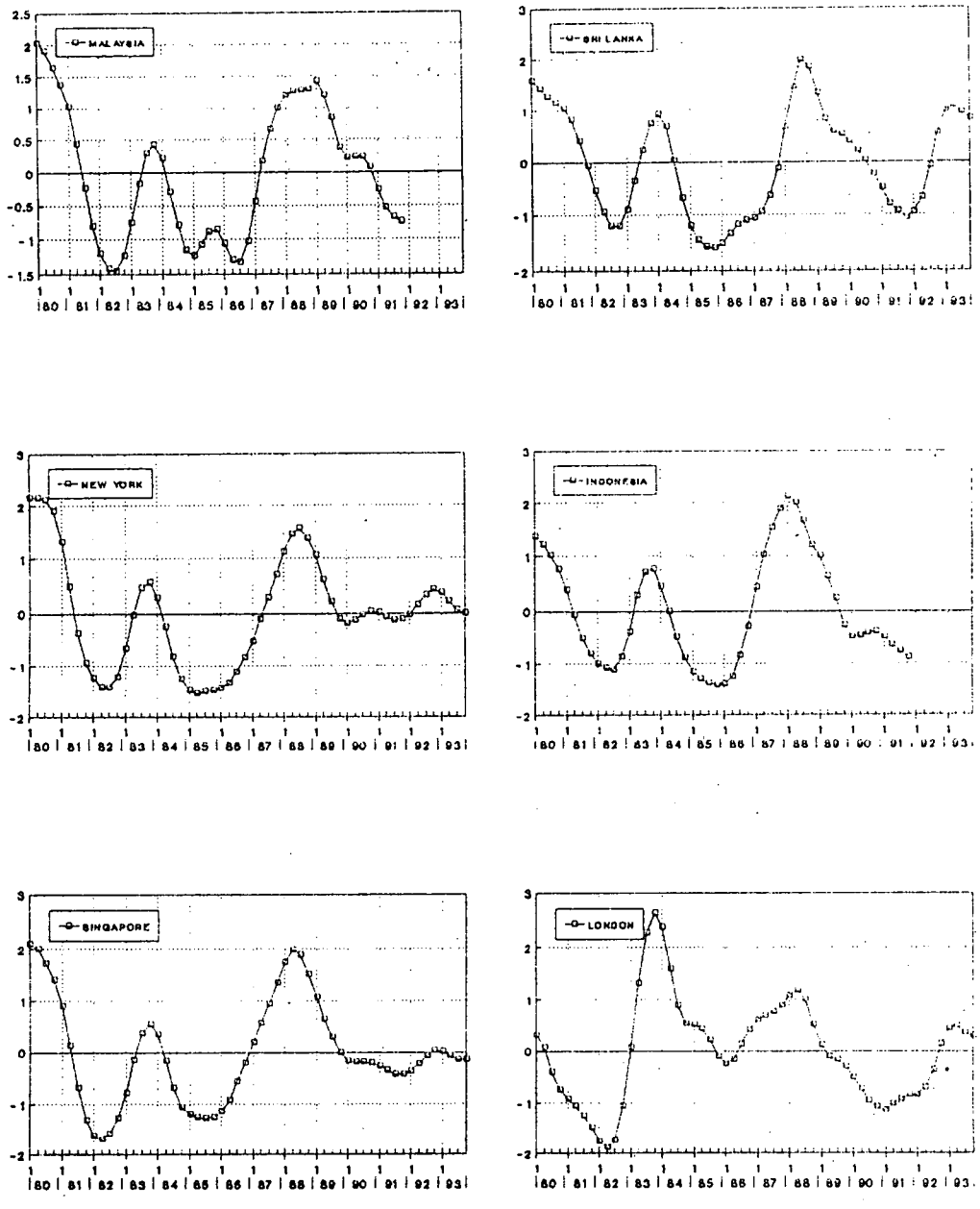


Fig. 1 Cyclical behaviour of prices in different NR markets

2. Inter-relationships of Prices with Production, Consumption, Exports and Stocks*

Being an agricultural commodity, characterized by seasonality in production, prices of NR may also indicates between and within year variations. Further, the consumption and stocks of NR may also affect prices. The relationships of prices with the above variables may be of great importance to identify the nature of competition and hence the market structure for natural rubber. The objective of this study was to examine the relationships if any, of prices to the variables such as production, consumption and stocks of NR.

Monthly and quarterly data on production, consumption, exports and stocks of NR were used in the analyses. The cross correlation functions were again employed in identifying the nature and strength of the relationship. The census II decomposition method is used in isolating trend-cycle and seasonal factors and in computation of seasonal indices.

a) *Price Fluctuations in Relation to Production*

Being a perennial crop, the yield of rubber varies within the year. Hence, the rubber production may show marked seasonality and is expected to have a direct impact on prices.

