ISSN 1391 - 0043

# Rubber Research Institute of Sri Lanka

# Annual Review 2000

RUBBER RESEARCH INSTITUTE OF SRI LANKA

ANNUAL REVIEW 2000

**Cover** : Main Photograph : Tea rubber intercropping is recommended to enhance land productivity and profitability.

**Insert** : First rubber tree planted in Asia 125 years ago at Henarathgoda.

**Photograph by** : Wimal Amaratunga

# Rubber Research Institute of Sri Lanka

## Annual Review – 2000

*1 st January 2000 to 31 st December 2000*

Editors
L M K Tillekeratne, PhD (Aston)
R C W M R A Nugawela, PhD (Essex)

**Head Office & Laboratories**
**Dartonfield**
**Agalawatta**

**Board Office & Laboratories**
**Telewela Road**
**Ratmalana**

## CONTENTS

## RUBBER RESEARCH BOARD OF SRI LANKA

### BOARD OF MANAGEMENT

***Members appointed by the Hon Minister of Public Administration, Home Affairs and Plantation Industries***

Mr R I Obeyesekere, PC, Chairman
Mr W T Ellawala, Chairman, Colombo Rubber Traders' Association
Mr W M Abeywardane, Member
Mr C R Perera, Member
Al. Haj A L M Bahawoodeen, Member

***Ex-Officio Members***

Mr G W S K de Silva, Additional Secretary, Ministry of Plantation Industries
Mr A Rajapaksa, Director, Department of National Budget, General Treasury
Mr Y A Dayaratne, Director General, Rubber Development Department
Hon. Kumara Welgama, MP for Kalutara District

### STANDING COMMITTEES

***Estates Committee***

Mr R I Obeyesekere, Chairman,PC, RRB
Dr L M K Tillekeratne, Director, RRI
Dr A Nugawela, Deputy Director (Research), RRI (From July 2000)
Mr J A F A Atapattu, Superintendent, Perth Estate, Horana
Mr W A Fonseka, Manager, Hartley Estate - West, Mahagama
Mr N B Seneviratne, Manager, Pallegoda Group, Dharga Town
Mr Sarath B Seneviratne, Superintendent, Frocester Estate, Govinna
Mr Salinga Dissanayake, Superintendent, Peenkanda Estate, Nivitigala
Mr Anusha S Perera, Superintendent, Salawa Estate, Hanwella
Mr Jehan Perera, Superintendent, Dartonfield Group
Mr D J B de Silva, Deputy Director (Administration), RRI (up to January 2000)
Mr B M S Bandaranayake, Accountant, RRI

***Administrative and Financial Committee***

Mr R I Obeyesekere, PC, Chairman, RRB
Mr G W S K de Silva, Additional Secretary, Ministry of Plantation Industries
Mr Y A Dayaratne, Director General, Rubber Development Department
Mr A Rajapaksa, Director, Department of National Budget, Ministry of Finance

*Scientific Committee*

Mr R I Obeyesekere, PC, Chairman, RRB
Dr L M K Tillekeratne, Director, RRI
Dr (Mrs) K G K de Silva, Deputy Director Research (Technology), RRI
Dr A Nugawela, Deputy Director Research (Biology), RRI
Dr C K Jayasinghe, Head, Plant Pathology & Microbiology Dept., RRI
Dr (Mrs) L Samarappuli, Head, Soils & Plant Nutrition Dept., RRI
Dr (Mrs) N M V K Liyanage, Head, Rubber Technology & Development Dept., RRI
Dr W M G Seneviratne, Head, Raw Rubber Processing Development & Chemical Engineering Dept., RRI
Dr D P S T G Attanayake, Head, Genetics and Plant Breeding Dept., RRI
Dr (Mrs) P Seneviratne, Botanist, RRI
Mr M T Warnakula, Assistant Biochemist, RRI
Dr Ranjan Jayaratne, Plant Pathologist, RRI
Dr Anura Dissanayake, Soil Chemist, RRI
Miss W P K Silva, Plant Pathologist, RRI
Dr V H L Rodrigo, Research Officer Intercropping, RRI
Mr L S S Pathiratne, Botanist, RRI
Mr A K Naranpanawa, Assistant Agricultural Economist, RRI
Mr K E Jayasooriya, Plant Pathologist, RRI
Mrs Wasana Wijesooriya, Biometrician, RRI
Mr J Perera, Superintendent, Dartonfield Group, RRI
Mr S Siriwardena, Rubber Chemist, RRI
Mrs M Jayasooriya, Rubber Chemist, RRI
Dr N Yogaratnam, Consultant, NIPM, M D H Jayawardena Mawatha, Athurugiriya
Mr R C Peries, Director (Plantations), Kotagala Plantations Ltd., Ellakanda, Horana
Mr R V K S de Livera, Manager, Kotagala Plantations Ltd., Padukka Estate, Padukka
Mr Dan Seevaratnam, Executive Director, Namunukula Plantations Ltd., 320/1, Union Place, Colombo 2
Mr I L A Fernando, Consultant, Namunukula Plantations Ltd., 320/1, Union Place, Colombo 2
Mr N B Seneviratne, Superintendent, Pallegoda Estate, Dharga Town
Mr N M Amarasekera, Director/General Manager Low Country, Kelanivalley Plantations Ltd., 400, Deans Road, Colombo 10
Mr A Amarasinghe, Group Manager, Devalakanda Estate, Dehiowita
Mr S A Eriyagama, GM-Plantations (Rubber), Agalawatta Plantations Ltd., No.10, Gnanartha Pradeepa Mawatha., Colombo 8
Mr R S Perera, Manager, Culloden Estate, Neboda
Mr Gamini Jayasooriya, Regional General Manager, Bogawantalawa Plantations Ltd., No.275/75, Prof. Stanley Wijesundera Mawatha, Colombo 7
Mr S B Dissanayake, Group General Manager, Mahaoya Group, Dehiowita

Mr D P A Perera, Deputy General Manager, Balangoda Plantation Ltd., P.O. Box 6, Palmgarden, Ratnapura

Mr S S R Kombalawithana, Superintendent, Rambukkanda Estate, Ratnapura

Mr A I Amithodana, Superintendent, Galatura Estate, Kiriella

Major M R C Peiris, Director, Pussellawa Plantations Ltd., 228, Havelock Road, Colombo 5

Mr S P J Wijesekera, Group Manager, Elston Estate, Puwakpitiya

Mr S N Gunaratne, Executive Director, Kegalle Plantations Ltd., 320/1, Union Place, Colombo 2

Mr S S Poholiyadda, Deputy General Manager, R & SP Kegalle Plantations Ltd., 320/1, Union Place, Colombo 2

Mr G B S de Silva, General Manager-Low Country, Horana Plantations Ltd., P.O. Box 2042, Sir Chittampalam A Gardiner Mawatha, Colombo 2

Mr S B Seneviratne, Manager, Frocester Estate, Govinna

Mr Y Ratnayake, Chief Executive Officer, Horana Plantations Ltd., P.O. Box 2042, Sir Chittampalam A Gardiner Mawatha, Colombo 2

Dr Y W Weerasooriya, Manager, Puritas Ltd., 400, Deans Road, Colombo 10

Mr S Korathota, Director, Kinetics (Pvt.) Ltd., C/o Puritas Ltd., 400, Deans Road, Colombo 10

Mr G W Wellala, Product Manager, Chemanex Ltd., P O Box 188, 52, Galle Face Court 2, Colombo 3

Mr A M J Bandara, Factory Manager, Chemanex Ltd., P O Box 188, 52, Galle Face Court 2, Colombo 3

Mr Lascelles Perera, Malwatta Valley Plantation Ltd., Talduwa Estate, Erracht Division, Dehiowita

Mr Abeynanda Dias, Director Plantations, Kahawatta Plantations Ltd., Seva Mandiraya, 46/38, Nawam Mawatha, P.O. Box 60, Colombo 2

Mr S A E A Perera, Group Director, Group Director's Office, Kahawatta Plantations Ltd., Rilhena Estate, Pelmadulla

Mr Susantha Pinto, Superintendent, Houpe Estate, Houpe

Mr D C R Perera, General Manager, C W Mackie & Co. Ltd., P.O. Box 89, 36, D R Wijewardena Mawatha, Colombo 10

Mr S D A Jayasuriya, Deputy General Manager (Plantations) SLSPC/JEDB, Sri Lanka State Plantations Corporation, No.55/75, Vauxhall Lane, Colombo 2

Mr N E D de Croos, Manager (Administration), SLSPC/JEDB, Sri Lanka State Plantations Corporation, No.55/75, Vaxuhall Lane, Colombo 2

Mr C M Wanigatunga, Deputy General Manager, James Finlay Plantation Holding Ltd., P.O. Box 8, Ratnapura

