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RUBBER RESEARCH INSTITUTE OF SRI LANKA



ANNUAL REVIEW 1993

RUBBER RESEARCH
INSTITUTE OF SRI LANKA



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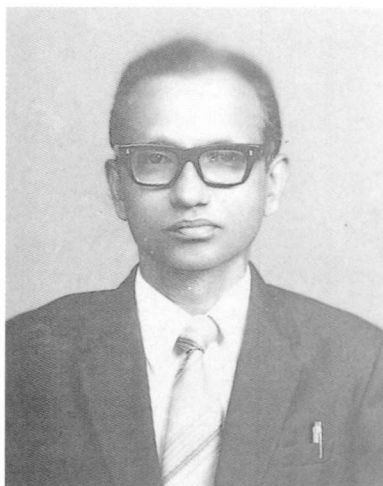
Rubber Research Institute of Sri Lanka

Annual Review – 1993
1st January 1993 to 31st December 1993

April 1994

Headquarters & Laboratories
Dartonfield
Agalawatta

Colombo Office & laboratories
Telawala Road
Ratmalana



PROFESSOR INDRARATNE BALASOORIYA
(An Appreciation)

It is with deep regret that we record the death of Prof I Balasooriya, Chairman, Rubber Research Board of Sri Lanka, on 16th October 1993, after a sudden illness.

Prof Balasooriya had a brilliant academic career. He entered the Colombo Campus in 1952 and received a Second Class (Upper Division) specializing in Botany and was subsequently awarded the PhD degree of the University of Liverpool, UK in 1964.

Since then he had been a Lecturer and then Professor of Botany, Dean of the Faculty of Science, the Vice-Chancellor of the University of Kelaniya and finally functioned as the Vice-Chairman, University Grants Commission.

During his four years of service as Chairman of the RRB, he had always maintained that the research work of the RRI must be alive to the needs of the industry and that the effectiveness of the research programmes should be judged by not only their findings but also their cost effectiveness and adaptability.

Prof Balasooriya was an innovative administrator who motivated and led his senior executive staff to fulfil their organizational obligations by creating a conducive environment. His academic brilliance coupled with superb administrative ability enabled him to contribute well to the RRI.

Death snatched him unexpectedly. The grief and the sad news of the loss of a valued person like Professor Balasooriya cannot be expressed adequately in words. Our sympathies go out to his wife Chintha and children. May he attain Nibbana, the eternal bliss.

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RUBBER RESEARCH BOARD OF SRI LANKA

BOARD OF MANAGEMENT

Members appointed by the Hon Minister of Plantation Industries

Professor I Balasooriya, Chairman, RRB, Professor of Botany, University of Kelaniya,
(up to 16.10.1993)
Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
Mr Sepala Ilangakoon, Secretary-General, Planters' Association of Ceylon
(up to 15.03.1993)
Mr P I Peiris, Deputy Chairman, M/s Richard Peiris & Co. Ltd.
Mr M M A Naina Marikkar, Planter (Smallholders' Representative),
Working Director, RRB
Mr R Wijegunaratne, Working Director, RRB

Ex-Officio Members

Mr G P S U de Silva, Secretary, Ministry of Plantation Services
Mr G W S K de Silva, Rubber Controller
Mr M A L Perera, Chairman, JEDB (up to 21.07.1993)
Mr L Madawela, Chairman, SLSPC (from June 1993)
Mr Sarath Ranawaka, MP for Kalutara District
Mrs C S Kumarasinghe, Deputy Director (Budget Division), Ministry of Finance
(up to September 1993)
Mr A Rajapaksa, Deputy Director (Budget Division) (from October 1993)
Mr M P Mohideen, Director, National Planning (from 15.03.1993)

STANDING COMMITTEES

Estate Committee

Professor I Balasooriya, Chairman, RRB (up to 16.10.1993)
Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
Mr M M A Naina Marikkar, Smallholders' Representative (Working Director, RRB)
Mr M R C Peiris, Chairman, SLSPC
Mr Denzil Peiris, Representative of the JEDB

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Dr L M K Tillekeratne, Director, RRI
Mr V M Katugaha, Estate Superintendent (In attendance) (up to February 1993)
Dr R C W M R A Nugawela, Overlooking Superintendent (In attendance)
(from March 1993)
Mr T H Wijesena, Asst. Administrative Officer (In attendance)
(from March 1993 to 05.11.1993)
Mr J A A S Ranasinghe, Secretary, RRB

Central Scientific Committee

Professor I Balasooriya, Chairman, RRB (up to 16.10.1993)
Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
Dr L M K Tillekeratne, Director, RRI
Mr S W Karunaratne, Deputy Director (Research) (I), RRI
Dr N Yogaratnam, Deputy Director (Research) (II), RRI
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Mr M M A N Marikkar, Board Member, Working Director, RRB
Mr G W S K de Silva, Rubber Controller, Board Member, RRB
Mr A Dahanayake, Actg. Director, ASD
Dr N E M Jayasekera, Head, Genetics and Plant Breeding Dept., RRI
Dr A Nugawela, Head, Plant Science Dept., RRI
Mr C K Jayasinghe, Head, Plant Pathology and Microbiology Dept., RRI
Dr (Mrs) L Samarappuli, Head, Soils and Plant Nutrition Dept., RRI
Dr (Mrs) K G K de Silva, Head, Polymer Chemistry Dept., RRI
Dr (Mrs) N M V Kalyani Liyanage, Head, Rubber Technology Dept., RRI
Dr W M G Seneviratne, Actg. Head, Raw Rubber Process Development and Chemical
Engineering Dept., RRI
Mr P H M U Herath, Asst. Agricultural Economist, RRI
Mr I N Samarappuli, Asst. Agricultural Economist, RRI
Mr L K Meegahawatte, Head, Development Division, ASD
Mrs N Yapa, Asst. Biochemist, RRI
Dr T Attanayake, Asst. Geneticist and Plant Breeder, RRI
Dr R Jayaratne, Asst. Plant Pathologist, RRI
Dr Anura Dissanayake, Asst. Soils Chemist, RRI
Mr Lakshman Rodrigo, Research Assistant (Intercropping), RRI
Mr S N Gunaratne, Chief Executive Officer, Kegalle Plantations Ltd.
Mr M R C Peiris, Director-Rubber, Free Lanka Management Co. (Pvt.) Ltd.

Mr N M Amarasekera, General Manager – Low Country, DPL Plantations Ltd.
 Mr R C Peries, General Manager–Rubber, Kotagala Plantations Ltd.
 Mr H P S Dasanayake, Regional General Manager, Bogawantalawa Plantations Ltd.
 Mr H N K Ratwatta, General Manager, Hapugastenna Plantations Ltd.
 Mr D J Perera, Chairman, Crop Management Services (Pvt.) (Ltd.)
 Mr A P Amarasinghe, Talduwa Estate, Avissawella
 Mr I L A Fernando, Superintendent, Pallegama Estate, Niyadurupola
 Lt. Col. G L F Marshall, Manager, Agalawatta Plantations Ltd.
 Mr D Wickremasinghe, General Manager, BC Plantations Services (Pvt.) Ltd.
 Mr Abeynatha Dias, General Manager, Carsons Agro Services (Pvt.) Ltd.
 Mr S P J Wijesekera, Superintendent, Elston Estate
 Mr M V Dirckze, General Manager, BC Plantations Service (Pvt.) Ltd.
 Mr G J K Nakandala, Superintendent, Rambukkanda Estate, Ratnapura
 Mr C L Perera, Estate Group Manager, Dehiowita
 Mr M Hapugoda, Manager, Kotagala Plantations Ltd.
 Mr K M Ganapathy, Chief Technical Advisor, Watawala Plantations Ltd.
 Mr U J D Vas Gunawardena, Manager, Pallegoda Estate, Dharga Town
 Mr N Saleem, Delhena Estate

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 Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
 Mr G W S K de Silva, Rubber Controller, RCD
 Mr P I Peiris, Deputy Chairman, Richard Peiris & Co. Ltd.
 Dr L M K Tillekeratne, Director, RRI
 Mr S W Karunaratne, Deputy Director (Research) (I), RRI
 Mr A Dahanayake, Actg Director, ASD
 Dr (Mrs) K G K de Silva, Head, Polymer Chemistry Dept., RRI
 Dr W M G Seneviratne, Actg. Head, Raw Rubber Process Development and Chemical
 Engineering Dept., RRI
 Dr (Mrs) N M V Kalyani Liyanage, Head, Rubber Technology and Development
 Dept., RRI
 Mr Gamini Herath, General Manager, Midland Retreads
 Mr S D Fernando, Proprietor, Hiquo Industries
 Mr L B C Von Hagt, Associated Auto Industries
 Mr Chry Santhus Fernando, Development Manager, Associated Motorways
 Mr M T M Kamardeen, Managing Director, Associated Speciality Rubbers
 Mr W D Hettiarachchi, General Manager, RRIATSCO Ltd.

Mr I A Wickremaratne, Works Manager, Ratnayake Rubber Industries
Mr S N Hari, Bensiri Rubber Products
Mr Samantha Wickremaratne, Microcells Ltd.
Dr Paul Cacioli, Technical Manager, Ansell Lanka Ltd.
Mr N A Nandasena, Senior Assistant Technical Manager, Samson Rubber Industries
Mr H P M Fernando, Production Executive, Plymouth Industries Ltd.
Mr J L D de Silva, Laboratory Manager, Bata Shoe Co.
Mr W A U N de Silva, Commercial Manager, D Samson Industries
Mr M N Pathirana, Proprietor, Ravi Auto Industries
Mr Tilak de Silva, Technical Manager, Sinwa Adhesive Ltd.

Administrative & Financial Committee

Professor I Balasooriya, Chairman, RRB (up to 16.10.1993)
Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
Mrs C S Kumarasinghe, Treasury Representative (up to September 1993)
Mr A Rajapakse, Treasury Representative (from 12.10.1993)
Mr G P S U de Silva, Secretary, Ministry of Plantation Services
Mr G W S K de Silva, Rubber Controller, RCD
Mr M M A Naina Marikkar, Smallholder Representative, Working Director, RRB
Mr R Wijegunaratne, Working Director, RRB
Mr G Fonseka, Accountant, RRI (In attendance) (up to 24.03.1993)

Provident Fund Committee

Mr M M A Naina Marikkar, Chairman, Provident Fund Committee of Management
Dr L M K Tillekeratne, Director, RRI
Mr J A A S Ranasinghe, Secretary, Provident Fund Committee of Management
→ Mr P R N Pandikorala, Chief Administrative Officer, RRI
Mr Gamini Fonseka, Accountant, RRI (up to 24.03.1993)
Mr K G A K Dharmawardene, Assistant Accountant, RRI (from 05.06.1993)
Mr A M A Perera, Elected Committee Member, Provident Fund Committee of Management
Mr K C Fernando, Elected Committee Member, Provident Fund Committee of Management

Extension Committee

Prof I Balasooriya, Chairman, RRB (up to 16.10.1993)
Mr Y W Gunawardane, Chairman, RRB (from 20.11.1993)
Mr G W S K de Silva, Rubber Controller, RCD
Mr M M A Naina Marikkar, Working Director, RRB
Dr L M K Tillekeratne, Director, RRI
Mr A Dahanayake, Actg. Director, ASD
Mr S W Karunaratne, Deputy Director (Research) (I), RRI
Dr N Yogaratnam, Deputy Director (Research) (II), RRI
Mr L K Meegahawatte, Head, Development Division, ASD
Dr N E M Jayasekera, Head, Genetics and Plant Breeding Dept., RRI
Dr R C W M R A Nugawela, Head, Plant Science Dept., RRI
Mr P Samaranayake, Regional Advisory Officer (Kalutara District)
Mr D D Dassanayake, Regional Advisory Officer (Kegalle District)
Mr A H Kularatne, Regional Advisory Officer (Ratnapura District)

Board Office

Chairman	Prof I Balasooriya (up to 16.10.93)
	Mr Y W Gunawardane (from 20.11.93)
Secretary to the Board	Mr J A A S Ranasinghe
Actg. Asst. Administrative Officer and Confidential Secretary to the Chairman	Mrs L J C Perera
Confidential Stenographer/Clerk	Mrs P Balasooriya
Clerk/Typist	Miss S N Munasinghe

Lawyers

Attorney General
Attorney General's Department,
(Government Institutions)
P O Box 502
Colombo 12

Auditors

M/s Tissa Fernando & Co.
Chartered Accountants
519/2 B, Elvitigala Mawatha
Colombo 5

Bankers

Bank of Ceylon
Corporate Branch
75, Janadhipathi Mawatha
Colombo 1

Bank of Ceylon
Agalawatta

Registered Office and Laboratories

Dartonfield, Agalawatta

Telephones:

Director	034 - 23078
General Office	034 - 71426
	034 - 71427
	034 - 71383
Fax	: 034 - 71427

Rubber Research Institute - Substation
Nivitigalakele, Matugama

Genetics and Plant Breeding Department
Telephone : 034 - 71368

Rubber Research Institute - Substation
Kuruwita, Ratnapura

Colombo Office and Laboratories

Rubber Research Board Office
Advisory Services Department
Polymer Chemistry Department
Raw Rubber and Chemical Analysis Department
Raw Rubber Process Development and Chemical Engineering Department
Rubber Technology and Development Department
Electronic Instruments Repair Unit

Telawala Road
Ratmalana
Mt. Lavinia

Telephones:

Chairman, Rubber Research Board	01 - 635142
General Office	01 - 633351
	01 - 635851
	01 - 635852
Fax :	01 - 605171

RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

(As at 31st December 1993)

<i>Chairman</i>	Professor I Balasooriya, BSc (Cey.), PhD (Liverpool), FI Biol (SL), FNAS (SL) (up to 16.10.1993) Y W Gunawardane, BA (Cey.), SLAS (from 20.11.93)
<i>Director</i>	L M K Tillekeratne, BSc(Cey.), MSc(Aston), PhD(Aston), FI Chem C, FPRI
<i>Deputy Director (Research) (I)</i>	S W Karunaratne, BSc (Cey.), MSc(Aston), FPRI, FI Chem C
<i>Deputy Director (Research) (II)</i>	N Yogaratnam, BSc Agric(Alld), PhD (Lond.)

RESEARCH DEPARTMENTS

Plant Science

<i>Head of Department</i>	R C W M R A Nugawela, BSc (SL), MSc (Lond.), PhD (Essex)
<i>Botanist</i>	Mrs G P W P P Seneviratne, BSc (SL), PhD (Bath)
<i>Research Officer (Intercropping)</i>	V H L Rodrigo, BSc Agric (SL), MSc (Essex)
<i>Assistant Botanists</i>	*Mrs M de Silva, BSc (SL) *L S S Pathiratne, M I Biol, MPhil (SL)
<i>Experimental Officers</i>	R B Gunaratne L S Kariyawasam
<i>Senior Technical Officers</i>	K A G B Amaratunga R P Karunasena Mrs G A S Wijesekera

Senior Experimental Assistant
Technical Officers

S Wilbert
Mrs C W Ranasinghe, BA (Cey.)
Mrs R K Samarasekera
U S Weerakoon
T U K Silva
M K P Perera
S M A Samarakoon, Dip. Agric.
W D M N de Alwis
Miss G G M de Soysa, Dip. Agric.
Mrs H D D E Jayawardena

Clerk/Typist

Genetics and Plant Breeding

Head of Department

N E M Jayasekera, BSc Agric (Cey.), PhD (Birm.)

Assistant Geneticist and Plant Breeders

D P S T G Attanayake, BSc Agric (SL), PhD (Birm.)

Mrs S Palihawadana, BSc Agric (SL)

Experimental Officer

K W Rupatunga

Senior Experimental Assistant

B M S G Peiris

A K M S Senaratne

Technical Officers

R A S K Ranatunga

I D M J Sarath Kumara

Miss H P S Damayanthi

Plant Pathology and Microbiology

Head of Department

C K Jayasinghe, BSc (SL), MSc (SL), MSc (Agric) (Aust.)

Assistant Plant Pathologists

A H R Jayaratne, BSc (SL), MSc (SL), PhD (Sheffield)

K E Jayasooriya, MSc (USSR)

*Miss W P K Silva, BSc (SL), MSc (SL)

Experimental Officers

L W Amaratunga

Senior Technical Officer

W A D D S Wettasinghe

Technical Officers

Mrs P C Wettasinghe

Mrs B I Tennakoon, Dip. Agric.

Miss T H P S Fernando

Miss E A D D Siriwardene

Miss D H S C Ariyaratne

Clerk/Typist

Mrs W S P Amarasekera

Soils and Plant Nutrition

Head of Department

Mrs M L A Samarappuli,
BSc Agric (SL), MSc (Calf.), PhD (SL)

Soils Chemist

D M A P Dissanayake, BSc Agric (SL),
PhD (Aberdeen)

Assistant Soils Chemist

R S Dharmakeerthi, BSc Agric (SL)

Experimental Officers

A M A Perera

H D S P Perera, BSc (SL)

J G de Mel

Mrs R P Hettiarachchi, BSc (SL)

Senior Technical Officers

Mrs S D C K Maheepala

S N Silva

Technical Officers

P Karunadasa, BSc (SL)

A H U Mitrasena

A N Yakandawala

T B Dissanayake

M D R Gunasekera

H P Dammika

Miss J A D C S Jayalath

Specification Assistant (Special Grade)

T M Ahamadeen

English Stenographer

Mrs K A D L Rupasinghe Perera

Biochemistry and Physiology

Assistant Biochemists

*M T Warnakula, BSc (SL)

**Mrs P N de Silva, BSc (SL)

Experimental Officer

E B Fernando

Technical Officers

M D C Seneviratne

Miss K V V S Kudaligama

Specification Assistant

P D J Rodrigo

Polymer Chemistry

Head of Department

*Mrs K G K de Silva, BSc (SL),
MSc (SL), PhD (Aston)

Rubber Chemist

Mrs S A P P Gunatilleke, BSc (SL), PhD
(Sussex)

Assistant Rubber Chemist

S M C E Silva, BSc (SL)

Experimental Officers

H N K K Chandralal, BSc (SL),
MSc (SL)

Mrs D I R Denawaka

Senior Technical Officers

Mrs W C M Kuruppu

S S Warnapura

Technical Officers

L P P Vitharana

S L G Ranjith

Miss D M S Wijesekera

Clerk/Typist

Mrs R S Wijeratne

Clerk/Stores Assistant

Mrs L Rukmanie

Raw Rubber and Chemical Analysis

Head of Department

L M K Tillekeratne, BSc (Cey.),
MSc (Aston), PhD (Aston), FI Chem C,
FPRI

Assistant Specifications Officer

L Karunanayake, BSc (SL)

<i>Assistant Rubber Chemist</i>	*Miss J A G S G Gunawardena, BSc (SL), MSc (SL)
<i>Senior Technical Officer</i>	Mrs L Wanigatunga
<i>Technical Officers</i>	Mrs K N A Baduge, BA (Cey.) Mrs H V K Gamage Mrs C S Lokuge R S Wijesundera G Wanigatunga P L Perera Miss R P G R Rajapakse
<i>Specification Assistants</i>	B Gunasiri W W Nandasena K R N Karunatilleke
<i>Clerk/Typist</i>	Mrs I Wijesinghe

Rubber Technology and Development

<i>Head of Department</i>	Mrs N M V K Liyanage, BSc (SL), PhD (Lond.)
<i>Assistant Rubber Chemists</i>	B P Weeraratne, BSc (SL), PhD (Ulster) Mrs H M M de S Jayasuriya, BSc (SL), MSc (SL) Mrs D G Edirisinghe, BSc (SL), MSc (SL)
<i>Experimental Officers</i>	D D Medagama Mrs H S Weeraman
<i>Senior Technical Officer</i>	M K Mahanama
<i>Technical Officers</i>	Mrs S I Yapa K M U Mitranande D P Wettasinghe

<i>Acting Head of Department</i>	W M G Seneviratne, BSc (SL), PhD (Sussex)
<i>Assistant Rubber Chemist</i>	S Siriwardena, BSc (SL)
<i>Experimental Officer</i>	P H Sarath Kumara, DPRI
<i>Technical Officers</i>	Mrs W K C Nalinie T A S Siriwardene E C D Senanayake
<i>Clerk/Typist</i>	Mrs S A Paranavithana

Electronic Instruments Repair Unit

<i>Instrument Technician</i>	L G P Lelwela
------------------------------	---------------

Biometry Section

<i>Assistant Biometrician</i>	Mrs B W Wijesuriya, BSc Agric (SL)
<i>Senior Technical Officer</i>	Mrs Nandanie Wanigatunge
<i>Technical Officers</i>	M A Bodiwansa Mrs H K D C S Munasinghe D Ramawickrema

Director's Office

Adaptive Research Unit

<i>Research Assistant/Agronomy</i>	S M M Iqbal, BSc Agric (SL), MPhil (SL)
<i>Development Officers</i>	F P W Silva P P Jayasinghe, LPRI W C Dayaratne K B A Karunasekera
<i>Senior Technical Officer</i>	E A T Senadeera

<i>Senior Technical Officer</i>	E A T Senadeera
<i>Specification Assistant (Special Grade)</i>	W A S Wijesekera

Agricultural Economics Unit

<i>Assistant Agricultural Economists</i>	*H Talgaswatte, BSc Agric (SL), MCom (Lincoln)
	P H M U Herath, BSc Agric (SL), MSc (SL)
	I N Samarappuli, BSc Agric (SL), MSc (Reading)
	Mrs S Amaratunge, BA (SL), MA (SL)

Library

<i>Librarian and Publications Officer</i>	Mrs Kamani Perera (ASLLA)
<i>Library Assistant and Assistant Publications Officer</i>	Mrs D T Dantanarayana
<i>Clerk/Typist</i>	Mrs R M Amaratunge

ADMINISTRATION DEPARTMENT

<i>Chief Administrative Officer</i>	P R N Pandikorala, BSc Agric (Cey.)
<i>Assistant Medical Practitioner</i>	K V de Silva
<i>Office Assistant</i>	J D Gunaratne
<i>Chief Clerk</i>	D U Kannangara
<i>Clerks (Special Grade)</i>	Mrs W Paul
	Mrs R S Amarasekera
	R G D Sakaraja

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Mrs P W Neelamanie
Mrs K P R Gunasekera
Mrs M D P Mandalawatta

Telephone Operator

Mrs P Edirimanne

Pharmacist

S Lankeshwara

Internal Audit Unit

Internal Auditor

R M T K Pattepol, B Com (Special)

Assistant Internal Auditor

Neil C de Silva

Internal Audit Assistants

S W S G Gunawardene

D E C Warnakula

Works Section

Works Engineer

G Mahanama

Transport Officer

B D Ponnampuruma

Electrical Foreman

W D Ratnasinghe

Mechanical Foreman

S D Gunawardene

Building Foreman

M A D K Jayasumana

Chief Clerk

S A L Chandrawansa

Clerk/Typists

Miss M Gunawathie Silva

Miss J A S Dharshanie

Mrs K C S Wickremasinghe

Charge Hand (Buildings)

H A Somasiri

Accounts Department

Assistant Accountant

K G A K Dharmawardena

Accounting Assistant

W Kularatne

Book-keeper

D A Rajapakse

<i>Graduate Assistants</i>	Mrs G K Somasiri, BA (Cey.) Mrs K Jagoda, BA (Cey.)
<i>Accounts Clerks (Special Grade)</i>	G S Doolwela G A Kannangara
<i>Accounts Clerks</i>	Mrs C C Silva Mrs Irene Perera Mrs M Gunawardena Mrs K Kapuge K C Fernando
<i>Cashier</i>	Miss G A D L H Jayawardena
<i>Clerk/Typists</i>	Mrs W A C Weeramanthrie Mrs R Handungoda
<i>Store Keeper</i>	D C P Pothmitiyage
<i>Assistant Store Keepers</i>	P D Somadasa K D Sumanasena

ESTATE DEPARTMENT

<i>Senior Assistant Clerk</i>	K K P Gunawardena
<i>Junior Assistant Clerks</i>	Mrs C Dissanayake ***A K D A Wickremasinghe
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<i>Rubber Factory Supervisor</i>	W D D Senanayake
<i>Field Officers</i>	H M J Premalal S K S de Silva (attending to Clerical Work)
<i>Assistant Field Officer</i>	J A Wimalasena
<i>Field Supervisors</i>	S R Vadivel T Somaratne N L D Reggie

Kuruwita Sub-Station

Visiting Superintendent

N M Cooray

Assistant Estate Superintendent

S A R Samarasekera

* On study leave overseas

** On study leave local

*** On no pay leave overseas

THE RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

L M K Tillekeratne

Rubber being a canopy crop in a tropical forest, contributes to the environment by removing a considerable amount of carbondioxide from the atmosphere. This process has a direct impact on green house effect which is causing severe changes in weather patterns all over the world. *Hevea* tree also prevents soil erosion compared to other agricultural crops. For instance, in tea plantations the amount of fertile soil eroded away annually is known to be around 60 metric tonnes/ha. But in rubber plantations this figure is substantially low and thereby the erosion problem in hilly areas is reduced to a great extent by this environmental friendly crop, existing in Sri Lankan soil for over 100 years.

Total natural rubber production in Sri Lanka during this year was around 106 000 metric tonnes indicating a marginal increase compared to 1992. Nevertheless, the production would have been much higher if not for the adverse rain interference experienced throughout this year. It is also evident that productivity of rubber lands is increasing largely due to the adoption of RRI recommendations by the management companies without adhering to commercial scale use of Ethrel stimulation in any of the estates during this year. In most of the months of the year, number of tapping days recorded has been in the region of 10 - 15. In Dartonfield Estate where the RRI laboratories are situated there had been 115 days of no tapping during 1993 due to rain-interference. Further, 52 days of late tapping have also been recorded during this year. A 25% increase in yields has been recorded by commencing normal tapping on 198 days only, out of the expected 320 tapping days for the year. These results clearly demonstrate that Sri Lanka must go for rainguards in a very big way in the future in order to harvest the rubber plantation without interruption under the unpredictable weather conditions prevailing in the country. The growers and plantations management companies have already been informed of the importance of using rainguards. The manufacturers of the sealant have been asked to be ready to cater to the needs of the plantation. It was possible to control the problem of cricket attacks on apron-type rainguards by applying waste engine oil, kerosene oil or some other insect repellent on the inside of the polythene skirt. Bon fires in the rubber land during night time too will eliminate this problem to a great extent. However, this problem is common only in areas where the rubber lands are covered with weeds. The

unusual whether that prevailed in 1993 also contributed to the severe outbreak of *Phytophthora* leaf fall and bark rot during South-West monsoon period. However, this situation was predicted early and appropriate preventive measures were taken by the RRI in order to prevent the diseases reaching epidemic levels.

Total natural rubber production in the world in 1993 is estimated to be around 5 617 000 metric tonnes, which is 0.2% less compared to year 1992. However, even in the year 1993, there is a glut in the production and the inflow of TSR L grade into the market has been on the increase. Hence the price of this grade of rubber which ultimately determines the latex crepe price came down to around US cents 92 per kilogram during the last quarter of the year. This is a fairly bad sign for the producers of traditional grades of crepe in Sri Lanka. In the first half of 1994 it is unlikely that the latex crepe price would increase above Rs 40.00 per kg.

This situation may change to some extent depending largely on two factors. Firstly, the political changes in the former USSR will have a direct bearing on rubber prices. During the days of USSR, due to their close economic policy, there was a scarcity of foreign exchange and hence the rubber industry in USSR was discouraged from using natural rubber except when this was unavoidable. As a result USSR developed synthetic rubber rich formulations for those products purely to consume the new synthetic rubber produced by them at 1/4 of the world's synthetic rubber price. However, if the rubber consumption in Russia and Ukraine increased tremendously after the independence from USSR (these two countries consume nearly 15% of the world natural rubber production), the above situation might improve slightly in favour of natural rubber producing countries. Secondly, if the Natural rubber production in South-East Asia continued to increase, such improvement in prices is unlikely to occur in the world market.

Biology

Twenty six new clones selected from Hand Pollination programmes from 1974 upto 1981 have been identified as promising clones for large scale planting and are registered under new RRISL 200 series. Most of them have given yields higher than RRIC 100 and RRIC 600 in small scale trials and few of them are as good as RRIC 121 which is the highest yielding clone among the clones recommended for large scale planting. Two high yielding genotypes have also been identified from the IRRDB germplasm selection.

Plants obtained through embryo culture and micropropagation of juvenile material are growing satisfactorily in the field. Even in relatively drier areas, young budding gives 100% establishment success and early growth rates comparable to 2-3

whorled polybagged brown buddings. Among the different low frequency tapping systems tested, S/2 d/3 + Ethrel continued to give the highest total annual yields although it is less than that of conventional S/2 d/2 system. Exploitation of higher panels, once panels BO-1 and BO-2 are tapped, gives only marginal yield increase than from downward tapping of renewed BO-1 panel, ie BI-1. Moreover the rate of bark consumption is also much higher.

Different spatial arrangements tested for rubber, in order to provide more space for intercropping have no influence on early growth of the rubber plants. Intercropping of rubber with sugarcane, cinnamon and timber eg. *Alstonia*, has also given promising results.

Field investigations suggest the possibility of using EPPAWELA rock phosphate (ERP) as a source of phosphate for immature rubber plants also, in some soils. It also appears that the rate of P currently recommended for immature rubber may not be sufficient to meet the plant's demand for P in some soils. Use of ERP even at double the currently recommended level will be more economical than IRP. It appears possible to use the conventional mixtures 12:14:14 and 7:9:9:3 for young budding plants as well.

Residual effect of mulching on latex production was seen even at the 5th year after discontinuation of mulching. This practice would benefit the rubber smallholder sector most, as they would normally have mulching materials on the site at no extra cost. The minimum paddy extent required to obtain the recommended straw requirement to mulch one hectare of rubber holding would be about 42 hectares. Among the mulching materials that were tested, loppings of legume trees were found to be superior to paddy straw as their contribution in terms of nutrients other than K, was much higher than what is contributed by paddy straw. The estate sector could therefore grow bush/tree legumes also in the inter rows during the immature period, which would provide adequate biomass for use as dead mulch.

Incidence of Black Stripe and Bark rot caused by the same fungus was more severe than in previous years. The most severely affected clones in the field were RRIC 131, RRIC 600, PB 86 and RRIC 130.

A newly developed collar protectant, 2% PCP formulation proved to be very effective in the management of White Root disease. Systemic fungicides, Bayleton and Bayfidan at concentration of 5g of active ingredient per tree in two applications at 6 monthly intervals also appear to be very effective in controlling white root disease in young rubber plants provided the disease is recognized at the early stages of infection. *Geotrichum* sp., a saprophytic fungus, was found to be the organism responsible for causing the network of whitish mycelium on *Hevea* root stocks which resembles the symptoms of White Root disease.

New nursery diseases viz Collar Rot caused by *Sclerotium rolfsii*, Target Leaf Spots caused by *Thanatephorus cucumeris*, Foot Canker caused by *Nattrassia*

mangiferae identified during the recent past could be eradicated by adopting the correct cultural practices recommended by RRISL.

Adaptive Research programmes on intercropping rubber with banana and pineapple have been very successful in the smallholder sector and new programmes on rubber with cinnamon and rubber with cocoa were started. Multicropping of rubber with tea is also becoming very popular in this sector. Programme on the use of rainguards clearly indicated that extra tapping days are possible in areas with rainguards. Growing bush/tree legumes as a soil conservation measure and to increase soil fertility, the use of rubber serum as a source of nutrients to vegetables and paddy and organic manures such as poultry litter to rubber have given promising results. Use of varnish coated coconut shells for latex collection is gaining popularity among the smallholders after the usefulness of this had been demonstrated to them in the field. Economic analysis done on the lifespan of rubber suggests that although a unique lifespan cannot be determined for rubber, the present 30 year cycle appears to be acceptable for practical purposes. Most of the studies conducted by the Agricultural Economics Unit stress the importance of improvement in labour productivity by technological improvement in order to compensate for the escalating wage rate.

An econometric model of the world rubber economy was developed to explain the behaviour of the natural rubber price and its consumption share over time. The simulation results indicated that the model is quite capable of capturing most of the past behaviour of key endogenous variables. The estimated elasticities confirm the prior expectation and suggest some insight into policy implications. Further, the magnitude of the estimated coefficients indicate that if the industry cannot respond very quickly to changes in price, a divergent cob-web type fluctuation in rubber prices is possible.

Chemistry and Technology

It has been shown that depolymerized NR can be blended with NR in the presence of a blowing agent to produce a material with low density which is suitable for floating components in fishing nets. The use of depolymerized rubber as an adhesive has been tried out by a local adhesive manufacturer.

Three plastics manufacturers have shown interest in the use of Thermoplastic Natural Rubber for making coagulating pans and an agreement has been signed with them for this purpose. These manufacturers are now using recycled polypropylene to manufacture them under the assistance of RRI. About 7 000 coagulating pans made out of TPNR have been distributed at a cost of Rs 55/- per pan. Many smallholders are encouraged by this project due to economic reasons and for convenience.

The discoloration of positex during storage has been solved by modifying the initial production process. Positex can be blended with bitumen to make water proofing emulsions and positex/clay mixtures have improved the physical properties of building blocks such as bricks.

A new technique for characterization of latex/bitumen emulsions in road construction was developed. Plant trials in the *in situ* preparation of latex bitumen emulsions using cationic slow setting emulsions were more successful than with cationic rapid setting emulsions.

Several new latex formulations were developed for fabric coating, carpet backing and foam manufacture.

Two treatment plants to treat the effluents from rubber factories are now under construction at Nakiadeniya rubber and oil palm factories based on the anaerobic/aerobic digestion technique, a cost effective treatment process, developed by the RRI recently.

In the field of raw rubber processing, Mooney viscosity of rubber was found to be low at the latex stage and increasing during subsequent processing. If the initial viscosity is stabilized prior to coagulation of latex, manufacture of CV rubber with Mooney viscosity ranging from 55 – 65 could be accomplished.

In response to the problem of leachable proteins in rubber gloves, a series of tests have been carried out to compare the extractable water soluble proteins in the samples of gloves using micro kjeldahl method. The nitrogen content of the leached samples was determined as a measure of the protein content. The protein content of the leached sample reached a constant value after 16 hours of leaching.

Raw Rubber Process Development and Chemical Engineering Department continued to advise estates to improve the quality of raw rubber manufacture and reduce the cost of manufacture. The primary role of the Department has been to advise estates on pollution control and assist in the setting up of cost effective effluent treatment systems.

Raw Rubber and Chemical Analysis Department continued to issue shipment certificates for TSR manufactured in Sri Lanka and provided factories with analytical services to analyze raw materials including water samples.

Certificates for the shipment of end products such as examination and surgical gloves, certifying the level of soluble proteins as well as the complete absence of Pentachloro Phenates have also been issued by this laboratory. Issuing certificates for the export of reclaimed rubber certifying the absence of NR in them for custom duty purposes has also been commenced by this Department this year.

OVERSEAS VISITS

Dr L M K Tillekeratne, Director attended the Annual General Meeting of the IRRDB held in U K during the period 13th to 17th September. He also visited Federal Republic of Germany during the period 21st September to 25th September on a joint research programme with (DIK) FRG. The Director also visited USA during the period 24th October to 7th November to participate in a trade exhibition to promote Sri Lanka Crepe rubber.

Mr S W Karunaratne, Deputy Director (Research) (I) visited India during the period 10th February to 12th February to attend a Workshop on Global Development of the Rubberwood Industry and an International Forum on Investment Opportunities in the Rubberwood Industry. He also visited Malaysia during the period 20th September to 24th September to attend a Workshop on Global Development of the Rubberwood Industry.

VISITORS

Visitors to the Institute included:

Mr David Shaw, EJR
Mr J D Deosthau, Bombay
Mr Leong Tet Thim, Malaysia
Mr Abdul Rahim Hassan, Malaysia
Mr Rudol Golkowsky, Germany
Mr O T Jayachandran, India

GENETICS AND PLANT BREEDING

N E M Jayasekera

SUMMARY

Twenty six new clones selected from Hand Pollination programmes from 1974 upto 1981 have been registered under new RRISL 200 series. Two high yielding genotypes have been identified from the IRRDB germplasm selection. PR 261 and RRIM 712 which were recommended in Group IV for experimental scale planting were removed from the recommendation.

DETAILED REVIEW

Staff

Head of the Department visited the School of Biological Sciences of the University of Birmingham UK from January 1993 to March 1993. The visit was sponsored by the British Council under the Birmingham - RRI higher educational link.

Dr D P S T G Attanayaka, Assistant 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, Mr A K M S Senarathna, Experimental Assistant, Mr I D M J Sarathkumara, Technical Officer, Mr R A S K Ranatunge, Technical Officer were on duty throughout the year.

Mrs K D R Tissera, Clerk/Typist vacated the post in March 1993 and Miss K P S Nilmini, Technical Officer resigned from the post in September 1993.

Miss S Palihawadana (Mrs S Herath) assumed duties, in May 1993, as Assistant Geneticist and Plant Breeder.

Meetings and Seminars

Head of the Department attended the Scientific committee meetings.

Dr D P S T G Attanayaka, Asst. Geneticist and Plant Breeder, attended the following:

Scientific committee meetings.

Seminar on Forestry Research Master Plan.

Scientific committee Diagnostic team (Biological aspects) meetings.

Planters' Association (Kalutara region) meeting.

Training

Head of the Department and Dr D P S T G Attanayake conducted lectures on Rubber (*Hevea*) breeding and Introduction to Quantitative Genetics and Molecular Biology respectively to the students of Uva and Vayamba Affiliated University Colleges.

Dr Attanayake addressed the participants and trainees of the following field days and training programmes.

- Field day for field officers of Namunukula Plantations Ltd. The topic of the lecture was "Rubber Planting Material".
- Training day for Assistant Superintendents of Kotagala Plantations Ltd. The topic of the lecture was "Recommended Rubber Clones".

Four NDT students from Hardy Institute underwent a training at the Department.