An overall declining trend was observed for Sri Lanka's production as depicted in figure 2 during 1979 to 1983, except for the megre increase in production during 1983. Since then, there appeared a gradual decline in production around an annual figure of 382 metric tonnes.

The seasonal indices for average auction price and production are presented in figure 3. The seasonal indices computed for production were highest during March and first quarter on monthly and quarterly basis respectively. In general, the seasonal indices for prices tend to fall when the production tend to rise, establishing a negative relationship. However, the analysis of cross correlations confirmed that the impact of production on prices was mild.

b) *Price Fluctuations in Relation to Consumption*

The domestic consumption of NR in Sri Lanka had a steady increase after 1985, around 175 MT per year as shown in figure 2. This increase coincided with the declining behaviour observed in exports and production.

The seasonal demand usually fall below the average from February to July. There is a tendency to consume more rubber during the latter part of the year as in figure 3, which depicts the link with seasonality in product manufacture towards the end of the year. However, a rise in seasonal demand evoked little response in respect of price. This may be due to the oligopolistic structure of the Sri Lankan market where few buyers can influence prices through their purchase and by adjustments of stocks.

c) ***Price Fluctuations in Relation to Exports***

Sri Lanka's NR exports also declined after 1985 with a rate of 520 MT per year (Fig. 2). Monthly export figures exhibit marked seasonality as shown in figure 4, which closely follow the pattern of variation of production. The exports are usually high during the first quarter of the year and drops below average during second and third quarters. However, there appeared no significant relationship between average auction prices and exports at any time lag.

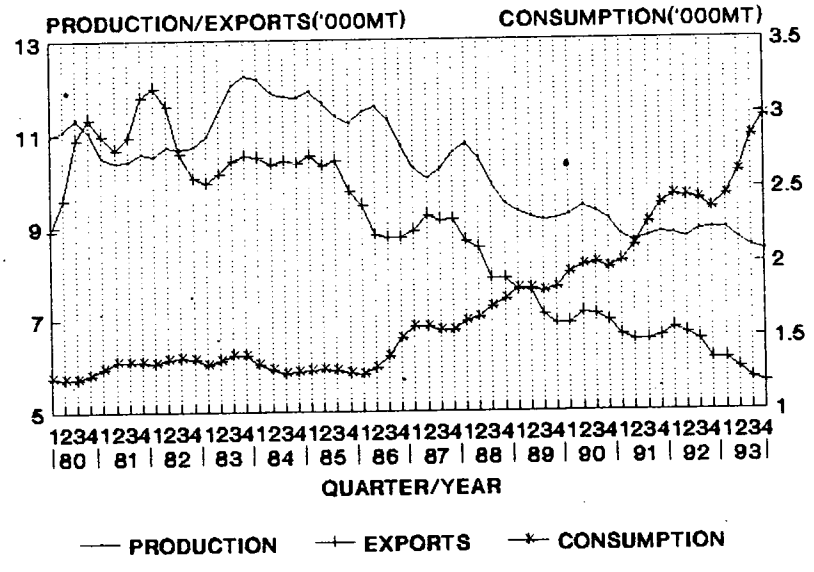


Fig. 2 Variation in trend-cycle component of production, consumption and exports of NR

d) *Price Fluctuations in Relation to Stocks*

Stock adjustment and speculation are important sources of profit in the trading of durable commodities. The seasonal indices of stocks worked out showed that it declined from February and remained below average until August. Then it picked up from August to reach the peak index in October. This gives an indication that there is an accumulation of stocks towards the end of the year. Moreover, the seasonal variation in consumption closely follow the sequence observed for stocks (fig.4). This shows the adjustments in stock inventories according to the seasonal demand of rubber. However, no relationship was found between average auction prices and stocks of NR. This is due to stock manipulation being carried out for different needs and not necessarily related to prices.

3. Forecasting of Natural Rubber prices*

Natural rubber prices in the Colombo auction are subjected to change from time to depending on the supply and demand of the materials in the market. Prices also tend to fluctuate due to various non economic factors. These make it difficult to the forecaster to predict prices of NR grades. Under such circumstances, where there are unusual peaks due to structural changes in the world economy, the involvement of econometric models in forecasting is inevitable. However, for short term forecasting, the Box-Jenkins univariate method has been extensively used in forecasting NR prices with considerable success. In this study an attempt was made to forecast NR prices in the Colombo market using Box-Jenkins univariate approach.

Monthly rubber prices for the period, 1979 January to 1995 july, of 3 different NR grades; RSS-1, L-1 and S-1 and average FOB prices in the Colombo market. FOB prices of RSS-1 in the Singapore market were employed in the analyses with a total series length of 187. Univariate models were developed using the test period, 1989 to 1992. Consequently, the selected models were applied to different segments of the series and the consecutive 12 months were forecasted to test these models. the precision of the forecasted prices was assessed by mean absolute percentage error (MAPE).