Dr Sudantha Liyanage, Dept. of Chemistry, Faculty of Science, University of Sri Jayawardenapura, P.O. Box 6, Nugegoda

Dr L Karunanayake, Dept. of Chemistry, Faculty of Science, University of Sri Jayawardenapura, P.O. Box 6, Nugegoda

Dr M A R V Fernando, Senior Lecturer, Dept. of Mechanical Engineering, University of Moratuwa, Moratuwa
Mr K Subramaniam, Senior Lecturer, Dept. of Chemical Engineering, University of Moratuwa, Moratuwa
Mr Sarath Kularatne, Manager, Loadstar (Pvt.) Ltd., Minuwangoda Road, Opatha, Kotugoda
Mr P H Piyatillake, Qunt Assu, Manager, Loadstar (Pvt.) Ltd., Minuwangoda Road, Opatha, Kotugoda
Dr M R N Fernando, Loadstar (Pvt.) Ltd., Police Park Terrace, Colombo 5
Mr Anusha Perera, Superintendent, Siriniwasa Estate, Waga
Mr Salinga Dissanayake, Superintendent, Peenkanda Estate, Nivitigala
Mr W A Fonseka, 633, A10, Daisy Mawatha, Kotte
Mr J F Atapattu, 101/3, Puwakgaswatta, Makandana, Madapatha, Kesbewa
Mr W T Ellawala, Chairman/Colombo Rubber Traders Association, C/o Ceylon Chamber of Commerce, 50, Nawam Mawatha, Colombo 2
Mr Amanda Weerasinghe, Director, Almar Trading, 342, Basil Building, Colombo 3
Mr B S Samarasinghe, Forbes & Walkers, 46/38, Nawam Mawatha, Colombo 2
Mr Upali Bandaranayake, Forbes & Walkers, 46/38, Nawam Mawatha, Colombo 2
Secretary, Plastics Rubber Institute, Telawala Road, Ratmalana
Mr Keerthi Wanasinghe, Trellebough Ltd., Sapugaskanda, Makola
Secretary, Rubber Products Manufacturers & Exports Corporation, P.O. Box 1755, 609, Dr Danister Silva Mawatha, Colombo 9
Mr Sarath Wimalaratne, 8, Sudarshana Road, Dehiwala
Mr M R Fernando, Malaboda Estate, Matugama
Mr Y W Dayaratne, Director General, Rubber Development Dept., P.O. Box 184, Colombo
Mr K Meegahawatta, Director (Development), Rubber Development Dept., P.O. Box 184, Colombo
Mr G W S K Silva, Additional Secretary, Ministry of Plantation Industries, 55/75, Vauxhall Lane, Colombo 2

***Provident Fund Committee***

Al. Haj A L M Bahawoodeen, Chairman
Dr L M K Tillekeratne, Director, RRI
Mrs L J C Perera, Secretary
Mr B M S Bandaranayake, Chief Accountant, RRI
Mr P D Somadasa, Elected Committee Member
Mr S S Warnapura, Elected Committee Member

**Board Office**

| | |
|---|---|
| Chairman | Mr R I Obeyesekere, PC |
| Secretary to the Board | Mrs L J C Perera |
| Confidential Clerk/Stenographer | Mrs P Balasooriya |
| Clerk/Typist | Mrs S N Munasinghe |

**Lawyers**

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

**Auditors**

M/s Susantha Senanayake & Co.
Chartered Accountants
107/1, Elvitigala Mawatha,
Colombo 8

**Bankers**

Bank of Ceylon
Corporate Branch
75, Janadhipathi Mawatha,
Colombo 1

Bank of Ceylon
Agalawatta

**Head Office and Laboratories**
*Dartonfield, Agalawatta*

Telephones:

| | |
|---|---|
| Director | 034 - 48457 |
| Deputy Director Research (Biology) | 034 - 48458 |
| General | 034 - 47426 |
| | 034 - 47383 |
| | 034 - 23078 |
| | 034 - 48459 |

| | |
|---|---|
| Fax: | 034 - 47427 |
| E-mail | dirrri@tradenetsl.lk |

**Rubber Research Institute - Substation**
*Nivitigalakele, Matugama*

Genetics and Plant Breeding Department
Telephone: 034 - 47368

**Rubber Research Institute - Substation**
*Kuruwita, Ratnapura*
Telephone: 045 - 62115

**Board Office and Rubber Chemistry & Technology Laboratories**
Telewela Road, Ratmalana

Telephones:

| | |
|---|---|
| Chairman | 01 - 635142 |
| Director | 01 - 605171 |
| General | 01 - 633351 |
| | 01 - 635851 |
| | 01 - 635852 |
| Fax: | 01 - 605171 |

# RUBBER RESEARCH INSTITUTE OF SRI LANKA

## STAFF

### DIRECTORATE

| | |
|---|---|
| *Director* | L M K Tillekeratne, BSc (Cey.), MSc (Aston), PhD (Aston), FI Chem C, FPRI, FNASSL |
| *Deputy Director – Research (Technology)* | Mrs K G K de Silva, BSc (SL), MSc (SL), PhD (Aston), FI Chem C, MPRI |
| *Deputy Director – Research (Biology)* | R C W M R A Nugawela, BSc (SL), MSc (Lond.), PhD (Essex) |

### DIRECTOR'S OFFICE

| | |
|---|---|
| *Experimental Officer (Technical Officer to the Director)* | K K Liyanage, BSc Agric (SL) |

### RESEARCH DEPARTMENTS

#### Genetics and Plant Breeding

| | |
|---|---|
| *Head of Department* | D P S T G Attanayake, BSc Agric (SL), PhD (Birm.) |
| *Assistant Geneticist and Plant Breeders* | *Mrs S Herath, BSc Agric (SL) |
| | *Mrs S P Withanage, BSc Agric (SL) |
| *Experimental Officers* | K W Rupatunga |
| | B M S G Peiris |
| | I D M J Sarath Kumara |
| | L S Kariyawasam |
| *Technical Officers* | T M S K Gunasekera |
| | H P Peiris, Dip. Agric (Kundasale) |
| | Miss A K Gamage, BSc (SL) |
| | Miss S P M Wickramaratne |
| *Clerk/Typist* | Mrs S D P K L Peiris |

#### Plant Science

| | |
|---|---|
| *Head of Department* | Mrs G P W P P Seneviratne, BSc (SL), PhD (Bath) |
| *Research Officer (Intercropping) (Principal Research Officer)* | V H L Rodrigo, BSc Agric (SL), MSc (Essex), PhD (Wales) |

| | |
|---|---|
| *Botanist* | L S S Pathiratne, M I Biol, MSc (Reading), MPhil (SL) |
| *Assistant Botanists* | A M W K Senevirathna, BSc (SL), MSc (SL) |
| | K M G S N Kaluwewe, BSc (SL) (up to 15.02.2000) |
| *Experimental Officers* | K A G B Amaratunga |
| | R P Karunasena |
| | Mrs G A S Wijesekera |
| | S Wilbert |
| | Mrs R K Samarasekera |
| | U S Weerakoon |
| | T U K Silva, BSc Agric (SL) |
| | M K P Perera |
| | W D M N de Alwis |
| *Technical Officers* | Mrs C W Ranasinghe, BA (SL) |
| | D L N de Zoysa |
| | Miss A L A S K Liyanage |
| | P D Pathirana |
| | P K W Karunathilake, Dip. Agric (Ratnapura) |
| *Clerk/Typist* | Mrs H D D E Jayawardena |

**Plant Pathology & Microbiology**

| | |
|---|---|
| *Head of Department* | C K Jayasinghe, BSc (SL), MSc (SL), MSc (Agric) (Aust.), PhD (SL) |
| *Plant Pathologist (Principal Research Officer)* | A H R Jayaratne, BSc (SL), MSc (SL), PhD (Sheffield) |
| *Plant Pathologists* | K E Jayasuriya, MSc Agronomy (USSR), MPhil (Edinburgh), M I Biol (SL) |
| | Miss W P K Silva, BSc (SL), MSc (SL), Mphil ( Aust.) |
| *Experimental Officers* | Mrs B I Tennakoon, Dip. Agric (Kundasale) |
| | Mrs T H P S Fernando, BSc (SL), MPhil (SL) |
| | Mrs E A D D Siriwardene, BSc (SL) |
| *Technical Officers* | S C P Wijayaratne, NDT Agric (Hardy) |
| | Mrs N Jayawardene, Dip. Agric. (Bibile) |
| | S R D P C Peiris |
| | E A D N Nishantha, Dip. Agric. (Ratnapura) |
| *Clerk/Typist* | Mrs W S P Amarasekera |