Miss S G P Gunasekera was assigned to this Department as Trainee typist.

Reports

Jayasekera, N E M (1993) Annual Review of the Department for 1993.

LABORATORY INVESTIGATION

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

Isozyme analysis of *Hevea* clones was resumed using continuous starch gel electrophoresis of crude leaf extracts. After gel electrophoresis in tris/citrate electrode buffer, sliced gel pieces were stained for three oxidoreductase enzymes; Alcohol dehydrogenase (ADH), Malate dehydrogenase (MDH) and Shikimate dehydrogenase (SKD). All three systems showed regions of enzyme activity with sufficient resolution of protein bands. With regard to SKD system, 2 alleles pertaining to a single locus were identified. RRIC 130 was identified as homozygous for the slow moving allele (a) while RRIC 108 was homozygous for the fast moving allele (b). Rest of the clones (RRIC 100, RRIC 102, RRIC 110, RRIC 121, PR 261 and HN-1) tested were heterozygous for this locus. MDH system revealed a number of bands ranging from 3-5. It is known that this system gives many secondary isozymes (mitochondrial forms) depending on the quality of the protein extract. However RRIC 102 could be differentiated from other clones tested, by having a fast moving form of this enzyme which was not present in other clones tested. Low intense bands were detected for ADH system probably due to the insufficient proteins found on the uppermost gel slice. Planned experiments using individuals from segregating families are needed to

identify the allelic forms of these genetic loci (S Palihawadana, K B Karunasekera and D P S T G Attanayaka).

Study of number of latex vessel rings in germplasm clones collected from GPB/GP/85/2 trial planted at Kuruwita Sub-station.

Bark samples were collected at the height of 150 cm from the trees from three experimental blocks. Each clone has been replicated twice within a block. Trees were 8 years old and were in 3rd year of tapping. Samples were fixed for 48 hours. Cross sections of the bark samples were taken manually and stained with Safronin. Number of latex vessel rings were counted and analysis of variance was carried out. Results of the analysis are given in Table 1.

Table 1. *Analysis of variance of latex vessel rings*

Source	df	Ms	F	P
Clone	58	31.77	15.08	***
Block	2	5.60	2.66	NS
Error	268	2.10		

Probability *** = < 0.1 %

Results indicated the presence of genetic variation in number of latex vessel rings for clones tested. The highest number of latex vessel rings which was 18 was found in the control clone RRIC 121. Germplasm clones had their means ranging from 2-9 (S Palihawadana and D P S T G Attanayaka).

FIELD INVESTIGATIONS

Hand pollination programme 1993 (GPB/BST/HPS/93/1)

Hand pollination had to be curtailed as there was no sufficient supply of bamboos in time, to erect scaffoldings. Crosses attempted and number of pollinations done in each cross are given in Table 2.

Table 2. *Crosses attempted and number of pollinations (GPB/BST/HPS/93/2)*

Cross	No. of pollinations
RRIC 100 x PB 255	528
RRIC 130 x RRIC 130	446
RRIM 712 x RRIM 712	500
PB 255 x PB 255	335
RRIC 130 x RRIM 712	204
Total	2 013

All pollinations except those on RRIC 130 were carried out on female flowers initiated by ring barking and bending of nursery plants of high yielding proven foreign clones imported from Thailand under SRRP II.

Initial examination of hand pollinated flowers indicated a high percentage of success. But later all the young pods dropped before reaching maturity. Investigations revealed that pod drop was mainly due to *Phytophthora* attack (N E M Jayasekera, D P S T G Attanayaka and K B Karunasekera).

Evaluation of selection from 1974, 1975 and 1978 hand pollinated (HP) seedlings.

In the small scale trial (GPB/BST/HPS/74/3) planted at Kuruwita Sub-station 13 new selections are tested along with the 3 control clones (RRIC 121, RRIM 600 and RRIC 100). Yield in grams per tree per tapping (g/t/t) for the first 5 years, average yield over the first 5 years and mean girth for 1993 of the promising selections and control clones are given in Table 3 (N E M Jayasekera and B M S G Peries).

Table 3. *Yield and girth data (GPB/BST/HPS/74/3)*

Clone	Yield (g/t/t)					Mean	Girth (cm)
	Year	1989	1990	1991	1992	1993	
74-12		39.0	38.3	58.4	63.6	62.7	77.4
74-41		59.9	54.4	65.4	74.4	76.5	80.7
74-135		57.1	52.0	65.4	72.4	74.2	76.6
74-193		74.0	65.8	66.4	59.6	63.7	64.5
RRIC 121		40.5	34.4	80.6	86.6	96.3	85.4
RRIC 100		33.9	33.2	45.2	44.2	53.1	59.9
RRIM 600		37.2	36.3	41.7	38.0	46.2	59.3

In the small scale trial (GPB/BST/HPS/75/1) planted on Clyde Estate two promising clones, 74-33 and 74-143 have been selected for large scale testing. Their yield over first four years and mean girth (1993) with those of control clones are given in Table 4 (N E M Jayasekera and I D M J Sarathkumara).

Table 4. *Yield and mean girth of promising and control clones in the small scale trial (GPB/BST/HPS/75/1) on Clyde Estate.*

Clone	Yield (g/t/t)				Mean	Girth (cm)
	Year	1990	1991	1992	1993	
75-33		26.0	31.0	42.1	39.5	70.0
75-143		24.9	34.1	41.7	52.0	85.2
RRIC 121		27.8	36.7	48.1	53.2	74.2
RRIC 130		39.4	29.6	36.1	33.9	53.7
RRIC 100		22.0	23.5	26.9	27.1	58.6

Another promising clone has been identified from 1975 HP selections tested in the small scale trial (GPB/BST/HPS/75/2) established on Sorana Estate. Its yield and mean girth and those of control clones are given in Table 5 (N E M Jayasekera and K W Rupatunge).

Table 5. *Yield and mean girth of the promising clone and control clones in the small scale trial (GPB/BST/HPS/7/2) planted on Sorana Estate.*

Clone	Year	Yield (g/t/t)			Mean	Girth (cm)
		1990	1991	1992		
75-4		38.7	52.3	47.9	46.9	70.5
RRIC 121		33.2	49.6	52.4	45.1	78.0
RRIC 130		38.7	40.8	31.1	38.4	60.9
RRIC 100		25.1	37.0	35.4	32.5	63.0

Evaluation of 1979 HP seedlings (GPB/BST/HPS/79/2) planted on Eladuwa Estate.

Nine HP seedling families are tested in this trial without control clones. Yield of five highest yielding genotypes and their mean girth are given in Table 6 (N E M Jayasekera and I D M J Sarathkumara).

Table 6. *Yield of five highest yielding genotypes and their mean girth. (GPB/BST/HPS/79/2)*

Clone	Year	Yield (g/t/t)					Mean	Girth (cm)
		1988	1989	1990	1991	1992		
79-15		35.2	41.0	66.5	47.5	64.8	54.3	83.0
79-24		37.5	37.3	52.0	72.0	60.9	52.1	74.5
79-36		41.7	54.0	46.9	52.8	61.9	51.0	74.5
79-61		38.2	60.5	48.8	46.0	65.9	51.3	68.5
79-155		26.2	46.8	76.6	56.3	97.4	63.3	86.0

Evaluation of 1980 HP seedlings (GPB/BST/HPS/80/2), Eladuwa Estate.

In this trial HP seedlings derived from 1980 HP programme are tested. Yield in g/t of the five highest yielding genotypes and their mean girth are given in Table 7. In this experiment individual seedlings are fully randomized (N E M Jayasekera and I D M J Sarathkumara).

*Table 7. Yield and girth of promising selections made from 1980 HP seedlings.
(GPB/BST/HPS/80/2) Eladuwa Estate*

Clone	Year	Yield (g/t)				Mean	Girth (cm)
		1990	1991	1992	1993		
80-2		53.5	60.9	56.7	60.9	57.5	79.0
80-9		65.6	69.6	51.1	52.2	60.1	80.5
80-287		50.7	70.7	58.8	41.1	54.7	72.0
80-312		43.0	89.0	67.2	40.4	59.1	95.0
80-343		50.5	72.4	49.6	51.5	55.4	81.0

**Evaluation of 1981 HP seedlings (GPB/BST/HPS/81/2) Malaboda Division,
Eladuwa Estate**

In this trial also individual HP seedlings are tested. Yield and mean girth of 9 best genotypes are given in Table 8 (N E M Jayasekera and W D Armon).

Table 8. *Yield (g/t/t) and mean girth of best 9 genotypes (GPS/BST/HPS/81/2) at Malaboda Division of Eladuwa Estate.*

Year	1989	1990	1991	1992	Mean	Girth (cm)
Clone						
81-8	119.5	107.7	85.8	75.1	95.5	79.5
81-30	74.8	84.7	74.0	60.9	74.5	90.0
81-50	49.0	93.1	77.1	64.4	74.4	75.0
81-111	94.8	69.4	89.6	49.5	76.2	82.0
81-178	90.2	65.6	71.3	64.1	71.3	83.0
81-192	86.3	77.5	93.8	59.6	80.7	76.0
81-200	66.2	69.5	64.5	93.8	72.7	72.5
81-207	65.0	82.6	86.3	48.4	73.8	75.0
81-231	80.1	77.2	73.5	64.5	74.6	67.0

Evaluation of germplasm collection, Small scale trial (GPB/GP/85/2) at Kuruwita Sub-station.

1. In addition to the study of the latex vessel rings of bark samples collected from this trial, test tapping was carried out. Latex flow of the germplasm clones was too low to record the yield.

2. Test tapping of nursery plants at Neuchatel Estate.

About 300 plants in this nursery with a girth of 60 cm and above were marked at 90 cm above the bud union for test tapping. After few months test tapping, the clones that did not give promising yields were discontinued and another batch of 300 plants that had reached the required girth of 60 cm and above were brought into tapping. This second batch and the promising clones selected from the first batch are being test tapped to evaluate the yield potential.

Two highly promising clones which yield more than 100 g/t/t have been identified for future testing in large scale trials (N E M Jayasekera, D P S T G Attanayake, S Palihawadana, K B Karunasekera and R A S K Ranatunga).

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

Both Magnesium and Potassium deficiencies were noted on 2 clones viz PR 261 and RRIM 712.

These deficiencies were observed at Salawa and Kuruwita sites. On the recommendation made by the Soil Chemist a mixture of Kieserite and Muriate of Potash was given at the rate of 60 g per plant.

Soil Chemist, Dr Anura Dissanayake will make a detailed study to determine the cause of these deficiencies.

At the Bentota site, RRIM 712 had a severe attack of *Gloeosporium* followed by secondary infections. Due to this, die back of some plants was observed. On the recommendation of the Pathology Department, affected trees were given a foliar spray of 4% Dithane.

Due to nutrient deficiencies mentioned above, and also susceptibility to pests and diseases (Slug attacks on PR 261 and *Gloeosporium* attack on RRIM 712) growth performance of these two clones are below average at some experimental sites.

This was brought to the notice of the Scientific Committee of the RRI in which all the Plantation Management Companies are represented.

On the recommendation of the Head of Genetics and Plant Breeding Department, it was agreed to suspend planting of these two clones which have been recommended in Group IV for experimental planting on commercial estates.

This suspension is a temporary measure until the results of detail investigation for the cause of nutrient deficiencies are known (N E M Jayasekera, K B Karunasekera, K W Rupatunge and B M S G Peries).

New experiments planted in 1993

1. Testing of 1987 HP Selections (GPB/BST/HPS/87/1)

18 selections along with 4 control clones were planted in a randomized block design with 4 replicates. Eight plants per replicate were used and the trial was planted on Clyde Estate.

2. Testing of Ortet clones of the germplasm collection (GPB/GP/ORT/93/1)

In this trial 77 clones supposed to be high yielding and 4 control clones (RRIC 100, RRIC 102, RRIC 110 and RRIC 121) were planted in a randomized block design with 4 plants per replicate.

One replicate each was planted on the following estates during SW monsoon of 1993:

Yatadola Estate
Elston Estate
Padukka Estate
Dartonfield Estate

3. Testing of 1988 HP Selections (GPB/BST/HPS/1988/1)

In this trial 29 selections made from 1988 HP seedling progeny were planted along with RRIC 100, RRIC 102, RRIC 110 and RRIC 121. Randomized block design with 4 replicates and replicate size of 8 plants were adopted. Trial was planted on Dartonfield Estate.

4. Testing of 1992 HP seedlings (GPB/BST/HPS/93/1)

A total of 393 HP seedlings have been planted in this experiment and single tree randomization was adopted. Trial was planted on Dartonfield estate.

New Clones

Twenty six (26) new genotypes selected from hand pollinated seedlings generated from 1974 up to 1981 (inclusive of both years) have been identified as promising clones for large scale testing. Most of them in small scale trials have given higher yields than RRIC 100 and RRIM 600. Few of them are as good as RRIC 121 which is the highest yielding clone among the clones recommended for large scale planting.

In view of their performance in small scale trials it has been decided to register these 26 clones under a new series called RRISL 200 series. Each clone is given a separate RRISL number from RRISL 200 to RRISL 225.

RRISL number, present HP number and the parentage of each clone are given in Table 9.

In addition to these clones, selected from our crossing programmes, several clones from the IRRDB germplasm collection have been identified for their high yields. Of these selections two clones are of particular interest because of their very high yields of more than 100 g/t. These two clones have been given two identification numbers GPS 1 and GPS 2 which stand for Germplasm selection 1 and 2 respectively.

In future, when budwood is available, 26 RRISL clones and two GPS clones will be released to commercial estates for experimental^o planting. This will be in addition to the large scale trials that is be established in 1994.

Table 9. *RRISL number, HP number and parentage of clones registered under new RRISL 200 series.*

RRISL No.	HP No.	Parentage
RRISL 200	74-12	RRIC 103 x 8501
RRISL 201	74-41	RRIC 103 x 8501
RRISL 202	74-135	RRIC 103 x RRIC 115
RRISL 203	74-193	RRIC 100 x RRIC 101
RRISL 204	75-33	82 x RRIC 101
RRISL 205	75-143	82 x 82
RRISL 206	75-4	82 x RRIC 101
RRISL 207	79-15	RRIC 101 x RRIM 600
RRISL 208	79-24	RRIC 101 x RRIM 600
RRISL 209	79-36	RRIC 101 x RRIM 600
RRISL 210	79-61	RRIC 101 x RRIM 600
RRISL 211	79-155	RRIC 101 x RRIM 600
RRISL 212	80-2	Illegimate
RRISL 213	80-9	"
RRISL 214	80-287	"
RRISL 215	80-312	"
RRISL 216	80-343	"
RRISL 217	81-8	PB 28/59 x RRIC 121
RRISL 218	81-30	PB 28/59 x RRIC 121
RRISL 219	81-50	PB 28/59 x RRIC 102
RRISL 220	81-111	PB 28/59 x RRIC 121
RRISL 221	81-178	RRIC 52 x PB 28/59
RRISL 222	81-192	RRIC 102 x IAN 45/710
RRISL 223	81-200	PB 28/59 x IAN 45/710
RRISL 224	81-207	PB 28/59 x RRIC 102
RRISL 225	81-231	RRIC 102 x PB 28/59

PLANT SCIENCE

A Nugawela

SUMMARY

Plants obtained through embryo culture and micropropagation of juvenile material are growing satisfactorily in the field. Among the different low frequency tapping systems tested 1/2S d/3 + Ethrel (E) continued to give the highest total annual yields. Nevertheless, it is less than that of conventional 1/2S d/2 system. The advantages of low tapping costs and longer tapping cycles in the 1/2S d/3 + E system are being looked at.

Trees opened at 18" continue to give relatively lower yields. Further, the yield increment in trees opened at 18" is less than that of those opened at 20".

Exploitation of higher panels, once panels BO-1 and BO-2 are tapped, gives only marginal yield increases than that of downward tapping of renewed BO-1 panel, *ie* BI-1. Nevertheless, the rate of bark consumption is much higher and the effect on the yields of lower panels, *ie* BI-1 and BI-2 will have to be studied. Commencing to tap the renewed bark at a point higher than the height of opening results in lower yields due to creation of a bark island.

Even in relatively drier areas young budding gives 100% establishment success and early growth rates comparable to 2-3 whorled polybagged brown buddings. Long snag with leaves improves the growth of scion though sprouting is delayed.

Different spatial arrangements tested for rubber, in order to provide more space for intercropping have no influence on early growth of the rubber plants. Intercropping of rubber with Sugarcane, Cinnamon and Timber eg. *Alstonia* have so far given promising results.

A total of about 9 000 bare root budded stumps from 18 clones were distributed to the Plantations to establish budwood nurseries. A further 3 000 plants were issued from clones RRIC 100, RRIC 102 and RRIC 121, for the same purpose to the Private Commercial Nursery owners.

DETAILED REVIEW

Staff

The Head of Department, Dr A Nugawela, Mr V H L Rodrigo, Research Officer (Intercropping), Mr R B Gunaratne, Mr L S Kariyawasam, Experimental Officers, Mr R P Karunasena, Mr K A G B Amaratunge, Senior Technical Officers, Mr S Wilbert, Senior Experimental Assistant, Mrs C W Ranasinghe, Mrs G A S Wijesekera, Mr U S Weerakoon, Mrs R K Samarasekera, Mr M K P Perera, Mr S M A Samarakoon, Mr T U K Silva, Miss G M de Zoysa and Mr M de Alwis, Technical Officers, Mrs D E Jayawardena, Clerk/Typist were on duty throughout the year. Miss S M A Pasqual and Mr M F A Zaneer joined the staff as Technical Officers on 1st January 1993. Dr (Mrs) P Seneviratne, Botanist was on maternity leave from 1st August 1993 to 29th November 1993.

Mrs M S de Silva, Assistant Botanist continued her post graduate studies at the University of New England, Australia. Mr L S S Pathiratna, Assistant Botanist left on 24th September 1993 for his postgraduate studies at the University of Reading, UK.

Mrs G A S Wijesekera, Technical Officer was promoted to the post of Senior Technical Officer with effect from 10th May 1993.

Technical Officers Miss S M A Pasqual and Mr M F A Zaneer resigned from their posts with effect from 15th December 1993 and 1st December 1993 respectively.

Research Students

Miss G L Pradeepa Peries, an undergraduate student from the University of Ruhuna, completed her final year project on "The effect of maturity of budwood on the growth of the scion of budded *Hevea brasiliensis* Muell. Arg. plants" under the supervision of Dr A Nugawela.

Visits

Department staff made advisory visits to State Plantations and Smallholdings and regular visits were also made to the experimental sites.

Meetings and Conferences

The Head of Department addressed at the following meetings/conferences;

1. Field day for Superintendents of RPK Management Company.
2. Seminars on use of rainguards conducted for Rubber Extension Officers and Smallholders in different Rubber growing districts.
3. The Plantation Managers in Kalutara on "Planting to achieve high establishment rates".

4. The Plantation Managers of Kotagala Plantations Ltd. on "Exploitation for Economic Yields".
5. The Plantation Managers of Balangoda Plantations on "Planting to achieve high establishment rates".
6. Seminar on Nursery Management for Private Commercial Nursery owners in Kegalle Region.
7. Visiting lectures for Final Year Agriculture Students, University of Peradeniya.

Dr (Mrs) P Seneviratne conducted a work shop on nursery practices for the Assistant Controllers of the Rubber Control Department.

Staff Training

Mr R P Karunasena, Senior Technical Officer was trained on tapping and planting techniques at the RRIM from 11th December 1993 to 1st January 1994 under the IRRDB training programme.

Mr V H L Rodrigo and Dr (Mrs) P Seneviratne completed the correspondence training course on "Design and Analysis of MPTS Field Experiments" conducted by the Winrock International Institute for Agriculture Development, Thailand.

Training Programmes

The Department staff were involved with the following programmes.

1. Nursery management and planting practices – Training programme for all plantation management companies.
2. Field days to discuss tapping, rainguards, stimulation and planting in Estates managed by Balangoda Plantations Ltd.
3. Lectures for Affiliated University College students.
4. Refresher courses for Rubber Extension Officers.

Publications

Stirling, C M, Rodrigo, V H L and Thorne, P J (1993). Effect of growth temperatures on the photosynthetic performance of immature maize canopies. In "Resource Capture by Crops", Proceedings of the 52nd University of Nottingham Easter School. (In press).

Stirling, C M, Rodrigo, V H L and Emberru, J (1993). Chilling and photosynthetic productivity of field grown maize (*Zea mays*); Changes in the parameters of the light-response curve, canopy leaf CO₂ assimilation rate and crop radiation use-efficiency. *Photosynthesis Research*, **38**: 125-133.

Reports

Nugawela, A (1992). Annual Review of the Plant Science Department.

LABORATORY INVESTIGATIONS

Tissue Culture

Juvenile *Hevea*

Micropropagation of juvenile origin material was continued throughout with glass house grown material. The acclimatized plants that are growing in the field show satisfactory growth; the mean heights of embryo cultured and micropropagated plants were 3.07 m and 3.14m respectively, after 6 months of field planting.

Clonal *Hevea*

None of the established cultures showed satisfactory axillary shoot proliferation. However, successive grafting experiments are continued in order to induce juvenility and explants from the resulting plants will be used once the plant material is ready.

Other

A few cardamom cultures were established from the source bushes growing in the glass house. Shoot proliferation is yet to be achieved.

Explants from field grown pepper plants could not be established due to severe phenolic browning. Pepper seeds were sterilized and grown in culture to test the proliferation.

Shoot proliferation of papaw cultures is very high, but shoot elongation and acclimatization were not successful to date (P Seneviratne, G A S Wijesekera and G M de Zoysa).

Gas Exchange Studies

Stock seedlings raised from seeds of clones RRIC 100, RRIC 101 and PB 86 grown in polybags were green budded with same clones in all possible combinations. The young buddings raised this way were field planted during SW 1993.

Measurements on gas exchange parameters were made 3–4 months after field planting.

Table 1. *The effect of stock–scion interaction on gas exchange parameters, i.e. CO₂ assimilation rates (A, $\mu\text{mol m}^{-2} \text{s}^{-1}$), stomatal conductance (gs, $\text{mol m}^{-2} \text{s}^{-1}$) and internal leaf CO₂ concentration (Ci, $\mu\text{mol mol}^{-1}$).*

Stock plant	Parameter	Clones of Scion			Means
		RRIC 100	PB 86	RRIC 101	
RRIC 100	A	7.55	8.10	6.70	7.45
	gs	0.30	0.33	0.25	0.29
	Ci	279	280	274	278
PB 86	A	8.16	7.50	6.83	7.50
	gs	0.29	0.28	0.29	0.29
	Ci	271	274	283	276
RRIC 101	A	7.15	6.56	–	6.86
	gs	0.28	0.31	–	0.30
	Ci	278	285	–	282
Mean	A	7.62	7.39	6.77	
	gs	0.29	0.31	0.27	
	Ci	276	280	279	

There is no evidence for the stock to influence the gas exchange characters of the scion significantly. Differences if any may become evident later once the plants are well established in the field (A Nugawela and R K Samarasekera).

FIELD EXPERIMENTS

Tapping

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 1/2S d/2 system. Low frequency tapping systems can have the advantages of low tapping costs and longer tapping cycles.

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

The 1/2S d/3 + E and 1/2S d/4 + E systems are giving significantly higher dry rubber yields per tree per tapping (g/t/t) when compared with the conventional 1/2S d/2 system. Nevertheless, 1/4S d/2 system with stimulation continues to give the lowest yields (Table 2). The estimated total annual yield per tree (kg/t/year) based on the theoretical maximum possible days of tapping per year is only marginally less in 1/2S d/3 + E than in the conventional 1/2S d/2 system. The treatment differences are not significant in either the girth or girth increment.

Table 2. *Dry rubber yields, growth measurements and dry trees (TPD) of RRIC 100 trees tapped on different tapping systems.*

Tapping system	Yield		Growth		TPD
	g/t/t	kg/t/year	Girth (cm)	Girth increment	
1/2S d/2	32.6	5.93	73.5	4.4	11
1/2S d/3 + E*	42.8	5.22	75.3	4.1	11
1/2S d/4 + E*	45.8	4.17	74.3	3.2	10
1/4S d/2 + E*	27.1	4.93	78.7	4.5	4

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

The number of dry trees are lowest in the tapping system giving lowest yields, ie 1/4S d/2+E (A Nugawela, S Wilbert and T U K Silva).

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

1/2S d/3 and 1/2S d/4 tapping systems with stimulation give significantly higher dry rubber yields per tree per tapping (g/t/t) than other systems that are being tested. Nevertheless, the estimated total annual yield, based on the theoretical maximum possible days of tapping per year, is highest in the conventional 1/2S d/2 system (Table 3).

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

Table 3. *The dry rubber yields, growth measurements and dry trees (TPD) of clone RRIC 121 tapped on different tapping systems.*

Tapping system	Yield		Growth		TPD
	g/t/t	kg/t/year	Girth (cm)	Girth increment (cm)	
1/2S d/2	28.4	5.17	69.9	6.9	3
1/2S d/3 + E*	35.7	4.36	66.6	4.3	2
1/2S d/4 + E*	41.0	3.73	68.4	7.0	2
1/2S d/3	31.7	3.87	68.6	7.4	1

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

The number of dry trees appear to be low in tapping systems giving low yields (A Nugawela, S Wilbert and T U K Silva).

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

1/2S d/3 and 1/2S d/4 tapping systems with stimulation give significantly higher dry rubber yields per tree per tapping (g/t/t) than other systems that are being tested. The estimated total annual yields are comparable in 1/2S d/3 + E and the conventional 1/2S d/2 system (Table 4). The treatment differences in girth are not significant.

Table 4. *The dry rubber yields and growth measurements of clone RRIC 102 tapped on different tapping systems.*

Tapping System	Yield		Growth
	g/t/t	kg/t/year	Girth (cm)
1/2S d/2	43.5	7.9	66.1
1/2S d/3 + E*	57.9	7.1	68.2
1/2S d/4 + E*	59.3	5.4	67.8
1/2S d/3	53.4	6.5	67.5
1/4S d/2 + E*	35.2	6.4	66.8

E* 2.5% ET, Ba 0.8(2.5) 4/Y.
(A Nugawela and K A G B Amaratunge).

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

Three tapping systems are being tested on three different genotypes *ie* RRIC 1800, RRIC 101 and PB 86.

Though the g/t/t yield is high in the low frequency system with stimulation, the estimated total annual yields based on maximum possible days of tapping are high in the conventional 1/2S d/2 system of tapping (Table 5).

Table 5. *The mean yield (g/t/t) and estimated yield per tree per annum (kg/t/year) for different tapping systems (Mean of all 3 clones).*

Tapping system	Yield	
	g/t/t	kg/t/year
1/2S d/2	24.8	4.5
1/2S d/3	28.7	3.5
1/2S d/4 + E*	41.1	3.7

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

High Intensity Tapping of Virgin Panels

Trials on the above were initiated with the objective of finding out whether total yields obtained during the normal 24 year tapping cycle could be realised during a shorter tapping cycle.

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

Four clones are being tapped at high intensity with the normal (N) and double the normal (2N) level of fertilizer. Mean yields of 3 test tapplings done during the first three months of tapping are given in Table 6.

Table 6. *Dry rubber yields (g/t/t) for different clones and tapping systems.*

Tapping system	Clone	Dry rubber yield (g/t/t) and Fertilizer level	
		Normal	Double
1/2S d/1	RRIC 130	36.0	29.7
	RRIC 102	15.5	17.1
	RRIC 121	22.0	19.2
	RRIC 100	25.8	20.7
	Mean	24.8	21.7
1/2S d/2 + E*	RRIC 130	42.6	42.9
	RRIC 102	25.0	23.9
	RRIC 121	29.8	23.5
	RRIC 100	15.6	17.6
	Mean	28.3	27.0
1/2S d/2	RRIC 130	32.9	35.1
	RRIC 102	19.5	19.1
	RRIC 121	24.9	22.7
	RRIC 100	16.2	14.1
	Mean	23.4	22.8
1/2S d/3 + E*	RRIC 130	62.1	51.2
	RRIC 102	28.4	25.2
	RRIC 121	30.6	33.9
	RRIC 100	18.9	16.7
	Mean	35.0	31.8

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

Dry rubber yields, *ie* g/t/t are high in $1/2S\ d/2 + E^*$ and $1/2S\ d/3 + E^*$ systems. Yields of plants receiving the normal and the double the normal dose of fertilizer are similar. Incidence of tapping panel dryness was not observed so far in any treatment (A Nugawela and R P Karunasena).

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.

- 1. RRIC 100, 1985 Replanting - Dalkeith (TG/91/1)**
- 2. RRIC 100, 1985 Replanting - Kiriwanaketiya (TG/91/3)**
- 3. RRIC 100, 1985 Replanting - Eladuwa (TG/91/4)**

In each of the above clearings a tapping block was selected. Trees belonging to the following girth classes were identified in each tapping block and were tapped. Tapping is now done at 100% intensity and a test tapping is carried out each month of the year.

- T₁ 40 - 44.9 cm
- T₂ 45 - 49.9 cm
- T₃ 50 - 54.9 cm
- T₄ 55cm and above.

- 4. RRIC 121, 1984 Replanting - Perth (TG/91/2)**

Three adjacent tapping blocks were selected from the above clearing and a trial similar to above is conducted. Tapping is done at 67% intensity and a test tapping is carried out each month of the year.

The mean dry rubber yield per tree per tapping (g/t/t) girth and girth increment for different treatments in both clones are summarised in Table 7.

Table 7. *Mean dry rubber yield per tree per tapping (g/t/t), the girth (cm) 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	18.1	16.9	46.4 (2.8)	46.7 (2.6)
T ₂ 45–49.9	21.6	23.0	51.2 (3.1)	53.4 (3.0)
T ₃ 50–54.9	25.7	30.9	55.8 (3.4)	59.2 (4.3)
T ₄ 55 and above	32.1	42.8	62.9 (3.5)	69.4 (4.1)

In both genotypes, ie clones RRIC 100 and RRIC 121, trees opened at 45–49.9 cm give significantly lower yields than trees opened at 50–54.9 cm.

The percentage yield increase over last year in clone RRIC 121 is 5,6.5, 22 and 33 for girth classes 40–44.9 cm, 45–49.9 cm, 50–54.9 cm and 55 cm and above respectively. The yield increment in lower girth classes is low. The girth increment is also significantly low in trees opened at a lower girth (A Nugawela, S Wilbert).

Height of Opening (TH)

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

RRIC 100, 1985 Replanting – Dalkeith (TH/91/1)

RRIC 100, 1985 Replanting – Kiriwanaketiya (TH/91/2)

The trials were initiated in 1991. Three adjacent tapping blocks tapped by the same tapper, were selected from each of the above clearings. In each tapping block, the treatments mentioned in Table 8 were introduced randomly. Tapping is done at 67% intensity. Information on yield, bark consumption rate and girthing are summarised in Table 8.

Table 8. *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	30.2	21.5	2.5	26.6	25.1	3.2
T ₂ – 60" Jebong and 48" Push knife	31.8	21.7	2.8	25.4	23.9	2.6
T ₃ – 48" Push knife	29.9	24.1	3.0	23.8	22.3	2.9

In both trials during the initial year the rate of bark consumption was significantly high when tapped using Jebong Knife. Nevertheless, during the second year, when tapping heights are lower, there is no difference in bark consumption rates. Also, no significant differences are observed with regard to yields and girthing of plants (A Nugawela, S Wilbert and T U K Silva).

Exploitation of Renewed Bark

The objective of this trial is to identify suitable bark for tapping once the virgin panels, *ie* 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)

Two tapping blocks, *ie* A and B rounds of the same tapper were selected from each of the above clearings. In each tapping block, following treatments were introduced randomly, selecting 12 trees per treatment.

- T₁ Commencing tapping on panel BI-1 at original height of opening.
- T₂ Commencing tapping on the virgin bark 15cm above panel BI-1.
- T₃ Upward tapping on higher virgin bark above panel BI-1.
- T₄ Downward tapping of higher virgin bark using a ladder.
- T₅ Puncture tapping of higher virgin bark.

In all treatments except T₅ the tapping system used is 1/2S d/2. A test tapping was done each month and the yield data are summarised in Table 9.

Table 9. *The dry rubber yield (g/t/t) of the different treatments in trials ERB/93/1 and ERB/93/2.*

Treatment	ERB/93/1		ERB/93/2		Mean
	Block 1	Block 2	Block 1	Block 2	
T ₁	39.1	37.6	50.6	48.6	43.9
T ₂	33.7	20.9	32.8	32.7	30.0
T ₃	41.3	33.2	59.5	57.9	47.9
T ₄	31.4	30.1	47.8	43.0	38.1
T ₅	15.2	13.1	23.6	18.8	17.8

Upward half spiral cut on higher virgin panels (T₃) gives slightly higher yields than the downward 1/2S cut on renewed panel, *ie* BI-1. Nevertheless, the effect of exploiting higher virgin panels on the yields of lower renewed bark will have to be looked into. Downward tapping of higher virgin bark above the original height of opening (T₂) gives relatively low yields, possibly due to the creation of a bark island. The yield from ladder tapping (T₄) is not promising.

The rate of bark consumption during first year is ca.35–40% higher in upward tapping of higher virgin bark, *ie* T₃ (A Nugawela and R P Karunasena).

Planting Techniques

The objective of these experiments is to compare the performance, *ie* 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 and the establishment rates and girth after 2 years of growth are given in Table 10 for the different types of planting material tested.

Table 10. *The different types of planting material tested and their mean establishment success (%) and girth (cm).*

Planting material	Establishment Success (%)	Girth (cm)
Two whorled young buddings	100	16.9
Two whorled brown buddings	100	17.3
Bare root brown buddings	88	14.3
Bare root green buddings	96	14.9

The establishment success and early growth rates are similar in young buddings and two whorled brown budded polybag plants (A Nugawela and S M A Samarakoon).

Mohamadi (PT/92/1)

Planting of this trial was undertaken during SW 1992. Five types of planting material mentioned in Table 11 are tested and the establishment rates and girth after one years growth are given in Table 11.

Table 11. *The different types of planting material tested and their establishment success (%) and girth (cm).*

Planting material	Establishment Success (%)	Girth (cm)
1. Bare root Green buddings	93	5.9
2. Bare root Brown buddings	99	6.1
3. Green budding polybags	94	6.5
4. Young buddings	100	7.0
5. Brown budding polybags	98	8.6

The establishment success of young buddings is 100% and that of bare root brown buddings and brown budding polybags are comparable. The girthing at the end of the first year is slightly better in brown budding polybags than in young budding (A Nugawela and S M A Samarakoon).

Pallegama (PT/93/1)

In this trial the types of planting material tested in PT/92/1 are tested in relatively dry conditions. Planting was undertaken during SW 1993. The establishment success (%) of the different types of planting material are given in Table 12.

Table 12. *The different types of planting material used and their establishment success (%)*.

Planting material	Establishment Success (%)
1. Bare root Green budding	90.6
2. Bare root Brown budding	82.3
3. Green budding Polybags	99.2
4. Young budding	100.0
5. Brown budding Polybags	98.8

Establishment success of all types of polybag planting material is superior to bare roots. Among the different types of polybag planting material young budding has a better rate of establishment success (A Nugawela and K A G B Amaratunge).

Dartonfield (PT/92/2)

Young buddings of RRIC 121 were superior to bare root green buddings and the differences in height and girth, after 1.5 years of growth were significant, although such differences were not observed in clone RRIC 100 in which the growth is slightly less than RRIC 121 (P Seneviratne, A Nugawela and S M A Samarakoon).

Young Budding

Budgrafting success of RRIC 102 is superior to that of RRIC 100. Long snag with leaves improves the growth of scion, though this caused a delay in sprouting (P Seneviratne, A Nugawela and S M A Samarakoon).

Planting Density

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

Millawa, 1977 Replanting – CD/77/1

The experimental details were described in the Annual Review of 1992. The girth and yield data (g/t/t) for different treatments after the 9th year of tapping are given in Table 13.

Table 13. *The girth (cm) and yield (g/t/t) of clones RRIC 101 and PB 86 planted at different densities (trees/ha).*

Spacing (m)	RRIC 101			PB 86	
	Density (trees/ha)	Yield (g/t/t)	Girth (cm)	Yield (g/t/t)	Girth (cm)
2.5 x 10	400	–	71.8	24.2	61.5
2.5 x 7.5	533	34.0	65.6	21.2	67.6
2.5 x 6	666	20.2	58.7	23.7	60.8
2.5 x 5	800	25.6	59.4	15.4	57.2
3.87 (Triangular)	771	22.0	58.2	16.8	61.0
3.54 (Triangular)	920	23.5	55.2	14.0	54.5

There is no evidence of any systematic changes in either the girth or yield with increasing planting density. The yield per unit area of land appears to increase with increasing planting density (A Nugawela, V H L Rodrigo and K A G B Amaratunge).

Kuruwita 1992 Replanting – PD/92/1

Experimental details were reported in Annual Review 1992. Analysis of girth measurements indicates no significant differences in plant growth among densities, so far. However, clonal differences in growth are highly significant. Density into clone interaction is not significant.

Girth measurement in density wise

Density (plants/ha)	Girth (cm)
500	8.425
600	8.275
700	8.354
800	8.602

Girth measurements in clone wise

Clone	Girth (cm)	T grouping
RRIC 100	8.429	B
RRIC 110	7.904	C
RRIC 121	8.909	A

(Values with the same letter are not significantly different)

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

Rainguards

In view of finding a suitable solution to damage caused to the skirt type rainguard, by cricket (insect) this preliminary study was carried out. 15 rainguards were fixed from each of the following treatments.

Treatment	No. of rainguard damaged within a period of 6 months
Control (ordinary rainguard)	10
Ash colour rainguard	7
Black colour rainguard	9
White colour rainguard	5
Yellow colour rainguard	8
Red colour rainguard	8
Blue colour rainguard	10
Green colour rainguard	10
Application of Boric acid to rainguard	3
Application of CuSO_4 to rainguard	7
Application of Engine oil	4

Every colour was attacked by crickets, but white colour was attacked slightly less. Applying boric acid, or used engine oil on the polythene controls the damage to a certain extent (V H L Rodrigo, A Nugawela and S M A Samarakoon).