During the stage of model identification for Sri Lankan NR prices, it was found that for RSS-1 and average FOB prices, the non seasonal ARIMA models compared equally well with seasonal models. However, the seasonality is theoretically desirable to include in the model based on prior information. Therefore, the predictions were based on seasonal ARIMA models for each series.

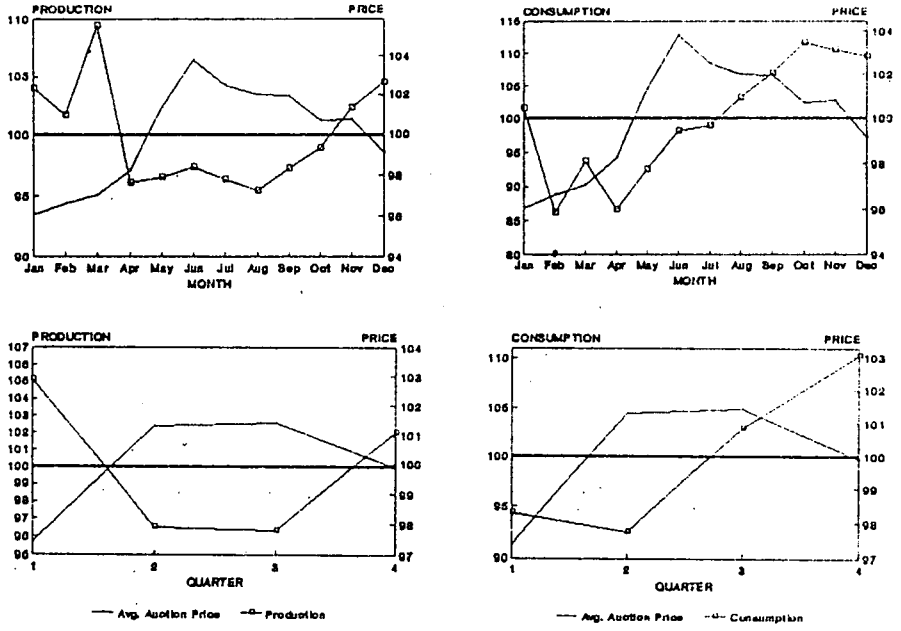


Fig. 3 Seasonal indices of production and consumption of NR

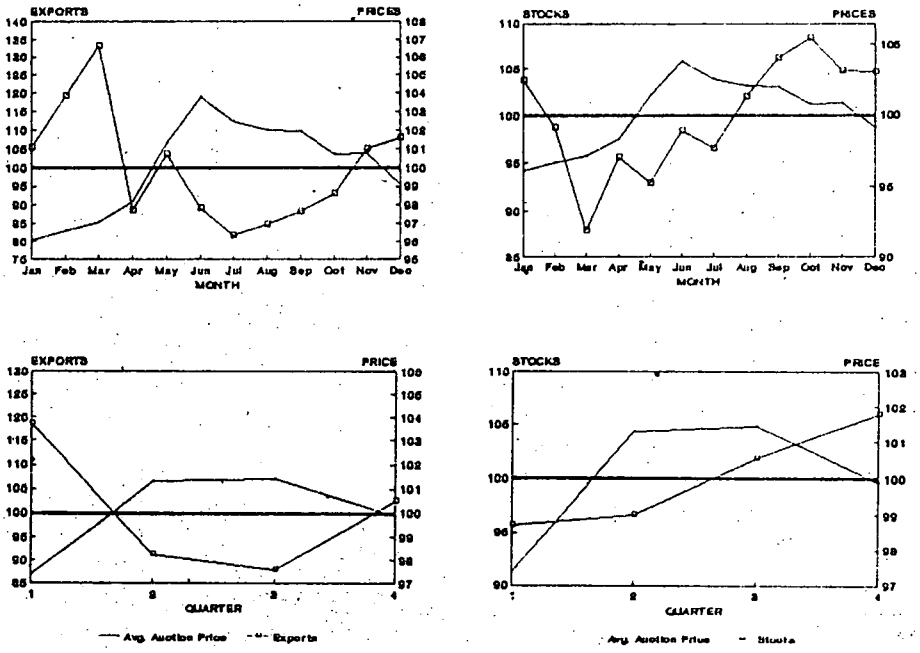


Fig. 4 Seasonal indices of exports and stocks of NR

The prices of RSS-1, and average FOB price in the Colombo market can be described by a single model in the form;

$$(1-B)(1-B^{10})Log_{10}Y_t = (1-\theta B)(1-\Theta B^{10})e_t ,$$

while prices of L-1, S-1 and RSS-1 (FOB) in the Singapore market can be explained by the form;

$$(1-B)(1-B^{10})(1-\phi B^{10})Log_{10}Y_t = (1-\theta B)(1-\Theta B^{10})e_t ;$$

Where,

B	=	backward shift operator,
ϕ	=	seasonal auto-regressive parameter,
θ	=	non-seasonal moving average parameter and,
Θ	=	seasonal moving average parameter.