*Audio visual Aids and Photographic Unit*

| | |
|---|---|
| *Audio Visual Aids Production Officer* | L W Amaratunge |

**Soils and Plant Nutrition**

| | |
|---|---|
| *Head of Department* | Mrs M L A Samarappuli, BSc Agric (SL), MSc (California), PhD (SL) |
| *Soils Chemist (Principal Research Officer)* | D M A P Dissanayake, BSc Agric (SL), PhD (Aberdeen) |
| *Assistant Soils Chemists* | *R S Dharmakeerthi, BSc Agric (SL), MSc (SL) |
| | D N P Wickremasinghe, BSc (SL) |
| *Experimental Officers* | H D S P Perera, BSc (SL) |
| | J G de Mel |
| | Mrs R P Hettiarachchi, BSc (SL) |
| | Mrs S D C K Maheepala |
| | S N Silva |
| | P Karunadasa, BSc (SL) |
| | A H U Mitrasena |
| | A N Yakandawala |
| | T B Dissanayake |
| *Technical Officers* | Miss V U Edirimanne, BSc (SL) |
| | Miss A P Thewarapperuma |
| | P A C R Puhambugoda, NDT Agric (Hardy) |
| | Mrs J K D P Kumarie, BSc (SL) |
| | J A Sarath Chandrasiri |
| | P D T C Gunatilleke |
| *English Stenographer* | Mrs K A D L Rupasinghe Perera |

**Biochemistry and Physiology**

| | |
|---|---|
| *Assistant Biochemist* | M T Warnakula, BSc (SL) |
| *Experimental Officers* | E B Fernando |
| | D Ramawickrema |
| *Technical Officer* | P D J Rodrigo |

**Polymer Chemistry**

| | |
|---|---|
| *Head of Department* | Mrs K G K de Silva, BSc (SL), MSc (SL), PhD (Aston), FI Chem C, MPRI |

| | |
|---|---|
| *Assistant Rubber Chemists* | Mrs A H L R Nilmini, BSc (SL) |
| | Mrs C J Wellappili, BSc (SL), MSc (SL) |
| *Experimental Officers* | H N K K Chandralal, BSc (SL), MSc (SL) |
| | Mrs D I R Denawaka, Dip. Rubber Tech. (PRI) |
| | Mrs W C M Kuruppu, Dip. Rubber Tech. (PRI), Certificate Rubber Tech. (Moratuwa) |
| | S S Warnapura |
| | S L G Ranjith, Dip. Rubber Tech. (PRI) |
| | S M A Samarakoon, Dip. Agric. (Kundasale) |
| | Miss D M S Wijesekera, Dip. Rubber Tech. (PRI) |
| *Clerk/Typist* | Mrs R S Wijeratne |
| *Store-Keeper* | Mrs L Rukmanie |

**Raw Rubber and Chemical Analysis**

| | |
|---|---|
| *Officer in Charge & Specifications Officer* | L Karunanayake, BSc (SL), PhD (North London) (up to 23.06.2000) |
| *Experimental Officers* | Mrs L Wanigatunga |
| | Mrs H V K Gamage |
| | Mrs C S Lokuge |
| | R S Wijesundera |
| | L P P Vitharana |
| | P L Perera |
| | K R N Karunatilleke, Dip. Rubber Tech. (PRI) |
| *Research & Development Assistant* | Miss G M Priyanthi Perera, BSc (SL), MSc (SL) |
| *Technical Officers* | Mrs K N A Baduge, BA (SL) |
| | B Gunasiri |
| | Mrs U M S Priyanka, BSc (SL) |
| | W D Wimaladasa |
| | W W Nandasena |
| *Clerk/Typist* | Mrs I Wijesinghe |

*Electronic Instruments Repair Unit*

| | |
|---|---|
| *Instrument Technician* | L G P Lelwela |

## Rubber Technology and Development

| | |
|---|---|
| *Head of Department* | Mrs N M V K Liyanage, BSc (SL), PhD (Lond.) |
| *Rubber Chemist* | Mrs H M M de S Jayasuriya, BSc (SL), MSc (SL) |
| | Mrs D G Edirisinghe, BSc (SL), MSc (SL) |
| *Experimental Officers* | Mrs H S Weeraman, Certificate, Rubber Tech. (Moratuwa) |
| | Mrs M K Mahanama, Dip. Rubber Tech. (PRI) |
| | Mrs S I Yapa, Dip. Rubber Tech. (PRI) |
| | Mrs P C Wettasinghe |
| *Research and Development Assistant* | Miss D N Wickramarachchi, BSc (SL), MSc (SL) |
| *Technical Officer* | T A A I Siriwardene |

## Raw Rubber Process Development and Chemical Engineering

| | |
|---|---|
| *Head of Department* | W M G Seneviratne, BSc (SL), PhD (Sussex) |
| *Rubber Chemist* | *S Siriwardene, BSc (SL), MSc (Australia) |
| *Assistant Rubber Chemist* | P H Sarath Kumara, DPRI |
| *Research Assistant* | R M U N Ratnayake, BSc (SL) |
| *Experimental Officers* | Mrs W K C Nalinie, Dip. Rubber Tech. (PRI) |
| | T A S Siriwardene |
| | E C D Senanayake |
| *Technical Officers* | Miss V C Rohanadeepa |
| | A K D W Prasad |
| *Clerk/Typist* | Mrs S A Paranavithana |

## Biometry Section

| | |
|---|---|
| *Biometrician* | Mrs B W Wijesuriya, BSc Agric (SL), MPhil (SL) |
| *Experimental Officers* | Mrs H K D C S Munasinghe, Certificate, Polymer Tech. (Moratuwa), Dip. Rubber Tech. (PRI) |
| | Miss K V V S Kudaligama, BSc (SL) |
| *Technical Officer* | O V Abeyawardene, Dip. Agric. (Kundasale) |

## Adaptive Research Unit

| | |
|---|---|
| *Research Assistant/Agronomy* | S M M Iqbal, BSc Agric (SL), MPhil (SL) |
| *Research Assistants (Adaptive Research)* | W A D D S Wettasinghe |
| | R B Gunaratne |
| | A M A Perera |
| *Development Officers* | P P Jayasinghe, LPRI |
| | K B A Karunasekera |
| *Experimental Officer* | E A T Senadeera |

## Agricultural Economics Unit

| | |
|---|---|
| *Assistant Agricultural Economist* | *R M A K B Naranpanawa, BSc Agric (SL) |

## Library and Publications Unit

| | |
|---|---|
| *Librarian* | S U Amarasinghe, BSc (SL), ASLLA |
| *Library Assistants and Assistant Publications Officers* | Mrs D T Dantanarayana, DLS (Univ. Kelaniya) |
| | Mrs R M Amaratunga , Intermediate; Library Science, Documentation & Information (SL) |
| *Clerk/Typist* | P M P Jayantha |

## ADMINISTRATION DEPARTMENT

| | |
|---|---|
| *Assistant Medical Practitioner* | M Subasinghe |
| *Administrative Assistant* | D U Kannangara |
| *Clerks (Special Grade)* | Mrs R S Amarasekera |
| | Mrs W Paul |
| | R G D Sakaraja |
| *Clerk/Typists* | Mrs P W Neelamanie |
| | Mrs K P R Gunasekera |
| | Mrs M D P Mandalawatta |
| | Mrs J A D Wijayanthi |
| *Apprentice Translator* | Mrs D N Muthuranwala, BSc (SL) |
| *Pharmacist* | S Lankeshwara |

## Internal Audit Unit

| | |
|---|---|
| *Internal Auditor* | Neil C de Silva, APFA |
| *Internal Audit Officer* | K C Fernando |

| | |
|---|---|
| *English Stenographer* | Mrs J A H S Kumarie |

**Works Section**

| | |
|---|---|
| *Resident Engineer* | L L D W Jayatilleke, BSc (SL) |
| *Electrical Foreman* | W D Ratnasinghe |
| *Mechanical Foreman* | S D Gunawardene |
| *Building Foreman* | M A D K Jayasumana |
| *Chief Clerk* | S A L Chandrawansa |
| *Transport Officer* | M P R A Perera |
| *Clerk/Typists* | Miss M Gunawathie Silva |
| | Mrs J A S Dharshanie (Dip. In Management) |
| | Mrs K C S Wickremasinghe |
| *Work Supervisor (Buildings)* | H A Somasiri |
| *Works Supervisor (Electrical)* | T M R P Tennakoon |

**Accounts Section**

| | |
|---|---|
| *Chief Accountant* | B M S Bandaranayake, Dip. in Com. Dip. in Acct. MAAT, FPFDA, LICA |
| *Accountant* | W Kularatne |
| *Book-keeper* | D A Rajapakse |
| *Graduate Assistants* | Mrs G K Somasiri, BA (SL) |
| | Mrs K Jagoda, BA (SL) |
| *Accounts Clerks (Special Grade)* | G S Doolwela |
| | G A Kannangara |
| *Accounts Clerks* | Mrs C C Silva |
| | Mrs Irene Perera |
| | Mrs M Gunawardene |
| | Mrs K Kapuge |
| *Cashier Clerk* | Mrs G A D D Jayawardena |
| *Clerk/Typists* | Mrs W A C Weeramanthrie |
| | Mrs R Handungoda |
| | Miss G P Kukulewithana |
| *Store-Keeper* | D C P Pothmitiyage |
| *Assistant Store-Keeper* | P D Somadasa |
| *Assistant Purchasing Officer* | K D Sumanasena |