Nursery Inspection Unit

Inspections

Seventy private commercial nurseries were inspected and reports were submitted to the Rubber Control Department for the issue of permits.

Budded Stumps for Multiplication Nurseries

For the above purpose 8 337 bare root budded stumps from 8 clones were distributed to the Plantation Sector as follows.

Clone	Region				
	Avissawella	Ratnapura	Galle	Kalutara	Kegalle
RRIC 100	–	175	–	50	–
RRIC 102	125	65	–	10	–
RRIC 110	–	210	50	150	–
RRIC 117	100	150	20	225	100
RRIC 121	–	175	50	200	–
RRIC 130	75	210	100	–	100
RRIC 131	150	25	70	–	–
RRIC 133	50	–	–	75	–
PB 28/59	130	–	200	100	–
PB 217	305	–	150	175	–
PB 235	–	25	185	200	200
PB 255	85	10	150	200	200
PB 260	20	–	175	200	200
PR 255	100	–	150	–	100
PR 261	71	–	150	–	200
PR 305	113	–	150	–	200
BPM 24	75	–	150	200	300
RRIM 712	75	33	185	200	–

For the purpose of establishing private commercial budwood nurseries 2 904 bare root budded stumps were distributed as follows;

Clone	No. plants issued
RRIC 100	2419
RRIC 102	435
RRIC 121	50
PB 86	-

Training Programmes

For the private commercial nursery owners, training programmes were conducted at the training centre, Nivitigalakele, in collaboration with the Advisory Services Department.

The first of the three training programmes organised on Planting Materials and Field Establishment was conducted to all Plantation Management Companies separately (A Nugawela, R B Gunaratne, U S Weerakoon and M de Alwis).

Intercropping

Spatial Arrangements

The objective of these trials is to find out alternate spacing systems of the rubber crop that will provide more light for a longer period to facilitate intercropping.

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

Experimental details were reported in the Annual Review 1992. The treatment means of girth, measured at a height of 1 meter from the union are given below. The treatment differences are not significant ($P > 0.05$).

System/Treatment	Mean girth (cm)
1	8.55
2	8.14
3	8.01
4	8.43
5	7.26

(V H L Rodrigo and L S Kariyawasam)

Perth, 1992 Replanting – IC/S/92/2

The aim of this experiment is to study the advantage of planting rubber in east west rows, in flat terrain, as it is expected that such a system would provide more sunlight for the intercrops for a longer period than in the normal contour plantings.

The experimental details are discussed in the Annual Review 1992. The growth of both rubber and the intercrops are satisfactory. Mean girth (cm) of rubber plants in different treatments are given below.

Intercropping system	Row planting	Contour planting
1. Rubber + Grass	7.62	7.31
2. Rubber + Cinnamon	7.07	7.20
3. Rubber + Coffee	7.12	6.94
4. Rubber only	6.50	7.56

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

Intercropping Systems

Rubber and Timber

In this study the feasibility of growing timber crops with rubber is investigated.

Usk Valley, 1992 Replanting – IC/RT/92/1

Ambatenna, 1992 Replanting – IC/RT/92/2

Details of the experiments were reported in the Annual Review 1992. Girth (cm) of rubber plants in different systems and measured at a height of 1 meter from the union are given below;

		Trial	
Intercropping System		IC/RT/92/1	IS/RT/92/2
1. Rubber (8'x27')	No timber	10.04	8.27
	Halmilla	9.60	7.76
	Havarinuga	9.34	7.43
	Teak	8.69	7.28
	Mahogani	8.88	7.28

Intercropping System		Trial	
		IC/RT/92/1	IS/RT/92/2
2. Rubber planted in double rows	No timber	9.56	8.25
	Halmilla	9.26	8.04
	Havarinuga	10.82	7.43
	Teak	10.07	8.06
	Mahogani	10.96	7.82
3. High density rubber (8'x17')		9.33	7.48
4. High density rubber (8'x15')		9.70	6.91

Differences observed between treatments on the growth of rubber plants are not significant. Growth of Halmilla and Mahogani is not satisfactory (V H L Rodrigo and L S Kariyawasam).

Rubber and Sugarcane

Details of the experiment are given in Annual Review 1992. Both crops are growing very well and signs of competition are not evident. CO₂ assimilation rates of both crops were measured in one small holding under field conditions and a summary of the results are given below.

CO₂ Assimilation Rates of Rubber (μ mol m⁻² s⁻¹)

Treatment	Time of the day		
	0800 -100h	1200-1400h	1400-1600h
1. No Sugarcane	7.906	3.013	4.458
2. Sugarcane 4 rows	9.297	4.807	5.858
3. Sugarcane 5 rows	6.903	5.452	3.760

Treatment differences at each time of the day are not significantly different.

CO₂ Assimilation Rates of Sugarcane varieties ($\mu \text{ mol m}^{-2} \text{ s}^{-1}$)

Variety	Time (h)	0800–1000h		1200–400		1400–1600	
	System	4 row	5 row	4 row	5 row	4 row	5 row
1. SL 7103		24.7	14.3	23.8	14.1	9.4	8.6
2. SL 8306		17.5	13.5	16.6	10.1	9.9	6.6
3. H38/29/3		20.5	10.2	16.5	13.4	11.4	7.3
4. CO 775		23.6	11.3	16.7	9.2	9.0	7.5

Varietal differences in the CO₂ assimilation rates of sugarcane are not significant (A Nugawela and V H L Rodrigo in collaboration with the Sugarcane Research Institute, Uda Walawe and the Advisory Services Department of the RRB. This project is being funded by the CARP).

Rubber and Coffee/Pepper

Padukka IC/87/1

The experiment was established in 1987 and the experimental details are given in the Annual Review of same year. Girth and girth increment in the 5th year, which are given below, show that there is no significant effect ($P>0.05$) of intercrops on growth of rubber plants.

Treatment	Mean girth (cm)	Girth increment (cm)
1	53.0	6.6
2	53.2	6.3
3	52.7	7.5
4	55.5	6.9
5	55.5	5.8
6	51.1	6.2

(V H L Rodrigo and L S Kariyawasam).

Rubber and Grass/Legume

Neuchatle – IC/GL/91/1

The experiment was established in 1991 and the experimental details are given in the Annual Review of same year.

The growth of rubber plants are not affected by the intercrops at this stage. *Panicum maximum* var. Guinea B (PM) continue to give a higher dry matter production than *Brachiaria brizantha* (BB) (Table 14). The growth of tree legumes is very poor.

Table 14. *The dry matter production of grasses, legumes and growth of rubber.*

Treatments	Mean dry matter yield (kg/ha)		Mean girth of rubber (cm)
	Grasses	Tree legumes	
1. Rubber only	–	–	18.72
2. Rubber + PM	9 208	–	21.27
3. Rubber + BB	5 215	–	17.53
4. Rubber + Gliricidia	–	–	18.95
5. Rubber + Ipil Ipil	–	–	18.18
6. Rubber + PM + Gliricidia	8 953	–	20.61
7. Rubber + PM + Ipil Ipil	9 522	–	18.21
8. Rubber + BB + Gliricidia	5 368	–	20.27
9. Rubber + BB + Ipil Ipil	5 169	–	16.80

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

Rubber and Cocoa/Cinnamon

Dartonfield – IC/CC/91/2

In this trial the possibility of intercropping rubber grown in wet regions with cinnamon and cocoa, are investigated. Planting of the intercrops were undertaken during SW 1992. Three spacings are tested for each intercrop. The growth of the rubber plants are not affected significantly by the intercrops at this stage (Table 15).

Table 15. *The girth (cm) of rubber plants in the different treatments.*

Treatment	Girth (cm)
1. Rubber only	12.87
2. Rubber + Cinnamon (spacing 1)	11.56
3. Rubber + Cinnamon (spacing 2)	8.23
4. Rubber + Cinnamon (spacing 3)	10.53
5. Rubber + Cocoa (spacing 1)	10.39
6. Rubber + Cocoa (spacing 2)	8.72
7. Rubber + Cocoa (spacing 3)	12.46

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

Rubber x Banana

Present recommendation for planting density of banana when intercropped with rubber is based on the assumption that there is no adverse effect on rubber and spacing recommended in sole cropping. However aerial and edaphic environment of intercropped areas are radically different from those of mono cropped areas. No studies have so far been made on increasing the density of banana in rubber/banana intercropping system. Also, vigorous weed growth in the present rubber/banana system gives some indication of possibility of increasing banana density with rubber.

Results of most intercropping experiments are of little value beyond the site and season of the experiment due to their site and period specific nature.

This study aims to:

- determine the optimum planting density for banana with rubber.
- quantify the growth and yield, of component crops of rubber banana systems with respect to seasonal light and water use.

Experiment comprises five treatments, *ie* sole crop rubber, sole crop banana and three densities of intercrop consisting of an additive series of 1,2 and 3 rows of banana to one row of rubber.

This experiment was established in four blocks in an area of 5ha at Kuruwita Substation of RRISL. In addition, single block was established at Pallegoda estate near Agalawatta as an insurance against any disaster.

Solarimeters are required in large quantity for this experiment. Imported solarimeters cost ca. Rs.19 000/= each and are generally less than 1m. Solarimeters 1m and 2m in length as required were constructed locally with the help of National Engineering and Research Development Centre. The cost of 1m and 2m solarimeters were Rs.5 500/= and Rs.7 500/= respectively.

This project is jointly funded by the Council for Agricultural Research Policy and Overseas Development Agency (V H L Rodrigo, L S Kariyawasam and M F A Zaneer).

PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

SUMMARY

Secondary Leaf fall caused by *Oidium heveae* remained light in all rubber growing districts during the refoliation season of 1993. Incidence of Phytophthora Leaf fall during SW monsoon season was the highest recorded for last several decades. The incidence of Black Stripe and Bark rot caused by the same fungus was also more severe than in previous years. An interim circular was sent in advance predicting this situation and necessary advice was provided to all the affected plantations. The most severely affected clones in the field were RRIC 131, RRIM 600, PB 86 and RRIC 130.

2% PCP formulation, a newly developed collar protectant was proved to be very effective in the management of White Root disease, the most devastating root disease in rubber plantations.

Systemic fungicides, Bayleton and Bayfidan at concentration of 5g of a.i. per tree in two applications at 6 monthly intervals appear to be very effective in controlling white root disease in young rubber plants provided the disease is recognised at the early stages of infection.

Geotrichum sp. saprophytic fungus was found to be the organism responsible for causing the network of whitish mycelium on *Hevea* root stocks which resembles the symptoms of White Root disease.

It was shown that new nursery diseases viz Collar Rot caused by *Sclerotium rolfsii*, Target Leaf Spots caused by *Thanatephorus cucumeris*, Foot Canker caused by *Nattrassia mangiferae* discovered during the recent past could be eradicated merely by adopting the correct cultural practices recommended by RRISL.

The results of an island wide survey revealed that *Meloidogyne incognita*, the newly recorded nematode on *Hevea* is present in all the rubber growing areas and it infects the roots of *Hevea* seedlings.

DETAILED REVIEW

Staff

The Head of the Department, Mr C K Jayasinghe and Dr R Jayaratne, Assistant Plant Pathologist were on duty throughout the year. Mr K E Jayasuriya, Assistant Plant Pathologist, who was on study leave at the University of Edinburgh, UK returned to Sri Lanka on 2nd July 1993 to continue his field work. Miss P Silva, Assistant Plant Pathologist, was on duty until she left for post-graduate studies at the University of Sydney on 10th December.

The Experimental Officers Messers W Amaratunga, D S Wettasinghe and E B Fernando and Senior Technical Officer Mrs J L P C Wettasinghe continued to work in the Department. Mrs B I Fernando and Miss T H P S Fernando, Technical Officers, Mrs P Amarasekera Clerk/Typist were on duty through out the year. Misses D Siriwardena and C Ariyaratne assumed duties as Technical Officers with effect from 1st January 1993.

Mr C K Jayasinghe attended the Ninth Meeting of the ANRPC Technical Committee on South American Leaf Blight held in Pattaya, Thailand from 4th to 7th May.

Visits

Advisory	55
Experimental	259
Miscellaneous	121
Total	435

Training/Lectures/Seminars

Mr C K Jayasinghe, Dr R Jayaratne, Miss W P K Silva were involved in training Superintendents, Asst. Superintendents, Rubber Extension Officers, Students from Universities and NDT trainees.

Committees

Mr C K Jayasinghe served as a member of the Pesticide Formulary Committee.

Mr C K Jayasinghe and Dr R Jayaratne attended the scientific committee meetings of the Rubber Research Board.

Publications

Jayasinghe, C K, Parker C A and Kulasooriya, S A (1990). Seasonal variations nodule activity of *Pueraria phaseoloides*. *Jl. Rubb. Res.Inst.* **70** : 1-10.

Jayasinghe, C K (1991). Effect of combined nitrogen on nodule function of leguminous crops with special reference to tropical soils (Review) *Jl. Rubb. Res. Inst.* **71** (in press)

Jayasinghe, C K and Wettasinghe, D S (1991). Effect of combined nitrogen on growth and nodule function of *Pueraria phaseoloides*. *Jl. Rubb. Res. Inst.* **71** (in press)

Jayasinghe, C K, Fernando, E B and Fernando, I (1993). Management of *Thanatephorus cucumeris* on *Hevea* seedlings (A new record) in Sri Lanka. *Proceedings 49th SLAAS Annual Sessions*, 1993: 52.

Jayaratne, A H R. Transfer of carbon between "Donor" plants and "Receiver" seedlings in systems infected and uninfected with VA mycorrhizal fungi – sent for publication.

Jayaratne, A H R (1). Rate of spread of VA mycorrhizal mycelium and its influence upon carbon transport between plants.

(II) Uptake of ^{32}P labelled phosphorus by VA mycorrhizal fungi – sent for publication.

GENERAL

Secondary Leaf Fall caused by *Oidium heveae* was negligible in all the rubber growing districts, except in areas planted with susceptible clones.

The incidence of *Phytophthora* Leaf Fall and Bark Rot during South West Monsoon season of 1993 was the highest recorded for the last several decades. The main factors that contributed to this severe outbreak of *Phytophthora* disease were the unusual prolonged rainfall of SW monsoon and low incidence of *Oidium* Leaf Fall due to dry weather that was experienced during the beginning of the year.

This situation was predicted early and an interim circular was sent on 21st of April 1993 to the Rubber Controller, Director, Advisory Services Dept and all Estate Managing Companies requesting them to be vigilant of Bark Rot. However, we were made to understand that contents of this circular have not reached some of the growers well in advance. There were numerous requests throughout this period asking us to

assist in controlling the disease. Immediate steps were taken to educate the Estate Managers and Rubber Extension Officers on the importance of prophylactic measures in management of Bark Rot as surgical treatment is expensive and laborious. Even though *Phytophthora* Leaf Fall which reached epidemic proportions, disappeared by the month of October, Bark Rot on susceptible clones continued to be a serious problem as SW monsoon protracted over several months.

White Root disease caused by *Rigidoporus lignosus* is still the major root disease in the wet districts. An advisory circular was sent in December to all Estate Managing Companies, Rubber Controller and Director, Advisory Services Department explaining that eradication of White Root disease could be achieved by strictly following the RRISL recommendations during uprooting old clearings and planting new clearings. Further they were informed that PCP 2%, a newly developed collar protectant, could be used successfully in the management of the disease in young clearings.

Several new diseases, namely Collar Rot caused by *Sclerotium rolfsii*, Target Leaf Spot caused by *Thanatephorus cucumeris* and Foot Canker caused by *Nattrassia mangiferae*, were found to spread during the recent past in *Hevea* seedling nurseries causing a considerable economic loss. The observations of a survey conducted to find the reasons for this sudden outbreak revealed that correct cultural practices recommended by RRISL have not been implemented in all the affected nurseries. Hence, a series of seminars was conducted with the assistance of ASD to all rubber nursery owners to draw their attention to the importance in the adoption of correct cultural practices in management of *Hevea* nurseries.

Attention of the Ninth Meeting of the ANRPC Technical Committee on South American Leaf Blight (SALB) was drawn to the increased movement of people from SALB endemic countries to natural rubber producing countries free of the disease and the increasing danger with the recent introduction of direct flights from SALB endemic countries to Bangkok and Kuala Lumpur. Since early 1993, VARIG operates two flights every week from Sao Paulo to Bangkok. There is also a direct flight every week from Mexico to Kuala Lumpur with stop overs at Los Angeles and Taiwan. On the light of this situation the ANRPC Secretariat requested the member countries to pay special attention to increase the awareness on SALB among respective officers. A series of seminars was conducted to Plant Quarantine Officers of the Agriculture Department and all Rubber Extension Officers of the Advisory Services Department covering biology of the pathogen, symptomatology, measures to be taken against spread of SALB beyond tropical America and management strategies if it is detected in Sri Lanka. Further, the attention of the Director and the Rubber Research Board was drawn in March 1993 to the necessity for the formation of a country committee on SALB and implementation of the Plant Quarantine Declaration card to fulfil the requirements of ANRPC agreement on SALB in 1984.

Necessary advice on the management of *Hevea* diseases was provided to estates on their requests and to small holders at the request of the Rubber Advisory Service Dept and Rubber Control Dept.

LABORATORY AND FIELD INVESTIGATIONS

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

A. Screening of fungicides against *Rigidoporus lignosus*

White root disease (WRD) caused by *R. lignosus* is still a problem in rubber plantations of Sri Lanka. Several experiments were carried out during the last three years (Rubber Res. Inst. Ann. Rev. 1991, 1992) to find an alternative chemical for Penta Chloro Nitro Benzene which was suspended in 1989 with the discovery of its carcinogenic properties. The results of all these *in vitro* (Table 1) and *in vivo* (Table 2 and 3) experiments were analysed in 1993 and Penta Chloro Phenol (PCP) 2% was identified as a low cost potential fungicide in the management of WRD, provided that the disease is identified at early stages. The degree of infection at collar appeared critical to treatment success as shown in Table 2 and 3 (C K Jayasinghe, K E Jayasuriya and S Fernando).

Table 1. *Effect of different concentrations of PCP on the growth of R. lignosus on sterilized root pieces (in vitro)*

Fungicide	Percentage of the treated area covered by the fungus	
	Expt. 1	Expt. 2
PCP 0.035% ai	83.81 b	—
PCP 1.0% ai	2.7 C	—
* PCP 2.0% ai	—	1.87 c
* PCP 2.0% ai	—	0.56 c
PCP 2.5% ai	—	0.08 c
Tar & Greece	—	18.25 b
Control	96.79 a	76.22 a

* Same formulation from two different companies.

** Treatment means in the same column not followed by the same letter are significantly different at the 0.05 level according to Duncan's Multiple Range Test.

Table 2. *Effect of different fungicides on the control of WRD on inoculated Hevea plants.*

Fungicide	Disease severity index (from collar inspection)	Total number of trees treated	Number of trees reinfected/dead	% of treatment success	Duration of the experiment
PCP (0.6% ai)	A	16	2	87.5	13 months
	B	—	—	—	—
	C	—	—	—	—
PCP (1.0% ai)	A	4	0	100.0	13 months
	B	—	—	—	—
	C	—	—	—	—
PCP (1.5% ai)	A	5	0	100.0	13 months
	B	—	—	—	—
	C	—	—	—	—
Bayfidan (10 ml) (Single application)	A	11	1	91.0	13 months
	B	—	—	—	—
	C	—	—	—	—
Bayfidan (20 ml) (Single application)	A	13	2	84.0	13 months
	B	—	—	—	—
	C	—	—	—	—

(Disease severity index A, collar slightly infected; B, collar moderately infected, bark partially dead; C, collar severely affected, mycelium right round the collar, tap root partially or completely dead)

* Chi square test indicated that there are no significant treatment differences exist between fungicides tested.

Table 3. *Effect of different concentrations of PCP on the control of WRD on naturally affected Hevea plants.*

Fungicide	Disease severity index(from collar inspection)	Foliage symptoms of the plants in each category	Total number of trees treated	Number of trees reinfected/dead	% of treatment success	Duration of the experiment
PCP (0.6% ai) (Site a)	A	0(1);+(4);++(-);+++(-)	5	2	60	10 months
	B	0(2);=(3);++(1);+++ (3)	9	5	44	10 months
	C	0(-);+(1);++(1);+++ (3)	5	3	40	10 months
PCP (0.6% ai) (Site b)	A	0(2);+(-);++(1);+++ (4)	7	4	43	12 months
	B	0(-);+(4);++(2);+++ (1)	7	4	43	12 months
	C	0(-);+(1);++(-);+++ (2)	3	1	67	12 months
PCP (2.0% ai)	A	0(10);+(1);++(-);+++(-)	11	0	100	20 months
	B	0(2);+(1);++(1);+++ (1)	5	1	80	20 months
	C	0(-);+(-);++(1);+++ (1)	2	1	50	20 months

(Disease severity index

I. collar inspection A, collar slightly infected; B, collar moderately infected; C, collar severely infected, Mycelium right round the collar, tap root partially or completely dead

II. Foliage symptoms + slight buckling; ++ Moderate buckling & yellowing; +++ severe buckling and yellowing).

* Significant treatment differences exist in recovery rates when treated with PCP 0.6% ai (Site a)/PCP 2% ai (chi square test probability = 0.007) and PCP 0.6% ai (Site b)/PCP 2% ai (chi square test probability = 0.008).

* Significant treatment differences exist when the plants of disease index A are treated with PCP 2.0% ai compared to plants of disease index B and C (chi square test probability = 0.06).

B. Screening of two more fungicides against *Rigidoporus lignosus*

Screening of two systemic fungicides (Bayleton and Bayfidan) *in vitro* was carried out by incorporating the active ingredients in culture media (Malt Agar) at different concentrations. Their effectiveness was estimated according to the mycelial growth inhibition, compared to control cultures without fungicides (Table 4).

Bayleton at concentration 0.08% and Bayfidan at concentration 0.05% gave complete inhibition of the growth of the fungus.

Two field experiments were initiated at Main Division and Menerigama Division of Padukka Estate with fungicides, Bayleton, Bayfidan and Calixin to be used as a drench application. These chemicals were used at the following concentrations.

1. Bayleton 25 WP (25% triadimefon) – 20 g/litre of water
1 litre/tree (5g a.i./tree)
2. Bayfidan 250 EC (250 g triadimenol/l) – 20 ml/litre of water
1 litre/tree (5g a.i./tree)
3. Calixin – 750 EL Tridemorph (750 g/l) – 20 ml/litre of water
1 litre/tree (15g a.i./tree)

A second application was given after 6 months at the same rate.

Assessments were taken once in two months by inspecting the collar region of the plants (Tables 5,6,7).

Table 4. Mean colony diameter (cm) after 7 days of incubation at $28^{\circ}\text{C} \pm 2$ Temp. (Mean of time replicates)

[illegible]

Table 5. *Curative effect of fungicides drenching on one year old young trees. (1992 – Menerigama Div.)*

Fungicides	Pre-treatment assessment				Percentage recovery at 4th Assessment
	No. of trees with disease score				
	*1	2	3	4	
Bayleton	0	4	5	4	30%
Bayfidan	5	1	6	1	76%
Calixin	1	1	6	5	8%
Control (water)	2	3	2	1	0%(all dead)

Table 6. *Curative effect of fungicides drenching on 2 year old young trees (1991 – Menerigama Div.)*

Fungicides	Pre-treatment assessment				Percentage recovery at 5th assessment
	No.of trees with disease score				
	* 1	2	3	4	
Bayleton	2	1	5	1	55%
Bayfidan	–	1	5	1	43%
Calixin	–	2	4	4	Nil (all dead)
Control (Water)	–	2	1	3	Nil (all dead)

* Disease ratings

0 – No infection in collar

1 – Collar slightly affected no foliar symptoms.

2 – Collar half the circumference rotted with light foliar symptoms

3 – Collar badly rotted with severe foliar symptoms.

4 – Collar completely rotted with fully wilted leaves

Table 7. *Protective effect of fungicide drenching on 2 year old young trees. (1991 - Menerigama Div.)*

Fungicides	No. of trees treated on either side of an infected plant	No. of trees with disease score after 10 months.					
		0	1	2	3	4	Dead
Bayleton	17	17	-	-	-	-	-
Bayfidan	25	25	-	-	-	-	-
Control(water)	10	2	1	1	2	2	2

From these experiments it is clear that the degree of infection at the collar are critical to treatment success. When the disease advanced beyond the severe stage with concomitant yellowish foliage symptoms, these fungicides have very little effect on the recovery of plants. When the infection is slight to moderate, the drenching of systemic fungicides, Bayleton and Bayfidan at the rate of 20 g or 20 ml per litre of water per tree appears to be very promising in controlling the disease as well as serving as a protectant.

However, the economics of the use of these fungicides have still not been worked out as their prices are not known for commercial use (A H R Jayaratne, C K Jayasinghe and P C Wettasinghe).

Since the active ingredient of the currently recommend "collar protectant" is Pentachlorophenol which is classified under highly hazardous group (class 1b) by the WHO recommendation, it is necessary to replace this chemical with less toxic chemicals in future to reduce the contamination of ground water at these sites.

Phenol (C_6H_5OH) at concentration 2%, 5%, 8%, 10% were initially tested *in vitro* in a bituminous base using painting of root pieces technique.

8% and 10% phenols were found to be very effective in controlling the growth of *Rigidoporus*.

Phytotoxicity of the phenols at this concentration were tested on young nursery plants at Dartonfield and no toxic effects were evident. A nursery bed planted with 20 polybagged plants were artificially inoculated with white root disease infected roots of an old rubber tree. When the plants showed early symptoms of white root disease they were treated with 8 and 10% Phenol with 2% PCP as the control.

The same treatments were carried out at Talduwa Estate, Erraht division 1990 clearing which was very badly affected with white root disease. Results of these two experiments are not available yet (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

(C) Use of cashew nut shell liquid oil as a fungicide

The possibility of using cashew nut shell liquid (CNSL) oil which contains mainly phenolic compounds as a fungicide against White root disease was initiated.

Studies *in vitro* shows that there was a problem of contamination of plates through the CNSL. Therefore it was necessary to sterilize the CNSL liquid before it was tested against white root disease causing fungus. However, the preliminary investigations done did not show any inhibition of the growth of *Rigidoporus lignosus* even at 100% (Raw) CNSL oil. Further investigations are in progress to explore the possibilities of this by product, to be used as a cheap fungicide.

(D) New fungicides for control of Bark rot

New formulations of three chemicals namely Dithane M 45, Sandofan M and Oxadixil which were found to be potential fungicides to control Bark rot caused by *Phytophthora* spp. are being tested on the virgin panels of the clone PB 86 at Pimbura Estate. These experiments are designed to find both prophylactic as well as the curative effects of the above chemicals. The recommended fungicides, Brunolinum plantarium, Sandofan paste and Ridomil are used as controls (C K Jayasinghe and E B Fernando).

(E) Testing of spraying machine

Aspee turbulow mist blower from India was tested for its performance. Three spray liquids namely water, diesel and coconut oil were used to test the maximum height of reach by hanging the MgO coated slides on a rope attached to a tall rubber tree.

All 3 spray liquids reached the height of 50 feet effectively. Since the tree selected for this exercise was only 50–60 feet tall this has to be repeated to estimate the maximum reach of this machine (Table 8).

Table 8. *Details of particle properties collected on slides.*

Height	Spray oil	Mean Droplet size(μm)	Density of Droplets (sq.cm)
40 feet	Coconut oil	203 ± 15	30
	Diesel	157 ± 10	9
	Water	129 ± 22	35
45 feet	Coconut oil	149 ± 16	33
	Diesel	231 ± 25	11
	Water	103 ± 11	38
50 feet	Coconut oil	127 ± 18	29
	Diesel	225 ± 29	14
	Water	166 ± 26	20

(R Jayaratne, C K Jayasinghe, S Wettasinghe and D Siriwardene).

Improvement of cultural practices in management of *Hevea* Diseases (CP/89/1)

(a) Evaluation of yield drop due to the *Phytophthora* leaf fall.

Collection of yield data for the last 5 years from fields of PB 86 and RRIM 600 was initiated by circulating a questionnaire to 20 estates covering all rubber growing areas. So far 14 estates have responded. Collection of these data has to be continued until, at least, the end of next year to estimate the crop loss due to this leaf fall (R Jayaratne and C K Jayasinghe).

(b) Effect of an additional dose of fertilizer on yield of *Hevea* plants badly defoliated due to *Phytophthora*.

Four PB 86 fields were selected from four estates, namely Halwatura, Sirikandura, Eladuwa and Padukka and an extra fertilizer doze at the rate of 50 g of urea and Muriate of Potash/tree was given to half the number of tapping blocks in each field. The yield data from these fields will be collected separately for each tapping block (R Jayaratne, L Samarappuli, C K Jayasinghe, D Siriwardena and U Mitrasena).

Biological Control of White Root Disease (BC/89/1)

Fungicides used in Sri Lanka to control White root disease, show acute toxicity hazards to human and other components of the ecosystem.

However, Sri Lanka being a developing country, effective and safe chemicals cannot be recommended for rubber growers, as such chemicals are very expensive. Therefore, studies have been carried out to explore possible biological control techniques to manage white root disease of rubber tree. Naturally occurring potential biological control agents (mainly fungi) were isolated by using different methods. According to Foley and Deacon (1985) malt agar plates precolonised by *R. lignosus* (one specific isolate viz Ratnapura) were used to isolate such potential biological control agents from different soil samples collected from different zone, viz Kalutara, Sinharaja forest, Ratnapura, Galle, Matara, Kegalle districts and some areas of the dry zone of Southern part of Sri Lanka.

Potential antagonistic basidiomycetes were isolated mainly from basidiocarps of different wood rotting Basidiomycetes. Potentiality of those isolated hyphomycetes and Basidiomycetes to control or suppress *R. lignosus in vitro* was studied on dual cultural plates.

In successful biological control, use of sublethal doses of chemicals or sublethal physical treatments can be effective. Therefore, in the isolations of antagonistic micro-organisms from soil, furfural, a mild fumigant was used to weaken the pathogen colonised on *Hevea* root pieces, where they were used as pathogenic inoculum. Such weakened pathogenic inocula were buried in different locations of rubber planting regions to isolate naturally occurring antagonistic micro-organisms. When pathogen infected root pieces, weakened by different methods, were buried in soil for a particular time period, the concept of invading weakened organism by other stronger organism like a mycoparasite was considered as the phenomenon of mycoparasitism on living micro-organisms.

Total number of such isolated potential antagonistic fungi are around 45, the details of which are given in Table 9. Identification of those fungi is in progress. All fungal cultures are being stored in sterilised distilled water.

Test on pathogenicity of such isolated fungi on rubber seedlings is in progress. Wood decaying rates of same fungi are to be studied and experiments are in progress (K E Jayasuriya, J W Deacon, T H P S Fernando).

Table 9. *Different soils used for isolations of antagonistic micro-organisms which suppress or inhibit the growth of R. lignosus in culture media.*

Sample collected from	No. of samples	Reps used for isolation of biocontrol agents	No. of isolated antagonistic fungi
Ratnapura	5	50	1
Kegalle	3	30	3
Galle	3	30	—
Matara	3	30	3
Kalutara	6	60	2
Dry zone	8	80	1
Singharaja	3	30	—
Padukka (Col. Dist.)	2	20	—
Dartnfield	14	140	18

The biology of Basidiomycetes species namely *Lentinus squarrosulus* and *Gloeophyllum striatum* which were reported to be antagonistic to *Rigidoporus lignosus* was studied. (These two fungal cultures were kindly supplied by Dr Brunck of France)

A comparative study on the rate of wood decay between *Rigidoporus*, *Lentinus* and *Gloeophyllum* was initiated.

The effect of these two exotic fungi on *Hevea* seedlings was studied in pots by burying the infected wood dowels around the seedlings. So far no parasitic mode of action is evident in these plants (R Jayaratne and P C Wettasinghe).

Effect of temperature on the growth

Colony diameter of the two fungi were compared at five temperatures and on 3 culture media. Both fungi grew best at $38^{\circ}\pm 2^{\circ}\text{C}$. Growth on Malt Agar (MA), Potato Dextrose Agar (PDA) and Caepexdox Agar (CDA) are similar for *Lentinus* sp. whereas growth *Gloeophyllum* was slightly slower on CDA compared to MA and PDA.

Comparison of growth rate

Growth rates of the three fungi, *Rigidoporus*, *Lentinus* sp. and *Gloeophyllum* sp. were compared on Malt Agar (Table 10).

Table 10. Colony diameter (cm) of three fungi and Malt Agar

Time (hours)	<i>Lentinus</i> sp.	<i>Gloeophyllum</i> sp.	<i>Rigidoporus</i> sp.	L S D (p=0.05)
48	2.85	1.16	2.21	0.1875
78	4.98	2.87	3.85	0.4874
96	6.43	3.30	5.11	0.4592
120	8.5*	4.34	6.47	0.4067
144	8.5*	6.47	7.76	0.6371
168	8.5*	7.67	8.5*	0.0989
192	8.5*	8.5*	8.5*	0.0000

* 8.5 cm – Fully grown plates.

Effect of pH

Both these fungi showed an optimum pH of 5.0 on Malt Agar at room temperature (R Jayaratne and P C Wettasinghe).

Micro-organisms and Pests Associated with Rubber Plantations (MP/89/1)

(a) Root-knot nematode, *Meloidogyne incognita* infestations on *Hevea* seedlings.

An island wide survey was launched to find the distribution of *M. incognita*, a newly recorded nematode of *Hevea* nurseries in Sri Lanka. The results of the survey revealed that this nematode is present in all rubber growing areas and infect the roots of *Hevea* seedlings in nurseries. The roots of mature plants were also examined at several plantation sites, but no nematodes have been detected to date. However, further observations are in progress.

The findings of present study reaffirmed the wide distribution of *M. incognita* in the country. It has also been reported that *M. incognita* has a wide host range in Sri Lanka including: *Musa acuminata*, *Phaseolus vulgaris*, *Beta vulgaris*, *Daucus carota*, *Capsicum annum*, *Carica papaya* and *Lycopersicon esculantum* and the present report adds a new host to the list in Sri Lanka.

Economic losses from damage caused by nematode infestation are estimated to be around 10 percent of seedlings in affected nurseries. These seedlings will never reach the buddable growth at the expected age. Nematicidal screening trials were therefore undertaken with four chemicals namely Nematicur, Oncol, Carbofuran and Basimid. These chemicals are being tested in a pot experiment at Dartonfield and a field experiment at Mahagama (C K Jayasinghe and D S Wettasinghe).

(b) *Geotrichum* infestations on *Hevea* seedlings

The network of whitish mycelium on *Hevea* root stocks, reported in July 1992 at Suddagala, Kuruwita was confirmed to be a fungus associated with rotting plant material. The fungus was identified as *Geotrichum* Link with the kind assistance of CAB International Mycological Institute UK (IMI No. 354411). Immediate steps were taken to instruct the Rubber Control Department to accept the budded stumps from Suddagala rubber nursery.

The same problem was brought to our notice in December 1993 from Meerigama rubber seedling nursery and about 20 percent of the root systems of seedlings in the nursery was found to be invaded by *Geotrichum*. The tap roots and the laterals of the affected plants were found to be completely covered superficially with the mycelium (C K Jayasinghe and P C Wettasinghe).

(c) Foot canker of *Hevea*

A condition similar to the cankerous growth detected in young budding at Nakiyadiya Estate, Galle (Rub. Res. Inst. Ann. Rev. 1992) was reported from seven months old seedling nursery at Meerigama in February 1993. Disease symptoms consisted of sudden wilting of leaves and death of the plants during the driest months, February and March. Another striking symptom of the disease was an elongated canker in the bark of the collars of seedlings. Longitudinal cracks usually appeared in the bark and a brownish rot of the pith occurred in severe cases. This brown internal discolouration appeared above and below the canker where externally the bark appeared healthy. The fungus *N. mangiferae* was easily isolated from such tissue on PDA even without surface sterilization.

The causal organism was isolated from affected plants and sent to CAB International Mycological Institute, UK, where it was identified as *Natrassia mangiferae* (H Sydow and Sydow) B Sutton and Dyko and a specimen was deposited in the IMI herbarium as IMI 352075.

This is the first report of the occurrence of *Natrassia mangiferae* with association of foot canker in *Hevea* seedlings in Sri Lanka. Further, except for an unconfirmed report that this fungus is associated with die-back of rubber twigs in Malaysia (1976) there appears to be no previous record of it causing canker and sudden wilt of *Hevea* in any other part of the world (C K Jayasinghe and W P K Silva).

(d) *Cochliobolus eragrostidis* on *Hevea* leaves

Various concentrations of *Cochliobolus eragrostidis* spore suspensions were sprayed on to *Hevea* seedlings with the view of proving Koch's postulates. Typical symptoms of the disease were unable to be produced in 1993 too (C K Jayasinghe and P C Wettasinghe).

(e) Target leaf spot disease caused by *Thanatephorus cucumeris*

Thanatephorus cucumeris, a fungal pathogen first reported in 1991 in seed germination beds and subsequently in seedling nurseries in 1992 was found to spread to two year old field plants of unweeded clearings in several estates. In all instances it was noticed that weed creepers which covered the rubber canopies harboured the disease. Hence, attention of the estate managers was drawn to the importance of implementation of correct cultural practices in minimising diseases (C K Jayasinghe).

(f) *Cylindrocladium quinqueseptatum*

Several isolates of *C. quinqueseptatum*, a potential pathogen of *Hevea* in Sri Lanka were obtained from *Eugenia caryophyllus* to carry out further studies on the biology of the fungus (C K Jayasinghe and C Ariyaratne).