In general, the models forecast reasonably well for all series except for the years where there are peaks due to structural changes in the NR market. However, these models can be used in forecasting purposes since peaks do not appear frequently in any of the series. The forecasts up to August 1996 based on the identified models are presented in figure 5.

4. Use of Covariance Analysis in Improving Precision of Field Experiments in Hevea*

Presently a number of variables are being measured as pre-treatment records in experiments with rubber. Yet, no comprehensive study has been done to evaluate the effectiveness of covariates in terms of improvement in precision of results. This study, therefore attempts to identity effective covariates using secondary data of several field experiments conducted by the Rubber Research Institute covering experiments on nursery, immature and mature rubber plantations.
The ratio Vy/Vy.x was employed in evaluating the gain in precision,

where	Vy	=	Residual variance of the unadjusted dependant variable and
	Vy.x	=	Effective residual mean square of the adjusted dependant variable.

It was a common observation that the high variability in experiments with perennial crops continue to present problems, in spite of the recent advances in methods of field experimentation. Block designs may reduce unexplained variability in experiments in the presence of environmental variation but not regraded as an effective measure in the presence of variability inherent to individual trees.

Selection of uniform planting material can be practiced to control the unexplained variability in experiments. This study reveals that although precautions are taken in selecting uniform planting material, there appears certain extreme values when budded stump weight and seed weights were measured. However, a considerable gain in precision was found when seed and budded stump weights were used as covariates in analysis of variance. Promising results were also found when girth, volume of latex and yield were incorporated in analysis of covariance.

* Studies carried out for the postgraduate programme of Ms Wijesuriya under the guidance of Prof. R O Thattil of the University of Peradeniya.

Meteorological Summary - 1995

A fairly distributed rainfall pattern was observed in 1995 with a total of 4307.5 mm, an increase of 13% when compared to the preceding year. A comparison of weekly rainfall in 1994 and 1995 is given in figure 6. A fairly dry weather was observed during February and March when compared to the previous year. However, there were only two dry weeks out of the 52 standard weeks (fig. 6).

The highest rainfall experienced in June. The preceding two months also had fairly high values. As a consequence, the rainfall during the first inter-monsoonal period (IM1) was increased from 15% in 1994 to 25% in 1995. However, the contribution from North-East rains was reduced to 8% during this year (fig.7).

The amount of rainfall and number of rainy days under low moderate and high rainfall categories are listed in Table 2. Table 3 depicts the monthly values of some important meteorological observations together with averages for 1980 to 1992 (W Wijesuriya, N Wanigatunga and C Munasinghe).