**DARTONFIELD GROUP**

| | |
|---|---|
| *Estate Superintendent* | Jehan Perera |
| *Chief Clerk* | P Kannangara |

| | |
|---|---|
| *Senior Clerk* | K K P Gunawardena |
| *Junior Clerks* | Mrs C Dissanayake |
| | A K D A Wickremasinghe |
| | Mrs S I K Pathirage |
| *Factory Officer* | D S K Ranaweera |
| *Assistant Factory Officer* | W D D Senanayake |
| *Field Officers* | S K S de Silva (attending to Estate Office Work) |
| | J A Wimalasena |
| | T Somaratne |
| | N L D Reggie |
| *Assistant Field Officers* | H M J Premalal |
| *Junior Assistant Field Officers* | K A Sarath Kumara |
| | B M Siriwardene |
| | J K Nakandala |
| | N L D Nihal |
| | N V U S Vijitha Kumara |
| | A B Nakandala |

**Kuruwita Sub-Station**

| | |
|---|---|
| *Visiting Superintendent* | Anusha S Perera, Dip. in Personal Management (NIBM), AMIPM |
| *Assistant Estate Superintendent* | S A R Samarasekera |
| *Assistant Field Officers* | A K D I Rukmal |
| *Junior Clerk* | D S Jayasinghe |

* On study leave overseas

# RUBBER RESEARCH INSTITUTE OF SRI LANKA

## DIRECTOR'S REVIEW

**L M K Tillekeratne**

Natural Rubber prices remained low during this year too due to the slow down of the US economy and due to the release of heavy stocks of rubber from the stock pile in Japan. Weakening of the Indonesian Rupiah caused Indonesian NR to be more competitive in the world market and had an influence on the low prices.

Natural Rubber production in the country declined by 7-9% during the year and total production recorded was 87,636 MT out of which, 34,000 MT have been produced in the form of sheet rubber while 28,111 MT have been presented in the form of crepe rubber. In addition to that 4,512 MT of sole crepe and 1,488 MT of scrap crepe have also been produced. Production of TSR declined by 15% to 3,879 MT. The export price of NR during the year was 20 to 30% higher than in the previous year.

According to the figures provided by latex based product manufacturers of Sri Lanka, only 15,343 MT of latex have been consumed for this purpose. But the actual quantum of latex based products manufactured has been 23,000 MT which is nearly 26% of the total rubber production in the country.

This is a clear indication of the fact that the latex based products manufacturing sector is growing rapidly in the country. According to the predictions of glove manufacturers, 35,000 MT of rubber latex will be converted into dipped products by 2005.

According to the survey carried out by the newly set up Advisory Services Department of the RRI, not less than 8,500 ha. of mature rubber have been abandoned by the smallholders due to the poor prices paid by the village dealers for the sheet rubber manufactured by them. Hence, if these abandoned plantations are tapped, ca. 3,000 kg of latex could be harvested per year. This amount is adequate to run the extra capacity available in the centrifuged latex factories already set up in the country. The total installed capacity available with them is ca. 30,000 MT per annum. Hence, every effort will be made by the RRI and the RDD to collect and supply the latex from these abandoned lands to the *Thurusaviya Programme* to convert them into concentrated latex thereby paying them a reasonable farm gate price of not less than Rs.50-55 per kg. This price is much higher than what they get from the dealers for low grades of RSS produced by them.

The productivity of the plantation sector has been over 1000 kg/ha/yr which is higher than that of smallholdings which is, *ca.* 695 kg/ha/yr. This is a clear indication that most of the small holders, particularly the absentee land-lords owning small estates and running on hired labour, have abandoned their plantations without

tapping due to escalating costs of production and the prevailing poor farm gate prices.

Further, a couple of estates carefully following the recommended technology including growing of high yielding clones have been able to record yields over 1400 kg/ha/yr. This shows that in any estate, even though poorly managed during the past, the productivity can be improved upto *ca.* 1500 kg/ha/yr, if the management is perfected. Use of rain guards will help plantations to improve productivity quickly.

Based on a request made by the plantation companies, the clone RRISL 130, which has performed extremely well in the trials carried out during the past couple of years, was promoted to Grade 1 of the clones recommended to the estates, purely to improve the genetic base in the plantations.

The advisory circular on clone recommendation was revised during the year. Seven new clones registered under the RRISL 2000 series were included in the revised clone recommendation. Among the new clones recommended RRISL 205, RRISL 2000 and RRISL 2001 have shown characteristics suitable for timber production. The clone RRISL 224 which was found susceptible to *Corynespora* Leaf Disease, was removed from clone evaluation trials. A participatory approach involving the growers and the scientists was launched in order to accelerate the pace of adoption of new clones both by estate and smallholder sectors.

No significant differences were found in micro- tapping yield data between the two groups of progeny individuals of the family RRIC 130 x PB 260 categorized on the basis of *ref* gene polymorphism. The genetic authencity of the clones RRISL 217 and RRISL 219 was confirmed by PCR technique. PB 260 and BPM 24 continued to show high rubber yields in their third year of tapping in the SRRP clone trial. An experiment was planted to test the suitability of seedling populations collected from commercial clones for commercial planting.

Crown budding when carried out at early stages cause minimum set back in the growth. However, crown clone seems to affect the growth and the yield of the trunk clone. Removal of the base of the bag of young buddings and polybag plants favoured the initial growth of the plants when compared with the current recommendation of removing the whole bag at planting.

Girthing of untapped trees continues to be higher than in tapped trees in all clones. Girth decline after tapping is lowest in clone RRIC 121 amongst the clones tested. Low frequency tapping with stimulation continues to give a higher g/t/t than in conventional ½ S d/2 tapping with no adverse effects on girthing and incidence of Tapping Panel Dryness (TPD).

Although increase in plant density has resulted in a decrease mean plant girth, total number of tappable trees and hence the yield per hectare increased with increasing planting density.

Improved growth of rubber resulted by rubber/banana intercropping has continued through out the immature period resulting in increased number of tappable

trees and yield per hectare. Detailed physiological measurements indicated that shade alleviate radiation stress on rubber which is the case in most intercrops.

Studies on social and cultural effects show that most of farmers grow rubber as a permanent income source and to secure the ownership of encroached crown lands.

The conducive weather conditions experienced during refoliation period caused severe secondary leaf fall in clones RRIC 121, PB 28/59, RRIM 712, PB 217 and BPM 24. Flowers were also severely affected with *Oidium* and as a consequence *Phytophthora* leaf fall and bark rot were extremely mild during SW monsoon period.

The molecular weights of the polygalacturonase produced by five different isolates of *Phytophthora meadii* were shown to be 62 to 85 KDa. Studies on enzyme production by *Botryodiplodia theobromae* revealed that this fungus is capable of secreting pectin lyase, β-glucosidase and cellobiase in culture. Pectin lyase was shown to play a significant role in the pathogenicity of *Thanatephorus cucumeris*, a pest of quarantine importance to Sri Lanka. Hexaconazole (Contaf) and tebuconazole (Folicur) were found to be very effective in inhibiting the mycelial growth of four different isolates of *Rigidoporus microporus* at concentrations of 200 and 800 μg/ml respectively when screened using "soil fungicide screening test".

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

Field trials reveal that application of K fertilizers increase yield during early mature stage. The studies on use of organic manure in nursery stage of rubber suggested that application of organic manure is very effective in increasing the root growth of young budded polybag plants.

The site specific fertilizer recommendation programme for mature rubber provided data for fertilizer recommendations for 20,000 hectares in the estate sector. The soil and foliar survey programme for the small holder sector was not commenced as an economy measure due to the poor trading condition prevailing in the country.

The main focus of the Biochemistry Department was on development of appropriate technology for environmentally friendly management of rubber factory waste. Implementation of the ditch system for treating factory effluent was continued throughout the year.

In order to evaluate the extractability of proteins, use of various electrolytes as coagulants in latex dipping formulation was evaluated.

Also the use of water soluble polymers as extractable protein removers was investigated in order to find a solution for the protein allergy problem which is a burning problem in the gloves industry.

Application of NR latex as a binder for coir dust based articles used in agriculture and the techniques for the manufacture of Teflon based moulds for toy balloons were also developed.

A tyre paint suitable for improving the glossy appearance of tyre retreads and also a trial to increase the percentage of carbon black in latex/carbon black master batches were developed successfully.