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

I. Establishment of new clones for utilization in the clonal evaluation programmes in future.

Arrangements were made to erect fences using concrete posts in our thirteen nurseries located at Kalutara, Kegalle, Kelany Valley, Galle and Ratnapura regions as

plants in these nurseries were damaged by cattle and goats regularly. Further, all vacancies of previously established clones were filled and fertilizers were applied in January and May (C K Jayasinghe and D S Wettasinghe).

II. Screening of clones against powdery mildew caused by *Oidium heveae*.

Thirty three clones were screened at four localities namely Padukka Estate, Newland Estate, Bentota Estate and Doloswela Estate against powdery mildew caused by *O. heveae*. Reaction of the clones at different sites varied markedly probably due to the different maturity stages of leaves at the time of *Oidium* infection (C K Jayasinghe, D S Wettasinghe and I Fernando).

III. *Phytophthora* epidemic in rubber plantations from May to september.

The incidence of *Phytophthora* leaf fall and bark rot during South West monsoon season of 1993 was the highest recorded for last several decades.

Since its first detection in Sri Lanka the disease has been reported annually in endemic proportions from May to September in each year reaching epidemic proportions when the weather and other factors are conducive to the pathogen. However, its severity is governed by the weather conditions of the particular year. The first outbreak of the disease was detected in 1916 on susceptible clones. The next epidemic of *Phytophthora* leaf fall occurred in three consecutive years commencing in 1922. Since then PLF reached epidemic proportions once in 5-6 years till 1959. It is worthy to note that diseases caused by *Phytophthora* remained mild or moderate for 20 years since 1960 to 1979. The first outbreak after 1959 occurred in 1980 and subsequent epidemics took place in 1988, 1992 and 1993 (Fig. 1). However, the 1993 epidemic was the highest recorded since 1959 (C K Jayasinghe and R Jayaratne).

IV. field susceptibility of recommended clones to abnormal leaf fall and bark rot.

Phytophthora epidemics in 1992 and 1993 provided us a very good opportunity to screen the new clones under field conditions. The results of the surveys conducted during the year 1993 reaffirmed the observations made in the year 1992 (RRISL Ann. Rev. 1992). Following conclusions could be made by going through the 2 results of both surveys.

The clone RRIC 131 was found to be highly susceptible as RRIC 600 and PB 86 to black stripe. RRIC 130 was also found to be highly susceptible to black stripes in Avissawella region, the rubber growing area severely affected with *Phytophthora* diseases in 1992 and 1993. Though the leaf fall was severe on RRIC 121 as in PB 86 in all rubber growing areas, the black stripes incidence was mild. The clones RRIC

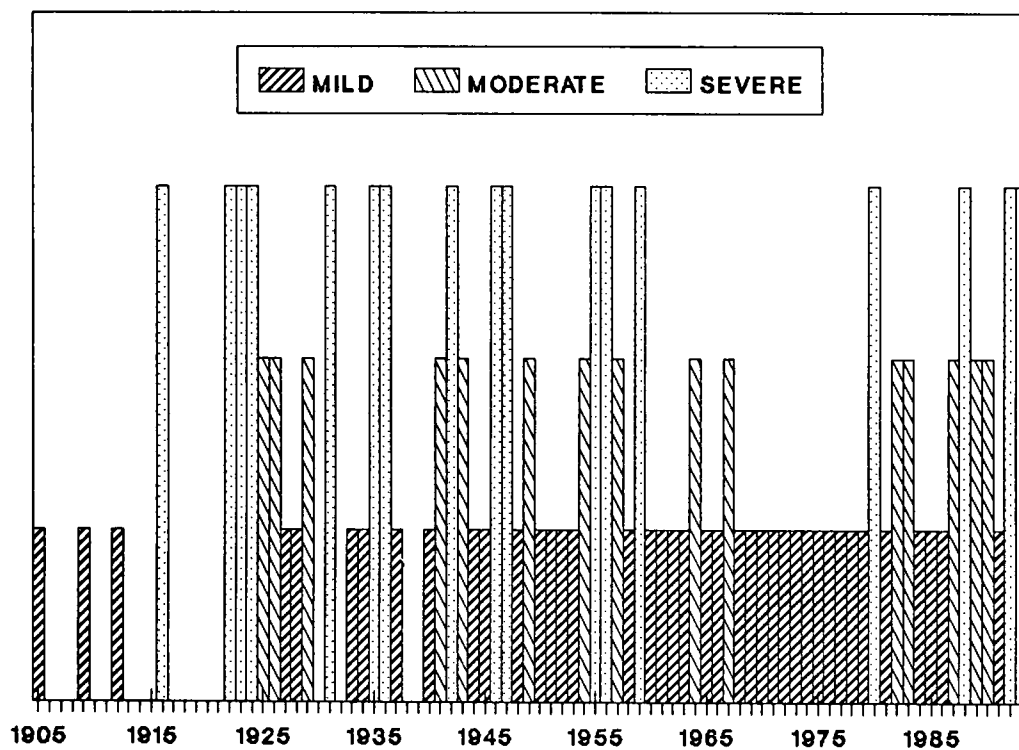


Fig. 1 The incidence of Phytophthora Leaf Fall from 1905 to date (Modified from Lloyd, 1963)

100, RRIC 102 and RRIC 110 showed a mild attack of *Phytophthora*. We should be cautious when recommending clones to Avissawella region as it was the worst affected area. Further, it is worthy to note that even clone RRIC 100 was found to be susceptible to black stripes unexpectedly in Avissawella (C K Jayasinghe and D S Wettasinghe).

V. Screening of *Hevea* clones against bark rot caused by *Phytophthora meadii*.

Thirty three clones were screened during South West monsoon period at four localities namely Padukka, Frocester, Rilhena and Madeniya estates against bark rot caused by *Phytophthora meadii*. Plants of different clones were artificially inoculated with a standard spore suspension of *P. meadii* and resulting lesions were measured after four weeks.

The results statistically analysed using DMRT are presented in Table 11. Though there are site to site variations it could be concluded that the clones RRIC 130, RRIC 133, RRIC 119, RRIC 110, RRIC 112 and PB 86 are highly susceptible to bark rot whereas clones such as RRIC 116, RRIM 717, PR 235, PB 260, RRIC 121, RRIC 102, PR 255, BPM 24, HP 74-213, RRIC 100, PR 261 and RRII 105 are resistant to the same disease (C K Jayasinghe and D S Wettasinghe).

Biology of Common Pathogens of *Hevea* (BCP/89/1)

Histological basis of resistance to *Corynespora cassiicola*

A modification of the method described by Shipton and Brown was found to be successful in clearing and staining the leaf tissue inoculated with *C. cassiicola* (C K Jayasinghe, W P K Silva and B I Fernando).

MISCELLANEOUS

1. Operation on eradication of *Corynespora* leaf fall disease in smallholdings and estates.

Several requests were made by smallholders directly or through the Rubber Control Department to get their clearings inspected. Necessary advice was given and certificates were issued to uproot the affected clearings (C K Jayasinghe, D S Wettasinghe and E B Fernando).

Table 11. *Susceptibility of different clones to Bark Rot at four different localities.*

Clone	Padukka	Frocester	Rilhena	Madeniya
RRIC 130	15.81 a	16.58 a	10.93 b	11.03 bcde
RRIC 133	9.17 defgh	16.96 a	12.64 a	–
RRIC 119	9.39 defg	11.99 cd	8.73 cdefghi	18.07 a
RRIC 110	12.25 b	14.81 ab	9.38 bcde	11.47 bc
RRIC 112	12.79 b	15.27 a	8.17 defghi	10.89 bcde
PB 86	10.65 cd	11.65 cd	10.45 bc	11.03 bcde
RRIC 120	9.29 defgh	12.51 bc	8.01 defghijk	11.60 b
RRIC 114	11.65 cd	10.00 cdef	8.57 defghi	11.10 bcde
RRIC 132	–	10.00 cdef	9.28 bcdef	11.34 bc
HP 74–181	8.72 efghi	11.76 cd	10.75 b	9.29 cdefghij
RRIC 117	9.44 defg	11.73 cd	8.90 cdefgh	9.78 bcdefgh
RRIC 115	8.67 efghi	12.59 bc	8.06 defghij	10.32 bcdefg
RRIC 101	9.48 def	9.28 def	9.00 cdefg	11.16 bcd
HP 74–193	8.58 efghi	12.65 bc	8.92 cdefgh	8.60 fghij
HP 74–194	9.87 de	–	9.82 bcd	9.00 defghij
RRIC 109	9.43 defg	11.60 cd	7.52 ghijkl	9.38 bcdefghi
RRIC 111	8.25 efghi	11.10 cde	7.14 hijkl	10.60 bcdef
RRIC 113	9.20 defgh	11.61 cd	7.24 ghijkl	8.89 efghij
PB 2859	8.49 efghi	12.05 cd	7.48 fghijkl	8.55 fghij
RRIM 600	8.36 efghi	–	8.12 defghijk	10.14 bcdef
RRIM 712	8.14 fghi	11.08 cde	7.51 fghijkl	8.28 ghijk
PRII 05	7.41 i	–	7.13 hijkl	11.06 b
PR 261	9.15 defgh	10.31 cdef	7.05 ijkl	–
RRIC 100	8.65 efghi	8.55 ef	9.75 bcde	7.16 ijk
HP 74–213	–	10.41 cdef	7.98 efghijk	7.91 hijk
BPM 24	7.19 i	11.37 cd	7.42 ghijkl	7.48 ijk
PR 255	–	–	–	8.40 fghijk
RRIC 102	8.00 fghi	10.07 cdef	8.60 defghi	7.25 ijk
RRIC 121	8.46 efghi	9.88 cdef	6.52 jkl	8.32 ghijk
PB 260	7.63 hi	11.94 cd	7.26 ghijkl	6.20 k
PR 235	9.21 defgh	–	–	7.31 ijk
RRIM 717	7.76 ghi	9.60 def	6.03 l	7.77 hijk
RRIC 116	7.26 i	7.76 f	6.32 kl	7.12 jk

SOILS AND PLANT NUTRITION

Lalani Samarappuli

SUMMARY

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

Field investigations suggest the possibility of using EPPAWELA Rock Phosphate (ERP) as a source of phosphate for immature rubber plants also, in some soils. It also appears, that the rate of P currently recommended may not be sufficient to meet the plant's demand for P in some soils. Use of ERP even at double the currently recommended level will be more profitable than IRP.

Residual effect of mulching on latex production was seen even at the 5th year after discontinuation of mulching. This practice would benefit the rubber smallholder sector most, as they would normally have mulching materials on the site at no extra cost. The minimum paddy extent required to obtain the recommended straw requirement to mulch one hectare of rubber holding would be about 0.42 hectares. Among the mulching materials that were tested, loppings of legume trees were found to be superior to paddy straw as their contribution in terms of nutrients other than K, was much higher than what is contributed by paddy straw. The estate sector could therefore grow bush/tree legumes also in the inter rows during the immature period, which would provide adequate biomass for use as dead mulch.

It appears possible to use the conventional mixtures 12:14:14 and 7:9:9:3 for young budding plants as well.

The soil and foliar survey programme which commenced in late July, provided data for fertilizer recommendations for 19 000 hectares.

DETAILED REVIEW

Staff

The Head of the Department, Dr (Mrs) Lalani Samarappuli and Dr D M A P Dissanayake, Assistant Soils Chemist, who was promoted to Senior Staff Grade I with effect from 3rd August 1993 were on duty throughout the year. Mr S Dharmakeerthi,

Assistant Soils Chemist, reassumed duties on 5th October, after his post graduate studies leading to an MSc Degree in Soil Science at the Post Graduate Institute of Agriculture, University of Peradeniya. Mr P I Yapa, Assistant Soils Chemist, resigned from the services of the Rubber Research Institute in June.

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

Senior Technical Officer, Mrs C Maheepala, Technical Officers Messrs S N Silva, P Karunadasa, U Mitrasena, T B Dissanayake, A N Yakandawela, T M Ahamadeen and the English Stenographer Mrs Lakshmi Perera, were on duty.

Mrs M K Mahanama Technical Officer was transferred to Rubber Technology and Development Department with effect from 1st January.

Miss Chandani Jayalath, Miss T Pieris and Mr H P Dhammika assumed duties as Technical Officers with effect from 1st January. Miss T Pieris resigned from the services of the Rubber Research Institute in May.

Research Students

Miss K de Silva, an undergraduate student from Ruhuna University, completed her final year project on "Rice straw as a source of nutrients for immature *Hevea* plants" under the supervision of Dr (Mrs) Lalani Samarappuli.

Visits

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

Seminars, Meetings and workshops

Dr (Mrs) Lalani Samarappuli addressed the symposium on agronomy organized by the LH Plantations Ltd. on "Soil Fertility Management for High Yielding Rubber Plantations" held in Hotel Lanka Oberoi, Colombo.

Dr (Mrs) Lalani Samarappuli* and Dr D M A P Dissanayake** attended the following seminars, meetings and workshops:

- * Fertilizer Advisory Committee
- * The working group on fertilizer mixtures of the Sri Lanka standards Institution.
- *** Central Scientific Committee
- * Seminar on "Introduction of the Concept of SALT in Tea Plantations" organized by the TRI.

- ** FAO/IAEA Regional Seminar for Asia and the Pacific on "Nuclear Related Methods in Soil/Plant Aspects of Sustainable Agriculture".
- *** Workshop on "Land Suitability for Coconut" organized by the CRI.
- ** Workshop on "X – Ray Fluorescence" organized by IFS, Kandy.
- ** Workshop on "EPPAWELA Rock Phosphate Development" organized by Lanka Phosphate Limited.

Mr A M A Perera participated in a workshop on "Repair and Maintenance of Nuclear Equipments" organized by the Atomic Energy Authority at the Radio Isotope Center, Colombo.

Mr A M A Perera and Mrs R Hettiarachchi attended a seminar on "Use of special gases in Instrumental Analysis" organized by the Colombo Oxygen Company.

Training Programmes

Dr (Mrs) Lalani Samarappuli and Dr D M A P Dissanayake were involved in the following training programmes:

Rubber Extension Officers of the Advisory Services Department

Assistant Superintendents of Kotagala Plantations Ltd.

Field Officers of Namunukula Plantations Ltd.

Superintendents/Assistant Superintendents of all the estates managed by different companies on the soil and foliar survey programmes.

Affiliated University students preparing for the National Diploma in Plantation Management

Publications

Dissanayake, D M A P, Dissanayake, T, Gunasekera, R and Jayasekera, Surani (1993). Clonal differences in rock phosphate utilization by *Hevea*. *Jl. Rubb. Res. Inst. Sri Lanka* (in press).

Dissanayake, D M A P, Atkinson, D and Edwards A C (1993). EPPAWELA rock phosphate : A useful source of fertilizer P (in preparation).

- Dissanayake, D M A P, Dissanayake, T and Maheepala C K (1993). Role of EPPAWELA rock phosphate in the nutrition of immature and mature *Hevea*. (submitted for publication in the *Jl. Rubb. Res. Inst. Sri Lanka*).
- Dissanayake, D M A P, Dissanayake, T, Perera, P and Jayalath, Chandani (1993). A comparative study on physical, chemical and mineralogical properties of commercially available EPPAWELA rock phosphate (in preparation).
- Dissanayake, D M A P and Silva, Jayasena (1993). Behavior of EPPAWELA rock phosphate in rubber soils. *Proc. 49th Annual sessions of the SLAAS, 1993*
- Samarappuli, L (1993). Weed management in rubber cultivation. In *Weed management for developing countries*. eds R Labrada and J C Easley, FAO, Rome.
- Samarappuli, L and Dissanayake, D M A P (1993). Soil and foliar sampling techniques for discriminatory fertilizer recommendation for rubber. *Rubb. Res. Inst. Sri Lanka Bulletin* (in press).
- Samarappuli, L and Ratnayake, N (1993). Some aspects of soil moisture status in rubber growing soils. *Proc. 49th Annual session of the SLAAS, 1993*.
- Samarappuli, L, Yogaratnam, N, Karunadasa, P and Mitrasena, U (1993). Preliminary studies on the use of Neutron Probe in some rubber growing soils. *Jl. Rubb. Res. Inst. Sri Lanka* (in press)
- Samarappuli, L, Yogaratnam, N, Samarappuli, I N, Karunadasa, P and Mitrasena, U (1993). Towards shorter immaturity and improved yields by mulching with rice straw. *Jl. Rubb. Res. Inst. Sri Lanka* (in press)
- Samarappuli, L, Yogaratnam, N and Hettiarachchi, R (1993). Performance of some RRIC 100 series clones under different soil moisture regimes. *Jl. Rubb. Res. Inst. Sri Lanka* (in press)
- Samarappuli, L, Yogaratnam, N and Hettiarachchi, R (1993). Role of potassium on growth and water relations of rubber plants. (in preparation)
- Samarappuli, L, Yogaratnam, N and Hettiarachchi, R (1993). Comparison of different establishment practices for rubber in moisture deficit situations. (in preparation)

Yogarathnam, N (1993). Fertilizer trends and policies in soil-plant studies. *Rubb. Res. Inst. Sri Lanka Bulletin* (in press)

LABORATORY INVESTIGATIONS

Use of live and dead mulch

A laboratory incubation study was carried out for 15 weeks to quantify the nutrients released over a period of time by paddy straw (Table 1). In general, application of paddy straw increased, with time, the nutrient concentrations of all the nutrients analysed except soil Fe content. This experiment is being continued for further evaluation of nutrient release pattern and also to evaluate other benefits of straw mulching such as soil moisture retention capacity, aggregation, etc (L Samarapuli, K de Silva and R Hettiarachchi).

P fixation in rubber soils

Chemical analysis of soils collected to represent all the rubber growing areas, were done. P adsorption/desorption curves also will be fitted in addition to mechanical analysis (A Dissanayake, T Dissanayake, C Maheepala, and C Jayalath).

FIELD INVESTIGATIONS

(1) Agronomic practices to overcome moisture deficit situations

(i) Use of live and dead mulch

a. Residual effect of mulching on latex production was studied in experiment SM/82/5. Application of straw was discontinued after the trees came into tapping. The residual effect of treatments on latex production is given in Table 2.

Table 1. *Changes in soil nutrient contents with time*

Treatment	Weeks after treatment	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)	Mn (ppm)	Zn (ppm)	Fe (ppm)	Cu (ppm)
Control (without straw)	3	0.09	7.90	108.7	197.4	43.3	1.53	1.61	10.9	0.36
	5	0.08	7.90	97.7	194.0	37.9	1.36	1.50	9.4	0.32
Straw in- corporation	3	0.13	13.60	609.4	306.3	60.9	2.90	1.98	15.3	0.51
	5	0.33	10.83	980.5	263.7	91.8	3.92	3.20	6.0	0.65
Straw mulching	3	0.12	13.00	151.5	281.6	44.8	2.50	1.89	14.94	0.49
	5	0.32	10.36	495.7	233.8	65.8	3.71	3.10	6.4	0.62

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

Treatment	Yield (kg/ha/yr)				
	1989	1990	1991	1992	1993
Naturals	803a	878a	899a	1 218a	1 385a
Legumes	850a	907a	928a	1 242a	1 395a
Dead mulch	953b	1 035b	1 235b	1 595b	1 619b

In addition to be able to tap early, yield of latex was also higher in mulched plots and this beneficial effect continued to be significant even in the 5th year after discontinuation of mulching.

The rubber smallholder sector which covers approximately 33% of the total rubber area, grows other crops including paddy also. Mulching with paddy straw would therefore benefit the rubber smallholder sector most, as they would normally have mulching materials on the site at no extra cost. The minimum paddy extent required according to rubber holding sizes to obtain the recommended straw requirements is given in Table 3.

Table 3. *Extent of minimum paddy holding for supply of annual straw requirement according to rubber holding sizes*

Size of rubber holding (ha)	Straw requirement (kg/ha/yr)	Equivalent paddy holding size (ha) ^{1/}
0.2	1 000	0.08
0.4	2 000	0.17
0.6	3 000	0.25
0.8	4 000	0.33
1.0	5 000	0.42
1.5	7 500	0.63
2.0	10 000	0.83
2.5	12 500	1.04

^{1/} 6000 kg/harvest/ha – 2 harvesting seasons/yr

One of the main drawbacks in mulching under commercial estate conditions would be lack of sufficient mulching material close to the field for the mulching operation and for replenishing the mulch layer at suitable intervals. Therefore, growing of bush legumes such as *Crotolaria*, *Tephrosia* and *Gliricidia*, that would provide enough material for mulching and using their loppings 2 to 3 times annually could be an acceptable agronomic practice. Among the materials that were tested, loppings of legume trees were found to be superior to paddy straw as their contribution in terms of nutrients other than K, was much higher than what is contributed by paddy straw (Table 4).

Table 4. *Mineral composition of different mulching materials.*

Treatment	C/N	N(%)	P(%)	K(%)	Ca(%)	Mg(%)
Rice straw	40.6	1.61	0.28	1.27	0.84	0.31
Coir dust	68.7	0.85	0.23	0.36	0.62	0.22
<i>Pueraria</i>	16.2	1.87	0.36	0.62	1.05	0.31
Guatamala	38.8	1.48	0.38	1.13	0.76	0.31
Vetiver	43.2	1.01	0.21	0.42	0.56	0.16
<i>Tephrosia</i>	14.1	2.50	0.50	0.52	1.15	0.31
<i>Sesbania</i>	17.1	1.73	0.34	0.51	0.97	0.25

There was a significant difference ($P < 0.001$) between different mulching materials on plant diameter of one year old rubber plants (Table 5).

Table 5. *Effect of different mulching materials on plant diameter.*

Treatment	diameter (mm)
<i>Pueraria</i>	16.65 a
<i>Sesbania</i>	16.55 b
Rice straw	15.45 bc
Guatamala	15.35 bcd
Vetiver	14.70 cd
Coir dust	14.65 d
No mulch (Control)	13.55 e

The estate sector should, therefore, consider growing not only creeping legumes in the inter rows during the immature period but also bush/tree legumes which would provide adequate biomass for use as dead mulch (L Samarappuli, P Karunadasa and U Mitrasena).

b. Optimum N P K Levels for rubber mulched with rice straw (Response Function Approach)

In this experiment optimum N,P,K levels 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.

Girth data up to 7th year of planting were used to investigate optimum N P K levels under different management practices viz with and without straw. An analysis of variance (ANOVA) and a response surface analysis were used on trunk girth for comparison of treatment effects.

The results obtained from this study provide the following guidelines:

- * The present recommended level of nitrogen appears to be sufficient irrespective of the management practice
- * According to the ANOVA followed by a mean separation procedure, the K level has to be doubled from the 6th year onwards under both management practices. The currently recommended level and the most optimum levels obtained by mean separation with respect to N P K levels are given in Table 6.

Table 6. A Comparison of N P K Levels – Current Recommendation and the most optimum Levels Obtained through Mean Separation

Year after Planting	N	P	K	
			Current Recommendation	Optimum Levels via. mean Separation
01	33	17	33	33
02	66	33	66	66
03	99	51	99	99
04	99	51	99	99
05	132	68	132	132
06	132	68	132	264
07	99	51	99	198

- * The optimum P and K levels varied according to management practices when response function analysis technique was used (Table 7).

Table 7. *Optimum levels of P and K under different management practices obtained from response surface analysis*

Year	P		K	
	Without Straw	With Straw	Without Straw	With Straw
01	17	17	33	33
02	33	33	66	66
03	51	51	128	99
04	53	75	123	112
05	69	78	175	158
06	70	80	150	144
07	52	64	101	106

The present P level appears to be sufficient under conventional management practices (without straw), but an approximate increase of 20% is required in the presence of straw to optimize trunk girth.

* Also, a higher requirement of K from 3rd and 4th years after planting is indicated for plants with and without straw mulch respectively. The requirement of K (as fertilizer) appears to be lower under with straw management compared to without straw. This may be due to partial substitution of K by straw. It is also evident that the level of K application can be brought down to the currently recommended level after the commencement of tapping.

The differences in K levels observed by mean separation and response surface regression procedures suggest a possible quadratic behavior of girth in response to applied K. This implies that the girth reaches the maximum between the recommended (K1) and double the recommended level (K2).

The predicted girth under different management practices are listed in Table 8.

Table 8. *Predicted girth under different management practices*

Year after planting	Predicted girth (cm)	
	without straw	with straw
3	32.80	36.10
4	38.40	42.40
5	45.50	51.50
6	51.02	56.70
7	53.67	60.30

This indicates that the immaturity period could be reduced by one year with application of straw and optimum N,P,K levels (L Samarappuli, P Karunadasa and U Mitrasena).

ii. Fertilizer practices for overcoming moisture stress

Studies on soil moisture and potassium (SM/88/4) indicated that under moisture stress situations increasing the level of potassium application, improved the growth of one year old rubber plants. A Field experiment is in progress at Nalanda Estate, Ulpota, to confirm the above results under field conditions in a comparatively drier area.

Another experiment was planned to study the effect of both potassium and mulching on moisture stress, growth and latex production of *Hevea*.

Treatments are as follows:

Two agroclimatic regions

C1	-	Dry
C2	-	Wet

Three mulching techniques

M0	-	no mulch
M1	-	surface mulching
M2	-	sub surface mulching (incorporation)

Four potassium levels

K1	-	half the recommended level
K2	-	recommended level
K3	-	one and half the recommended level
K4	-	double the recommended level

(L Samarappuli, P Karunadasa and U Mitrasena)

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

An experiment was planned in collaboration with the Adaptive Research Unit to evaluate the water use pattern under tea/rubber multicropping system in order to improve the water use efficiency of both crops (L Samarappuli, N Yogaratnam, S M M Iqbal and P Karunadasa).

2. Evaluation of the performance of *Hevea* clones under soil moisture deficit situations

(i) Development of an index to evaluate clones to moisture stress

This experiment was planned to develop an index using important plant physiological characteristics viz transpiration rate, leaf diffusive resistance, leaf water potential and growth parameters, to screen clones for planting in marginal areas (L Samarappuli and R Hettiarachchi).

ii. Preliminary arrangements were made in collaboration with the Genetics and Plant Breeding Department to study the effect of soil moisture deficit on the performance of 10 *Hevea* clones in Bibile, Yatawatta, Bentota and Eladuwa Estates (L Samarappuli, N E M Jayasekera, P Karunadasa and U Mitrasena).

3. Assessment of land degradation in rubber plantations

Preliminary investigations were commenced in order to assess land degradation effects using the soil and foliar analytical data collected over the last 15 years (L Samarappuli, N Samarappuli, N Yogaratnam and H P Dhammika).

4. Ground cover management

Arrangements were made to start a field experiment 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. The nutrient composition of the *Mucuna* leaves and petioles is given in Table 9.

Table 9. *Nutrient composition of Mucuna leaves and petioles*

Nutrient	Leaf (%)	Petiole (%)
N	3.750	1.450
P	0.250	0.249
K	1.100	1.400
Mg	0.173	0.203
Ca	0.455	0.455

(L Samarappuli P Karunadasa and U Mitrasena)

5. Nutrient recycling as a measure of fertilizer economy

(i) Organic manure

The use of organic manures in immature *Hevea* plantations is being studied at Elston estate (OM/86/1), Paiyagala estate (OM/86/2) and Hewagama Estate (OM/88/1) (N Yogaratnam, and J de Mel).

ii. Bowl sludge as a potential fertilizer for *Hevea*

An experiment was started at Paiyagala estate to evaluate bowl sludge as a fertilizer for immature rubber. The mineral composition of bowl sludge is reported in Table 10.

Table 10. *Mineral composition of bowl sludge*

Nutrient	%
N	6.00
P	7.40
K	4.80
Mg	6.80
Ca	0.14
Moisture	60.00

(L Samarappuli and A M A Perera)

iii. Use of leguminous trees (SM/92/1 and SM/93/1)

These experiments were started to study the performance of leguminous trees as hedges and their effects on soil and moisture conservation and growth of *Hevea* plants.

It was observed that the recovery of leguminous trees after pruning was much better when the prunings per year was reduced to 3 compared with 6 prunings per year (L Samarappuli, U Mitrasena, P Karunadasa and E A T Senadeera).

IV. Nutrient dynamics and synchronization of nutrient supply and demand

The objectives of this study is to improve soil fertility and fertilizer use efficiency in traditionally and intensively managed rubber plantations through management of soil biological processes using mulches; quantification of nutrient cycles in a managed rubber plantation; and development of a better short-term predictive understanding of nutrient availability to form a basis for management recommendations. This study which was done under the Tropical Soil Biological and Fertility Programme will be reactivated (N Yogaratnam, L Samarappuli, S M M Iqbal and W C Dayaratne in collaboration with Prof N Gunatilleke of the Botany Dept., University of Peradeniya).

6. Soil moisture studies

The water retention relationship was characterized for **Boralu** series soils using samples obtained from three depths viz 0 – 10, 10–20 and 20–30 cms. Field capacity (FC) and Permanent Wilting Point (PWP) increased with depth and showed a positive relationship with clay content. When the pore size distribution was estimated using water retention results, all three depths showed a macro porosity around 40% (Table 11).

Even though the **Boralu** series soils are categorized as a shallow, poorer class of soil; according to this study, rubber cultivated in these areas would perform well.

Table 11. *Different soil parameters in relation to soil depth*

Depth	PWP (%)	FC (%)	Clay (%)	Micro porosity (%)	Macro porosity (%)
0–10 cm	9.42	13.26	5.1	13.26	41.44
10–20 cm	10.77	16.49	7.2	16.50	33.91
20–30 cm	11.60	16.88	12.4	16.88	32.28

(L Samarappuli and N Ratnayake).

7. SUL–PO–MAG based fertilizer mixtures

A formulation of SUL–PO–MAG based fertilizer mixture containing NPKMg in the proportion recommended by RRI was calculated. Cost analysis indicates that, this mixture is 30% expensive than the 12:14:14 + dolomite mixture and 14% cheaper than the 7:9:9:3 mixture with kieserite.

An experiment was planned to study the effectiveness of SUL–PO–MAG in immature rubber (L Samarappuli, N Yogaratnam, J G de Mel and H P Dhammika).

8. Phosphate Nutrition

A. Nursery Plants

Two experiments conducted at Ambetenna and Dartonfield were completed. Laboratory analyses were completed in both soil and plant samples. Statistical

analyses are in progress (A Dissanayake, T Dissanayake, R Gunasekera and Peter Perera).

B. Immature rubber

i. Effect of different sources and levels of P

This experiment was continued. Girth measurements made for the 6th year also showed that there is no significant difference between rock phosphate sources and this suggests the possibility of using EPPAWELA Rock Phosphate (ERP) as a source of P for immature rubber plants in some soils. It also appears that the rate of P currently recommended may not be sufficient to meet the plant's demand for P in some soils. Use of ERP at double the currently recommended level will be profitable than the use of Imported Rock Phosphate (IRP), which amounted to 3.8 – 3.9%. Savings at different stages of the immature period are given in Table 12.

Table 12. *Cost comparison of P fertilization*

Year	Cost (Rs)			% Saving	
	IRP L-1	IRP L-2	ERP L-2	ERP L-2 vs IRP L-1	ERP L-2 vs IRP L-2
1	656.25	1 312.50	631.60	3.86	51.89
2	687.50	1 325.00	660.96	3.87	51.90
3	1 000.00	2 000.00	961.40	3.90	51.90
4	1 000.00	2 000.00	961.40	3.90	51.90
5	1 375.00	2 750.00	1 321.00	3.90	51.90
6	1 375.00	2 750.00	1 321.00	3.90	51.90
Total savings during the immature period				23.33	311.39

ii. Ability of different clones to utilize ERP

Experimental plots have been demarcated at Devalakanda to allocate treatments. Pre-treatment soil samples were collected for physico-chemical analysis.

iii. Possibility of using both imported and locally available rock phosphates during the immature period.

Arrangements have been made to demarcate experimental plots at Vogan Estate where P fertilizer has been applied according to the normal RRISL recommendations. Treatments will be introduced in September 1994 (A Dissanayake, T Dissanayake R Gunasekera and Peter Perera).

C. Mature rubber

i. Residual effect of added rock phosphate

This experiment was continued for a further period of one year. Monthly assessments of yield were not done regularly due to interference by heavy rain. But, both soil and leaf samples were collected and uniform application of N,K and Mg fertilizers was made. Application of P fertilizers will be done in 1994.

ii. Evaluation of clonal differences in rock phosphate utilization

The experiments on clonal effects on P utilization were continued at Sorana, Perth and Clyde estates. Fertilizers were applied according to the experimental treatments and annual girth measurements were also made. Soil and foliar samples were taken to analysis.

Also, in addition to yield assessments soil and leaf samples were taken from selected plots to investigate the efficiency of different types of fertilizers (A Dissanayake, T Dissanayake, C Maheepala, R Gunaeskera, Peter Perera and C Jayalath).

C New approaches to increase availability of P from ERP

i. Composting technique

Arrangements were made to commence this experiment and samples of organic materials such as poultry litter, cowdung, rice straw and rubber factory effluent were collected for chemical analysis in the laboratory.

ii. Mixing with coir dust

Preliminary investigations made on the possibility of mixing ERP with coir dust and making "coir dust bricks" were successful. Arrangements were made for bud grafting of plants for the experiment and soil samples were also collected.

iii. Effect of management practices

A site at Culloden estate was selected to study the effect of different agronomic practices on dissolution of ERP. The experimental plots were demarcated to allocate treatments and application of rice straw will be done in April, 1994. Soil samples were collected for pre-treatment chemical analysis.

iv. Suitability of ERP to cover crops during immaturity.

Pueraria plants were raised in *Boralu* series soils to check the natural mycorrhizal inoculation in collaboration with the Plant Pathology Department. Soils were also collected from Eladuwa estate for laboratory pot experiment (A Dissanayake, Ranjan Jayaratne, T Dissanayake, C Maheepala, R Gunasekera, Peter Perera and C Jayalath).

E. Mineralogy of rubber growing soils

This study is being undertaken initially in *Boralu* series soils. An area covering an extent of 100 sq. miles in the Horana region was selected for soil sampling. Soil samples were taken from 3 depths (0-15, 15-30 and 30-45 cm) at 1 mile distance and samples were air dried, sieved and subjected for mineralogical analysis in collaboration with CISIR. Cone and Quaterning method was adapted in the preparatory work of soil samples and preliminary investigations were done through microspic observations (x 50). Quartz, Amphibol group (Hornblend), Garnet and laterite were identified.

Selected samples were further examined through x-ray diffractometry at the Department of Materials Engineering, University of Moratuwa. But, most of the peaks in the x-ray diffraction traces show that quartz is the predominant mineral in the soil. However, there are few peaks which could not be identified easily which indicates the presence of other minerals also in the *Boralu* series soils. Therefore, further studies will be carried out to identify these minerals (Fig. 1). Chemical analysis of soil samples are in progress in the laboratory of the Soils and Plant Nutrition Department (A Dissanayake, A M A Perera and T Dissanayake).

9. Evaluation of fertilizer mixtures for young budding

This study was started with the objective of evaluating the effectiveness of fertilizer mixtures currently used for immature rubber and polybag plants for young budding plants in comparison with the current recommendation for young budding.

Following treatments were allocated to single plant plots replicated 25 times in randomized complete block design.

T1	-	RP(50g) + SA/DAP/SOP/CES - Current recommendation
T2	-	RP(50g) + SA/TSP/MOP/kieserite
T3	-	RP(75g) + SA/MOP/Kieserite
T4	-	RP(50g) + 12:14:14:/kieserite
T5	-	RP(50g) + 7:9:9:3
T6	-	Doubled the treatment (2)
T7	-	Doubled the treatment (4)
T8	-	Doubled the treatment (5)
T9	-	SA/TSP/MOP/Kieserite
T10	-	Doubled the treatment (9)

Plant diameter recorded at 2 weeks intervals are given in the Table 13. It was found that the current fertilizer mixtures for poly bags *ie* 12:14:14 and 7:9:9:3 are equally effective in comparison to the current recommendation for young budding. The fertilizer should be applied at weekly intervals. Another experiment was planned to evaluate the frequency of fertilizer application (S Dharmakeerthi and S N Silva).

Table 13. *Effect of different fertilizer treatments on Plant diameter*

Treatment	Plant diameter (mm)		
	1 1/2 months	2 months	2 1/2 months
T1	5.28	5.92	6.23
T2	5.39	5.99	6.23
T3	5.29	5.91	6.29
T4	5.49	6.12	6.35
T5	5.19	5.98	6.26
T6	5.21	5.93	6.17
T7	5.07	5.84	5.95
T8	5.44	6.02	6.29
T9	4.84	5.31	5.65
T10	4.62	5.31	5.71

10. Fertilizer requirement of new clones: (F/92/1F) and (F/92/1P)

High yielding and vigorously growing clones may have different nutrient requirements. Two experiments (field and pot) were therefore started to study the fertilizer requirements of clones RRIC 121 (C1), RRIC 110 (C2), PB 260 (C3), 74 – 193 (C4) and RRIM 712 (C5). Following treatments were allocated to each plot and a pre-treatment soil analysis was done.

Treatments

Pot experiment

T1	–	No fertilizer
T2	–	1/2 the current recommendation
T3	–	Current recommendation
T4	–	1 1/2 times the current recommendation
T5	–	doubled the current recommendation

Field Experiment

T1	–	No fertilizer
T2	–	1/2 the current recommendation
T3	–	Current recommendation
T4	–	1 1/2 times the current recommendation

Girth measurements, leaf and soil nutrient content were recorded at different time intervals. Girth data are given in Table 14.

11. Economics of fertilizer use in mature rubber

Economics of fertilizer utilization by mature rubber is being investigated in an experiment at Clyde estate, Dorset Division. Following treatments were allocated to each plot in a randomized complete block design with five replicates.

T1	No fertilizer from the first year of panel C
T2	No fertilizer from the second year of panel C
T3	No fertilizer from the third year of panel C
T4	No fertilizer from the fourth year of panel C
T5	Fertilizing throughout the panel C.