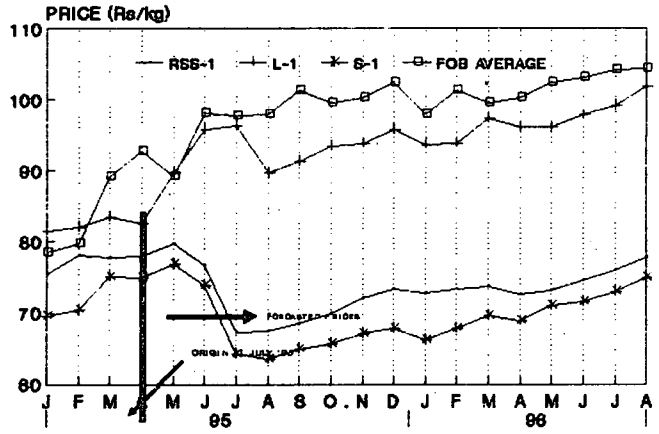


Fig. 5 Forecasted NR prices by Box-Jenkins univariate approach

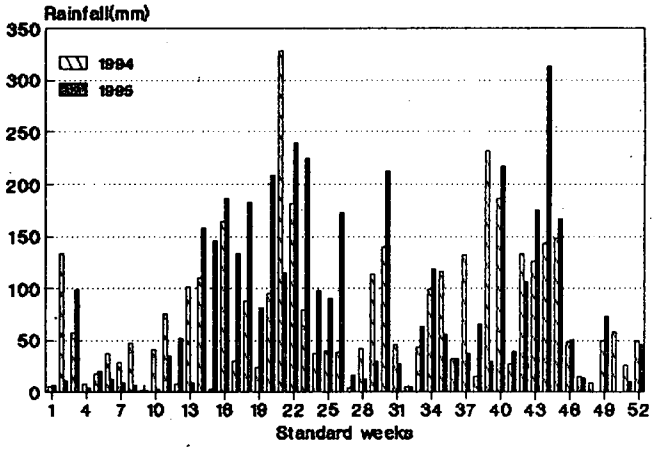
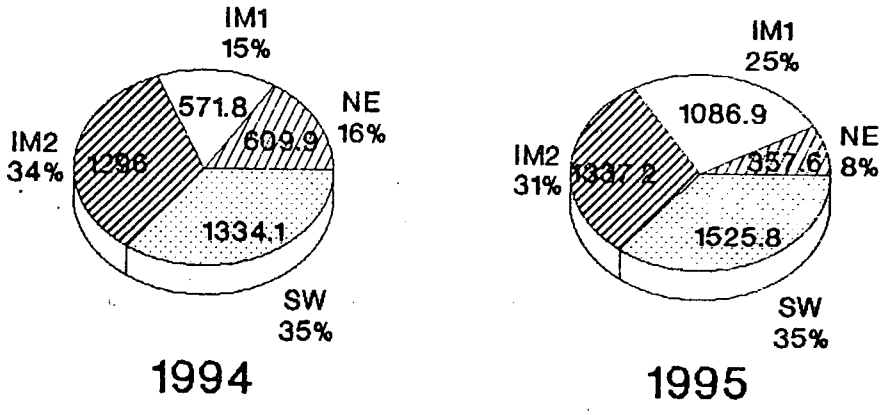


Fig. 6 Rainfall distribution at Dartonfield on standard week basis



Monsoonal seasons

NE = North East
SW = South West

Inter-Monsoonal seasons

IM1 = Mid March to Mid Nov.
IM2 = Sept. to Mid Nov.

Fig. 7 Seasonal variation in rainfall at Dartonfield

Table 2. *Monthly variation of rainfall and rainy days in 1995*

Month	Rainfall mm	Average** mm	No. of rainy days*	Avg.** days	No. of days under each category		
					0.3 - 2.5 mm	2.5 - 50 mm	>50 mm
January	124.1	(121)	12	(10)	02	10	-
February	47.5	(116)	08	(09)	04	04	-
March	100.3	(252)	10	(17)	04	06	-
April	624.2	(449)	25	(21)	01	23	01
May	683.9	(629)	27	(24)	03	19	05
June	740.0	(440)	29	(24)	05	20	04
July	277.9	(299)	14	(22)	02	10	02
August	225.2	(257)	24	(21)	04	20	-
September	299.9	(391)	23	(22)	03	19	01
October	550.2	(476)	21	(22)	01	17	03
November	505.0	(448)	14	(20)	-	10	04
December	129.3	(282)	10	(17)	03	06	01
Total	4307.5	(4160)	215	(229)	32	162	21

* Rainy days are defined as those with 0.3 mm or more

** Average values for 1980-1992 are shown in parentheses

Table 3. *Variation of observed meteorological factors at Dartonfield*

DARTONFIELD (Latitude 6°32': Longitude 80.09 E: Altitude 65.50 m)

Month	Temperature (°c)					Relative Humidity (%)			Wind speed
	Mean Max	Mean Min	Mean	No. of days min temp < 20	Soil at 10 cm	8.30 am	No. of days RH 8.30 > 90%	3.30 pm	Mean (kmph^{-1})
Jan	31.7 (32.3)	21.8 (20.8)	26.8 (26.5)	01	27.8	86 (87)	06	65 (67)	1.7
Feb	32.9 (23.3)	21.2 (21.1)	27.1 (27.2)	03	26.1	84 (85)	08	65 (64)	1.8
Mar	34.1 (33.5)	21.5 (21.7)	27.8 (27.6)	08	27.4	83 (84)	03	65 (66)	1.8
Apr	33.3 (32.9)	22.5 (27.8)	27.9 (27.8)	00	27.2	87 (84)	08	77 (73)	1.7
May	31.5 (31.6)	23.7 (23.3)	27.6 (27.5)	00	27.5	88 (87)	09	80 (77)	2.2
Jun	30.6 (30.8)	23.0 (23.1)	26.8 (26.9)	02	26.1	91 (88)	18	81 (76)	2.2
Jul	31.1 (30.2)	22.1 (22.8)	26.6 (26.5)	00	27.1	88 (88)	09	73 (74)	3.0
Aug	30.7 (30.2)	21.3 (22.7)	26.0 (26.5)	09	27.2	85 (87)	06	77 (74)	2.5
Sep	31.7 (30.6)	22.3 (22.4)	27.0 (26.5)	00	27.1	89 (86)	15	77 (74)	2.3
Oct	31.8 (30.9)	22.2 (22.1)	27.0 (26.5)	00	26.8	86 (85)	07	77 (77)	1.8
Nov	29.7 (31.4)	21.7 (21.8)	25.7 (26.6)	10	26.1	85 (84)	07	75 (77)	1.5
Dec	32.8 (32.0)	19.2 (21.4)	26.0 (26.7)	29	24.9	82 (84)	09	72 (74)	1.6

** Average values for 1980-1992 are shown in parentheses

LIBRARY AND PUBLICATIONS

Kamani Perera

SUMMARY

Maintaining, processing and publishing of Institute's regular publications, collecting and disseminating of information on natural rubber and related areas have been carried out throughout the year. The library continued to maintain cordial relationship with Agricultural Libraries Network (AGRINET) system.