Development of blends of NR/EPDM, with the aim of combining the excellent physical properties of NR with the ozone resistance EPDM was initiated. This study is important to cut down the high cost of EPDM rubber used in certain products.

Initial trials were carried out with latex samples from different clones treated to different conditions to denature the extractable proteins. Films of blends of NR/NBR lattices with compatibilizers were also tested for proteins. The effects on vulcanization methods were also monitored. Quantitative analysis of proteins in latex gloves were carried out using PCA method.

An adhesive was developed using general purpose neoprene and grafted neoprene using polymethylmethacrylate as the grafting agent. Attempts were also made to develop an adhesive using ENR latex and polyvinyl acetate emulsion and their blends.

Variation of MST at different conditions such as temperature variations, storage time, preservative system *etc.* was studied using centrifuged latex. Different types of Neem stabilized centrifuged latex samples were prepared and the properties were evaluated. Samples were sent to the industry to turn out gloves for comparison of physical properties, protein content etc. against standard glove samples.

A low cost, heat resistant mould out of NR latex was successfully developed.

An improved formulation was suggested to produce good quality coco peat dusted rubber latex based sacks. These are used in horticulture industry. Mould design and quality improvement were successfully completed and the technical know-how was transferred to the industry.

A new preservative system based on neem extract was used to prepare a large batch of centrifuged latex without using any toxic TMTD in the formulation.

For latex based dipped products a rubber based paint was successfully developed and a range of formulations, solvents etc. were tested to find out the most cost-effective formulation to satisfy the requirements of the customer.

A new project to introduce a soilless plant medium with tea dust and compounded latex was initiated in collaboration with the TRI to match an imported planting medium available in the market.

Trials were conducted with non-toxic chemicals to replace Hydroxylamine neutral sulphate (HNS) which is used to manufacture CV Rubber.

It was found that the much expensive conductive black used in the manufacture of conductive pads can be replaced with normal HAF black provided that the correct modified formulation is used.

Presently used toxic chemicals to coat metal wires used in tyre industry can be replaced by cheap and non-toxic latex compounds.

Routine activities such as testing grading and issuing certificates for TSR and concentrated latex were conducted throughout the year; while analysing the purity of chemicals, water and other vulcanisation ingredients.

Further, testing latex crepe and sole crepe properties on the request of the rubber based industries as well of the Plantation Companies was also conducted for the improvement of quality of the end-product manufactured and for the production control purposes of estates.

Specialised testings such as Sodium Pentacholorophenate content in gloves, rubber and other polymer contents in vulcanised products and the contamination of the dipped products with metal ions were conducted.

The institute actively participated in Round Robin cross check conducted by Malaysia while carrying out a similar cross check for the latex testing laboratories in Sri Lanka.

Organizing demonstrations and workshops on preparation of new brushable rain-guard sealant were done during the year.

Advisory visits were made to rubber factories to solve the problems associated with the crepe rubber manufacture. Effluent treatment mechanism developed by the institute to treat rubber factory and industrial waste water has gained considerable recognition over the years locally as well as internationally. Our services in this field was extended to the RRI of Thailand to support their ongoing activities.

Thirty one, rubber and other industries were visited to look into the problems connected with environmental pollution created with the discharge of waste water from their manufacturing processes. Proposals to construct effluent treatment plants in some of those factories were already forwarded. Pilot project on implementing a waste water treatment facility at Sanhinda Desiccated mill has completed and commenced operation successfully during the year.

The NSF funded project on Bio Gas generation from skim rubber effluent was continued as scheduled.

Waste water testing laboratory at the institute has already gained reputation as one of the recognized effluent water quality testing laboratories in Sri Lanka and various industries have obtained it's services during the year and 88 waste water testing certificates have been issued. Work on implementation of ISO 25 quality certification scheme for relevant laboratories is being done.

Assistance was extended to implement ISO 9002 - quality assurance scheme to Ms Busan and Boseang, a leading rubber product manufacturing industry in the country, having BOI status.

A project on suitability of using white rice husk ash as filler for rubber compounds was initiated.

## OVERSEAS VISITORS

Dr Clive Ireland, Writtle College, UK
Mr Aqrarushe Sbrdierevren, Holand
Mr Williams and family, England
Mr Fergus Sinccaire, University of Wales, UK
Ms Jane Myra Turner, South Australia
Mr Liane Sdimith, Germany
Mr Rehhard Krechlow, Germany
Mr Fam Bruccner, Austria

# GENETICS AND PLANT BREEDING

## D P S T G Attanayaka

### SUMMARY

The advisory circular on clone recommendation was revised during the year. Seven new clones registered under the RRISL 2000 series were included in the revised clone recommendation. Among the new clones recommended RRISL 205, RRISL 2000 and RRISL 2001 have shown characteristics suitable for timber production. The clone RRISL 224 which was found susceptible to *Corynespora* Leaf Disease, was removed from clone evaluation trials. A participatory approach involving the growers and the scientists was launched in order to accelerate the pace of adoption of new clones both by estate and smallholder sectors.

No significant differences were found in micro- tapping yield data between the two groups of progeny individuals of the family RRIC 130 x PB 260 categorized on the basis of *ref* gene polymorphism. The genetic authencity of the clones RRISL 217 and RRISL 219 was confirmed by PCR technique. PB 260 and BPM 24 continued to show high rubber yields in their third year of tapping in the SRRP clone trial. An experiment was planted to test the suitability of seedling populations collected from commercial clones for commercial planting.

### DETAILED REVIEW

**Staff**

The Head of the Department, Dr D P S T G Attanayaka, Development Officer, Mr K B Karunasekera, Experimental Officers Mr K W Rupatunga, Mr B M S G Peries and Mr I D M J Sarath Kumara, Technical Officers Miss A. K Gamage, Mr T M S K Gunasekera, Mr H P Peiris and Clerk/Typist, Mrs S D P K L Pieris, were on duty throughout the year. Mrs S P Herath, Assistant Geneticist and Plant Breeder continued her postgraduate studies at the University of Nagoya, Japan. Mrs S P Withanage, Assistant Geneticist and Plant Breeder left the island on 15th August for her postgraduate studies at the Punjab Agricultural University in India. Miss S P M Wickramaratna assumed duties as a Technical Officer on 2nd May. Mr L S Kariyawasam, Experimental Officer was transferred to this department with effect from 1st August.

**Research students/training**

Miss A K Munasinghe, an undergraduate from the Open University completed her research training and submitted a research report entitled "Testing of genetic authencity and genetic differentiation of RRISL 200 series clones of *Hevea brasiliensis* using Random Amplified Polymorphic DNA analysis.

## Meetings and Workshops

Dr D P S T G Attanayaka attended the following meetings and workshops.

- Central Scientific Committee
- CARP Committee on Specialist Group on Plant Breeders, Tissue Culturists and Biotechnologists
- Workshop on National Programme on Plant breeding on 28th March, organized by CARP. Presented a paper on "Rubber Breeding".
- National Workshop on Plant Genetic Resources, 8-10 November. Presented a paper on "Genetic resources of rubber and their conservation and utilization".
- Made a presentation on "National programme in Biotechnology" at the Biotechnology Working Group meeting at the Department of Agriculture on 4th December.
- Attended workshop organized by ITDG on National Priorities for Agricultural Biotechnology in Sri Lanka on 1st December.

## LABORATORY INVESTIGATIONS

### Molecular biology of *Hevea* GPB/MM/97

The progeny individuals categorized on the basis of the *ref* gene polymorphism were further tested by micro- tapping. No significant differences were found between the two groups with respect to mean latex volume, mean dry rubber yield and girth. But it was evident that the highest yielding plants were more abundant in the *Eco* RI digested *ref* gene category of plants. RAPD technique was used for the genetic differentiation of RRISL 200 series clones. The genetic authenticity of the two clones RRISL 217 and RRISL 219 was confirmed by PCR technique (D P S T G Attanayaka, A K Munasinghe, S P M Wicramaratna and Anusha Gamage).

## FIELD EXPERIMENTS

### Hand pollination (HP) programme – 2000 (GPB/BST/HP/00)

Mother trees of BPM 24, PB 235, PB 260 and RRIC 121 clones from the Neuchatel estate were selected for the cross pollination programme. The final fruit set success of the pollinations done during the year recorded the highest ever figure of 6.28%. The number of pollinations done in each cross, number of pods produced and seedlings obtained are given in Table 1.