Yield data obtained from the above experiment are given in Table 15.

Table 14. *Effect of different fertilizer treatments on girthing of 5 clones*

Clone	Treatment	Diameter (mm)				
		3 month	6 month		12 month	
		Pot	Field	Pot	Field	Pot
C1	1	7.38	11.84	9.33	21.1	18.3
	2	6.88	11.55	9.38	24.8	27.8
	3	6.38	10.79	9.13	25.5	27.8
	4	6.63	11.50	9.25	26.8	27.0
	5	7.50		9.88		28.0
C2	1	6.38	10.30	7.50	20.8	15.8
	2	7.80	10.80	9.25	25.7	22.3
	3	7.00	11.24	8.75	25.7	24.0
	4	5.88	10.79	8.00	27.5	25.3
	5	6.75		10.13		27.5
C3	1	5.50	9.29	6.88	20.1	15.3
	2	5.88	9.81	7.63	21.8	23.8
	3	5.88	9.71	6.75	24.6	23.5
	4	5.38	10.19	7.05	26.0	26.3
	5	5.50		7.13		24.3
C4	1	4.00	8.33	6.00	16.2	14.8
	2	4.13	9.81	6.75	21.2	23.5
	3	5.00	9.71	7.38	20.3	22.8
	4	4.88	10.19	6.88	24.6	23.5
	5	4.75		7.00		25.3
C5	1	5.93	9.72	7.38	16.4	15.3
	2	6.13	9.60	7.50	20.9	21.0
	3	5.43	10.08	7.25	21.6	21.1
	4	6.25	9.90	9.25	21.1	27.8
	5	6.13		8.38		24.8

(S Dharmakeerthi and S N Silva)

Table 15. *Effect of different fertilizer treatments on the yield of Hevea*

Treatment	Yield (g/t/t)
T5	24.0 A
T1	21.7 AB
T4	21.6 AB
T2	20.2 AB
T3	18.7 B

(L Samarappuli and S N Silva in collaboration with N Yogaratnam)

12. Soil and Foliar Survey

As agreed at the meeting of the Scientific Committee held in May, 1993, where representatives from the Plantation Management Companies involved in rubber were present, RRI conducted training classes on the technique of sample collection for the above survey. These classes were attended by Superintendents/Assistant Superintendents of all the Management Companies and clear instructions were given to them on sample collection. In addition to this a team of officers from RRI carried out a random check in the field with regard to this exercise. On the other hand, there were some companies who were willing to provide transport for sample collection and in such cases RRI has collected the samples as had been the practice in the past. A total extent of 19,000 ha was covered under this programme and computerized fertilizer programme was sent to all the estates. (All the staff of the Dept.)

13. Chemical Analysis

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

14. Adaptive Research Programme

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. Experimental details and results are discussed in the Review of the Adaptive Research Unit (L Samarappuli, F P W Silva, W C Dayaratne and A T Senadeera).

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 and F P W Silva).

A new set of experiments were 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).

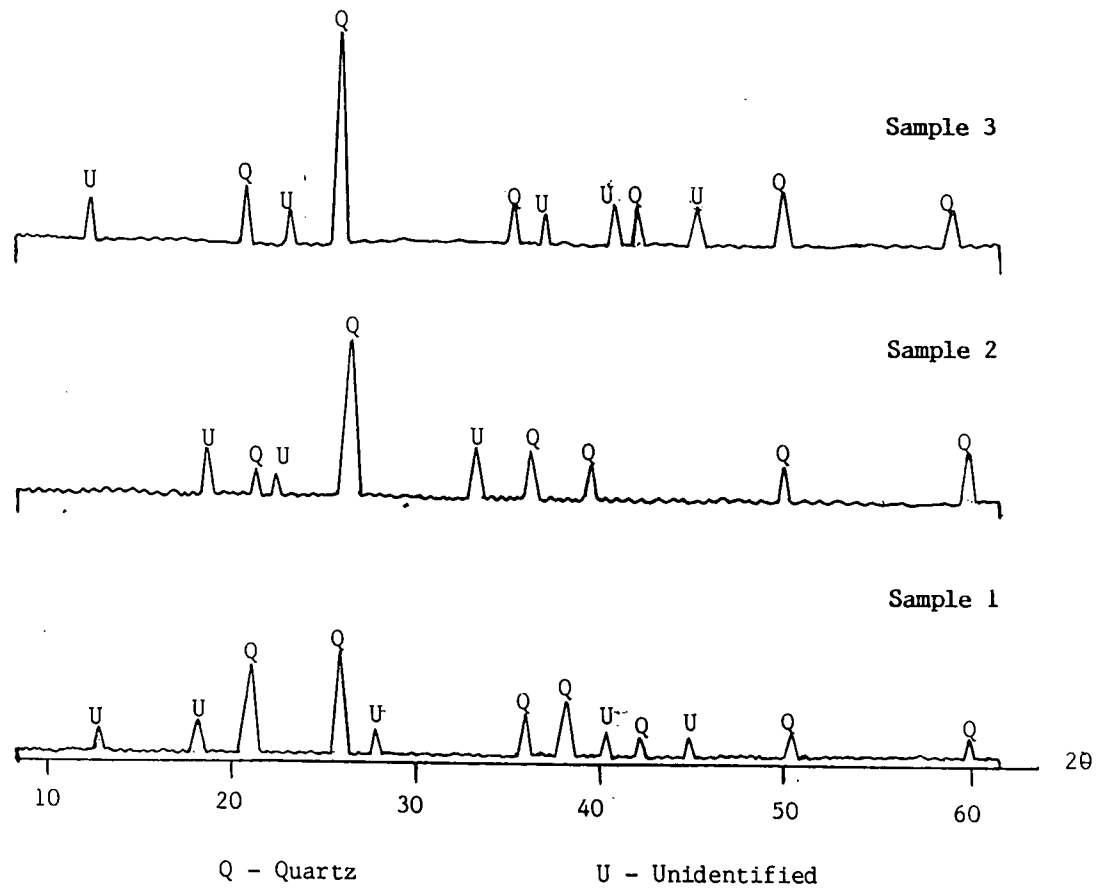


Fig 1. X - Ray diffraction traces of soil samples.

BIOCHEMISTRY AND PHYSIOLOGY

N Yogaratnam

SUMMARY

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

Staff

Mr M T Warnakula, Assistant Biochemist, continued his postgraduate studies in Australia. Mrs Neelamani Yapa, Assistant Biochemist, commenced her postgraduate studies at the PGIA, Peradeniya, in October. Mr M D C Seneviratne and Miss S Kudaligama, Technical Officers and Mr P D J Rodrigo, Specification Assistant, were on duty throughout the year. Mr D Ramawickrama, Laboratory Attendant, was promoted as Technical Officer with effect from 01.01.1993.

LABORATORY AND FIELD EXPERIMENTS

Effluent Utilization

Rubber factory effluent (serum) is known to be rich in several important nutrients. The amount of nutrients that can 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 - 31, metric tons/year. This study is therefore in progress at Culloden Estate, Neboda, to investigate the effectiveness of factory effluent as a source of nutrients to rubber and is being conducted in an area of about 6 acres on clone PB 86 in a 1986 replanting where the 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)

Latex yield per tree and dry rubber content (DRC) per 50 ml. of latex were recorded. Soil pH, N, P, K, Mg and Ca contents of soil and leaf samples were determined. Soil moisture measurements were also done (Neelamani Yapa, N Yogaratnam, M D C Seneviratne and P D J Rodrigo).

Tapping Panel Dryness (Brown Bast)

An experiment was started at Eladuwa estate to study the influence of soil/plant nutritional status of mature rubber on the incidence of brown bast. A completely randomized design was used. Forty (40) tress of clone RRIC 100 which were affected by brown bast were selected and 20 healthy trees from the same location were also selected for comparison.

TREATMENTS :	T ₁	-	Control (no. fertilizer application)
	T ₂	-	800g appropriate N, P, K mixture/plant/year + 150 kieserite.
	T ₃	-	1200g appropriate N, P, K mixture/plant/year + 150g kieserite.
	T ₄	-	1600g appropriate N, P, K mixture/plant/year + 150g kieserite
	T ₅	-	2400g appropriate N, P, K mixture/plant/year + 150g kieserite
	T ₆	-	1:1 diluted serum weekly/plant/2 gallons.

Following analyses were done:

- * Leaf analysis for N, P, K, Mg and Ca.
- * Dry rubber content in latex.
- * Latex, bark and leaf analysis for proline, proteins, sugar and sugar alcohols.
- * Density of active latex vessels in the bark.

Girth measurements were also taken (Neelamani Yapa, A Nugawela, M D C Seneviratne, S Kudaligama and D Ramawickrama).

Effluent Treatment

Research scale model of an effluent treatment plant installed at Dartonfield was used to study the effectiveness of biological processes in the treatment of rubber factory effluent. The rotating coir belt system was used in this process. Different rates of rotation and depth were considered in this study.

The following analytical tests on the biologically treated serum were done : COD, BOD, Total N, Sludge content, Volatile matters, K, Ca, P and Mg content.

Data on latex production and rainfall were collected from three estates in each district in order to devise suitable effluent treatment systems that could be adopted in these areas (M T Warnakula, M D C Seneviratne, S Kudaligama, P D J Rodrigo and D Ramawickrama).

Centrifuge Unit

The centrifuge unit functioned under the Biochemistry Department and provided centrifuged latex for the Chemical Analysis, Rubber Technology, Raw Rubber Development and Polymer Chemistry Departments.

RUBBER TECHNOLOGY AND DEVELOPMENT

N M V Kalyani Liyanage

SUMMARY

Work on latex/bitumen emulsions continued. A new and more realistic technique for characterisation of latex/bitumen blends was developed.

A latex compound suitable for making rubber moulds to be used in the preparation of thin plastic articles such as vehicle signs was developed.

Some latex formulations suitable for coating of fabric based gloves were developed.

A new latex foam formulation was developed to turn out creatures out of foam rubber to meet a request made by a small industrialist who is keen in producing a science fiction film.

A request made by Inter-Coir Ltd. to develop a substitute for PVC tufting on coir was successfully met.

Work on the preparation of oil extended natural rubber (OENR) using rubber seed oil (RSO) was continued. Mastication behaviour of the RSO based OENR was compared with that of OENR based with normal rubber processing oil using the Brabender Plasticorder.

The evaluation of the mastication behaviour of crepe rubber using the Brabender Plasticorder was completed.

Work on the effects of method of manufacture of RSS upon rheological and technological properties of vulcanisates has been continued. Some useful results have been gathered.

Several trials have been carried out to evaluate the performance of vein quartz powder and white carbon as fillers in tyre tread compounds and solid tyre formulations respectively.

Two short courses on "Rubber Products Manufacture" were conducted for the small industrialists of the Southern Province and Kegalle region.

DETAILED REVIEW

Staff

Dr (Mrs) N M V Kalyani Liyanage was on duty throughout the year. Mr B P Weeraratne, Assistant Rubber Chemist resumed duties of the Department on 15th November, 1993 after successfully completing his PhD degree at the University of Ulster, UK Assistant Rubber Chemists, Mrs Dilhara G Edirisinghe and Mrs Madhupani M Jayasuriya were on duty throughout the year.

Mr D D Medagama, Experimental Officer, was on duty throughout the year. Technical Officers, Mr K M U Mithrananda and Mrs Sriyani I Yapa were on duty throughout the year. Mrs Manel Mahanama, Senior Technical Officer was transferred to this Department from Soils and Plant Nutrition Department on 4th January, 1993. Mr D P Wettasinghe was on medical leave since 24th September, 1993.

Research Students

Mrs Deepa P Lekamge, a student from the University of Moratuwa, was trained under the National Apprenticeship Scheme.

Meetings, Seminars and Lectures

Dr (Mrs) N M V Kalyani Liyanage and Mrs Madhupani M Jayasuriya participated in progress control meetings of Road Development Authority to discuss the latex/bitumen emulsion project.

Dr (Mrs) N M V Kalyani Liyanage attended the meeting of Industrial Panel for manufactured rubber goods held at the Ministry of Rural Industrial Development and Tourism.

Dr (Mrs) N M V Kalyani Liyanage participated in committee meetings of RVNRL group held at the Atomic Energy Authority.

Dr (Mrs) N M V Kalyani Liyanage attended a committee meeting of Advisory Committee for manufactured rubber products held at the Export Development Board.

Dr (Mrs) N M V Kalyani Liyanage attended four scientific committee meetings of the Rubber Research Board.

Dr(Mrs) N M V Kalyani Liyanage attended the first Scientific Committee Meeting of the Rubber Technology Group.

Mrs Madhupani M Jayasuriya gave a lecture on the research projects carried out by her at the Rubber Technology and Development Department.

Dr (Mrs) N M V Kalyani Liyanage attended the seminar on "Grading and Packaging of Rubber" held at Plantation Association organized by the RRI.

Dr (Mrs) N M V Kalyani Liyanage and Mrs Madhupani M Jayasuriya attended a seminar on modified bitumen at Road Construction and Development Corporation.

Dr (Mrs) N M V Kalyani Liyanage delivered a speech on "Precured Retreading" at a Pre Launch Press Conference held at Hotel Ramada Renaissance organized by the Associated Motor Ways Ltd.

Mrs Dilhara G Edirisinghe conducted lectures for some trainees at Nivithigalakelle Training Centre.

Dr (Mrs) N M V Kalyani Liyanage, Mrs Dilhara G Edirisinghe and Mrs Madhupani M Jayasuriya served as lecturers for the course on "Rubber Products Manufacture" conducted for small industrialists of the Southern Province organized by the Rubber Technology and Development Department.

A similar course was organised for small industrialists of Kegalle region under the supervision of Mrs Madhupani M Jayasuriya.

Dr (Mrs) N M V Kalyani Liyanage, Mrs Dilhara G Edirisinghe and Mrs Madhupani M Jayasuriya served as lecturers for students of the Affiliated University.

Mrs Dilhara G Edirisinghe delivered a lecture for the Diploma course in Plantation Management held at the National Institute of Plantation Management, Athurugiriya.

Mrs Dilhara G Edirisinghe and Mrs Madhupani M Jayasuriya delivered speeches on the "Use of Brabender Plasticorder" and "Use of FTIR in Chemical Analysis" respectively at the seminar held at Sausiripaya organized by the Rubber Research Institute.

Dr (Mrs) N M V Kalyani Liyanage served as a lecturer for the Diploma course in Rubber Technology organized by the Plastics and Rubber Institute, and the MSc course in Polymer Science and Technology conducted by the University of Sri Jayawardenepura.

Dr (Mrs) N M V Kalyani Liyanage served as a moderator for the Science Examination conducted by the Sir John Kotalawela Defence Academy.

Dr (Mrs) N M V Kalyani Liyanage delivered a speech on "Precured Retreading" at the inauguration ceremony of "Precured Tyre Plant" at Midland Retreads (Pvt.) Ltd.

Publications

Liyanage, N M V K and Jayasuriya, M M (1993). "Latex Modified Bitumen Emulsions" proceedings of a seminar on "Modified Bitumen for Improved Performance in Road Works" organized by the Road Construction and Development Corporation (Pvt.) Ltd. in August 1993.

Liyanage, N M V K, Jayasuriya, M M, Mahanama M, Wettasinghe, D P and Yapa, S I (1993). "Performance of Latex Bitumen Emulsions on Road Surfaces" Proceedings of the 49th Annual Sessions of the SLAAS, December 1993.

Liyanage, N M V K, Edirisinghe, D G, Wettasinghe, D P and Mithrananda, K M U (1993). "Influence of Method of Manufacture of RSS upon Rheological and Technological Characteristics of Vulcanizates" a paper submitted for presentation in dkt'94 German Rubber Conference.

Weeraratne, B P, Hepburn, C (1993). "Behaviour of Encapsulated Urea Rubber Matrices in Soil". *Plastics, Rubber and Composite Processing and Applications* (In press).

Hepburn, C, Weeraratne, B P (1993). "Controlled Release Technology and Polymer" (Editorial). *Plastics, Rubber and Composite Processing and Applications* (In press).

Weeraratne, B P (1993). "Encapsulated Urea Rubber Composites as Slow Release Fertilizers", DPhil Thesis, University of Ulster UK.

Reports

Kalyani, N M V (1992). Annual Review of the Rubber Technology and Development Department.

LABORATORY INVESTIGATIONS

Latex Technology

1. Latex bitumen emulsions in road construction

Plant trials on the *in situ* preparation of latex bitumen emulsions were carried out by using cationic rapid setting (CRS) and cationic slow setting (CSS) emulsions. It was evident that the stability of latex bitumen emulsions prepared by using CRS was much lower than that of CSS. A small scale plant trial carried out by using CSS was successful and the resultant latex was used for a slurry sealing of a stretch of Dehiwela-Maharagama road.

A few lab scale experiments were done to prepare a latex with correct density in order to improve the stability of latex/bitumen blends. Some of these experiments produced reasonably good results.

Some studies were carried out to explore the possibilities of drying latex/bitumen blends using a rotary evaporator under reduced pressure, since it was felt that the residue collected from this procedure would be more suitable for characterising latex/bitumen blends. This modified procedure was found to be more suitable for characterisation of latex/bitumen blends (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Manel Mahanama, D P Wettasinghe and Sriyani I Yapa).

2. Development of a suitable latex compound to prepare a rubber mould used in making thin plastic articles.

A small scale plastics products manufacturer requested for a latex compound to prepare rubber moulds suitable for making thin plastic articles such as vehicle signs. A latex compound which seems to be ideal for this purpose was developed (N M V Kalyani Liyanage, Madhupani M Jayasuriya, Sriyani I Yapa and Manel Mahanama).

3. Latex coatings for fabric gloves

Some work on the development of a suitable latex compound for coating of fabric based gloves has been done. Some of the formulations tested were found to give films of satisfactory thickness and adhesion properties (N M V Kalyani Liyanage, Madhupani M Jayasuriya and Sriyani I Yapa).

4. Development of a latex based substitute for PVC tufting on coir.

A few Natural Rubber(NR) latex based formulations were tested to develop a latex based substitute for PVC tufting on coir, to meet a request made by Inter-Coir Ltd. The Company was very impressed with our development (N M V Kalyani Liyanage, Manel Mahanama and Madhupani M Jayasuriya).

5. Foam Rubber

A suitable formulation was developed to turn out creatures out of foam rubber to meet a request made by a small industrialist who is interested in producing a Science Fiction film. The creatures produced from foam rubber were found to be better than those produced from casting techniques since the flexible parts of a creature can be turned out successfully without much of a difference in the flexibility. Only a small volume of compounded latex is required to turn out a large creature and therefore the cost of production of a creature happens to be very low. The industrialist is willing to acquire the technology which he believes is suitable for his work (N M V Kalyani Liyanage, Dilhara G Edirisinghe and Sriyani I Yapa).

Dry Rubber Technology

1. Oil extended natural rubber in tyre retreading

New laboratory trials were carried out on this project to see whether the new method which was developed to incorporate rubber seed oil (RSO) into rubber at the latex stage could be used successfully in the preparation of oil extended rubber (OENR) with a high level of RSO (eg: 25 pphr). These trials were successful and the mastication behaviour of laboratory scale samples prepared by varying the amount of RSO was compared with the samples prepared with normal rubber processing oil (PO). It was observed that the Mooney viscosity of the RSO samples decreases with the increase of the percentage of RSO incorporated into latex and the energy required

for mastication also shows the same trend. Hence it can be concluded that RSO acts as a processing aid. Although Mooney viscosity of the sample prepared with PO was higher than that of the corresponding sample prepared with RSO it cannot be confirmed since there was a difficulty in incorporating PO into latex using this new method. Further work is being done in large scale to prepare OENR with RSO which could be used in tyre retreading and to study the breakdown behaviour in detail for the confirmation of the results obtained (N M V Kalyani Liyanage, Dilhara G Edirisinghe, D P Wettasinghe, K M U Mithrananda and D D Medagama).

2. Mastication behaviour of crepe rubber

Work on this project has been completed. And a paper titled "Assessment of processability of crepe rubber and its management" is being prepared for publication. The studies on the rate of breakdown of the molecular weight of crepe rubber were carried out using the Brabender Plasti-corder. Crepe rubber samples used in this study were obtained from selected commercial sources and there was no distinct difference in the breakdown behaviour between these forms of crepe rubber. The results also show the same expected trend for crepe rubber as for RSS and TSR grades studied by E.L. Ong and C.L. Lim of RRIM in the dependence of mastication efficiency and mastication energy with temperature.

Mastication behaviour of skim rubber samples was also studied and it was noted that the expected trend was not observed in the range of 100–130 C unlike in the case of RSS, TSR and crepe rubbers (S W Karunaratne, N M V Kalyani Liyanage, Dilhara G Edirisinghe, D P Wettasinghe and Manel Mahanama).

3. Effects of method of manufacture of RSS upon rheological and technological properties of vulcanizates.

A third batch of RSS sheets was prepared by varying the dilution ratio under careful conditions since there was no consistency in the results obtained with the first two batches. In addition to the physical properties of an ACS compound and a tyre tread compound made out of the RSS sheets prepared, the rheological properties and the mastication behaviour of raw RSS sheets were also studied. Monsanto rheographs and Brabender plastographs showed that cure characteristics, specially the scorch time of the ACS and tread compounds increase with dilution. There is also a trend in the variation of physical properties such as hardness, compression set and resilience. Although the ACS compound showed a significant difference in tensile properties with dilution there was no such difference in the tensile properties of the tread compound. But there was a slight increase in the percentage retention of the tensile strength of

the tread compound with dilution, after ageing at 100° C for 72 hours. Abrasion volume loss was a minimum in the tread compound prepared according to the dilution ratio 1:1. It was also noticed that the mastication energy of raw RSS sheets decreases with dilution. Although there was no significant difference in the Mooney viscosity values, dilution has a strange effect on the efficiency of mastication and in turn on the breakdown index. The abstract of the paper titled "Influence of method of manufacture of RSS upon rheological and technological characteristics of vulcanizates" based on the results of this work has been sent to Germany for the dkt'94 – German Rubber Conference for presentation (N M V Kalyani Liyanage, Dilhara G Edirisinghe, D P Wettasinghe, K M U Mithrananda and D D Medagama).

4. Vein quartz powder as a filler in the rubber industry

Several trials were carried out to evaluate the performance of vein quartz powder as a filler in tyre tread compounds. It has been observed that there was no significant improvement in physical properties. Further experiments are in progress (N M V Kalyani Liyanage, Anoma Gunawardene, Madhupani M Jayasuriya and D P Wettasinghe).

5. Use of white carbon as a filler in the rubber industry

A study was started to evaluate the use of white carbon as a filler in solid tyre formulations. Several trials have been carried out and the results have not shown any significant improvement in physical properties such as hardness, tensile strength and abrasion resistance.

However, the ageing resistance of the vulcanizates based on silica/carbon black filler mixture was found to be improved (N M V Kalyani Liyanage, Madhupani M Jayasuriya, K M U Mithrananda, D P Wettasinghe and Manel Mahanama).

Industrial Extension

The following industrialists have requested the services of the Rubber Technology and Development Department in product development and testing:

- | | |
|----------------------------------|--|
| Ratnayake Rubber Industries Ltd. | – Testing of tread compounds, solvents and cushion gum compounds |
| RRIATSCO (Pvt.) Ltd. | – Development and testing of tread and cushion gum compounds for pre-cured retreading. Advice on improvements in compound processing and curing and tyre building and curing conditions. Chemical analysis of given samples. |

Central Industries Ltd.	- Testing fusion behaviour and heat and shear stability of PVC compounds.
Associated Motorways Ltd.	- Testing of tread and cushion gum compounds.
Kandy Tyre House	- Testing and development of tread and cushion gum formulations.
Midland Retreads (Pvt.) Ltd.	- Development and testing of retread compounds and cushion gum compounds for pre-cured retreads.
Road Development Authority	- Testing of latex bitumen emulsions.
Export Development Board	- Development of a latex based substitute for PVC tufting on coir.
Inter-coir (Pvt.) Ltd.	- Analysis of PVC sheetings and PVC coated fabrics.
Lanka Vinyl (Pvt.) Ltd.	- Analysis of PVC sheetings and PVC coated fabrics.
Central Rubber (Pvt.) Ltd.	- Testing of examination gloves.
C.W. Mackie & Co. Ltd.	- Testing of DPNR and RSS samples
Neptune Tyre Retreaders (Pvt.) Ltd.	- Development of tread and cushion gum formulations
Lankaputhra Rubber Industries	- Development of cushion gum compounds.
Various small individual industrialists	- Advice on casting, dipped products, rubberised coir, etc.

POLYMER CHEMISTRY

K G Karnika de Silva and B P Weeraratne

SUMMARY

As the production process of depolymerized rubber is well established, much more emphasis is given to explore the avenues for the application of depolymerized rubber. Depolymerized rubber can be blended with NR in the presence of a blowing agent to produce a material with low density which is suitable for floating components in fishing nets. In addition the use of depolymerized rubber in the field of adhesive industry has been tested with the assistance of Sinwa Holdings (Pvt.) Ltd.

The process developed by us for the production of TPNR is economically viable, since it involves recycled polypropylene. Three parties are now interested in the use of Thermoplastic Natural Rubber (TPNR) and an agreement has been signed with them for this purpose. These manufacturers are now using this newly recommended process to manufacture coagulating pans and holders under the assistance of the RRI. About 7 000 coagulating pans out of TPNR have been distributed at a cost of Rs.55/-per pan among the smallholders during this year. Many smallholders are encouraged by this project due to economical reasons. The orders for these items can be placed either directly with the RRI or through the Regional Extension Officers of the ASD.

Research on production and applications of cyclised rubber (CR) was continued since cyclised rubber can be used as a potential binder for heat resistant paints etc. Also several trials were successfully conducted at Lankem Paints factory to investigate the suitability of cyclised rubber as a road marking paint. The solubility of cyclised rubber can be improved by use of low nitrogen latex and/or depolymerized latex as the starting material.

Large scale trials conducted to study the reproducibility and the efficiency of the preparation of Epoxidized Natural Rubber (ENR) in the latex form have revealed that the production of per acid using an *in situ* reaction provides high degree of epoxidation.

The discolouration of positex during storage has been solved by modifying the initial positex production process. Studies on the applications of positex show that the

material can be successfully blended with bitumen and this mixture finds potential applications in water proofing, for example, Positex/bitumen mixtures can be successfully used as a coating for trimmed tea bushes. In addition incorporation of positex into clay has improved the physical properties of the bricks, positex/cement mixtures show improved water permeability and other physical properties.

Effect of the maturation on the gel content of latex and the effect of processing method on gel formation in rubber have been studied since these properties are important for the modification of NR. Studies reveal that the bleaching has a prominent effect than the fractionation. Also the removal of proteins from latex reduces the formation of gel up to a significant level.

A project was initiated on blends of NR/NBR to improve the oil resistant properties of the blends. Oil resistant properties in various oils can be improved when natural rubber is replaced with Superior Processing (SP) rubber. Grafted NBR and NBR/SP blends show improved heat resistant properties than NR/NBR blends.

A project on rubberized coir pads was initiated on a request made by WIN/Sujatha Foundation to introduce employment opportunities to rural women. In addition fertilizer has been successfully incorporated into rubberized coir to achieve slow releasing action.

DETAILED REVIEW

Staff

Dr K G Karnika de Silva, Head Polymer Chemistry Department left for UK in October 1993 for a period of five months to participate in a UNIDO sponsored project on 'Polymer Blends'.

Dr Pushpa Goonetilleke, Rubber Chemist went on maternity leave with effect from November 1993.

Mr S M C E Silva, Asst Rubber Chemist returned to Sri Lanka on 24th December 1993 after completing the first part of his postgraduate studies leading to a MPhil, at the University of North London.

Mr H N K K Chandralal, Experimental Officer was on duty through out the year.

Mrs Indra Denawake, Experimental Officer was on maternity leave from 17th May to 20th September 1993.

Mrs Chithra Kuruppu and Mr S S Warnapura, Senior Technical Officers were on duty throughout the year.

Messers S L G Ranjith and L P Vitharana Technical Officers were on duty throughout the year.

Miss Medhavi Wijesekera assumed duties on 1st January 1993 as a Technical Officer.

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

Messers S Weerasiri, P G Sigera, Laboratory Attendants and Mr L Piyasena, W D S Dharmawardene and J Dayaratne were on duty throughout the year.

Research Students

Mr S Kularatne, BSc student, University of Colombo, worked on the project titled 'Study of Variation of Gel content in dry rubber'.

Miss Krishanthi Muthukrishna, MSc student from the University of Sri Jayawardenepura, completed her project on 'Some Aspects of NBR/NR Blends'.

Overseas Visits

Dr K G Karnika de Silva visited Malaysia to attend IRTC'93.

Publications and Reports

de Silva, K G Karnika, Ranjith, S L G, Abeysekera, W P M, Warnapura, S S. Some Aspects of Rheological characteristics of NR and PP Blends. To be published in proceedings of IRTC'93.

de Silva, K G Karnika. (1992) Annual Review of the Polymer Chemistry Department.

de Silva, K G Karnika. Report on the participation at IRTC'93 held in Malaysia and on Industrial visits by K G Karnika de Silva.

de Silva, K G Karnika. Behaviour of Depolymerised NR in raw rubber blends and vulcanizates. Proceedings of IRRDB symposium on New Materials from NR held in September' 93 in UK.

de Silva, K G Karnika, Ranjith, S L G, Warnapura, S S. Chemicals Incorporated Granular Natural Rubber and Polypropylene Blends. Paper submitted to Journal of RRISL for publication.

de Silva, K G Karnika, Hamilelec, A E. Graft Copolymerization of Natural Rubber with Unsaturated monomers. Paper submitted to Journal of RRISL for publication)

Goonetilleke, Pushpa, Silva, S M C E, Vitharana, L P, Denawake, I. Preparation and characterisation of soluble cyclised rubber from NR latex. To be published in proceedings of IRTC'93.

Goonetilleke, Pushpa, Silva, S M C E, Vitharana, L P, Denawake, Indra (1992) Chemical Modification of Natural Rubber. *Jl. Rubb. Res. Inst. Sri Lanka* Vol.72, 1992 (in press)

Lectures/Seminars/Exhibitions/Visits

Dr K G Karnika de Silva attended a seminar on Human Resources Development Organized by the Institute of Chemistry.

Dr K G Karnika de Silva attended a seminar on ISO 9000 held at the ARTI.

Dr K G Karnika de Silva participated as a member of the diagnostics team at the workshop on rubber processing held at Meewanapalana.

Dr K G Karnika de Silva attended three Central Scientific Committee Meetings.

Dr K G Karnika de Silva attended a seminar on Grading Packaging of rubber at the Planters' Association.

The members of the Department assisted the students of Ananda College in organizing the Science exhibition.

Dr K G Karnika de Silva attended IRTC'93 held in Malaysia and presented a paper on TPNR. Also she participated at a latex protein workshop held at Shangrila Hotel, Malaysia.

Dr K G Karnika de Silva delivered a lecture on 'Some thoughts about research and development activities in the rubber products industry' at a seminar organized by the RRI.

Dr K G Karnika de Silva and Dr Pushpa Goonetilleke served as lecturers for National Diploma in Plantation Management Course, organized by NIPM.

Dr K G Karnika de Silva attended four committee meetings of the Adaptive Research Unit.

Dr K G Karnika de Silva participated at meetings held at the Richard Peries & Company Ltd., Ishan Enterprises and Consolidated Plastics Company Ltd., on TPNR.

Dr K G Karnika de Silva, H N K K Chandralal, S S Warnapura attended a seminar organized by the PRI on 'New developments in plastics' and a discussion of latex with Mr Peter Mitchel held at Hotel Taj Samudra.

Dr K G Karnika de Silva visited Elston estate and had discussions on Preservative systems of latex.

Department staff assisted scientific exhibitions held at Museus College and St Peter's College Colombo.

Department staff assisted scientific exhibition held at NARESA, Colombo from 1st December – 5th December 1993.

FIELD AND LABORATORY INVESTIGATIONS

1. Depolymerized Natural rubber

Various materials have been tested for their suitability as packaging material for depolymerized rubber for export market. Silica coated paper has been found to be the best but since the cost of this paper is high, oil paper has been used as an alternative material for packaging of depolymerized rubber. A large scale trial has been conducted on a request made by Associated Speciality Rubbers to draw the final specifications of this rubber.

Experimental trials on applications of depolymerized rubber have been commenced in laboratory scale. Certain blowing agents were incorporated into the blends of depolymerized rubber and natural rubber to get soft materials with low density, suitable as floats for fishing nets on a request made by Fifa Enterprises. An adhesive based on depolymerized rubber has been tested to bond rubber to wood, on requests made by C W Mackie and Sinwa Holdings (Pvt.) Ltd.

The incorporation of depolymerized NR in raw rubber has shown to give improvements in flow properties with low energy consumption in processing. Also the vulcanized rubber shows improvements in modules, abrasion resistance and hardness values.

A paper titled 'Behaviour of depolymerized Natural Rubber in raw rubber and vulcanizates has been presented at the IRRDB symposium held in September' 93 (K G Karnika de Silva, L P Vitharana, Dilhara Edirisinghe).

2. Thermoplastic Natural Rubber

It was interesting to note that certain chemicals used in TPNR processing can be incorporated as dispersions in the latex phase for better dispersions, uniform quality and for convenience of TPNR product manufacture.

Rheological studies were conducted on these blends at the University of Moratuwa. A blowing agent used in plastics manufacture has been incorporated to 60:40 PP-rubber blend to get a material suitable for bicycle handles, on a request made by a consumer.

A convenient and economical method to produce TPNR coagulating pans has been carried out. Trials have shown promising results.

Coagulating pans and latex collecting cups, out of TPNR, have been manufactured and distributed among the smallholders on request.

Several discussions were held with various plastic manufacturers and tender procedures have been followed to call for quotations to supply TPNR pans regularly. An agreement has been signed with an interested party for this purpose. These manufacturers would use the newly recommended economical process to manufacture the coagulating pans and hence the pans could be offered to the smallholders at a reduced price in the future. A paper titled 'Chemicals incorporated Granular natural rubber with polypropene has been submitted for publication in the Journal of RRISL (K G K de Silva, H N K K Chandralal, S L G Ranjith).

3. Cyclised Rubber

3 a. New techniques for the production of cyclised rubber

Work on this project has been continued to rectify the problems encountered with the cyclisation reaction and the solubility of the product. It has been found that the following factors can markedly affect the efficiency of cyclisation:

- (i) Molecular weight of natural rubber
- (ii) Nitrogen content of natural rubber
- (iii) Maturation period of low nitrogen latex.

The trials conducted during this year are mainly based on low nitrogen latex and more emphasis were given to lower the molecular weight of rubber by following methods.

- a. Depolymerized latex was used for the cyclisation to see whether there is a limit to lower the molecular weight by singlet oxygen method.

- b. A peptizer, namely Renacit-7 has been incorporated to the latex before cyclisation in order to lower the molecular weight.

A paper titled 'Preparation and characterisation of soluble cyclised rubber' has been submitted for the IRTC'93 conference (Pushpa Goonetilleke, S M C E Silva, L P Vitharana and Indra Denawake).

3.b Cyclised rubber for road marking paints and Heat resistant paints

The experiments designed to study the applications of cyclised rubber show that the cyclised rubber can be used as a good binder for heat resistant paints. In addition the suitability of cyclised rubber for the preparation of road marking paints was investigated with the assistance of a leading paint manufacturer in Sri Lanka. Furthermore a specially designed stirrer was fabricated in order to disperse paint ingredients during the mixing processes.

4. Epoxidation of Natural Rubber

Experimental work on this project are two fold.

a. Epoxidation using different NR lattices with two epoxidising agents.

Suitable reaction conditions for the successful epoxidation of NR latex have been conducted to study the reproducibility and the efficiency of the reaction. Initially performic acid was used as the peracid to carryout the reaction at room temperature. However it is found that the production of peracid using an *in situ* reaction provides a high degree of epoxidation. In addition lattices with different DRC contents were used to study the efficiency of epoxidation; FTIR results show that the latex with 40% DRC content can be epoxidized up to 50% or more.

b. Concentration of ENR latex

Concentration of epoxidized NR latex is a problem as it is not centrifuged due to the specific gravity difference between rubber particles and serum. Moreover the concentration of ENR by evaporation or creaming methods are reported to be less favourable. Details of ultra filtration methods for concentration of ENR latex was requested from RRIM to see whether it is economical for Sri Lanka (Pushpa Goonetilleke, Chitra Kuruppu and L P Vitharana).

5. Positex

(a) The discolouration of positex during storage has been solved by modifying the initial positex production process. This modification provides a positex with better stability and storage characteristics (Pushpa Goonetilleke, Chitra Kuruppu).

(b) Positex/Bitumen for water proofing

Positex was mixed in various proportions with cationic bitumen emulsion to obtain the most effective mixture for water proofing. These samples were applied as a coating on cut branches of a bush to protect the trimmed branches from water and fungal attacks. Preliminary trials carried out with the assistance of TRI have shown that the positex/bitumen mixtures can be successfully used to protect the trimmed tea bushes. However a fungicide has to be incorporated in order to optimize the efficiency of these mixtures. 10 kgs of Positex/bitumen mixture was supplied to TRI for further testing (Pushpa Goonetilleke, Chithra Kuruppu and S L G Ranjith).

(c) Positex/Cement mixes

A collaborative project was initiated with the Department of Civil Engineering, University of Moratuwa to study the physical properties of positex/cement mixes. The incorporation of rubber to cement improved several physical properties, such as crushability, water permeability, strength *etc* Furthermore positex has been incorporated successfully into clay to improve the physical properties of bricks. Samples were supplied to the Department of Civil Engineering, University of Moratuwa for further testing (Pushpa Goonetilleke, S L G Ranjith, Asoka Perera, University of Moratuwa).