DETAILED REVIEW

Staff

Mrs Kamani Perera, Librarian & Publications Officer, Mrs Tilaka Dantanarayana, Library Assistant & Assistant Publications Officer (Colombo Officer), Mrs Ramani Amaratunga, Clerk/Typist and two Library Attendants were on duty throughout the year.

Resource development activities

Book/Serial acquisition

The Library stock increased to 4667 books and the bound volumes to 3190 by the end of the year.

The Library subscribed 64 journals and about 33 journals were also received as gift/exchange. RRISL is grateful to all those persons and organisations who donate documents to the RRISL Library collection.

Meetings/Seminars

Librarian & Publications Officer attended the meeting of the AGRINET Librarian's held on 28.07.95 at the CARP Office, Colombo.

Publications

The following publications were published during the year.

Annual Review 1994
RRISL Bulletin Vol.32 (I) 1995
RRISL Bulletin Vol.32 (II) 1995
RRISL Journal Vol.75, 1995
RRISL Journal Vol.76, 1995
Rubber Puwath Vol.17, 1994

Advisory Leaflets

Fertilizers to Rubber 1995/01
Corynespora 1995/02
Phytophthora 1995/03
White Root Disease 1995/04
Control of Nursery Diseases 1995/05
Budwood Nurseries 1995/06
Rootstock Nurseries 1995/07
Green Budding 1995/08
Field Establishment 1995/09
Stumped Buddings 1995/10
Etheral Stimulation 1995/11
Weeds 1995/12
Mulching 1995/13
Soil Conservation 1995/14
Ground Covers 1995/15
Nutrient Deficiencies in Rubber 1995/16

Librarian & Publications Officer compiled the following cumulative indexes.

Journal of the RRISL Vol. 1-34 (1924-1958)
Journal of the RRISL Vol.35-43 (1959-1967)
Journal of the RRISL Vol.44-53 (1968-1976)
Journal of the RRISL Vol.54-74 (1977-1994)

Reports

Perera, Kamani(1995). Review of the Library & Publications Section. Annual Review. RRISL. 1994.

Office Equipments

Datamini Computer with laserjet printer and heavy duty staple machine were purchased during the year.

Reader Services

International Photocopy Service (BLDS)

Under this service, 18 articles were obtained for RRISL scientist.

ILL/Reprint Service

Inter-Library loan activities continued satisfactorily. While 28 items were loaned to other libraries, 68 articles were received for our users. Literature surveys based on *Hevea*/rubber were done using available CD-ROMS at IIMI, CARP agricultural libraries.

Information Services

Contents of the current periodicals have been distributed among the users. The facilities and the services of the library were also extended to planters, manufacturers, smallholders and others connected to rubber industry. Research scholars and students from universities and technical colleges also utilized the services of the library.

AGRINET Services

We received content pages of 40 Journal titles according to our user requirements and we also forwarded contents of 32 Journal titles to AGRINET libraries.

DARTONFIELD GROUP

A Nugawela

SUMMARY

A crop of 155.097 kg were harvested during the year which is an increase of 4.6% above the estimated crop for the year and 6.1% more than the crop of the previous year.

The relative tapping intensity during the year in 100% tapped areas was 73%, as a result a productivity of 928 kg per hectare per year (YPH) was achieved.

The average intake per tapper for 250 tree tapping tasks, is 6.20 kg, which is the same as in the previous year. The highest intake per tapper recorded during the year was 17 kg from 250 trees in the 1986, RRIC 100 clearing at Gallewatta Division.

The average number of normal, late, double and no tapping plus rain interference days were 205, 54, 8 and 106 days respectively. The relative tapping intensity, *i.e.* 73% is less than the previous years figure of 78%.

A total rainfall of 4369.5 mm was recorded over 185 wet days. The total rainfall is 485 mm more than the previous year.

The total cost of production and net sale average for the year were Rs.36.60 and Rs.80.73 respectively, which resulted in a profit of Rs.44.13 per kg and Rs.6.844 million from the entire revenue area. The profit recorded per hectare of revenue area is Rs.40 957.64 during the year which is significantly higher than that of the previous year.

The manufacture records reveal that the latex grade 1 percentage is around 96. This was possible due to the manufacture of unfractioned unbleached rubber and have resulted in a high net sale average, of Rs.80.73.