Table 1. *Details of 2000 hand pollination programme*

| Cross | No. of Pollinations | No. of fruits collected | No. of Seedlings |
|---|---|---|---|
| BPM 24 X PB 235 | 1501 | 60 | 178 |
| BPM 24 X PB 260 | 1029 | 56 | 142 |
| BPM 24 X RRIC 121 | 976 | 60 | 154 |
| BPM 24 X GP 36/104 | 271 | 06 | 19 |
| PB 235 X PB 260 | 1063 | 22 | 63 |
| PB 235 X RRIC 121 | 1329 | 128 | 372 |
| PB 260 X RRIC 121 | 576 | 95 | 268 |
| PB 260 X PB 260 | 1089 | 23 | 60 |
| RRIC 121 X PB 235 | 603 | 70 | 197 |
| RRIC 121 X PB 260 | 290 | 38 | 111 |
| RRIC 121 X BPM 24 | 06 | 00 | - |
| RRIC 121 X RRIC 121 | 209 | 00 | - |
| RRIC 121 X GP36/147 | 213 | 17 | 49 |
| Total | 9155 | 575 | 1613 |

(D P S T G Attanayaka, K B Karunasekera, I D M J Sarath Kumara, T M S K Gunasekera).

## Evaluation of hand pollinated progenies

### *Small scale clone trials*

The department continued to monitor the Small Scale Clone Trials listed in Table 2.

Table 2. *Details of the small scale clone trials*

| HP year | Site | Planting date |
|---|---|---|
| 1976 | Hillstream – Tempo | May 1985 |
| 1982 | Clyde – Kethhena | Sept. 1987 |
| 1985 | Hillstream – Tempo | May 1989 |
| 1986 | Kuruwita | May 1990 |
| 1987 | I) Clyde- Kethhena | May 1993 |
| | II) Galawatta | June 1988 |
| 1988 | Dartonfield | July 1993 |
| 1992 | Dartonfield | May 1993 |
| 1995 | Sorana | June 1998 |
| 1996 | Kuruwita –I | May 1999 |
| | Kuruwita – II | May 1999 |
| 1991 | Pallegoda | August 2000 |
| | Vogan | November 2000 |
| 1997 | Clyde –I | June 2000 |
| | Clyde –II | June 2000 |

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

Yearly girth measurement (at 150 cm) and the test tapping data were recorded from the eight new clones selected and the two control clones (RRIC 100 and RRIC 121). The mean yield of the ninth year after tapping (BO 2 panel 5$^{th}$ year) based on six test tappings and the girth of these clones are given in Table 3.

Table 3. *Mean yield of the ninth year in grams per tree per tapping (g/t/t) and the mean girth of promising clones (GPB/BST/HPS/76/1)*

| Clone | Mean Yield (g/t/t) | Mean girth (cm) |
|---|---|---|
| 76- 121 | 28.16 | 74.06 |
| 76-158/RRISL 2004 | 52.56 | 78.73 |
| 76-182/RRISL 2003 | 59.11 | 89.15 |
| 76-198 | 43.84 | 84.11 |
| 76-52/RRISL 2001 | 73.74 | 88.73 |
| 76-8/ RRISL 2000 | 66.87 | 102.29 |
| 76-82/RRISL 2002 | 91.33 | 91.33 |
| 76-9 | 46.18 | 71.7 |
| RRIC 100 | 49.59 | 49.59 |
| RRIC 121 | 70.67 | 94.54 |

(D P S T G Attanayaka, K W Rupatunga and K B Karunasekera).

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

In this trial 61 new clones are monitored along with five control clones. Six test tappings were possible during the year, which was the fifth year of tapping (BO 2 first year of tapping). Table 4 shows the mean yield and the girth of promising selections along with the performances of the control clones.

Table 4. *Mean yield and mean girth of promising H.P. Seedlings. Clyde estate (GPB/BST/HPS/82/2)*

| Clone | Mean yield g/t/t | Mean girth Cm |
|---|---|---|
| 82 - 15/RRISL 2005 | 70.99 | 81.95 |
| 82 - 37 | 32.09 | 66.66 |
| 82 - 54 | 33.91 | 81.62 |
| 82- 110 | 35.01 | 80.9 |
| 82 - 111 | 36.05 | 72.55 |
| 82 - 124 | 40.85 | 67.17 |
| 82 - 140/RRISL 2006 | 51.42 | 78.07 |
| 82 - 144 | 38.80 | 79.13 |
| 82 - 152 | 36.63 | 81.50 |
| 82 - 157 | 33.46 | 75.85 |
| 82 - 163 | 39.2 | 87.0 |
| RRIC 100 | 29.68 | 66.10 |
| RRIC 102 | 35.11 | 71.75 |
| RRIC 121 | 46.71 | 78.02 |

(D P S T G Attanayaka, I D M J Sarathkumara and K B Karunasekera).

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

No test tapping was possible in this trial (third year of tapping) during the year. The girth measurements were recorded. Due to loss of plants caused by wind damage the trial was discontinued during the year (D P S T G Attanayaka, K W Rupatunga and K B Karunasekera).

**Evaluation of 1986 H.P. Selections - Kuruwita Sub Station (GPB/BST/HPS/86)**

Seventh year girth measurement and the results of the Duncan's Multiple Range Test for promising clones are given in Table 5. Test tapping data relevant to the second year of tapping based on eight observations are given in Table 6. The two clones, 86-81 and 86-21, though growing very vigorously have yielded only 24.0g and 19.19g of dry rubber per tree per tapping respectively.

Table 5. *Mean girth in cm of promising H.P. clones*

| Clone | Mean girth (cm) and DMRT grouping |
|---|---|
| 86-81 | 73.77 a |
| 86-21 | 69.92 ab |
| RRIC 121 | 69.52 ab |
| 86-77 | 67.92 abc |
| 86-87 | 64.86 bcd |
| 86-24 | 64.17 bcde |
| 86-76 | 63.27 bcdef |
| 86-82 | 62.34 cdefg |
| RRIC 110 | 62.15 cdefgh |
| 86-22 | 61.05 cdefghi |

Table 6. *Mean yield of promising H.P. clones*

| Clone | Yield (g/t/t) and DMRT grouping |
|---|---|
| 86 – 22 | 45.00 a |
| RRIC 110 | 43.00 ab |
| 86 – 32 | 42.87 ab |
| RRISL 121 | 41.92 abc |
| 86- 87 | 40.80 abcd |
| 86-25 | 38.12 abcde |
| 86-11 | 37.75 abcdef |
| 86-24 | 37.08 abcdef |
| 86-66 | 35.07 abcdefg |
| BPM24 | 33.14 abcdefgh |

(D P S T G Attanayaka, H P Pieris and K B Karunasekera).

**Evaluation of 1987 H.P. Selections - Clyde Estate (GPB/BST/HPS/87/1)**

Seventh year girth measurement and the results of the Duncan's Multiple Range Test (DMRT) are given in Table 7. This trial was opened for tapping at the end of 1999. Test tappings were commenced during the year. Mean yield based on nine test tappings is given in Table 8.

Table 7. *Mean girth and the results of DMRT of the 1987 H.P. selections*

| Clone | Girth in cm and DMRT grouping |
|---|---|
| RRIC-121 | $62.81^{a}$ |
| 87-370 | $62.48^{a}$ |
| RRIC 110 | $60.75^{ab}$ |
| 87-371 | $58.48^{bc}$ |
| 87-364 | $56.13^{cd}$ |
| RRIC100 | $55.90^{cd}$ |
| 87-372 | $54.41^{de}$ |
| 87-375 | $54.40^{de}$ |
| RRIC 102 | $53.84^{de}$ |

Table 8. *Mean yield and the results of DMRT of the 1987 H.P. selections*

| Clone | Yield (g/t/t) and DMRT grouping |
|---|---|
| 87-372 | $53.39^{a}$ |
| 87-382 | $52.61^{a}$ |
| 87-376 | $38.17^{b}$ |
| RRIC110 | $37.45^{b}$ |
| 87-368 | $37.38^{b}$ |
| 87-373 | $33.50^{bc}$ |
| 87-370 | $30.93^{cd}$ |
| 87-369 | $30.68^{cd}$ |
| 87-364 | $30.38^{cd}$ |
| RRIC121 | $29.80^{cd}$ |
| 87-365 | $29.77^{cd}$ |
| 87-375 | $28.20^{cde}$ |
| 87-383 | $26.54^{def}$ |
| RRIC100 | $25.93^{def}$ |
| RRIC102 | $25.25^{defg}$ |

(D P S T G Attanayaka, I D M J Sarathkumara and K B Karunasekera)

**Evaluation of 1987 H.P. Seedlings - Galewatta division, Dartonfield estate (GPB/BST/HPS/87/2)**

Progeny size, mean girth and mean yield of the seedling families are given in Table 9. Yield data of each family are based on six test tappings.