6. Study of variation of gel content in NR latex and in dry rubber

- a). The effect of maturation on the gel content of latex was further studied since the reduction of gel content is an important aspect in the modification of NR-latex. The variations of gel content with maturation of latex were monitored for several months. The removal of proteins was found to reduce the formation of gel up to significant levels.
- b). A study was commenced to determine the effect of processing methods on gel formation in rubber. Following sample were used to determine the gel content of each sample over a period of one month by using toluene as the solvent.
 - i) Unbleached unfractionated rubber
 - ii) Unbleached fractionated rubber
 - iii) Unfractionated bleached rubber
 - iv) Bleached and fractionated rubber

Bleaching is reported to have a more prominent effect than the fractionation. Both unbleached rubber samples show similar trend in the variation gel content with maturation of the rubber. Further studies are in progress to confirm these conditions (Pushpa Goonetilleke, H N K K Chandralal, S Kularatne, University of Colombo).

7. Adhesive for water proofing applications

An adhesive based on NR and tar has been developed as a substitute for currently used imported adhesive. This particular adhesive primer is used to paste sheets of Multiplast (supplied by Lankem Developments Ltd.) on concrete roofs for water proofing. The properties of the new product were compared with the imported adhesive. The results of these experiments reveal that the peel strength of the new adhesive is comparable to or better than that of the imported product (Pushpa Goonetilleke, H N K K Chandralal).

8. Elastomer Composites

Project on blends of NR/NBR was continued. Several formulations based on NR/NBR have been tested for improvements in oil resistant properties of the blends. Die swell values, crosslink density and oil resistant properties in various oils seem to improve notably when natural rubber was replaced with superior processing (SP) rubber. A significant improvement in these properties was noted when NR was replaced with grafted natural rubber. Heat resistant properties are also evaluated and, it was observed that NBR alone and NR/NBR show poorer heat resistant properties than NBR/grafted and NBR/SP blends.

Slight blooming effect was observed in some NBR blends with high percentage of NBR. The analysis shows that MBTS/MBT tend to bloom faster in NBR. A project on 'Some Aspects of NR/NBR blends' was completed and a thesis was submitted as a partial fulfillment of requirement of MSc degree by the University of Sri Jayawardenepura (K G Karnika de Silva, S S Warnapura, Medhavi Wijesekera, K Muthukrishna, University of Sri Jayawardenepura).

9. MG Rubber

An adhesive based on MG rubber has been developed on a request made by C W Mackie & Co. Ltd., MG 49 and neoprene rubber seems to give comparable results when tested as a suitable adhesive for rubber/wood bond.

10. Modified lattices (for screen printing, shoe cleaning fluid/rubber based emulsion paints and textile coating)

Applications on modified lattices was continued to improve the quality according to customer requirements. Several formulations have been tried out and samples have been handed over to interested parties (K G Karnika de Silva, Indra Denawake).

11. Dipped Products

Some evaluations were carried out on the formulations used by the Central Rubbers (Pvt.) Ltd., at Biyagama in the manufacture of examination gloves. It was realized that the amounts of chemicals used in their formulations were high and prevulcanization of the compounded latex occur faster than expected. This has caused problems in the manufacturing plant and steps have been taken to overcome this problem after carrying out several trials at RRISL.

Further trials to improve the stability of compounded latex is in progress. The steps taken by the Malaysians to improve the quality of examination gloves to remove extractable proteins and the quality controlling procedures have been passed on to the industrialists (K G K de Silva, Anoma Gunawardena, Chithra Kuruppu).

12. Rubberized coir pads/coir fertilizer Blocks

i Rubberized coir pads

Several trials were conducted to obtain a bonding medium to give a clear transparent effect to a finished product with coir fibre. This project was conducted on a request made by WIN/Sujatha Foundation to introduce employment opportunities to rural women. The product is said to have good export potential and a workshop will be organized to educate the people concerned (K G Karnika de Silva, Anoma Gunawardena, Medhavi Wijesekera).

ii Coir fertilizer polls

Trials have been successful in adding fertilizer into the Rubberized coir for slow releasing action. The thickness of the outer coating with rubber latex could be varied to effect the efficiency of the liberation of fertilizer to the soil.

A joint project with Soil and Plant Nutrition Department was commenced to see the possibilities of introducing these fertilizer encapsulated blocks into rubber

nurseries to get the slow releasing effect. This will reduce the labour costs *etc.* on adding fertilizer at various stages during the year (K G K de Silva, Lalani Samarappuli and Medhavi Wijesekera).

Industrial extension

The following industries requested the services of the Polymer Chemistry Department for development and testing:

Mason Mixtures Ltd.	Primer based on cyclised rubber
Ceylon Sports Footwear)	
Dipped Products)	
Palma Ltd.)	Elastomer Analysis
CIC)	
Polymer Products)	
Associated Speciality Rubbers	Gel content
Central Rubbers (Pvt.) Ltd.	Examination Gloves
C W Mackies	Development of hard rubbers for shoe soles Developments of adhesive based on MG rubber
Multi Packs	NR/NBR blends
Bata Shoe Co.	Bloom analysis
Jafferjee & Sons (Pvt.) Ltd.	Speciality rubbers
Sinwa Holdings	Adhesive/Elastomer Analysis
Siyath Foundation	Rubberized coir pads
Richard Peries)	
Consolidated Plastics)	TPNR pans and cups
Industrial Composites)	
Ishan Enterprises	Elastomer analysis of plastics and rubber products
D & W Enterprises	DPNR pads for water seals
Visakha Automotive Products	Water seals Doctor Blade
Kojakee Latex Products	Baby teats
Pusellawa Plantations	Preservative systems

RAW RUBBER AND CHEMICAL ANALYSIS

L M K Tillekeratne

SUMMARY

The Raw Rubber and Chemical Analysis 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 of rubber chemicals and water used in the industry.
- (c) Analysis and certification of concentrated latex manufactured in the country for local industries and for exports.
- (d) Testing of finish products such as SPP content in rubber gloves, free sulphur content in rubber products and tensile properties of rubber gloves.
- (e) Analysis and certification of masterbatch and Reclaimed Rubber for exports.
- (f) Research work was carried out in following fields.
 - * Use of Paddy husk Ash, as a filler for Tyre Tread.
 - * Effect of measuring conditions on the values of Po and PRI.
 - * Effect of sea water on different types of rubber.
 - * Water soluble proteins in rubber gloves.
- (g) Assistance was given to other Departments in their research and extension work by analysing dry rubber, latex, chemicals and water samples.

DETAILED REVIEW

Staff

Dr L M K Tillekeratne, Director who is overlooking the Department was on duty throughout the year.

Mr L Karunanayake, Assistant Specifications Officer, returned to the country on 24th December 1993 after completing first part of his research project at University of North London UK. He will continue the 2nd part of his MPhil degree programme at the RRI.

Miss Anoma Gunawardena, Assistant Rubber Chemist, proceeded to Japan on 20.07.1993, for a period of six months to undergo a training programme on "Radiation Pre-vulcanisation of Natural Rubber" under a project funded by the Science and Technology Agency of Japan (STA).

Mr A S Dekumpitiya, Experimental Officer, retired from service on 9th March 1993. Mrs Sriyanthi Weeraman, Experimental Officer, was on duty throughout the year. Technical Officer, Mrs L Wanigatunga, was promoted to Senior Technical Officer grade with effect from 10th May 1993.

Technical Officers Mrs Nanda Baduge, Mrs Vasantha Gamage, Mr R S Wijesundra and Mrs Champa Lokuge, were on duty throughout the year. Instrument Technician, Mr P Lelwela, was on duty throughout the year.

Specifications Assistants, Messrs G Wanigatunga and P L Perera were promoted to the Technical Officer grade with effect from 1st January 1993.

Miss Geethani Rajapakse, assumed duties as a Technical Officer with effect from 1st January, 1993.

Specifications Assistants, Messrs B Gunasiri, W W Nandasena, K R N Karunatileke, were on duty throughout the year.

Clerk Typist, Mrs Indrani Wijesinghe was on duty throughout the year.

Laboratory Attendants, Messrs Wimaladasa Vithanage, Sirisena Gallege and Laboratory Labourers Messrs G H Somasiri were on duty throughout the year.

Visits

Miss Anoma Gunawardena, Assistant Rubber Chemist, made advisory visits to following industries.

1. Central Rubber (Pvt.) Ltd., FTZ Biyagama.
2. Group Processing Centre, Meewanapalana.

Meetings and Seminars

Miss Anoma Gunawardena, Assistant Rubber Chemist, delivered lectures on the following topics to the newly Recruited Extension Officers of the ASD.

1. Determination of DRC and the metrolac.
2. Collection of latex and its preservation.

Miss Anoma Gunawardena delivered lectures on "Manufacture of TSR" and "Testing of raw rubber and latex" for the,

1. Diploma Course in Plantation Management conducted by the NIPM.
2. Students from Affiliated University College, Niyagama.

Mrs Sriyanthi Weeraman, Experimental Officer, delivered a lecture on "TSR and Latex Testing" for students from Affiliated University College, Niyagama.

Training

Two Technical Officers from Ansell Lanka Ltd. have been trained on Natural Rubber Latex Testing.

Practical classes were conducted for MSc students from University of Sri Jayawardanapura.

LABORATORY INVESTIGATIONS

Use of Paddy husk ash, as a filler for Tyre Tread

Carbon black filler was partly replaced with paddy husk ash. This ash was used as 15, 10 and 5 pphr. in a tyre tread formulation and physical properties were compared. The ash content of this sample was found to be only 90% (N M V Kalyani Liyanage, Anoma Gunawardna and W W Nandasena).

Effect of measuring conditions on the values of Po and PRI

For these experiments Po values were measured and the following effects were studied.

1. Papers used for the measurement.
 - Tissue papers.
 - Typing duplicate papers.
 - Thin polythene.
2. No of times of blending
 - 6 times.
 - 10 times.

This was done in collaboration with the Kelani Tyre Co.(Anoma Gunawardena, Nalini Jinadasa and R S Wijesundera).

Effect of Sea water on different types of rubber

A consignment of rubber salvaged from the harbour was analysed for the physical properties. This consignment consisted of SLRL, SLR 5 (RSS), SLR 20 and Pale and Brown crepes.

It was found out that these rubbers were degraded showing low values of Po and PRI.

A project was started to find out the effect of fresh water and sea water with time on every type of rubber. For this experiment SLR L, 5L, 10, 20 and RSS 1, 2 and 3 are being used (S W Karunaratne, Anoma Gunawardena and Wasantha Gamage).

Water soluble proteins in Rubber Gloves

In response to the problem of leachable proteins in rubber gloves, a series of tests have been carried out to compare the extractable water soluble proteins in the samples of gloves using micro kjeldhal method.

In this investigation, samples of surgical gloves were leached for different time intervals at room temperature and nitrogen content of the leached samples was determined as a measure of protein content. It has been observed that the protein content of the samples reached a constant value after 16 hours of leaching in water as can be seen in Fig.1 (L M K Tillekeratne, Sriyanthi Weeraman and Wasantha Gamage).

MISCELLANEOUS

Table 1. *Number of samples tested from each TSR factory during 1992*

Code	Producer	No of samples
AA	Sri Lanka Rubber Manufacturing Co Ltd., Mawanella.	—
AD	Statcon Block Rubber factory, Getahetta.	1 575
AF	Ceymac Block Rubber Factory, Horana.	4 061
AE	Shermans Block Rubber Factory, Ingiriya.	808
AI	Associated Speciality Rubbers Co.Ltd., Colombo.	200
	Total	6 644

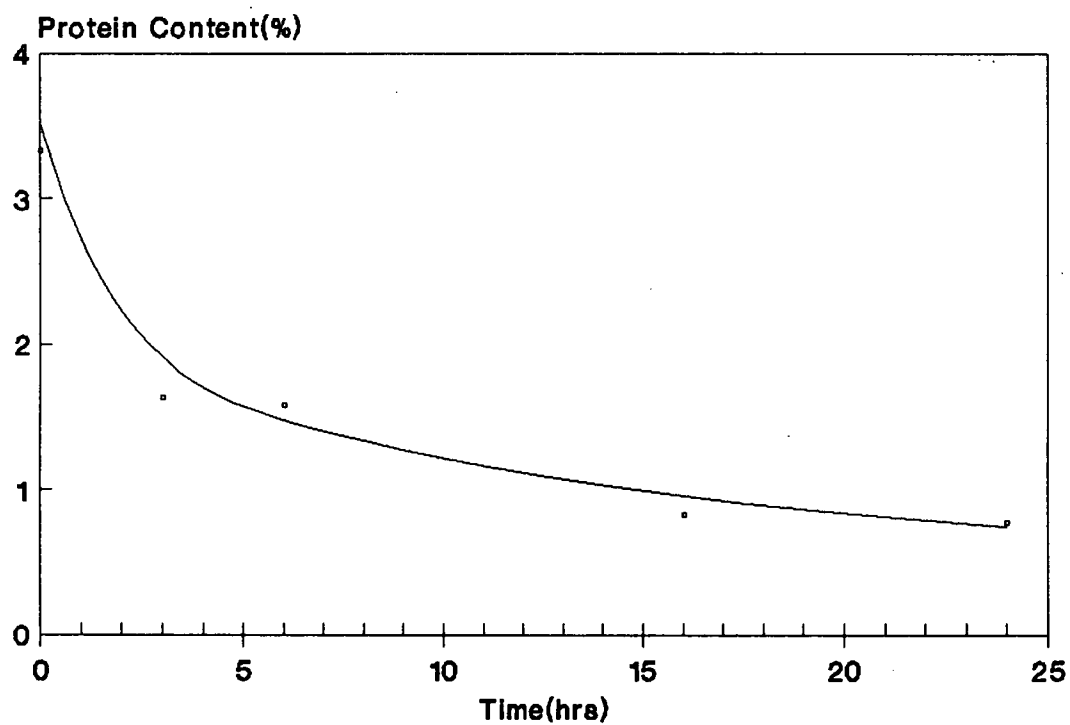


Fig. 1 Effect of leaching on the water soluble proteins

Table 2. *Miscellaneous samples tested during the year.*

Rubber samples	775
Latex samples	231
Chemical samples	70
Water samples	09
Gloves samples	34
Masterbatches	59
Teats	01
Saw dust	01
 Total	 1 180

RAW RUBBER PROCESS DEVELOPMENT & CHEMICAL ENGINEERING

W M G Seneviratne

SUMMARY

Two treatment plants are now under construction to treat the effluents at Nakiadeniya rubber and oil palm factories based on Anaerobic/Aerobic digestion technique, a cost effective treatment process developed by the RRI recently. Similar treatment plants were proposed to few other places too where the environmental pollution in nearby areas is severe due to rubber effluent discharge.

Studies of the raw rubber properties carried out on pale crepe rubber produced in factories in different regions revealed that pale crepe rubber could be produced to conform to certain specifications if correct processing practices are followed. The data gathered were very useful in replying to foreign buyers who have made numerous enquiries with regard to supply of crepe rubber conforming to strict specifications laid down by them. Variations of these raw rubber properties with regard to the changes in the processing methods were carefully studied at Yatadola Estate.

Investigations revealed that Mooney viscosity of rubber is lower at the latex stage and gets increased during subsequent processing. If the initial viscosity is stabilized prior to coagulation of latex, manufacture of CV rubber with Mooney viscosity ranging from 55 – 65 could be accomplished.

Different types of crepe rubber and low nitrogen NR were tested for their physical properties including their dynamic properties with the intention of presenting the rubber to the market according to customer requirements.

Blends of skim rubber with different types of Natural rubber were prepared to test their physical properties in order to study the viability of incorporation of skim rubber in formulations for making rubber products.

Plans are underway to recommence the studies on use of solar energy in drying of rubber.

Rubber estates and factories were visited during the year to help them in improving the quality of their products.

DETAILED REVIEW

Staff

Dr W M G Seneviratne, Acting Head of Department, was on duty throughout the year.

Mr Susantha Siriwardena, Assistant Rubber Chemist, was on duty throughout the year.

Mr P H Sarath Kumara was promoted to the post of Experimental Officer with effect from 22nd October 1992.

Messrs C D Senanayake, T A S Siriwardane and Mrs W K C Nalini, Technical Officers, were on duty throughout the year.

Messrs U Dharmasena and H A Ariyaratne were also on duty throughout the year.

Research students

One student from the University of Moratuwa was trained under the National Apprenticeship Board training scheme.

Visits

Advisory visits for development work on crepe, RSS and block rubber processing and manufacture

The following estates and rubber factories were visited during the year in order to sort out the problems encountered by them.

Pallegama Valley Estate

Inspected the general defects of their smoke house and investigated the possibility of converting the abandoned tea factory into a smoke house and found this to be uneconomical. Hence, a comprehensive report was sent with several recommendations to modify the existing out-dated smoke house to increase its capacity.

Sapumalkande Estate

Discolouration of crepe rubber was reported by this estate during the first quarter. After investigation it was found that this defect occurred mainly due to

overheating of the mills. Also the quality of the water used for processing was found to be poor. A comprehensive report was sent with necessary recommendations. Another visit was made to this estate during the final quarter to investigate the problem of tackiness of their rubber. It is believed that the problem is due to overheating of laces in the drying tower. A thorough study of the drying tower will be carried out.

Hillstream Estate

Variation of DRC in the field and the factory was reported. Samples of field latex were collected from each division and the DRC estimated by the metrolac and DRC estimated by standard laboratory technique were compared. A comprehensive report was sent.

Rambukkande Estate

To increase the capacity and to improve the drying condition, forced air drying system was suggested to replace the existing boiler radiator system. Visit was made along with the engineers of M/s Brown and Company Limited to attend to this work. A detailed report with the estimate was subsequently sent to the estate by Brown & Company Limited.

Vogan Estate

The factory of this estate was inspected twice during the year to investigate the causes for the discolouration and the delay in drying of rubber. Ventilation of the drying tower has been completely interrupted due to the blockage of the vents on the roof. Factory Officer was advised accordingly to clear the vents and a detailed report was subsequently submitted.

Padukka Estate

Trial fractionation by aeration was carried out at Padukka estate. This trial was done to demonstrate this technique on a request made by the Superintendent - Padukka Estate.

Sirisala Estate

A visit was made to this estate on request to inspect the RSS factory. A comprehensive report was sent with certain recommendations for modification of the same factory.

Paiyagala Estate

This estate was visited several times to see the progress in the construction of the rubber trap cum anaerobic digester unit. This unit is now partly constructed and effluent is pumped and distributed in the field periodically in different areas of the estate. Plans are underway to test the soil in these areas on a regular basis.

Frocester and Ellakande State Plantations

Visited these two estates with a representative from the Netherlands government to finalize matters pertaining to the construction of two treatment plants in these estates.

Nakiadeniya State Plantation

DRC determination of various divisions of the estate was carried out and a comprehensive report was sent.

Pelmadulla Estate and Hunuwella Estate

These two estates were visited to explore the possibility of using the premises of the unutilized building at Hunuwella State Plantation to be converted into a centrifuged latex factory.

Nakiadeniya State Plantation

Visited this estate with M/s Industrial Engineers to speed up the construction of the proposed effluent treatment plants (oil palm and rubber).

Mawanella SRMC

This factory was visited to inspect the construction of an anaerobic digester unit which is the first stage of the effluent treatment unit coming up at this site. This is based on RRI recommendations and has been completed satisfactorily.

Lalan Rubbers – Warakapola

This factory was visited in order to inspect the newly installed machinery at the centrifuging plant on a request made by the Rubber Control Department for payment of subsidy.

Neuchatal Estate

The colour of the crepe rubber produced in this factory is poor and also the laces are susceptible to mould contamination due to the delay in drying which is carried out in the loft. The drying tower does not function perfectly and also the capacity is not sufficient to cope up with the daily crop. A report was submitted with certain suggestions to improve the rate of drying in the loft if the drying tower cannot be renovated up to the required condition.

Dartonfield Rubber Factory

An inverter supplied by M/s Harvest Engineering Ltd. was fixed to the 1st macerator to investigate the possibility of cutting down electricity usage. This inverter has the facility to regulate the speed of the motor of the mill and will be advantageous smoothing out crepe laces to required standards.

Dangampola Rubber Industries – Dehiowita

The factory of this estate was visited on a request made by the Rubber Controller to inspect the newly installed smooth mill and to recommend for payment of subsidy.

Galatura Estate

The factory of this estate was inspected to make necessary recommendations for the modification of the existing factory to meet processing facilities for the anticipated extra crop. A report was sent to this effect with a plan of the factory and also with a sketch for a modern water filtering system.

Reucastal Estate

The factory was inspected twice during the year. The reasons for discolouration of their crepe rubber was found to be due to the delay in drying which is carried out in a two storeyed large loft. Although two propeller fans, driven by the engine during the day time, had been installed to accelerate the rate of drying, the improved drying efficiency was not observed because of the larger size of the lofts. Also the location of the loft and high humidity levels prevalent in the surrounding area may have largely contributed to the inefficiency. Extra number of fans cannot be installed as electrical power supply is not available. Therefore, the construction of a

drying tower was recommended without which discolouration of crepe rubber is unavoidable due to the delay in drying in the loft.

Vijaya Latex centrifuging plant – Horana

A factory, constructed halfway, was inspected and certain modifications were suggested with regard to the proposed installation sites for certain machinery. A comprehensive report was submitted to the Rubber Control Department for the purpose of subsidy payments.

Eheliyagoda Estate

This estate was visited with the company officials to solve the recurrent pollution problems in the area due to the discharge of effluent into the nearby stream, Bisodola. Although temporary measures are being adopted by the factory at present, to discharge the effluent within their premises, a comprehensive report was sent with inclusive of a cost estimate for a full scale treatment plant.

Meetings, seminars and lectures

Mr Susantha Siriwardena attended a workshop on Evaluation of priority areas of research activities of Research Institutions in Sri Lanka organized by NARESA.

Dr W M G Seneviratne delivered a lecture on "Standardization of the process of crepe and sole crepe rubber manufacture" in the grading and packing of rubber seminar organized by the Ceylon Planters' Association at their auditorium.

Dr W M G Seneviratne and Mr Susantha Siriwardena delivered talks in a one day field programme held at Meewanapalana GPC in the field of RSS manufacture.

Mr S W Karunaratne and Dr W M G Seneviratne held an Introductory discussion on ISO 9000 for Watawala Plantation Limited at Nakiadeniya Estate.

Dr W M G Seneviratne attended NIPM Technical committee meetings held during the year and one committee meeting with the Heads of two Affiliated

Universities and NIPM officials as the course coordinator of the rubber sector for the two year diploma course on Plantation Management.

Dr W M G Seneviratne, Susantha Siriwardane and P H Sarath Kumara attended a one day work shop at Dewalakanda estate, organized by Kelani Valley Plantations Limited. All the aspects of processing of crepe rubber was covered and followed by a demonstration on fractionation of latex by aeration.

Dr W M G Seneviratne attended a workshop on ISO 9000 organized by Sri Lanka Standards Institution.

Dr W M G Seneviratne attended all Scientific Committee meetings held during the year.

Dr W M G Seneviratne and Susantha Siriwardane attended a seminar on 'Small Effluent treatment systems' organized by the Institution of Water and Environmental Management Sri Lanka branch.

Dr W M G Seneviratne attended a meeting on Effluent treatment project chaired by the Honourable Minister of Plantation Services at Dartonfield.

Dr W M G Seneviratne delivered a lecture on 'Choice of raw rubber in the rubber products manufacture' at a seminar held at Savsiripaya. This was organized by the RRI and its theme was "The Role of Research and Development in Rubber Products Manufacture".

Dr W M G Seneviratne attended a one day work shop on ISO guide 22 (laboratory testing) at the CISIR.

Dr W M G Seneviratne delivered a talk on "Standardization of manufacture of crepe rubber" for the planters of the Kegalle Plantations Limited.

Dr W M G Seneviratne attended a seminar on "Environmental pollution control" organized by the IWEM at Savsiripaya.

Dr W M G Seneviratne attended a meeting at the Open University of Sri Lanka to discuss matters pertaining to proposed syllabus on Polymer Chemistry Degree Course.

Dr W M G Seneviratne participated in a workshop on Energy Management in Industrial and Commercial Sectors organized by the Sri Lanka Energy Managers Association in collaboration with the Ministry of Energy Conservation between 6th and 18th of September. A recognized certificate was awarded.

Mr P H Sarath Kumara delivered a talk on "Introduction to Latex Based Products Manufacture" at a seminar for smallholders organized by the Atygalle Smallholders Co-operative Society jointly with the Advisory Services Department of RRB.

Dr W M G Seneviratne served as a visiting lecturer on Polymer Science and Technology at the University of Sri Jayawardanepura and University of Colombo.

Dr W M G Seneviratne, Mr Susantha Siriwardane and Mr P H Sarath Kumara delivered lectures for planters at the NIPM for their pre-examination training programme.

Dr W M G Seneviratne and Mr Susantha Siriwardane delivered lectures and conducted practical classes for the students from the two Affiliated University Colleges of Uva Province.

Mr Susantha Siriwardane delivered a lecture on 'Economic Ways of Drying RSS in Smallholdings and Designing of Smoke Houses' for nine batches of Rubber Extension Officers and Rubber Inspectors in a Refresher Course for them.

Mr Susantha Siriwardane and Mr P H Sarath Kumara delivered lectures for Rubber Extension Officers absorbed by the ASD of the RRB from IDB in a Refresher Course for them.

Mr S W Karunaratne delivered a talk on ISO 9000 at a workshop for Planters, Factory Officers and Field Officers of the Balangoda Plantations Ltd., Ratnapura. Dr W M G Seneviratne, Mr Susantha Siriwardane and Mr P H Sarath Kumara also delivered talks on rubber processing and manufacture at the same workshop.

Mr Susantha Siriwardane attended the meeting of the Laboratory Accreditation Committee held at the Sri Lanka Standards Institution.

Dr W M G Seneviratne attended the Environmental Group Meeting chaired by the Hon. Minister of Environment at the Ministry of Environment and Parliamentary Affairs (MEPA) to discuss matters related to environmental issues coming up from time to time.

Public lectures

Dr W M G Seneviratne delivered a public lecture on "**Treatment of Rubber Factory Wastes**" organized by the Institution of Water and Environmental Management (IWEM), Sri Lanka branch, on 15th December, on their invitation, at the Headquarters of the Institute of Engineers.

Publications

Seneviratne, W M G, Siriwardane, S and Siriwardane, T A S (1993). Cost effective treatment method for factory effluent discharged from rubber factories in Sri Lanka, Annual sessions, SLAAS.

Seneviratne, W M G, Abeykoon, A M C and Sarath Kumara, P H (1993). Use of blends of glove wastes and natural rubber in rubber products manufacture, Annual sessions, SLAAS.

LABORATORY AND FIELD INVESTIGATIONS

Unification of raw rubber properties of pale crepe

A project was undertaken to study the variation of raw rubber properties of pale crepe produced in crepe rubber factories in Sri Lanka. From the few estates selected for this study from main rubber growing areas of the country, only two estates continued to send the samples on a monthly basis. Therefore the data collected was hardly sufficient to make the necessary recommendations. However, the data so far collected shows that Sri Lankan pale crepe could easily be produced conforming to the specifications given in Table 1 (W M G Seneviratne and P H Sarath Kumara).

Table 1. *Raw Rubber Specifications for crepe rubber.*

Property	Specifications
Dirt Content (% w/w)	0.020 (max.)
Volatile Matter Content (% w/w)	0.350 (max.)
Ash Content (% w/w)	0.20 (max.)
Initial Plasticity Number (P ₀)	45 5
Plasticity Retention Index (PRI)	70.00 (min.)
Nitrogen Content (% w/w)	0.35 (max.)
Mooney Viscosity (ML 1 + 4 @ 100°C)	75 – 85
Lovibond Colour	1.5 (max.)

Evaluation of properties of various types of NR

It is now realized that visually graded Sri Lankan rubber will have a better market if presented in a Technically Specified form. This would enable the buyers to select the pale crepe according to their product requirements. Therefore a project was started to evaluate the physical properties of different types of crepe rubber prepared from the same batch of latex. The project also deals with dynamic properties of Low Nitrogen Natural Rubber (LNNR) in comparison with the other forms. The following types of rubbers were subjected for testing.

- UFUB – Unfractionated unbleached rubber
- UFB – Unfractionated bleached rubber
- FUB – Fractionated unbleached rubber
- LNNR – Low Nitrogen Natural Rubber
- FB – Fractionated bleached rubber
- YF – Yellow fraction rubber
- RSS – Ribbed Smoked Sheets

Yellow fraction rubber and unfractionated rubber are characterized by high ash and nitrogen contents.

Table 2. *Comparison of physical properties of different grades of NR.*

	UFUB	UFB	FUB	LNNR	FB	YF	RSS
Tensile strength (MPa)	29.00	28.00	27.50	26.00	28.00	29.00	26.90
Resilience %	57.00	57	60	61	57	51	57
Abrasion Resistance Index	0.044	0.033	0.031	0.030	0.043	0.047	0.049
Tan δ	0.121	0.067	0.064	0.070	0.077	0.083	0.076

Physical properties were evaluated from a standard tyre tread formula. Tensile properties and abrasion resistance were found to be slightly higher in rubbers having non rubber substances. As expected, resilience is highest in LNNR. This is also in fair comparison with the tan δ values of these rubbers. Tan δ is an indicative measure of the dynamic properties of rubbery materials. Hence materials which possess lower tan δ are those with less heat build up in the material which is in motion. Therefore LNNR is expected to behave well in engineering applications. Further studies on this project are in progress (W M G Seneviratne and T A S Siriwardane).

Manufacture of CV and LV grades of RSS and Crepe rubber

A series of samples of RSS were prepared with varying quantities of papain and peptiser to reduce the viscosity of rubber followed by part coagulation with acid. The viscosity was stabilized by adding hydroxyl amine neutral sulphate to latex. By adopting certain cost effective heating techniques prior to smoking, viscosity of RSS could be reduced to desired levels. Consistency of this technique is to be evaluated further, before any recommendation is made.

Table 3. *Effect of variables on raw rubber properties of crepe rubber.*

Sample No.	Dilution	No. of mill passes			2nd mill heated	Sun drying for 2 hrs.	Amount of B.A.
		M	Sp	Sm			
1 (con)	1:1	2	3	1	No	No	Normal
1A	1:1	2	3	1	No	No	- do -
2	1:1	4	6	2	No	No	- do -
3	1:1	4	6	2	Yes	No	- do -
4	1:1	4	6	2	No	Yes	- do -
5	1:1	4	6	2	Yes	Yes	- do -
6	1:2	4	6	2	Yes	Yes	- do -
7	1:1	4	6	2	Yes	Yes	Double

Raw Rubber Properties

Sample No.	Ash %	N %	P _o	PRI	V _R
1	0.19	0.37	50	98	84
1A	0.26	0.28	33	94	64
2	0.27	0.34	30	96	61
3	0.20	0.36	32	94	59
4	0.19	0.33	30	94	59
5	0.21	0.32	34	97	57
6	0.18	0.40	27	93	55
7	0.19	0.38	31	86	55

M – Macerator

Sp – Spirally grooved mill

Sm – smooth mill

B.A. – Bleaching agent

Similarly, comprehensive studies were done on crepe rubber to manufacture CV and LV grades. This was attempted by changing dilution, the amount of bleaching agent added, number of mill passes and heating the laces etc. and also by changing the drying techniques. Viscosity of the final product could be stabilized without much difficulty if proper amount of HNS is added. Trials so far carried out show that the viscosity and the Wallace Plasticity of the rubber could reasonably be reduced when HNS is added to latex prior to coagulation, without any subsequent adjustments to the method of processing. Mooney viscosity (V_R) could be reduced by as much as 20 units with the incorporation of 0.15% HNS (on DRC) at the latex stage. It can be postulated that the initial Mooney viscosity of rubber is lower and it gets increased during the subsequent processing stages. If HNS is added into latex prior to coagulation, initial low viscosity could be stabilized to obtain CV rubber. Also the number of mill passes, passing the laces through heated mills and also heating in sunlight (for 2 hours) and dilution of latex have a certain bearing on the viscosity reduction of the final product as seen in the results given in Table 3 (W M G Seneviratne, P H Sarath Kumara, T A S Siriwardane and C D Senanayake).

Compilation of raw rubber properties-Yatadola State Plantation

Continuous analysis of raw rubber properties of crepe rubber produced at Yatadola Estate was carried out over a period of one month. This exercise would enable one to understand the variation of raw rubber properties with regard to changes in the processing methods, weather and processing of rain affected crepe etc. within the estate. The data gathered are summarized in Table 4.

Table 4. Mean and std. deviation for raw rubber properties of crepe rubber samples collected from Yatadola Estate.

Property	Mean	Std. deviation
Dirt % w/w	0.026	0.0291
Nitrogen % w/w	0.369	0.0870
Ash % w/w	0.126	0.0410
Volatile Matter % w/w	0.331	0.0690
Initial Plasticity (P ₀)	31.900	8.4100
Plasticity Retention Index (PRI)	67.100	8.8000
Mooney viscosity ML (1+4) @ 100°C	72.200	0.0100

Analysis of the data shows that P₀ and PRI are consistent over a certain period but P₀ tends to be significantly lower during the periods when metal contamination is higher as revealed by the higher ash content. Higher VM content was observed in a particular period and it could be attributed to the wet weather pattern which prevailed during the period. Mooney viscosity maintained the highest level of consistency whilst nitrogen content varied only slightly. Dirt and ash contents show a significant variation in certain periods which could again be attributed to the inconsistency in processing.

The entire data collected will be fully analyzed and a report will be published soon (W M G Seneviratne and Susantha Siriwardane).

Evaluation of physical and raw rubber properties of skim rubber/NR blends

Initial trials were carried out by blending various proportions of skim rubber with scrap rubber sorted and unsorted. All these were prepared at Mawanella SRMC with the help of its staff. Testing of the samples is carried out by the Raw Rubber & Chemical Analysis Department and the project is still in progress (W M G Seneviratne, Susantha Siriwardane, T A S Siriwardane and R Fernando of SRMC).

Solar energy for drying of rubber

Solar energy, a vital renewable source of energy is reconsidered as very useful for use in drying of rubber. Hence a project proposal was submitted to NARESA to obtain funds for this project and formal approval was granted by the donor

organization in Sweden. A separate proposal was also submitted to the Ministry of Power and Energy (S W Karunaratne, W M G Seneviratne, Susantha Siriwardane).

Effluent Treatment and Disposal

The treatment technique based on enclosed anaerobic digester coupled with aerobic process developed by the RRI is the most cost effective versatile treatment method available up to now to treat rubber factory wastes. Pilot plant experimental findings were published in the 1993 SLAAS annual sessions. Proposed system consists of the following;

1. Rubberized coir carrier matrix filled anaerobic septic tank digester
2. Aerobic process
 - i. Fine bubble aeration
 - ii. Effluent cascading plant
3. Sedimentation tank

Outstanding feature of the method is the very high organics removal rate achieved by the anaerobic digester. Various volumetric organic loading rates were tested ranging from low to high, ie 2.5 to 18.9 kg COD per m³ of the reactor volume per day. At 18.8 kg COD/reactor volume m³/day, organics removal rate was 86.2 % within a very short hydraulic retention time (only a day) which could be regarded as an excellent removal efficiency from an anaerobic digester. It was also revealed that removal efficiency increases with the loading rate.

Cascading plant consists of wooden planks on which coir brushes are mounted. Both anaerobic and aerobic digestion take place when anaerobically treated effluent travels through the cascading system. Table 5 gives the removal efficiencies of certain effluent parameters at high organic loading rate – 18.8 kg COD/m³ reactor/day.

Table 5. *Removal efficiencies of effluent parameters.*

Parameter	Raw effluent	Anaerobic digester removal efficiency %	Cascaders removal efficiency %
Total Nitrogen	1 350	40.0	64.3
COD	16 804	86.2	61.4
BOD	8 510	91.2	45.0
Ammoniacal Nitrogen	375	-18.9	37.0
Suspended solids	575	75.0	60.0
pH	4.8	6.1	7.4

* all values are in ppm except pH

RRI advocates fine bubble aeration as the secondary aeration process for the anaerobically treated effluent from the anaerobic septic tank. Locally manufactured fine bubble aerators are available in the market and these were particularly selected because of the very high oxygenation transfer capacity they possess compared to the other aerators. Satisfactory results could be achieved in this process if the following conditions are maintained in the aerobic tank.

$O_2/BOD \sim 1.5 - 2.0$

Oxygen concentration ~ 2 mg/l and solid concentration 3 000 – 4 000 mg/l maintained throughout the operation

Finally, digested mass will be settled in the clarifier and the supernatant liquid could be discharged.

Treatment plants are to be set up at Frocester and Ellakande rubber factories as pilot plants as proposed by the BKH consultants Netherlands under the full sponsorship of the Netherlands Government. This proposal was changed at the last moment and Anaerobic Septic Tank Digesters recommended by the RRI were incorporated in both designs. The original plan was to set up conventional treatment techniques based only on aerobic principle namely Rotating Biological Contractor Process at Ellakande and Oxidation Ditch Process at Frocester.

A project proposal was submitted to the Ministry of Environment to evaluate the efficiencies of modified version of the technique based on Anaerobic/aerobic principle which has been described above.

Treatment plants

Nakiadeniya oil palm and rubber factories – Enclosed Digester/Fine bubble aeration technique: –

Construction work of both plants has already been started and is expected to be completed before March 1994.

Mawanella SRMC: –

Enclosed anaerobic digester has been completed and now in operation. Fine bubble aeration is proposed as the second stage of the project.

Pallegama Estate: –

Rotating coir-belt contractor unit plant is in operation.

Matugama Rubber Mills:-

Anaerobic digester coupled with effluent cascading plant is in operation.

Atale and Siriniwasa Estates:-

Rotating coir-belt plant is proposed and plans are underway to commence the construction work in 1994.

Udapola Centrifuged Latex Factory:-

Anaerobic digester coupled with fine bubble aeration plant was proposed and they were instructed to complete this before June, 1994 by the Ministry of Environment.