DETAILED REVIEW

Staff

Dr A Nugawela, Acting Estate Superintendent; Mr P Kannangara, Chief Clerk; Mr K K P Gunawardena, Senior Clerk: Mrs C Dissanayake and Mr A K D A Wickramasinghe, Junior Clerks; Mr J A Wimalasena, Mr S K S de Silva and Mr T Somaratne, Field Officers; Mr S R Vadivel and Mr N L D Reggie, Assistant Field Officers; Mr J K Nakandala, Mr K A Sarath Kumara and Mr B M Siriwardena.

Junior Assistant Field Officers: Mr D S K Ranaweera. Rubber Factory Officer: Mr W D D Senanayake. Assistant Factory Officer: Mrs C S Hettiarachchi. Creche Attendant and Mr A K Piyasena Office Peon, were on duty through out the year.

Mr H M Jayantha Premalal. Field Officer was interdicted on 23rd December 1994 and reinstated as Assistant Field Officer at Dartonfield Division with effect from 16th May 1995.

Mr N L D Nihal was appointed as Junior Assistant Field Officer with effect from 4th September 1995.

Mr A K D I Rukmal. Junior Assistant Field Officer was transferred to Kuruwita Sub-station as Acting Assistant Field Officer with effect from 10th July 1995. Mr T D Kularatne. Assistant Field Officer. Kuruwita Sub-station was transferred to Dartonfield Estate in the same capacity with effect from 1st August 1995.

The Group cadre stood at 19 at the end of the year. made as follows:

Senior Staff	01
Assistant Staff	17
Minor Staff	01
Total	19

Hectarage

A summary of the Hectarage is given in Table 1.

Table 1. *Land distribution in Dartonfield Group*

	Dartonfield	Galewatta	Nivitigalakele	Total
Mature Area	24.42	97.85	44.84	167.11
Immature Area	17.46	49.40	-	66.86
Uprooting Area	-	19.87	-	19.87
Nurseries	7.27	-	7.69	14.96
Paddy Field/Deniya	-	1.22	-	1.22
Earth Slip Area	1.65	1.26	2.62	5.53
Rocks	0.29	1.80	1.21	3.30
Waste Land	0.19	0.18	-	0.37
Jungle	0.80	-	0.71	1.51
Roads	3.27	6.86	0.32	10.45
Buildings	16.14	5.07	7.79	29.00
Abandoned	-	-	8.06	8.06
Reserved for Buildings	2.53	-	-	2.53
Streams	-	0.84	-	0.84
State Land taken-in	0.27	-	-	0.27
Total	74.29	184.35	73.24	331.88

Crop

A total crop of 155,097 kg was harvested from an extent of 167.11 ha. during the year. This is 6797 kg or 4.6% above the estimated crop of 148,300kg for the year.

The yield per hectare for the last 5 years is given in Table 2 for the entire group and separately for each division.

Table 2. *The yield per hectare (YPH,kg) at Dartonfield Group from 1991 to 1995*

	Year				
Division	1991	1992	1993	1994	1995
Dartonfield	709	605	943	1037	714
Galewatta	636	740	958	1077	1039
Nivitigalakele	632	771	841	876	804
Group average	640	740	918	1012	928
Group Estimate	715	883	883	884	887

The Dartonfield Group yield per hectare during 1995, i.e. 928 kg, is above the estimated crop of 887 kg per hectare. Nevertheless, there is a decline in the yield per hectare than in the pervious year. This could be attributed to, a large extent coming into bearing during 1995 and the relatively low tapping intensity recorded during the year.

A monthly breakdown of the yield per hectare, separately for each division is given in Table 3.

Table 3. *The yield per hectare (YPH,kg) recorded during each month in 1995 in different Divisions*

Month	Dartonfield	Gallewatta	Nivitigalakele
January	78	122	107
February	61	81	79
March	70	90	86
April	24	28	37
May	22	11	9
June	14	19	11
July	91	145	101
August	56	100	81
September	49	85	53
October	60	87	59
November	82	121	64
December	114	161	115

The highest yields were recorded in the months of January, July, November and December. The crop harvested during these four months is around 50% of the total annual crop.

Tapper Productivity

The average intake per tapper (kg) during the past five years is given in Table 4

Table 4. *The average intake per tapper (kg) division wise for the last 5 years*

	Year				
Division	1991	1992	1993	1994	1995
Dartonfield	5.43	5.15	6.96	6.96	7.0
Gallewatta	4.10	4.78	6.06	6.35	6.7
Nivitigalakele	4.73	5.06	5.67	5.78	5.4
Group Average	4.40	4.9	5.97	6.21	6.20

The average intake per tapper for the Group (250 tree blocks) has increased steadily since 1991 indicating an improvement in tapper productivity.