Table 9. *Mean girth and mean yield of the 1987 HP seedling families*

| Family | Progeny size | Mean Girth (cm) | Mean Yield (g/t/t) |
|---|---|---|---|
| RRIM 600 X RRIC 101 | 09 | 67.1 | 36.02 |
| RRIC 101 X GT 1 | 32 | 57.29 | 21.41 |
| RRIC 100 X GT 1 | 57 | 71.77 | 46.74 |
| RRIC 100 X RRIC 101 | 10 | 64.75 | 34.62 |
| RRIC 100 X RRIC 110 | 12 | 69.37 | 52.21 |
| RRIC 100 X RRIC 121 | 34 | 68.98 | 43.59 |
| PB 86 X RRIC 121 | 15 | 66.96 | 35.36 |
| RRIC 102 X GT 1 | 04 | 67.87 | 89.57 |
| RRIC 121 X RRIC 110 | 27 | 67.40 | 30.55 |
| RRIC 110 X RRIC 100 | 08 | 64.12 | 73.1 |
| RRIC 110 X RRIC 121 | 02 | 60.25 | 8.0 |

(D P S T G Attanayaka, T M S K Gunasekera, K W Rupatunga and K B Karunasekera).

**Evaluation of 1988 H.P. Selections - Dartonfield estate (GPB/BST/HPS/88)**

The seventh year girth measurement was taken and the mean girth arranged according to the Duncan's Multiple Range Test is given in Table 10.

Table 10. *Mean girth in cm of the 1988 HP progeny*

| Clone | Mean girth and DMRT grouping |
|---|---|
| 88-36 | 59.76 $^{a}$ |
| 88-32 | 57.85 $^{ab}$ |
| 88-28 | 55.65 $^{abc}$ |
| 88-31 | 55.22 $^{abcd}$ |
| RRIC100 | 54.36 $^{bcde}$ |
| 88-16 | 53.43 $^{bcdef}$ |
| 88-40 | 52.90 $^{bcdef}$ |
| 88-39 | 52.69 $^{bcdef}$ |
| 88-8 | 51.75 $^{cdefg}$ |
| RRIC110 | 51.0 $^{cdefgh}$ |
| RRIC121 | 50.28 $^{defghi}$ |
| RRIC102 | 50.09 $^{defghi}$ |

(D P S T G Attanayaka, L S Kariyawasam and K W Rupatunga).

**Evaluation of 1992 H.P. Seedlings Dartonfield Estate (GPB/BST/HPS/92)**

The trees of this trial are in the first year of tapping. The progeny size and the family means of the seventh year girth measurements taken at 150 cm from the ground level and the yield based on six test tappings are given in Table 11.

Table 11. *Family means of girth and the yield of the 1992 HP progeny*

| Family | Progeny size | Girth (cm) | Yield (g/t/t) |
|---|---|---|---|
| RRIC 100 x RRIM 712 | 60 | 52.46 | 24.85 |
| RRIC 100 x PB 255 | 75 | 60.19 | 28.64 |
| RRIC 100 x PR 255 | 61 | 52.21 | 20.78 |
| RRIC 121 x PB 255 | 44 | 56.07 | 30.65 |
| RRIC 102 x PB 255 | 31 | 54.25 | 18.03 |
| BPM 24 x RRIM 712 | 06 | 49.66 | 24.77 |
| RRIC 100 x PR 309 | 31 | 53.43 | 24.95 |
| RRIC 121 x PR 255 | 11 | 50.68 | 18.50 |
| RRIC 102 x PR 309 | 03 | 53.25 | 19.60 |
| RRIC 121 x PR 309 | 07 | 43.28 | 27.03 |

(D P S T G Attanayaka, A K Gamage, K W Rupatunga and T M S K Gunasekera)

**Evaluation of 1995 H.P. Seedlings Sorana estate (GPB/BST/HPS/95)**

In this trial 41 test entries along with two control clones are tested in a randomized block design with four replicates. Plot size of each clone is eight trees. The second year girth taken at a height of 120 cm is given in Table 12.

Table 12. *Mean girth in cm of the 1995 HP progeny*

| Clone | Mean girth and DMRT grouping |
|---|---|
| RRIC 121 | 17.53 [a] |
| 95-22 | 17.53 [a] |
| 95-23 | 17.35 [ab] |
| 95-55 | 17.06 [abc] |
| 95-33 | 16.98 [abc] |
| 95-51 | 16.76 [abcd] |
| 95-50 | 16.59 [abcde] |
| PB255 | 16.35 [abcdef] |

(D P S T G Attanayaka, I D M J Sarathkumara and K B Karunasekera)

**Evaluation of 1996 H.P. Seedlings - Kuruwita Estate (GPB/BST/HPS/96 -1 and 96-2)**

Two trials, 96-1 and 96-2 were established using fully randomised design with 15 replicates per treatment. In the trial 96-1, 27 hp clones and in 96-2 experiment 23 hp clones were included with three control clones. Diameter measurements from both these trials were taken. Table 13 shows the diameter of the promising entries and of the control clones in both trials.

Table 13. *Mean diameter in cm of the 1996 HP progeny*

| Mean diameter(cm) from 96-1 trials | | Mean diameter(cm) from 96-2 trials | |
|---|---|---|---|
| 96-8 | 2.100 | 96-53 | 2.538 |
| 96-31 | 2.029 | RRIC 121 | 2.114 |
| 96-4 | 1.971 | 96-26 | 1.808 |
| 96-2 | 1.964 | 96-37 | 1.753 |
| RRISL 205 | 1.958 | 96-36 | 1.693 |
| 96-5 | 1.942 | 96-32 | 1.667 |
| 96-16 | 1.886 | 96-28 | 1.650 |
| 96-7 | 1.880 | 96-45 | 1.633 |
| 96-56 | 1.850 | 96-50 | 1.600 |
| 96-59 | 1.838 | 96-39 | 1.573 |
| PB260 | 1.831 | 96-55 | 1.556 |
| 96-18 | 1.823 | 96-44 | 1.554 |
| | | 96-35 | 1.540 |

(D P S T G Attanayaka, H P Peris and K B Karunasekera)

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

Yearly girth measurement and the test tappings were done. Table 14 shows the mean girth and the yields obtained from each site. Clones PB 260, BPM 24 and RRIC 121 have given high mean yields during the third year of tapping when averaged over the four sites tested.

Table 14. *Mean girth (cm) and yield (g/t/t) obtained from SRRP II clone trials*

| Clone | | Eladuwa | Salawa | Kuruwita | Atale | Bentota | Yatawatta |
|---|---|---|---|---|---|---|---|
| PB 260 | Girth | 59.02 | 54.87 | 56.38 | 64.04 | 64.45 | 51.81 |
| | Yield | 40.85 | 51.05 | 53.61 | 46.99 | | |
| PB 235 | Girth | 61.53 | 58.69 | 61.6 | 62.88 | 66.83 | 50.96 |
| | Yield | 32.43 | 39.7 | 43.58 | 36.61 | | |
| BPM 24 | Girth | 54.91 | 50.54 | 47.18 | 55.66 | 52.31 | 48.28 |
| | Yield | 38.25 | 39.57 | 49.91 | 39.69 | | |
| PR 255 | Girth | 53.01 | 52.48 | 46.43 | 59.99 | 50.36 | 47.31 |
| | Yield | 28.95 | 32.81 | 27.83 | 32.02 | | |
| PR 261 | Girth | 53.27 | 53.2 | 46.65 | 58.85 | 53.15 | 47.91 |
| | Yield | 27.66 | 38.81 | 37.24 | 26.98 | | |
| RRIM 712 | Girth | 54.8 | 48.76 | 45.88 | 61.01 | 45.00 | 49.96 |
| | Yield | 35.84 | 40.42 | 35.94 | 41.25 | | |
| RRIC 121 | Girth | 61.79 | 58.3 | 60.85 | 72.48 | 64.13 | 54.37 |
| | Yield | 40.35 | 33.07 | 39.13 | 44.53 | | |
| RRIC 100 | Girth | 58.77 | 57.67 | | | | |
| | Yield | 38.29 | 44.53 | | | | |
| RRIC 110 | Girth | 57.88 | 55.88 | | | | |
| | Yield | 28.78 | 39.91 | | | | |
| PB 217 | Girth | 54.92 | 55.5 | | | | |
| | Yield | 33.56 | 46.54 | | | | |

(D P S T G Attanayaka, K W Rupatunga, I D M J Sarathkumara, B M S G Peiris, H P Peris and K B Karunasekara)

**Genotype environment interaction (G X E) studies (GPB/GE/98)**

Yearly girth measurement was recorded in this trial (D P S T G Attanayaka, K B Karunasekera, K W Rupatunga, I D M J Sarathkumara and H P Peiris).

**Performance of multi-clonal stands (GPB/MCS/98/KU)**

A diameter measurement was taken. ANOVA showed highly significant differences between the treatments and blocks. Table 15 shows the mean diameter of each treatment, *i.e.* Control clones, Monoclone blocks, Bi -clonal and Tri-clonal mixtures.