Eheliyagoda Estate:-

Anaerobic digester/fine bubble aeration technique is proposed.

(W M G Seneviratne, T A S Siriwardane, Susantha Siriwardane and C K Nalini)

Other activities

A working model of a set of anaerobic digester, fine bubble aerator and sedimentation tank were displayed at the Exhibition held at NARESA from 1st to 5th of December.

ADAPTIVE RESEARCH

N Yogaratnam

SUMMARY

Adaptive Research programmes on intercropping rubber with banana and pineapple have been very successful in the smallholder sector and new programmes on rubber with cinnamon and rubber with cocoa were started. Programme on the use of rainguards indicated that extra tapping days are possible in areas with rainguards. Measures were taken to prevent insect attack on polythene rainguards. Growing bush/tree legumes as a soil conservation measure and to increase soil fertility appears to be promising and multicropping of rubber with tea is also becoming very popular in this sector. Use of rubber serum as a source of nutrients to vegetables and paddy and organic manures such as poultry litter to rubber has given promising results. Use of varnish coated coconut shells for latex collection is gaining popularity among the smallholders after the usefulness of this had been demonstrated to them in the field.

DETAILED REVIEW

Staff

The Deputy Director (Research), Dr N Yogaratnam, coordinated the activities of this Unit. Mr S M M Iqbal, Research Assistant in Agronomy, Mr F P W Silva, Mr W C Dayaratne, Mr P P Jayasinghe, Mr K B A Karunasekera, Development Officers, Mr E A T Senadeera, Senior Technical Officer and Mr S Wijesekera, Specification Assistant, were on duty throughout the year.

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 V H L Rodrigo, Research Officer in Intercropping, Mr C K Jayasinghe, Head, Plant

Pathology and Microbiology, Dr (Mrs) K de Silva, Head, Polymer Chemistry, Mrs Neelamani Yapa, Assistant Biochemist and Mr P H M U Herath, Assistant Agricultural Economist.

b) Extension Personnel:

Mr K Meegahawatta, Head, Development Division, Advisory Services Department, Mr P Samaranayake, RAO, Kalutara, Mr D D Dasanayake, RAO, Kegalle, Mr A H Kularatne, RAO, Ratnapura, Mr M C Samarasekera, RAO, Galle and Mr A L H Silva, RAO, Colombo.

Temporary Workers

Miss D Senaratne and Miss Rupani Ratnasinghe continued to work in this Unit as Temporary Technical Assistants in programmes funded by the Council for Agricultural Research Policy (CARP).

Visits

The World Bank mission of the SRRP II and the Agricultural Research Project made inspection tours to the adaptive research experimental areas.

Meetings

Mr S M M Iqbal addressed the Kegalle and Kalutara region smallholders on 'Multicropping of Rubber with Tea'.

Mr W C Dayaratne delivered a lecture on "Agriculture Extension" at the Forest Department, Western Province.

Mr E A T Senadeera gave a lecture on Rainguard, Rubber diseases and Multicropping of Rubber with Tea in the Kegalle Region for smallholders.

The Adaptive Research Unit staff attended the following:

Quarterly Progress Review Meetings of ARU and ASD.

Monthly conferences of REO's in all regions.

Adaptive Research Training Programmes.

Publications

- Iqbal, S M M (1993). Multicropping of Rubber with Tea. *Bull. Rubb. Res. Inst. Sri Lanka*. (in press).
- Dayaratne, W C (1993). Agriculture Extension and the Farmer. *Bull. Rubb. Res. Inst. Sri Lanka*, Vol. 29. p.
- Silva, F P W (1993). Rubber with Cinnamon. *Rubber Puwath* (In press).
- Silva, F P W (1993). New approach – Increasing Income of Rubber Smallholders. *Rubber Puwath* (In press).
- Senadeera, E A T (1993). Rubber with Tea (General) – Kegalle. *Rubber Puwath* (In press).

FIELD INVESTIGATIONS

Adaptive Research Programmes in Rubber Smallholdings:

1989 – Integrated Programme

- | | | | |
|----|-------------------------------|---|--------------------|
| 1. | Field Establishment Practices | – | (A Nugawela) |
| 2. | Clones | – | (N E M Jayasekera) |
| 3. | Planting Density | – | (A Nugawela) |
| 4. | Intercropping | – | (L Rodrigo) |

The following treatments are being tested in the Ratnapura, Kegalle, Kalutara, Colombo and Galle/Matara regions.

A. In holdings less than 1.5 Ac.

Treatment No.

Treatments

- | | |
|----------------|--|
| 1 | 12'x18'; Bare root; RRIC 100 |
| 2 | 9' x22'; Bare root; PB 86, 1/2 intercropped. |
| 2 _A | 9' x22'; Bare root; PB 86 |
| 3 | 12'x18'; Bare root; PB 86 |
| 3 _A | 11'x18'; Bare root; PB 86 |
| 4 | 14'x14'; Bare root; PB 86 |
| 5 | 12'x18'; Poly bag; RRIC 100 |
| 6 | 8' x27'; Poly bag; RRIC 100, 1/2 intercropped. |
| 7 | 11'x18'; Young budding/Poly bag; PB 86 |
| 7 _A | 11'x18'; Young budding/Poly bag; RRIC 100 |
| 7 _B | 8' x27'; Young budding/poly bag; RRIC 100 |

B. In holdings size 1.5 Ac. – 4.00 Ac.

Treatment No.	Treatments
8	8' x27'; Poly bag/Bare root; RRIC 100; 1/2 intercropped
9	12'x18'; Poly bag/Bare root; RRIC 100
10	12'x18'; Bare root; RRIC 100/102/121
11	8' x27'; Bare root; RRIC 100/102/121; 1/2 intercropped.
12	8' x27'; Young budding/Poly bag/Bare root; RRIC100
12 _A	8' x27'; Young budding/Poly bag/Bare root; RRIC100

Results obtained from some of these trials are being analysed using the student t-test technique. Results of some of the trials showed significant girth differences between sites and treatments. In the 1989 intercrop trials, most of the intercrops appeared to be weak due to shading by the rubber trees.

1990 – 1993 Programme

Clone Evaluation

This programme was started in 1990. The following treatments are being tested in the Kegalle and Kalutara regions.

Treatments: Clone RRIC 100, RRIC 102, RRIC 110 and RRIC 121 with provision for comparisons of:

- (a) Smallholder Management Practices (SMP)
- (b) RRISL Recommendations (RRI)

Experiments on two sites in the above programme were discontinued due to negligence by smallholders. In some of these trials banana was planted as intercrops to provide some income to the smallholders during the immature period. Assessments of girth were continued (N E M Jayasekera, F P W Silva, W C Dayaratne and E A T Senadeera).

Intercropping

1990 – 1991 Programme

Experiments on rubber with banana and pineapple were continued in the Colombo region. Girth data recorded from these sites do not show any significant differences between intercrops and without intercrops (Table 1).

Table 1. *Mean girth of the rubber in the plots intercropped and not intercropped in the 1990 programme.*

Treatments	Mean Girth (cm) 1993
With intercrop	22.78
Without intercrop	20.42
	N.S.

(L Rodrigo and F P W Silva)

1992 Programme

Trials were in progress on three smallholder sites in the Kegalle region. Pineapple grown with rubber at Hettimulla gave a profit of over Rs.2 000/= within 7 months and another trial at Atale over Rs.1 300/= within five months in 1993. Trial on rubber with coffee at Undugoda was in progress (L Rodrigo, W C Dayaratne and E A T Senadeera).

1993 Programme

The following programmes were started:

Smallholder and Address	Extent Treatment
Kegalle region	
9 _A) A P K Arambegedera Murathatetawala, Mawanella.	1 Ac, Rubber with cocoa

Ratnapura region

- 9_C) Mr J D S Wickramaratna 1/2 Ac, Rubber with pineapple
Katandola,
Ratnapura.

Galle region

- 9_D) Mr Mohotti, 1/2 Ac, Rubber with cinnamon
Aparakke.
- 9_E) Mr H P Gunapala 1/2 Ac, Rubber with cinnamon
Thiyagoda.
- 9_F) Mr F K P Bandusena 1/2 Ac, Rubber with cinnamon

(L Rodrigo, F P W Silva, W C Dayaratne, E A T Senadeera and S W Wijesekera).

Soil Moisture and Conservation Practices

Programme on growing of bush legumes was continued in the Kegalle Region. Girthing of the rubber plants in plots with legumes showed significant increase over the plants without legumes (Table 2).

Table 2. *Effectiveness of growing bush legumes on girth of rubber plants (cm).*

Treatment	Mean girth (cm) - 1993
With legumes	31.23
Without legumes	28.75**
	C.V. = 2.0
(Mrs L Samarappuli, W C Dayaratne and E A T Senadeera).	

Use of Rainguards

Five holdings were selected in each region, *i.e.* Kegalle, Ratnapura, Galle, Kalutara and Colombo. Rainguards were fixed in one tapping block, in each holding. Details and results of this programme are presented in Table 3.

Table 3

Region	Site No.	Period	Extra tapping days	Remarks
Kegalle	10	May – November	20	.Insect damage, 5%
	11	March – November	46	.Insect damage, 5%
	12	–	–	.Terminated – Irregular tapping
	13	March – November	15	.Tapper damage, 40% .Insect damage, 20% .Melting of sealent, 5% .Tapper absent during June–July
	14	April – November	34	.Insect damage, 5%
Ratnapura	15	March – December	31	.Insect damage, 40% .Tapped daily
	16	March – November	49	.Insect damage, 50% .Brunolinum applied on the under side of the polythene. .Tapper damage, 5% .Well maintained plot
	17	March – September	32	.Insect damage, 5%
	18	March – December	33	.Insect damage, 40% .Poor tapper response
	19	March – December	23	.Insect damage, 60% .Brunolinum applied .Tapper absent on wet days.
Kalutara	20	March – November	27	.Insect damage, 5% .Tapper damage, 13% .Poor tapper response
	21	July – December	20	.Tapper damage, 20% .Melting of sealent, 80% .Tapper absent, March–June.
	22	–	–	.Tapping not done properly; shallow tapping

Region	Site No.	Period	Extra tapping days	Remarks
	23	March - December	73	.Insect damage, 5% .Tapped daily
	24	March May	10	.Terminated in May due to floods.
Colombo	25	-	-	.Tapper absent
	26	March - June	29	.Poor tapper response
	27	March - December	29	.Insect damage, 5% .Heavy rain in Sept., Oct., & Nov.
	28	March - December	34	.Insect damage, 5%
	29	March - December	29	.Insect damage, 5%
Galle/ Matara	30	March - May	28	.Terminated after June due to floods
	31	March - May	32	.Insect damage, 50% .Tapper was not in favour of this system; rainguards were removed by the tapper.
	32	March - December	52	.Insect damage, 40% .Well maintained plot
	33	March - June	14	.Insect damage, 75% .Tapping not done on rainy days .Records not maintained properly by the smallholder.

Grasshoppers were found to cut the polythene in the Ratnapura and Galle regions. This is more common in areas where there is a thick growth of weeds. The growers were advised to adopt the following measures:

1. To clear the shrubs in the land.
2. 'Bon fire' - Regularly.
3. Spraying of waste engine oil, kerosine oil and Brunolinum on the inner side of the polythene.

(A Nugawela, L M K Tillekeratne, S M M Iqbal, F P W Silva, W C Dayaratne and E A T Senadeera)

Tapping Systems

In the programme on rainguards where tapping is done by s_2d_2 systems, the yield, incidence of tapping panel dryness and rate of bark consumption are being studied in comparison with the smallholder tapping system *ie* daily tapping during favourable weather (A Nugawela).

Use of Organic Manure

1991 Programme

Application of poultry litter to immature rubber and pineapple was continued in the Kalutara region.

1993 – 1994 Programme

Smallholder sites in the Kalutara and Kegalle regions were selected to introduce rice straw and poultry litter as sources of nutrients to immature rubber (Mrs L Samarappuli, F P W Silva and W C Dayaratne).

Rubber Processing and Use of Rubber Factory Effluent

(a) Latex Collection Cups

In 1993, four more sites were selected in the Matara region to test varnish coated coconut shells for collection of latex. Also, the performance of varnish coated coconut shells on latex quality and scrap content was assessed.

Matara Region

Dry weight of scrap was recorded on 10 tapping days (Table 4).

Table 4. *Scrap weight in coated coconut shell plots and uncoated coconut shell plots on 10 tapping days 1993.*

Site	Weight of scrap in g/100 trees/10 tapping days	
	Varnish coated coconut shell	Uncoated coconut shells
1	82 g	167 g
2	64 g	287 g

(K G Karnika de Silva, P P Jayasinghe)

(b) Use of Rubber Factory Effluent as Fertilizer

In these programmes, application of rubber factory effluent to vegetable, paddy and rubber were in progress in the Kegalle, Colombo and Kalutara regions.

Kegalle Region

Site I

Income from the vegetable plots which were treated with effluent are as follows (Table 5).

Table 5. *Income from vegetable plots - 1993.*

Month	Income (Rs.)
January	96.00
February	228.00
March	86.00
May	80.00
June	55.00
July	70.00
August	168.00
September	75.00
Total	858.00

Site II

This trial was started in December 1993, using factory effluent as fertilizer for paddy. The following treatments were tested.

Treatments : T₁ - Smallholder Management Practice
T₂ - Recommended Paddy Fertilizer
T₃ - Effluent + Lime Level I
T₄ - Effluent + Lime Level II

Colombo Region

Programme on the use of rubber factory effluent for coconut, king coconut and banana was continued (Neelamani Yapa and P P Jayasinghe).

Multicropping of Rubber with Tea

State Sector 1

The Rubber Research Institute of Sri Lanka commenced studies on this subject in 1985 in collaboration with the Tea Research Institute in some commercial Estates. Annual yield figures and girth of the rubber plants were recorded. The following assessments were also made and the data are being analysed.

01. Gas Exchange Studies (Light intensity, Photosynthetic rate, Transpiration etc.).
02. Shade measurements (Photosynthetic Active Radiation).
03. Test plucking of tea.
04. Test tapping of rubber.
05. Collecting of soil and leaf samples.

Average made tea yield per month from two estates are presented in Table 6.

Table 6. *The effect of multicropping of rubber lands with tea on yield of tea (T – Tea only plot; R+T – Rubber and Tea plots) N.S. – Not Significant; C.V. – Critical value of t.*

Estate	Year	Mean yield of made tea (kg/ha)/month			Remarks
		Tea 100% (Actual)	R + T 65% (Actual)	100% (Calculated)	
Miriswatta	1991	161.30	87.19	134.14	N.S.
Wellipenna (Spacing 8' x 30')	1992	77.50	75.85	116.69*	C.V. = 2.101; Plucking not done during the drought in tea only plots.
	1993	114.82	103.36	159.01*	C.V. = 2.086
Kiriporuwa	1991	89.25	70	93.33	N.S.
Yatiantota (Spacing 8'x40')	1992	50.10	132	176**	C.V. = 2.878 Plucking not done during drought in tea only plot
	1993	80.2	110.80	147.73***	C.V. = 3.922

Significant differences between treatments on girth of the rubber were seen (Table 7) where girthing of rubber in rubber grown with tea plots was superior to rubber only plots.

Table 7. *The effect of multicropping of rubber lands with tea on girth of rubber (R - Rubber only plot; R + T - Rubber and Tea plot; C.V. - Critical Value of t).*

Estate	Mean girth (cm) 1993		Remarks
	R	R + T	
Miriswatta Welipenna	57.75	60.71*	C.V. = 2.021
Kiriporuwa Yatiyanthota	57.93	61.93*	C.V. = 2.021

State Sector II

Two experiments were continued in Dartonfield and RRISL Sub Station in Kuruwita.

Experiment 1. [RRISL Sub Station, Kuruwita]

All the management practices were done according to the recommendations of the RRI and the TRI. Data on girthing of rubber and rubber leaf nutrients are presented in Table 8 and 9. Duncan's new multiple Range Test was used to compare the treatment effects and all the means followed by a common letter are not significantly different.

Table 8. *The effect of multicropping of rubber lands with tea on growth of rubber.*

Treatments	Mean Girth (cm)	
	1992	1993
Rubber only	17.83A	29.86A
Tea (Rehab) + Rubber 8'x 27'	18.28A	30.53A
Tea (Unrehab) + Rubber 8'x 27'	19.00A	31.57A
Tea (Rehab) + Rubber 8'x 40'	19.15A	30.97A
Tea (Unrehab) + Rubber 8'x 40'	20.15A	31.56A

Table 9. *The effect of multicropping of rubber with tea on rubber leaf nutrient content*
- 1993.

Treatments	Nutrients (%)				
	N	P	K	Ca	Mg
Rubber only	3.75A	0.125A	0.705A	0.024A	0.291A
Tea (Rehab)+Rubber 8'x27'	3.73A	0.195A	0.691A	0.027A	0.344A
Tea (Unrehab)+Rubber 8'x27'	3.70A	0.133A	0.592A	0.102A	0.345A
Tea (Rehab)+Rubber 8'x40'	3.20A	0.218A	0.589A	0.025A	0.356A
Tea (unrehab)+Rubber 8'x40'	3.55A	0.140A	0.600A	0.028A	0.327A

Experiment II [RRISL, Agalawatta]

This experiment was in progress. Planting of *Gliricidia* was completed. Manuring of rubber and Mana grass was done according to the schedule (N Yogaratnam and S M M Iqbal in collaboration with the TRI).

Smallholder Sector

Three smallholder trials were in progress in the Kegalle region. Manuring of rubber and tea, lopping of *Gliricidia*, centering of tea and tipping of tea were done by smallholders in the recommended manner (N Yogaratnam, S M M Iqbal and E A T Senadeera).

This programme on multicropping of rubber with tea is partially funded by the Council for Agricultural Research Policy under their contract research programme (N Yogaratnam, S M M Iqbal in collaboration with the TRI).

Multicropping of Rubber with Tea - Under IRDP Programme, Kalutara

This programme was implemented on smallholder fields in the Kalutara region in 1991 and 1992 by the Advisory Services Department. Observations were made by RRISL staff and arrangements have also been made to assess the growth of rubber and tea plants (N Yogaratnam, S M M Iqbal, K Meegahawatta and P Samaranayake).

AGRICULTURAL ECONOMICS

P H M U Herath

SUMMARY

Studies conducted on the economic lifespan of rubber suggest that the present 30 year cycle appears to be acceptable.

The existing tax structure of the local rubber based industries was re-examined to identify the major constraints faced by the local product manufacturers. This study suggests a series of policy measures to rectify the ill effects caused by the present tax system.

Implications of various policy options were studied as the present income of the RRI based on rubber exports is inadequate for research. A supplementary research levy of 3% on imported rubber products appears to be the best long-term solution.

A survey conducted in the Ratnapura district reveals that non farm activities such as gemming, rain interference in tapping and some government policies such as Janasaviya have negative effects on the availability of tappers at smallholder level.

Most of the studies conducted by the Agricultural Economics Unit stress the importance of increasing the efficiency of labour productivity by way of technological improvements in particular to compensate for the escalating wage rate.

A study on rainguards showed that the return for investment on Apron type is higher than on the Gutter type. However, if sealent could be manufactured at less than Rs.20/Kg there will be no difference between the two types.

An econometric model of the world rubber economy was developed to explain the behaviour of the natural rubber price and its consumption share over time. The simulation results indicated that the model is quite capable of capturing most of the past behaviour of key endogenous variables. The estimated elasticities confirmed to prior expectation and suggest some insight into policy implications. Further, the magnitude of the estimated coefficients indicates that if the industry cannot respond very quickly to changes in price a divergent cob-web type fluctuation in rubber prices is possible.

DETAILED REVIEW

Staff

Mr H Thalgaswatta continued his PhD research work at Lincoln University, New Zealand and Mr I N Samarappuli, Assistant Agricultural Economist, his PhD programme at the PGIA in addition to attending to the work of the Unit. Mrs S Amaratunge completed her MA degree at Sri Jayawardenapura University and she was on secondment to the Ministry of Plantation Services since 11th of June 1993. Mr P H M U Herath, Assistant Agricultural Economist and Miss S Patabandi, Technical Officer were on duty throughout the year.

Training

Mr P H M U Herath was involved in training Rubber Extension Officers on some economic aspects of rubber industry and also conducted lectures for the students of Affiliated University Colleges of UVA and Vayamba.

Meetings and Seminars

I N Samarappuli addressed the following seminars/meetings:

1. The 5th Annual Congress of PGIA at Plant Genetics Resources Centre, Peradeniya, in November, on 'An Econometric Study of the World Rubber Economy'.
2. Planters' Association Meeting at Planters' Association in September, on 'Economic Lifespan of the Rubber Tree'.
3. Seminar on Further Incentives Needed for Rubber based Local Industries at the Scientific Committee Meeting (Technology) in October, on 'The Tax Structure, its Impact and Incentives Needed for Rubber Based Industries'.
4. The Technical Session of the AGRINET User Seminar held at the Training Centre, Nivitigalakele on 29th September 1993.

Mr P H M U Herath attended the progress review meetings of the Adaptive Research Unit and the meeting of the diagnostic team with rubber smallholders in the Agalawatta range on 23rd March 1993.

Scientific Awards

I N Samarappuli was awarded the PGIA Scholarship (based on merits) for academic year 1993/94.

I N Samarappuli's research presentation on 'An Econometric Study of the World Rubber Economy' was adjudged the best in the Session in Social Sciences at the 5th Annual Congress of the PGIA.

Publications

Samarappuli, I N (1993). An econometric study of the world rubber economy, *Tropical Agricultural Research*, Vol.5.

Samarappuli, I N. A proposed research cess on imported rubber products: some policy implications. *Sri Lanka J. of Agrarian Studies* (In press).

Samarappuli I N. The tax structure and its impact on local rubber based industries, *Ann. J. of NIPM* (In press).

Samarappuli, I N. An overview of the rubber industry, *Bull. Rubb. Res. Inst. Sri Lanka* (In press).

Samarappuli, I N. The natural rubber industry: Some key economic issues, *Bull. Rubb. Res. Inst. Sri Lanka* (In press).

Samarappuli, I N. Some technical and economic interactions between natural and synthetic rubbers, *Bull. Rubb. Res. Inst. Sri Lanka* (In press)

Samarappuli, I N. The automotive industry and the lowest cost producer: An evolving global concept, *Bull. Rubb. Res. Inst. Sri Lanka* (In press)

Samarappuli, I N. Marketing of natural rubber: a historical review, *Bull. Rubb. Res. Inst. Sri Lanka* (In press)

Samarappuli, I N (1993). A case study on world natural rubber economy. Submitted in partial fulfillment of the PhD degree, Postgraduate Institute of Agriculture, Peradeniya.

Reports

Thalgaswatta, H (1992). Annual Review of the Agricultural Economics Unit.

RESEARCH

Survey on production efficiency

A survey was conducted in the Ratnapura district to collect necessary data to study the technical and economic efficiency of rubber production in rubber plantations and smallholdings according to their farm size. Necessary data were collected from records and by interviewing farmers. Approximately 225 smallholders were interviewed. Twelve farmers were interviewed from each Rubber Extension Officer's (REO) range and 17 REO ranges were randomly selected from Ratnapura district. Preliminary analysis showed that the non farm activities such as gemming have had adverse effects on the rubber industry (H Thalgaswatta and P H M U Herath).

Developing a simulation model for rubber industry in Sri Lanka.

This programme mainly involves the development of a mathematical relationship between factors affecting rubber production. A comprehensive development of complete model will be a long term process. Initially, simulation was planned to conduct separately for different components of the production. Biological, local and foreign marketing trends, socioeconomic, political (policy decisions) and environmental factors were identified as main components that will affect the final output of rubber. Initially counting of all the biological aspects has been conducted. An explanatory model to include all the biological factors that are involved in the rubber industry was developed. Quantification of the effects of different biological aspects on production is being conducted in collaboration with other biological departments (P H M U Herath).

Study on tapping labour scarcity problem and its importance to the industry at smallholder level

Preliminary data in this regard were gathered from the survey conducted in Kegalle, Kalutara and Ratnapura districts and by literature survey. This indicates that the low tapping wage at smallholder level is the major factor governing this problem. Tapping labour problem is aggravated by non farm activities like gemming specially

in Ratnapura district and by rain interference. Apart from these, present government policies like rapid progress toward Garment industry development and janasaviya programme have had negative effects on tapping labour availability. Further studies have been planned based on Todaro model on this aspect. To quantify the effect of different factors, available literature was gathered on population dynamics and other relevant aspects. Results showed that commercialization programmes are essential to make the agriculture sector more efficient (P H M U Herath and H Thalgaswatta).

A Financial and Economic analysis on the use of rainguards

A detailed analysis was carried out in collaboration with Plant Science Department. This study revealed that the price of rubber and sealent and the intake per tapper are the main factors that will decide on the economic viability of rainguards. According to this study the return from apron type was higher compared to the gutter type under the present market conditions. However, this study further indicates that if sealent could be manufactured at half the present cost, there will be no difference between apron and gutter type rainguards. Hence, this study suggests that if the methodology on manufacturing sealent and training on manufacture is provided it would be more beneficial to the industry than allowing a single company to manufacture and sell. Current pest problem faced by apron type rainguards further justifies this suggestion as gutter type is less vulnerable to pest attack. Considering the severe rain interference in main rubber growing areas and consequent ill management practices at smallholder levels a subsidy scheme for rain guards is suggested. Part of the money already allocated to the present subsidy scheme could be diverted to the rainguards. Moreover, presently the demand for rubber wood is high and is expected to be high and stable in future also. Income from rubber wood could therefore be used for the replanting which would enable the proposed subsidy on rainguards to be implemented (P H M U Herath).

A study on the Cost of Production of the Dartonfield Estate

A detailed comparison of the (COP) between 1992 (up to August) and 1993 was carried out at the request of the Estate Department. This study indicates that despite the increase in wage rate by about 24 percent the revenue and general COP have increased by 3 and 9 percent respectively in 1993 compared to 1992. This is mainly due to the increase in yield by around 28 percent in 1993 compared to 1992. Increase in land productivity due to proper management practices may have lead to this improvement (P H M U Herath).

Economics on the use of some fungicides to control white root disease

The necessary information collection was initiated by mail survey (P H M U Herath).

Environmental aspects on the economic lifespan of rubber

A detailed study on this aspect has been conducted. Accordingly, cost of production (COP) is one of the major factors that will decide on the economic life of rubber. Tapping labour component of the COP is important as it accounts for around 30 to 40 percent at estate level and around 70 percent at smallholder level. In future this component is expected to increase further. Hence, shortening the life cycle on the basis of direct cost and benefits is not advisable. The indirect benefits from the rubber plantations should also be taken into account. Contribution from rubber to conserve and improve the environmental conditions must be given strong considerations. The study stresses the fact that the development programmes should be sustainable. Decisions to shorten the cycle may cause irreversible damages to the environment. Hence, the study suggests to continue with present 30 year period cycle with proper measures to reduce the cost of production. Replanting at 3 percent rate with suitable high yielding clones should be accelerated. Developing proper mechanical ways of tapping is also important to reduce COP (P H M U Herath).

Economic life span of rubber

An analysis was done to assess the optimum lifespan of the rubber tree using the economic principles of optimum replacement. A stream of practical situations, viz. interest rates, technological changes, output prices and government policy variables were taken into consideration. A set of time series yield data collected from public sector estates by the Genetics and Plant Breeding Department with respect to 3 clones; PB 28/59, RRIC 100, PB 217 were used for the analysis. The important findings of this study can be summarized as follows;

- (a) A unique optimum lifespan cannot be determined for rubber
- (b) The economic lifespan varies with :

Technological changes : Yield pattern (clone) Agronomic practices (Tapping systems, Length of immaturity, Intercropping patterns).

Policy Decisions : Interest rates
Subsidy rates
Tax rates

Prices : Output (Rubber, Timber)
Inputs

- (c) The long run average profit curve becomes much flatter or stabilizes around the optimum date of replanting. This implies that the loss from choosing an arbitrary, sub optimal date, a couple of years either side of the optimum has very little effect on the average profits in the long run.
- (d) The timing of the effect of technological change is critically important.
- (e) Innovations which allow rubber to be tapped earlier and raise yield in the early years (virgin panel) are much more important to the long-run viability of the industry than the effort to raise yield during the tapping in renewed bark.
- (f) Intercropping is more important in its effects on profitability than the introduction of stimulation. The reason for this is the timing of these two types of technology.
- (g) A reduction in lifespan will have a greater positive impact under following conditions.
 - Higher yield in the early years
 - At high replanting subsidy rates
 - A substantial additional income from Intercropping
 - At reduced immature period
 - Flexibility in adopting new technologies
- (h) Introduction of wood as an important by-product is likely to have no impact on optimum replacement dates at existing market prices (I N Samarappuli).

The Tax Structure of the Local Rubber Based Industry

A study was done to re-examine the existing tax structure of the local rubber based industries with a view of safe guarding the local producers. The important policy implications and suggestions arrived from this study are stated below;

The current system of indirect taxes appears to be complex in nature. The product is taxed at each stage of the chain from primary producer to final consumer. The tax rate also varies with the product. Hence, administration of indirect taxes has become difficult both from an organization and government's point of view. Small scale producers who may violate the tax payments have caused a threat to competitive and loyal companies. The recent fiscal measures have affected adversely on the domestic rubber product manufacturing industry. The increases in indirect taxes have been directed primarily towards the manufacturing sector as opposed to trading. Table 1 shows how, an imported rubber product with a CIF price equivalent to the manufacturing cost of locally produced item would be priced by allowing a same profit mark-up in value terms. It is evident that the present tax system induces local producers to shift from manufacturing to trading which will defeat the successful implementation of the industrialization policy of the government.

On the other hand, the rubber products industry is capital intensive and it needs modern technology (machinery and equipment) to produce quality products of international standards. This issue will become important with the introduction of ISO 9000, which will come into operation in year 1994 in all the EEC countries. Presently large scale exporters (exporting more than 50% of their products) are given duty relief for capital investment (eg. machinery and equipment). Small scale exporters or domestic manufacturers seeking to improve their products by using improved technology are not provided with such relief facilities. As a result, domestic manufacturers are compelled to keep the prices low by sacrificing the quality of the product in order to compete with imported substitutes since they can not afford to invest on high tech machinery to improve their products. Consequently, domestic manufacturers cannot either improve their products or expand their enterprise. Therefore, a measure of relief need to be provided to domestic manufacturers to finance purchase of capital goods. Further, duty concessions given to export oriented companies on capital investment should be extended to local manufacturers to improve the quality of their products. This will also create a platform to test their products locally before expanding to capture the export market.

The following guidelines may be of paramount importance in formulating the policy decisions to rectify the detrimental impact of the present tax system.

1. Exempt the import of the plant and machinery from duties and cess irrespective of whether the project is export oriented or not.
2. A measure of relief is needed to be given to finance the purchase of capital goods to partially off-set the impact of prevailing (very high) interest rates.

Table 1. *Formulation of Selling Price: Manufacturing vs Importation*

Duty Rate	Imported								Local
	50%	40%	35%	30%	25%	20%	15%	10%	
Cost/CIF	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Duty	50.00	40.00	35.00	30.00	25.00	20.00	15.00	10.00	
Cess	5.00								
Profit	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
TT & DL – Point of Import	43.13	40.25	38.81	37.38	35.94	34.50	33.06	31.62	0.00
Excise Duty	10.44	9.69	9.40	9.15	8.88	8.61	8.35	8.07	10.42
TT & DL – Point of Sale	2.61	2.42	2.36	2.29	2.22	2.15	2.08	2.02	47.92
Selling Price	261.19	242.37	235.59	228.82	222.04	215.26	208.48	201.71	208.33

Basis of Calculation:

CIF = Cost of manufacturing

Profit : same for both Imported and Local products

Excise duty : Imported goods = 5% of Whole sale price (i.e. whole sale price = 80% of selling price)

: Local goods = 5% of selling price

Turnover tax + Defence levy : at point of import = [(CIF + Duty) x 125%] x 23%

: at point of sale : Imported Items = 1% of selling price

: Local Items = 23% of selling price

3. Impose a minimum of 50% duty coverage for imported substitutes for a period of 5 years to allow the domestic industry to develop. A similar policy adopted in Japan to protect the domestic automobile industry has shown fruitful results.
4. The indirect tax structure should be revised as follows.
 - a) A less complex indirect tax system should be devised.
 - b) One system of indirect tax system for all rubber products would be ideal as opposed to a system of turnover taxes, defence levy and excise duty.
 - c) The turnover taxes should be reduced to a more realistic level. A partial reduction in the indirect tax component from 28% to 8% may be sufficient to offset the adverse effects of the present tax structure (This is identical to the removal of manufacturer's turn over tax of 20%)
5. Any relief/rebates of duty on imported raw material (used in local manufacture) would encourage further investment on the rubber manufacturing industry (I N Samarappuli).

Econometric Study of the World Rubber Economy

An econometric model of the world rubber economy was developed to explain the behaviour of the natural rubber price and its consumption share over time. The model presented is focussed primarily on market for natural rubber. The supply equations were directly estimated for all major rubber producing countries. The demand for natural rubber was determined in two steps. Firstly, the joint demand was computed for natural and synthetic rubber with respect to different regions. The demand for natural rubber was then derived with a set of market share equations using the Nerlovian partial adjustment model. The data from the period 1975–1992 were used to estimate all the behavioral equations.

The simulation results indicate that the model is quite capable of capturing most of the past behaviour of key endogenous variables, viz. supply, demand, stocks and prices of the world natural rubber economy. The estimated elasticities confirmed to prior expectations and suggest some insight into policy implications. The inelastic short run supply price elasticities suggested that the producers adjust their production to some extent in response to changes in market prices. The response was more pronounced in countries where bulk of the production comes from smallholdings.

The computed short run price elasticities for the market share of NR with respect to relative rubber prices indicated only a marginal influence on the decision to select among two types of rubbers. Yet, this impact was much stronger in the long-run. Moreover, both short and long run elasticities were much lower in developed countries as opposed to developing countries largely due to the vertically integrated nature of the tyre industry that appear in developing countries.

The magnitudes of the estimated coefficients indicate that if the industry cannot respond very quickly to changes in price, a divergent cob-web type fluctuation in rubber prices is possible (I N Samarappuli).

Inadequacy of Cess Income for the management of the RRI

The present research cess income of the RRISL generated from raw rubber exports is not only insufficient to carry out research activities but is also declining at a rate of Rs.1.6 million per year, particularly due to marked increase in domestic consumption (Figure 1). A study was therefore undertaken to investigate the implication of four policy options, viz annual grant from the treasury, research cess on exported raw material, research cess on domestic consumption and research cess on imported substitutes. The study reveals that a supplementary research cess of 3% on imported rubber products appear to be the best long term solution. The proposed cess mechanism comprises of the following unique advantages/characteristics;

1. Protects the local manufacturers against competitive imported substitutes.
2. Similar protective strategies are being implemented in many parts of the world (even in Japan, U.S.A, E.E.C) to develop the domestic industry.
3. Encourage local manufacturers to invest more on technology (machinery and equipment) to improve their products.
4. Motivate local consumer to shift from expensive imported products (due to the proposed cess) to relatively cheap local substitutes.
5. Provide a platform to test the products locally, before competing with overseas industries in gaining international markets.
6. It neither imposes any adverse impact on manufacturers producing for the export market nor on treasury funds.
7. RRISL can invest more funds to develop the most appropriate technology to produce quality products equivalent to international standards.
8. Provides a long term solution to the operational activities of the RRISL by easing its severe financial constraints.
9. A similar dual cess mechanism (import cess + domestic cess) is already in operation to finance the SRI. Introduction of a research cess on imported sugar in 1992 (@=10 per Kg) to supplement the existing research cess on locally produced sugar (@=10 per Kg) has improved the financial situation of the SRI to a greater extent.

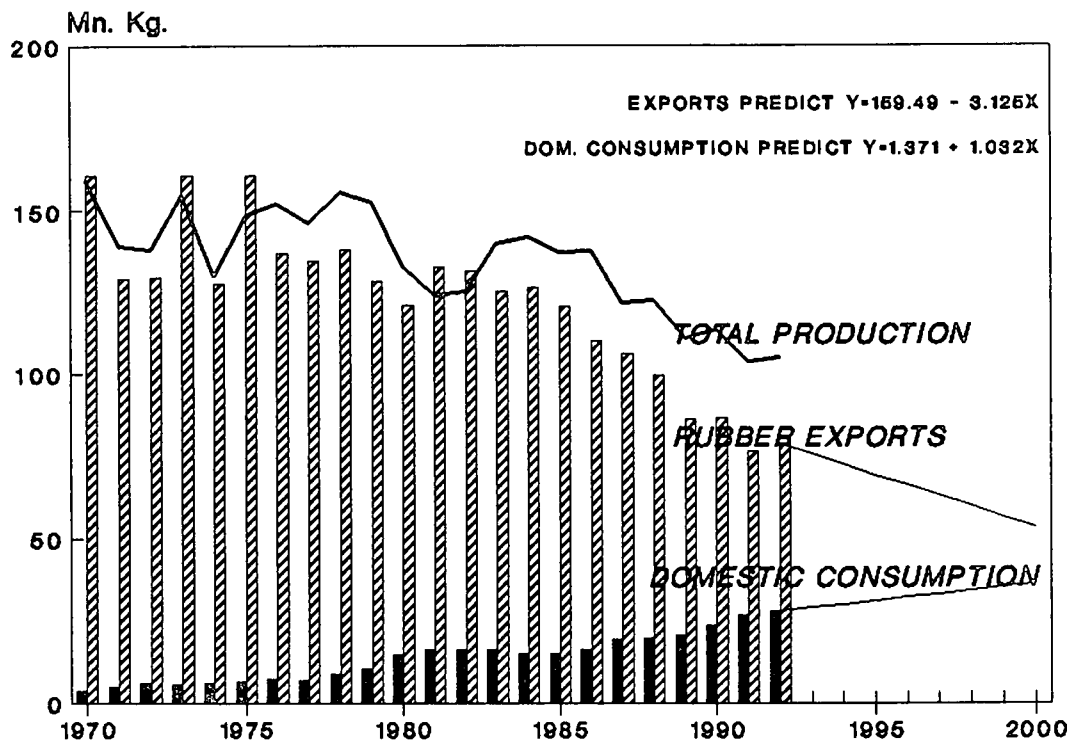


Fig. 1 Rubber Production, Exports and domestic consumption (1970-2000)

10. Reinforce the government's long term vision to establish Sri Lanka as a rubber products manufacturing center in the region.
11. The proposed cess falls in line with the government's national policy of achieving NIC status by the year 2000 (I N Samarappuli)

Performance assessment survey on society development

A survey was conducted in late 1993 in collaboration with the Advisory Services Department to study the Socio-Economic impact of the IRDP assisted rubber smallholder societies (K Meegahawatta, P Samaranayake and I N Samarappuli).