Manufacture

A summary of the manufacture records during the year is given in Table 5.

Table 5. *Details of the crop manufactured in Dartonfield Group*

Grade	Amount (kg)	Grade %	Latex/Scrap %
Crepe No.1	133467	86	96
Crepe No.3	6127	4	4
Scrape Crepe No.1	11202	7.2	72
Scrape Crepe No.2	3910	2.05	25
Scrape Crepe No.3	391	0.3	3

The grade 1 percentage in latex and scrape is 96 and 72 respectively. High grade 1 percentage in latex is due to the manufacture of unfractioned unbleached rubber (UFUB). This results in a higher NSA and a lower manufacturing cost due to less off-grades, low labour and chemical costs.

Weather

The annual rainfall (mm) and the number of wet days for the last 5 years are given in Table 6.

Table 6. *Annual rainfall (mm) and wet days for the last five years*

	Years				
	1991	1992	1993	1994	1995
Rainfall (mm)	3860.1	3974.4	4391.9	3884.7	4369.5
Wet days	185	163	192	185	185

The total rainfall for the year 1995 is higher than in 1994. Nevertheless, the number of wet days are similar.

The average number of normal, late, double and no tapping days for the last 3 years are given in Table 7. Further, the relative tapping intensity, average intake per tapper and the yield per hectare are also given for the same years to study the influence of wet weather on productivity.

Table 7. *The number of tapping days, relative tapping intensity, average intake per tapper and yield per hectare for the last 3 years in Dartonfield Group*

	Year		
	1993	1994	1995
1. Tapping days			
1.1 Normal	198	214	205
1.2 Late	52	57	54
1.3 Double	16	9	8
1.4 No	115	94	106
2. Relative Intensity	73	77	73
3. Average Intake Tapper (kg)	5.97	6.21	6.2
4. YPH (kg)	918	1012	928

The relatively high YPH in 1994 could be attributed to that of relative tapping intensity. If 50% of the tapping days that are lost can be recovered by means of rainguards, the YPH would have increased upto 1105 kg in 1995. Further the crop increase in the entire group would have been about 33300 kg.

Cost of production and profitability

Net sale average, labour rate and a breakdown of cost of production for the last 5 years are given in Table 8.

Table 8. *Net sale average (NSA.Rs.), Labour rate (LR.RS) and a break down of cost of production (COP.Rs.) for years 1991, 1992, 1993, 1994 and 1995*

	Years				
	1991	1992	1993	1994	1995
1. Labour rate	50.26	58.19	72.24	72.24	72.24
2. COP	44.69	44.68	35.15	33.45	36.60
2.1 Tapping	13.94	14.17	13.91	14.76	16.23
2.2 Manufacture	7.03	6.07	8.76	7.32	6.47
2.3 General Charges	18.37	19.07	6.57	7.34	9.17
2.4 Upkeep	5.35	5.37	5.35	4.03	4.03
3. NSA	23.52	35.15	39.01	55.22	80.73
4. Profit	(25.17)	(9.53)	3.86	21.77	44.73

The cost of production has declined from 1991 to 1994 but has increased by Rs.3.15 in 1995. Nevertheless the NSA has increased significantly since 1991 increasing the profits remarkably. Profit made during 1995 is Rs.6.84 million.

The increase in COP during 1995 is attributed to that of Total Tapping Costs and General Charges. A breakdown in Total Tapping Cost for years 1994 and 1995 is given below:

Table 9. *A break-down in Total Tapping Cost*

Cost Item	Cost (Rs.)	
	1994	1995
Tapping	13.28	14.36
Double Tapping	0.23	0.20
Kanganies	0.33	0.13
Over-kilos	0.68	1.17
Scrap Pay	0.18	0.28
Intentive to Field Staff	0.06	0.09
	14.76	16.23

Increase in Total Tapping Cost during 1995 is due to drop in take per tapper at N'kele Division, increase in incentive payment for tappers and scrape pay. Nevertheless, increase in the incentive payment for tappers and scrape pay have increased the total crop resulting in an increase in total profits.

General charges have increased in 1995 due to inclusion of depreciation and service gratuity.

The profitability per unit land area, *i.e.* ha during last 3 years is given in Table 10.

Table 10. *Total profit form revenue extent, the revenue extent and profit per ha of revenue area for year 1993, 1994 and 1995*

	Year		
	1993	1994	1995
Mature Extent	155.59	144.42	167.11
Total Profit (Mn Rs.)	0.48	3.2	6.84
Profit/Ha (Rs.)	3064.16	22031.69	40957.59

The profit per revenue hectare has increased steadily upto Rs.40 957.64 in 1995. Increase in productivity, tapper productivity, decline in cost of manufacture and improved net sale average have contributed to this increase in profitability.

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