Response Function Analysis

Further analyses were conducted to derive the response function for girth and yield to assess the optimal fertilizer combination for immature rubber, grown under different management systems. The results of this study are given under the respective reviews of Soils and Plant Nutrition Dept. and the Biometry Unit (I N Samarappuli, W Wijesuriya and L Samarappuli).

A Computer Model to Assess Agro-climatic feasibility for Rubber Cultivation in Sri Lanka.

Preliminary data are being collected in compiling parameter files to develop a user friendly computer model to assess the agro-climatic stability for commercial scale cultivation of rubber. The model determines to cover all rubber growing agro-climatic regions and intends to accommodate changes in suitability indices (I N Samarappuli, W Wijesuriya, N Yogaratnam and L Samarappuli).

Statistical Modelling on Run-off Studies

Experimental data available in the Soils and Plant Nutrition Dept. on soil erosion studies were re-analysed using standard statistical and econometric procedures. The statistical methods involved; principal component analysis, canonical discriminant functions, logistic functions, path analysis and regression procedures. The estimated mathematical models quantify the physical and biological relationships that exist among the variables. The direction and the magnitudes of the estimated coefficients provide valuable information for policy studies on land utilization in particular (I N Samarappuli, W Wijesuriya, N Yogaratnam and L Samarappuli).

Collaborative Research Project on Land degradation

Preliminary analyses were done in consultation with Dr Anura Ekanayake and Dr Sisira Jayasuriya with respect to land degradation of rubber growing areas using historical data available in the Soils and Plant Nutrition Department of the RRISL (Agric. Economic Unit in collaboration with the La Trobe University and Ministry of Plantation Industries).

Developing Commercially Viable Livestock Based Farming Systems for Sustainable Agriculture in the Rubber Growing Districts of Sri Lanka

The Specific Objectives of this Study are as follows:-

- a) Determine the types of farming system practiced by the small farmers in the rubber growing districts in relation to the land use patterns, type of crops-livestock, tenure patterns, management patterns of crops and livestock, input use, markets, prices received for farm produce and income earned.
- b) Develop a conceptual and analytical whole farm model on the existing farming systems practised in the study area.
- c) To suggest suitable policy alternatives to improve the farming system towards a sustainable market/export oriented enterprise.

In addition to collection of secondary data a questionnaire has been designed and pre-tested to conduct a detailed field survey on rubber growing districts, viz Kegalle, Kalutara, Ratnapura, Gampaha and Colombo (I N Samarappuli, C Bogahawatta).

Feasibility Study on the Rubber Wood Industry in Sri Lanka

Arrangements have been made to conduct a comprehensive study on the rubber wood industry. The study intends to cover the following aspects in particular, *ie* supply potential, export and domestic market, present and future users, processing techniques, machinery and infra-structure requirements, opportunities and constraints, integrated management systems at both smallholder and plantation level, Financial and Economic evaluations (I N Samarappuli, L M K Tillekeratne, S W Karunaratne).

Database on Rubber Industry

The statistical data already available are being updated under this programme. Information regarding the different organizations pertaining to the rubber industry were also collected (S Amaratunge and S Damayanthi).

Survey on Group Processing Centres

A detailed study of the group processing and latex collecting centres was carried out in Kalutara, Kegalle and Kandy districts. A report on this study was submitted to the Ministry of Plantation Services (S Amaratunge).

BIOMETRY

Wasana Wijesuriya

SUMMARY

The major role of the Biometry Section is to assist the Research Departments in designing of experiments, analysis and interpretation of results. Other services included providing graphic and word processing facilities for various kinds of reports and audio visuals, management of databases and documentation of computer programs for routine work of other Research Departments.

Preliminary analyses were conducted to investigate the possible approaches to minimize the initial variability in field experiments. Neighbouring plots in the analysis of covariance and block effect as a covariate in response surface regression have been tried in order to increase the precision of experiments.

The seasonal variations in yield of different *Hevea* clones were studied to develop a suitable basis for accurate estimation of annual yield with fewer number of observations.

Statistical modelling of girth in *Hevea* during the immature period was also carried out. The merits of response surface regression over mean separation procedures in finding the optimum levels were highlighted.

The meteorological station at Dartonfield and the computer database were maintained satisfactorily.

DETAILED REVIEW

Staff

Ms Wasana Wijesuriya was attending to the duties of Assistant Biometrician while continuing the postgraduate studies at PGIA. The Senior Technical Officer, Ms Nandani Wanigatunga and Mr M A Bodhiwansa, who joined the Biometry Section on 1st of January as a Technical Officer, were on duty throughout. Ms Chintha

• Munasinghe, Technical Officer from the Department of Rubber Technology continued to work in the Biometry Section from 12th January.

• **Workshops**

Ms Munasinghe and Mr Bodhiwansa attended the workshop conducted by the Department of Meteorology during 22nd to 27th July 1993 on "Recording and Maintenance of Meteorological data".

Publications

Wijesuriya, W, Jayasekara, A A, Sanmuganathan, K (1993). The impact of changes in land use for sugarcane cultivation in Reddish Brown Earth (RBE) soils of Sri Lanka. *Proc. Int. Seminar on Managing Red and Lateritic Soils for Sustainable Agriculture, Bangalore, India.*

Staff Training

A training programme was organized by the Biometry Section on 7th and 8th of December on the preparation of Annual Review drafts using Word Perfect, for Departmental Typists.

• **Statistical Services**

• Biometry Section assisted the Research Departments in their routine research work and the University students in their short term projects in designing and layout of experiments, analysis and interpretation of results.

Computing Services

Programming

The computer program developed for the soil and foliar programme of the Department of Soils and Plant Nutrition was re-structured according to their routine needs.

• *Word Processing*

• Technical support was provided in Graphic and word processing facilities for preparation of reports and audio visuals.

Database Management

The following databases were maintained.

- Daily meteorological observations of the Dartonfield station.
- The payroll, project and personnel information of RRI scientists.

RESEARCH

Response Surface Analysis for Fertilizer Experiments

The idea of conducting fertilizer experiments is to identify the values of factor variables that optimize a response. Application of response surface regression enables the prediction of the optimal values from the estimated surface. It also provides information to indicate the direction in which new experiments should be performed if the estimated surface is complicated or if the predicted optimum is far from the region of experimentation. Therefore, re-analysis of past records from fertilizer experiments was done to find the optimum levels of the major nutrients N, P and K.

Data obtained from a fertilizer experiment (Exp. No. SM/83/1) carried out by the Department of Soils and Plant Nutrition were used to study the response to applied N, P and K under different mulching techniques in collaboration with the Department of Soils and Plant Nutrition and Agricultural Economics Unit. A comparison of best levels obtained from response surface regression and ANOVA followed by mean separation procedures is given in Tables 6 and 7 (Review Soils and Plant Nutrition).

The response surface analysis provides a clear insight into the beneficial impact of mulching that can be used effectively in optimizing girth during the initial stages of *Hevea* by using appropriate N, P and K levels. Further, these optimum levels can be incorporated into the future experiments to come up with reliable recommendations. The use of block effect as a covariate was found to be effective in reducing error sums of squares in response surface regression.

This study will be extended to find the economic optimums of the yield response function with respect to the applied N, P and K under different mulching techniques (W Wijesuriya, I N Samarappuli and L Samarappuli).

Statistical Modelling

Four non linear models namely; Logistic, Asymptotic, Negative Exponential and Gompertz were tested using data on girth during the immature stages of *Hevea*. The criteria employed for model adequacy were; residual mean squares, asymptotic

standard errors, residual plots, ratio of regression sums of squares to the uncorrected total sums of squares and the confidence limits of parameter estimates. Considering the above criteria, the Logistic model;

$$Y = \alpha / (1 - e^{\beta - \gamma X})$$

was found to be the best fitted model to explain the variation of girth (Y) with time (X) during the initial stages of rubber which will be helpful in predictions.

This programme will be continued to decide on application of non linear modeling for yield and yield density relationships.

Seasonal Variations in Yield of Different *Hevea* Clones

The seasonal variations in yield of rubber were studied in order to identify different strata for sampling aspects to estimate annual yields with fewer number of observations.

The yield of *Hevea* showed seasonal variations. The four seasons, viz peak yielding (Nov-Jan), high yielding (Aug-Oct), wintering (Feb-Apr) and post wintering (May-July) were similar for all the clones studied (Fig 01). Hence, these seasons can be considered as different strata for sampling aspects.

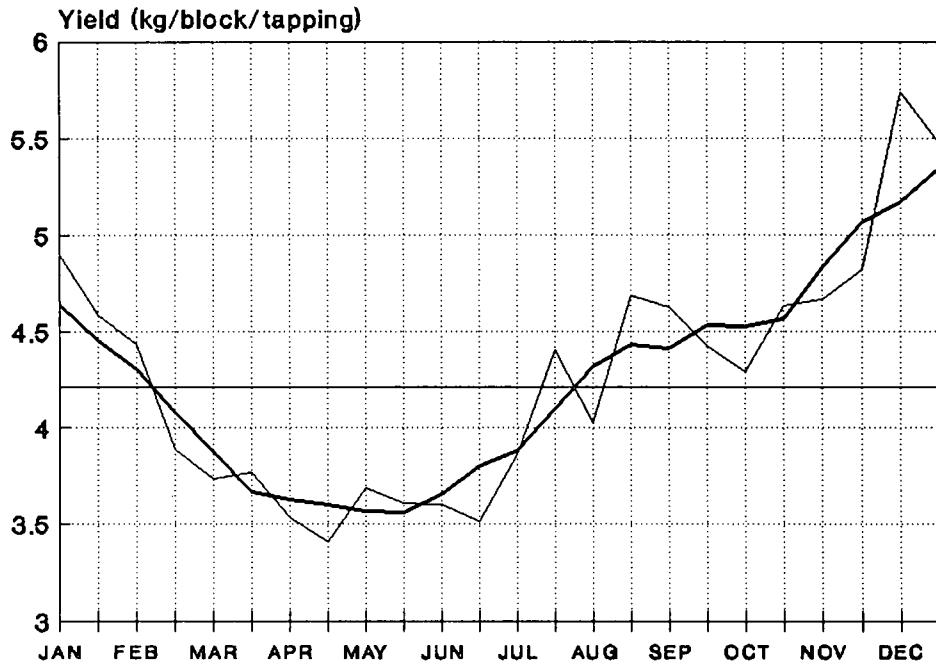
The Coefficient of Variability (CV%) for yield stabilizes around 15% when the sample size approaches 8 which suggest that increasing the sample size beyond 8 will not gain substantial precision in results. Further analysis will be continued to recommend suitable sampling points for accurate estimation of annual yield. This study will be extended to other rubber growing areas.

Possible Approaches to Minimize the Unexplained Variability in Experiments

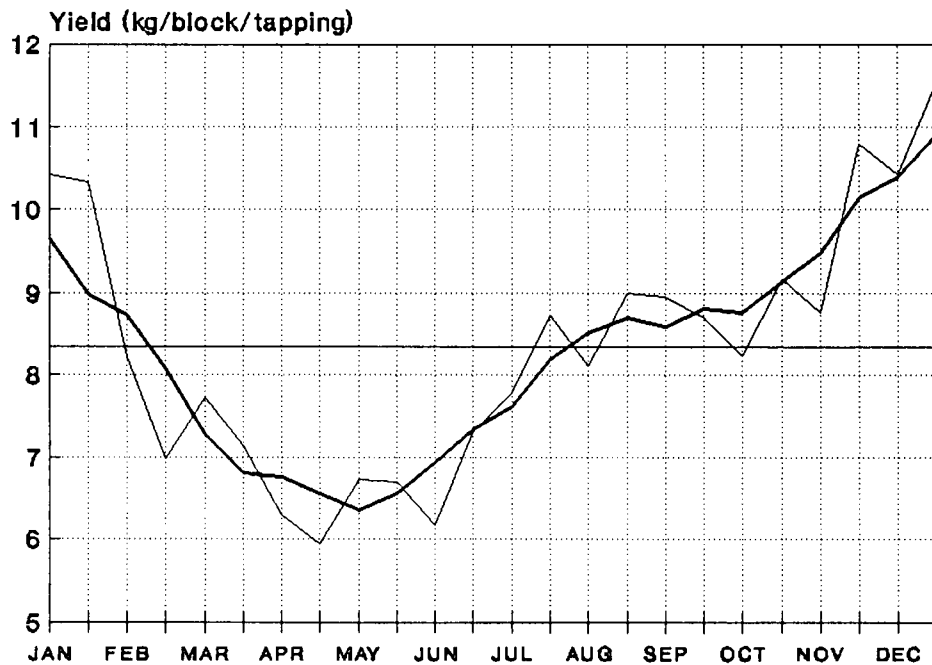
Preliminary approaches were made to evaluate the suitability of Nearest Neighbor methods to increase precision of field experiments. Past data of several experiments conducted by the Department of Soils and Plant Nutrition were used in this study.

The following conclusions can be drawn from the preliminary findings of this study:

1. Adjusting for nearest neighbours by Analysis of Covariance (ANACOVA) gave substantial increase in efficiency compared with no local control.
2. The improvement in efficiency is more when the block size is large where blocking itself will not provide good local control.



RRIM CLONES

Fig. 1 Seasonal Variation in Yield of *Hevea*

Meteorological Summary - 1993

The rainfall distribution during 1993 followed a typical bimodal pattern with a total of 4615 mm. Relatively dry weather occurred during the months of January and February. Rest of the months received rains higher than the 75% expected values Fig. 1 (Fig. 02). The highest rainfall was observed in May which is more than two times the expected value at 75% probability.

The rains experienced during different rainfall seasons with their expected values are presented in figure 03. The North - East rains, as usual, were experienced during the period of mid January at full strength (NEF) followed by a period of 2 months at partial strength (NEP). In general, the first inter-monsoonal period commenced from late March and extended to early May (IM1).

The South-West rains during 1993, contributed 42.53 % to the total rainfall. Nearly 50% of this amount was experienced during late May (South West as Partial Strength-SWP1). The second inter-monsoonal period (April-Early Nov/IM2) also contributed a significant amount (26.73%) to the total.

The North-East monsoon of this year started in mid November as expected and contributed 13.93% to the annual rainfall.

The number of rainy days in each month, the average number of rainy days during 1965-1991, the expected values at 75% probability and number of rainy days in 1993 under each category are listed in Table 01.

The monthly variations of other important meteorological factors are presented in figure 04 (W Wijesuriya, N Wanigatunga, C Munasinghe and M A Bodiwansa).

Table 01. *Monthly Variation of Rainy Days*

Month	Mean*	Expected Value(75%)*	0.3–2.5mm	2.5–50mm	>50mm	Total
January	10	07	01	03	–	04
February	09	06	02	–	–	02
March	17	13	01	12	–	13
April	21	18	–	16	–	16
May	24	21	01	16	08	25
June	24	22	03	17	03	23
July	22	19	04	19	01	24
August	21	17	05	16	01	22
September	22	19	04	14	01	19
October	22	19	01	16	07	24
November	20	17	04	14	03	21
December	17	14	02	16	01	19

* Period 1964 –1991

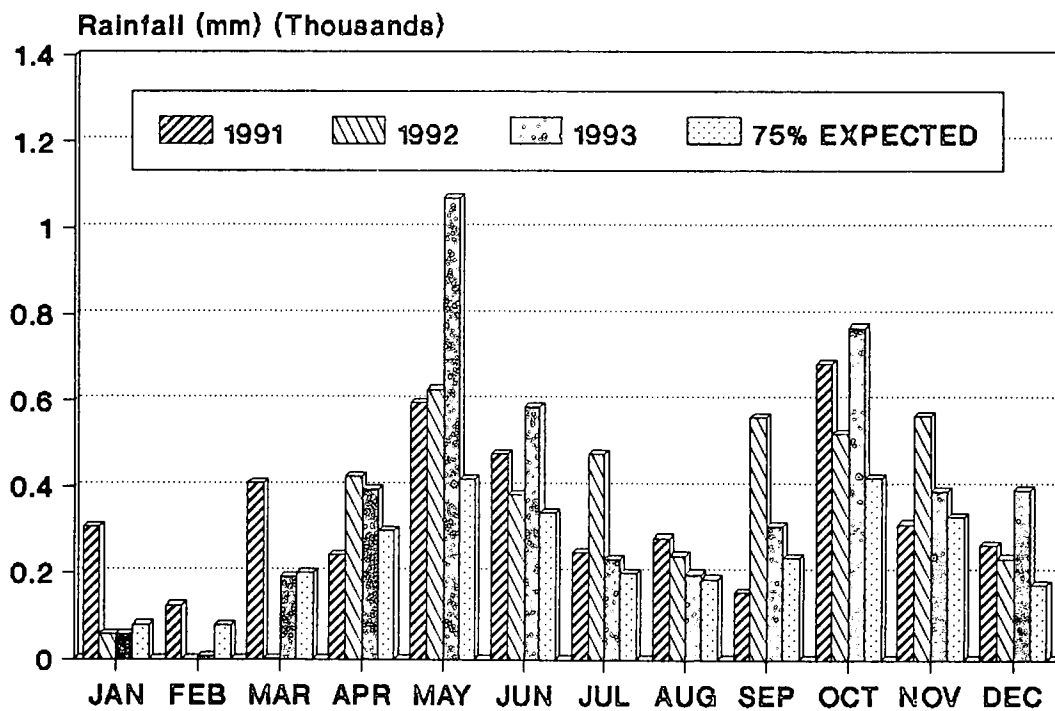


Fig. 2 Rainfall Distribution at Dartonfield

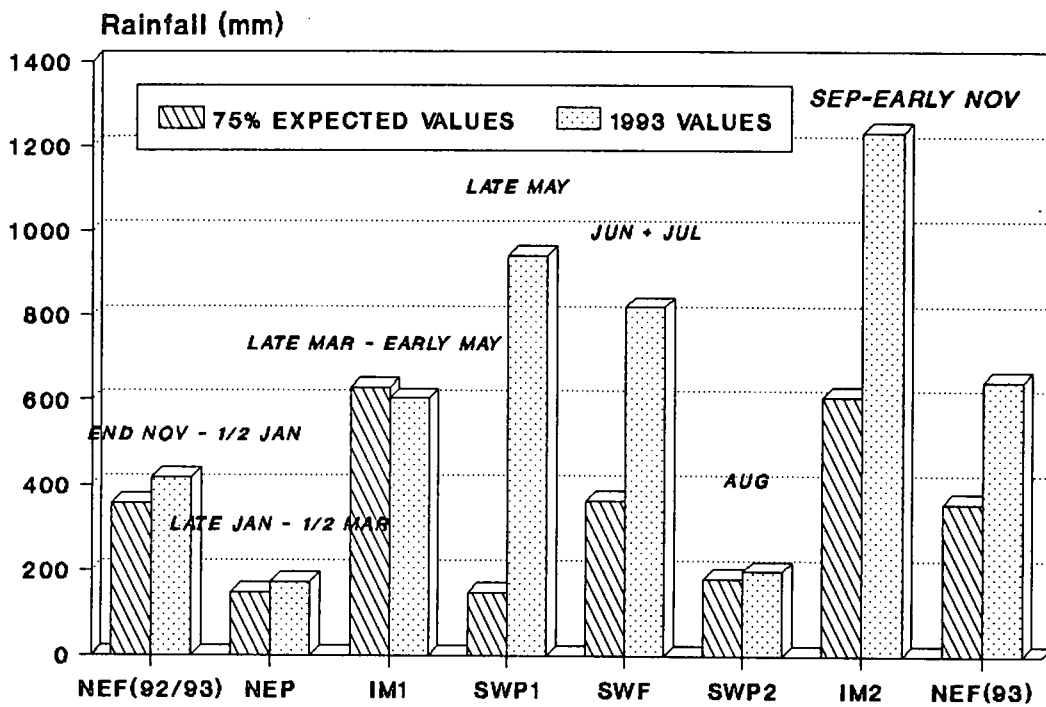


Fig. 3 Distribution of Rainfall in different Rainfall Seasons

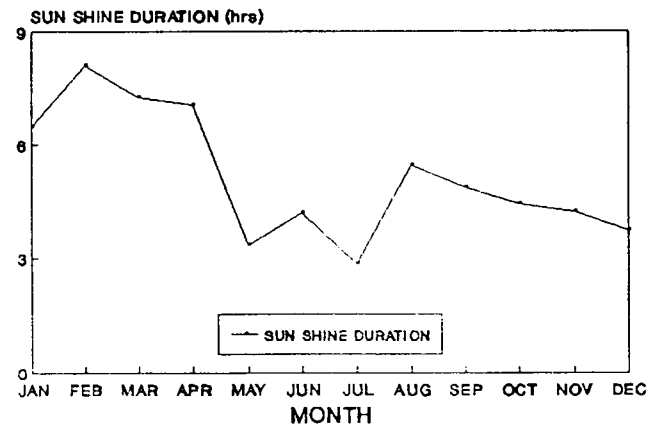
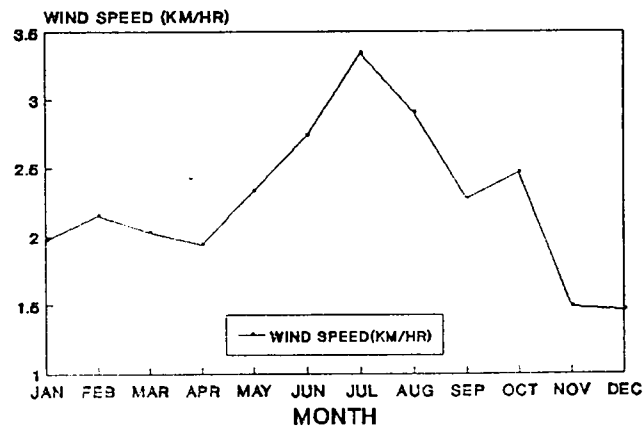
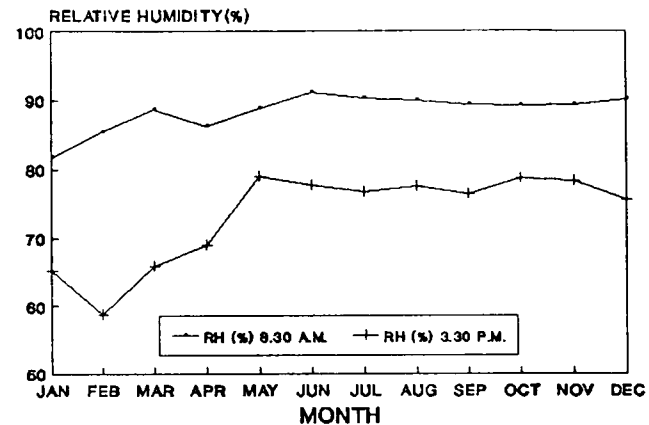
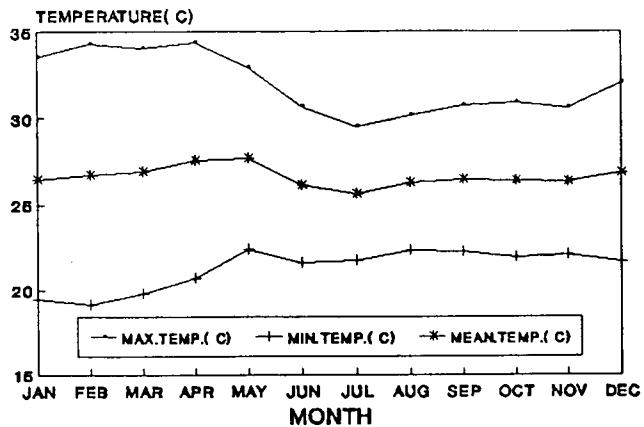


Fig. 4 Monthly variation in observed meteorological factors at Dartonfield

LIBRARY AND PUBLICATIONS

Kamani Perera and Ramani Amaratunga

SUMMARY

Main functions of the Library and Publications Section such as maintaining, processing and publishing of Institute's regular publications and collecting and disseminating of Information on natural rubber and related areas have been carried out throughout the year.

DETAILED REVIEW

Staff

Mrs Kamani Perera, Librarian and Publications Officer was on duty throughout the year except during the period 27th October to end of December. Mrs Tilaka Dantanarayana, Library Assistant and Assistant Publications Officer (Colombo Office), Mrs Ramani Amaratunga, Clerk/Typist, and two Library Attendants were on duty throughout the year.

Acquisitions

Books and Periodicals

With the addition of 67 acquisition, book collection increased to 4559 and the bound volumes to 2735.

The Library subscribed to 64 Journals and about 48 other Journals were also received as gift/exchange. RRI is grateful to all these persons and organizations who continually donate documents to the RRI Library collection.

Seminars/workshops

Mrs Kamani Perera, the Librarian and Publications Officer, attended the following seminars/workshops regarding Library and Information Science.

AGRINET Librarian's meeting held on 11.02.93 at CARP Office, Colombo.

Workshop on "Agricultural Information Technology" held on 08 March – 12 March at IIMI, Colombo.

AGRINET Librarians' meeting held on 13.05.93 and 10.09.93 at the CARP Office, Colombo.

The Librarian and Publications Officer presented a paper on "Information sources in Agricultural Science for AGRINET Users" at the AGRINET Seminar held on 29.09.93; Auditorium, Training Centre (ASD), Nivithigalakele, Matugama.

Reports

Perera, Kamani (1991). Review of the Library and Publications Section. Annual Review, RRISL, 1992.

Publications

Processing and publishing of RRISL publications were continued. The following publications were published during the year.

Annual Review 1992
RRISL Bulletin Vol.29, 1992
RRISL Journal Vol.71, 1991 (In press)
Rubber Puwath Vol.16, 1993 (In press)

Furniture etc.

A catalogue Card Cabinet from Gaylord Bros., USA and 05 Nos. Book holders (Metal) were purchased during the year.

AGRINET Services

The 3rd AGRINET User seminar was held in the Auditorium, Training Centre, ASD, Nivithigalakele for the RRI Scientist on 29.09.93.

Information Services

The Library continued to maintain a good collection of documents on rubber and related areas. Various services were provided based on the information intake. The Library and Publications Section also organised procurement of photocopies, news clipping services, CAS, SDI service *etc* with a view to disseminating the right information to the right user at the right time.

DARTONFIELD GROUP

A Nugawela

SUMMARY

Although weather conditions were not conducive for tapping, a crop of 123 511 kgs was harvested during the year which is an increase of 1% over the estimated crop for the same period.

The actual yield per hectare (YPH) and the average intake per tapper for the Group were 918 and 5.7 kg respectively. The highest intake per tapper recorded during the year was 17 kg from 250 trees in the 1981, RRIC 121 area at Gallewatta Division.

The average number of normal, late, double and no tapping days for the Group were 198, 56, 16 and 115 respectively. The total rainfall and number of wet days were 11 and 19 percent higher than in the last year respectively. A crop loss of about 25-30 per cent may have resulted from the rain interference.

The cost of production and the net sale average for the year 1993 were Rs.35.15 and Rs.39.01 respectively. This enabled to record a profit of nearly Rs.500 000 from the total revenue area.

The manufacture records during the year reveal that the latex grade 1 percentage is around 85.

A total extent of 7.98 ha was replanted in the Dartonfield Division. An extent of about 1 ha in the 1.30 ha mixed 1993 clearing of the Dartonfield Division was inter-cropped with Banana.

Uprooting of around 38.25 ha of old rubber in the Dartonfield Group is in progress and an income of about Rs.198 108.50 was generated from the sale of trees. 3643 and 117 yards of budwood of clones RRIC 100 and RRIC 102 were issued to smallholders of the area, respectively.

DETAILED REVIEW

Staff

Mr V M Katugaha, Estate Superintendent resigned with effect from 11th February 1993. Dr A Nugawela, Head Plant Science Department, and Mr T H Wijesena, Assistant Administrative Officer, were appointed to overlook the duties of the Estate Superintendent. Mr T H Wijesena retired from duties on the 6th November 1993.

Mr S A L Chandrawansa, Chief Clerk, resigned to take up duties as Chief Clerk of the Works Section of the Institute with effect from 8th April 1993. He was appointed to act for the Chief Clerk, Estate Department, until a suitable replacement is made.

Mr K K P Gunawardena, Senior Assistant Clerk, Mr A K D Wickramasinghe, Junior Assistant Clerk, M/S H M J Premalal and S K S de Silva, Field Officers, Mr J A Wimalasena, Assistant Field Officer, M/S S R Vadivel, T Somaratne and N L D Reggie, Field Supervisors, Mr D S K Ranaweera, Rubber Factory Officer, Mr W D D Senanayake, Factory Supervisor, M/S A K D I Rukmal, J K Nakandala, K A Sarath Kumara and B M Siriwardena, Assistant KPP, Mrs C S Hettiarachchie, Creche Attendant and Mr K Piyasena, Office Peon, were on duty throughout the year. Mrs C Dissanayake, Junior Assistant Clerk, was on maternity leave from 10th March 1993 to 26th June 1993.

The Group cadre stood at 18 at the end of the year, made as follows;

Senior Staff	01
Assistant Staff	16
Minor Staff	01
Total	18

Hectarage

A Summary of the Hectarage is given in Table 1.

Table 1. *Land distribution in Dartonfield Group*

	Dartonfield	Galewatta	Nivitigalakele	Total
Mature area	9.90	100.85	44.84	155.59
Immature area	20.90	39.55	—	60.45
Uprooting area	10.38	27.87	—	38.25
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 Building	2.08	—	—	2.08
Streams	—	0.84	—	0.84
State Land taken-in	0.27	—	—	0.27
	73.14	185.50	73.24	331.88

Crop

The yield per hectare (YPH) data for last 5 years is given in Table 2. The average yield per hectare of the Group has increased by 7% from that of the previous year. Also it is higher than the estimated crop for the year. It should be mentioned that the entire estimated tappable hectareage was not tapped, though it has been used to calculate the yield per hectare. The yield per hectare of the three divisions and of the Dartonfield Group, based on actual tapping extent is given in the Table 3.

Table 2. *Yield per Hectare (kg) records from 1988 to 1992*

Division	Year				
	1993	1992	1991	1990	1989
Dartonfield	605	605	709	696	612
Galewatta	792	740	636	805	795
Nivitigalakele	841	771	632	929	706
Average	794	740	640	866	738
Estimated	786	883	715	740	700
Tapping Hectarage	155.59	135.13	145.14	108.00	107.00

Table 3. *Yield per Hectare (kg) based on estimated and actual tapping extent*

Division	YPH (kg) based on	
	Estimated Extent	Actual Extent
Dartonfield	605	943
Gallewatta	792	958
Nivitigalakele	841	841
Dartonfield Group	794	918

The actual yield per hectare for the Dartonfield Group is 918 kg and would have been even better if not for the unfavorable weather conditions for tapping that prevailed during the year.

A monthly breakdown of the actual YPH (kg) in each Division is given in Table 4.

Table 4. *The YPH (kg) recorded during each month in year 1993 in the different Divisions*

Month	Dartonfield	Galewatta	Nivitigalakele
January	140	109	120
February	70	67	79
March	86	65	80
April	62	56	47
May	31	25	16
June	48	58	36
July	72	94	81
August	100	120	109
September	73	81	59
October	56	73	38
November	87	98	83
December	119	111	93

From Table 4 it is evident that the YPH in cropping months, *ie* May to December, is less than the potential. This could be attributed to weather conditions not being conducive for tapping (Refer Tables 8 and 9). A total crop of 123 511 kg were harvested from an extent of 134.50 hectares during the year. This is 1 161 kg above the estimated crop for the year 1993. A Division wise breakdown of the estimated and actual crop (kg) harvested is given below in Table 5.

Table 5. *A Division wise breakdown of the crop (kg) harvested during 1993*

Division	Estimated	Actual	%Increase(Decrease)
Dartonfield	6 120	5 992	(2.1)
Gallewatta	77 240	79 797	3.3
Nivitigalakele	38 990	37 722	(3.3)
Total	122 350	123 511	1.0

The average intake per tapper for the Group during the year is 5.97 kg (Table 6). This is a 22% increase over the average intake per tapper in the year 1992.

Table 6. *The average intake per tapper, division wise for years 1992 and 1993*

Division	1992	1993	Percentage increase
Dartonfield	5.15	6.96	35.1
Galewatta	4.78	6.06	26.7
Nivitigalakele	5.06	5.67	12.0
Group Average	4.90	5.97	22.0

Manufacture

A summary of the manufacture records during the year is given in Table 7.

Table 7. *Details of the crop manufactured in Dartonfield Group (Aggregate of Latex and Scrap percentage)*

	Total (kg)	Latex %	Scrap %	Crop %
Pale Crepe No.01	95 658	85.5	–	77.5
Pale Crepe No.03	16 246	14.5	–	13.1
Scrape Crepe No.01	8 338	–	72	6.8
Scrape Crepe No.02	3 001	–	26	2.4
Scrape Crepe No.03	268	–	2	0.2
Total	123 511	100	100	100

The grade 1 percentage of latex and scrap is 85.5 and 72 per cent respectively.

Weather

Rainfall figures (mm) for 1993 and 1992 are given below in Table 8.

Table 8. *Rainfall distribution for 1993 and 1992*

Months	1993	1992
January	39.4	70.2
February	13.0	46.2
March	126.7	2.6
April	338.5	306.3
May	926.9	572.1
June	508.3	417.3
July	205.3	526.8
August	186.9	232.7
September	401.2	593.0
October	724.6	512.2
November	417.0	473.4
December	487.7	221.6
Total	4 391.9 (111)	3 974.4 (100)
Total wet days	192 (118)	163 (100)

The normal rainfall and the total number of wet days in 1993 were 11 and 18 percent higher than those of year 1992 respectively.

Monthly breakdown of the average of normal tapping (NT), late tapping (LT), double tapping (DT) and no tapping (No.T) days of the Group are given in Table 9.

During the year a total of 115 no tapping days are recorded, due to interference of rain. This would have resulted in about a 25-30% loss in crop.

Table 9. *A monthly breakdown of the average number of normal tapping (NT), late tapping (LT), double tapping (DT) and no tapping (No.T) days of the Dartonfield Group.*

	No. of days			
	NT	LT	DT	No.T
January	29	01	05	01
February	27	–	–	01
March	25	03	–	03
April	16	03	–	11
May	07	03	–	21
June	10	03	02	17
July	11	08	–	12
August	19	06	03	06
September	14	05	–	11
October	10	05	01	16
November	15	06	02	09
December	15	09	03	07
Total	198	52	16	115

Cost of Production and Profitability

A breakdown of the total cost of production (COP) and the net sale average for years 1991, 1992 and 1993 are given below. Despite of a 24% wage increase in 1993, the tapping and upkeep costs have increased only marginally. This can be attributed to increases recorded in the intake per tapper and total crop. Nevertheless the manufacture costs have increased by about 30% in 1993. Further, the general charges component is significantly less in 1993 due to apportioning of general charges to Research Departments and also due to high total crop secured during the year.

COP/kg	Year		
	1991	1992	1993
1. Total	44.69	44.68	35.15
1.1 Tapping	13.94	14.17	14.47
1.2 Manufacture	7.03	6.07	8.76
1.3 General charges	18.37	19.07	6.57
1.4 Upkeep	5.35	5.37	5.35
2. NSA/kg	23.52	35.15	39.01
Profit (Loss)	(21.17)	(9.53)	3.86

A breakdown of the COP and the profit/loss estimated for 1993, and the actual COP and the profit/loss, with and without (as done in previous year) apportioning of general charges to Research Departments are given below for comparison.

COP/kg	1993 (Estimated)	1993 (Actual)	1993 (As per last year)
1. Total COP	49/67	35.15	42.38
1.1 Tapping	18/54	14.47	14.47
1.2 Manufacture	7/51	8.76	8.76
1.3 General charges	13/34	6.57	13.80
1.4 Upkeep	8/89	5.35	5.35
2. N S A	38/50	39.01	39.40
3. Profit (Loss)	11/17	3.86	(2.39)

The above table further confirms that although the labour wages have increased the different components of the COP have not increased due to higher intakes and the total crop.

During the year 1993 a profit of Rs.3.86 on a kilo and a profit of nearly Rs.500 000 from the entire revenue extent are recorded.

Factory Machinery

The dry blanketing mill was repaired and it is in working order now. The main switches and a starter, which were defective were replaced in some mills. The condition of the factory machinery is satisfactory.

Factory Building

The chimney of the drying tower was repaired during the year. The other chimney also needs repairing.

Roads

The macadamised roads leading to Institute bungalows and the estate divisional roads were maintained satisfactorily.

Pests and Diseases

Barkrot was evident in clones PB 86 and RRIC 130 and was controlled by the application of Brunolium.

Fertilizer

Fertilizer application for mature and immature fields was carried out as scheduled.

Replanting

The replanting programme for the year was completed, except in an extent of 0.5 ha. due to a delay in uprooting. A total of 7.98 ha was planted in the Dartonfield Division.

Nurseries

Approval of the Estate Committee was obtained to uproot budwood nurseries which are more than 7 years old.

A Seedling Nursery having about 20 000 stock plants was established at the Gallewatta Division.