Table 15. *Mean diameter obtained from each treatment*

| Treatment | Mean diameter (cm) |
|---|---|
| RRIC 102 | 2.7151 |
| RRIC 102/RRIC 121 | 2.6720 |
| RRIC 121 | 2.6600 |
| RRIC 100/RRIC 121 | 2.6337 |
| RRIC 100/RRIC 102/ RRIC 121 | 2.5875 |
| RRIC 100/ RRIC 102 | 2.5456 |
| RRIC 100/ RRIC 133/ RRIC 121 | 2.5432 |
| RRIC 100/ RRIC 102/ RRIC 133 | 2.5256 |
| RRIC 133/ RRIC 121 | 2.4684 |
| RRIC 102/RRIC 133/RRIC 121 | 2.4667 |
| RRIC 102/RRIC 133 | 2.3563 |
| RRIC 100/ RRIC 133 | 2.2710 |
| RRIC 133 | 2.2670 |
| RRIC 100 | 2.2364 |

(D P S T G Attanayaka, K B Karunasekera and H P Peiris in collaboration with Plant Science Dept)

**Estate/RRI collaborative clone trials (ECT's) GPB/BST/ECT/99**

Routine monitoring was done. Annual girth measurements taken from these trials are given in Table 16.

Table 16. *Annual girth measurements recorded from ECTs*

| Clone | Site | Date of planting | Girth in cm at 120 cm height at different ages | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th |
| RRISL 205 | Pallegoda | 1995 | | 12.8 | 25.1 | 38.5 | 47.8 | | |
| | Vogan | 1997 | | 18.9 | 29.6 | | | | |
| RRISL 206 | Pallegoda | 1995 | | 10.8 | 20.8 | 33.3 | 42.5 | | |
| RRISL 218 | Vogan | 1997 | | 20.1 | 30.0 | | | | |
| | Pallegoda | 1995 | | 14.3 | 25.2 | 33.5 | 40.7 | | |
| RRISL 2001 | Pallegoda | 1995 | | 11.5 | 21.6 | 34.8 | 46.3 | | |
| RRISL 201 | Tempo | 1996 | 9.5 | 17.0 | 25.0 | 35.4 | | | |
| | Moralioya | 1996 | | | 15.1 | 27.6 | | | |
| | Kuruwita | 1994 | | | | 19.4 | 34.4 | 46.3 | |
| RRISL 202 | Moralioya | 1996 | | | 17.3 | 33.0 | | | |
| | Kuruwita | 1994 | | | | 24.0 | 36.1 | 42.4 | |
| RRISL 204 | Tempo | 1996 | 9.3 | 15.7 | 23.6 | 32.3 | | | |
| RRISL 215 | Tempo | 1996 | 9.1 | 17.5 | 26.5 | 33.6 | | | |
| RRISL 217 | Vorgan | 1997 | | 19.4 | 28.9 | | | | |

**Conservation and evaluation of the IRRDB germplasm (GPB/GP/85/2)**

The *Hevea* germplasm collection was maintained by adopting agronomic practices. The germplasm clone GP 36/147 was used in the pollination programme (D P S T G Attanayaka and K B Karunasekera).

**New planting**

I) ***GPB/BST/HPS/97/01, GPB/BST/HPS/97/02, GPB/BST/HPS/91/01 and GPB/BST/HPS/91/02***

Two Small Scale Clone Trials were planted at Clyde estate to test the 1997 HP progeny. Further two experiments were planted to test the 1991 HP progeny at Pallegoda and Vogan estates. All of these experiments were planted in a fully randomised single tree plot size design with 15 replicates per clone (D P S T G Attanayaka, H P Pieris and K B Karunasekera).

II) ***Open pollinated seedling progenies from commercial clones (GPB/BST/SP/99/01)***

An experiment was planted to evaluate the open pollinated seedling populations collected from commercial clearings. Seedlings collected from clones PB 86, PB 28/59, PB 260, RRIC 121 and RRIC 100 were planted with the parental clones in the same experiment to compare the performances of seedlings with their mother clones.

**Estate/RRI collaborative clone trials (GPB/BST/ECT/99/Sa)**

RRII 176, an introduced clone from India was planted (200 trees) at Pallegoda estate under ECT programme.

## PLANT SCIENCE

**P Seneviratne**

### SUMMARY

Crown budding when carried out at early stages cause minimum set back in the growth. However, crown clone seems to affect the growth and the yield of the trunk clone. Removal of the base of the bag of young buddings and polybag plants favoured the initial growth of the plants when compared with the current recommendation of removing the whole bag at planting.

Girthing of untapped trees continues to be higher than in tapped trees in all clones. Girth decline after tapping is lowest in clone RRIC 121 amongst the clones tested. Low frequency tapping with stimulation continues to give a higher g/t/t than in conventional ½S d/2 tapping with no adverse effects on girthing and incidence of Tapping Panel Dryness (TPD).

Although increase in plant density has resulted in a decrease in mean plant girth, total number of tappable trees and hence the yield per hectare increased with increasing planting density.

Improved growth of rubber resulted by rubber/banana intercropping has continued through out the immature period resulting in increased number of tappable trees and yield per hectare. Detailed physiological measurements indicated that shade alleviate radiation stress on rubber which is the case in most intercrops.

Studies on social and cultural effects show that most of farmers grow rubber as a permanent income source and to secure the ownership of encroached crown lands.

### DETAILED REVIEW

**Staff**

Dr A Nugawela, Head of the Department (upto 24th February), Dr (Mrs) P Serneviratne, Dr V H L Rodrigo, Mr L S S Pathiratna, Botanists, Mr K A G B Amaratunge, Mr R P Karunasena, Mrs G A S Wijesekera, Mr U S Weerakoon, Mr S Wilbert, Mrs R K Samarasekera, Mr M de Alwis, Mr M K P Perera, Mr T U K Silva, Experimental Officers, Mrs C W Ranasinghe and Mr L Zoysa, Technical Officers and Mrs D E Jayawardena, Clerk/Typist were on duty throughout the year.

Mr P D Pathirana and Mr P K W Karunatilaka assumed duties as Technical Officers with effect from 3rd July and 1st September respectively. Miss S Liyanage and Mr Asela Siriwardhana assumed duties as Technical Officers on 2nd May and Mr

A Siriwardena was transferred to the Rubber Technology and Development Department with effect from 05.09.2000. Mr L S Kariyawasam was transferred to Genetics and Plant Breeding Department with effect from 1st August.

Dr A Nugawela, the Head of the Department assumed duties as the Deputy Director Research (Biology) with effect from 25th February. Dr (Mrs) P Seneviratne was appointed as the Acting Head of the Department with effect from 20.12.2000. Mr A M W K Seneviratne, Assistant Botanist left to the Institute of Terrestrial Ecology, UK, with regard to his post graduate studies on 01.10.2000 and returned to the institute on 31.10.2000.

**Projects carried out by research students**

- Miss K K C Kaneru of University of Ruhuna completed her final year project on "The effect of rejuvenated shoot material on axillary bud proliferation and elongation of *Hevea brasiliensis*" under supervision of Dr (Mrs) P Seneviratne.

**Meetings and Conferences**

- The Head of Department attended the PGIS, University of Peradeniya Board Meetings.
- Dr V H L Rodrigo attended the IUFRO World Conference, Malaysia
- All Research Officers attended the Scientific Committee Meetings

**Number of training programmes conducted**

- Dr V H L Rodrigo organized a training programe on intercropping for officers of Second Perennial Crop Development Project.
- Altogether one hundred and twenty five (125) training programmes were conducted during the year.

**Training programmes attended**

- Dr V H L Roadrigo and Mr L S S Pathirantna attended the workshop on new frontiers for the spice and essential oil industry in the new millennium.

**Advisory visits**

Fourteen advisory visits were undertaken during the year.

## LABORATORY INVESTIGATIONS

**Tissue culture**

Nodal explants harvested from fifth successive graft generation of two clones

were tested for juvenility using axillary shoot proliferation experiments. *In vivo* characteristics of the shoots from which the explants were taken showed a gradual change in morphology towards the juvenile phase. Similar trend was observed *in vitro* too but the performance of cultures established even from the fifth passage were not similar to that of juvenile origin tissues (P Seneviratne, G A S Wijesekera and S Liyanage).

## FIELD EXPERIMENTS

### Rooted cuttings

Experiments conducted revealed that the induction of roots on clonal cuttings is difficult even under a permanent mist spray. Contrary to this, rooting can be induced on seedling originated cuttings, aged from 2 weeks up to 2-3 years without any difficulty.

Morphology of the root systems of cuttings taken from one half of the splitted seedlings, was similar to the tap root system of the other half. Girth increment in the field up to 2½ years showed better girthing in cuttings when compared to seedlings.

### Branch induction

The objective of the study is to compare different methods of branch induction and to findout the effect of branching on the tree growth. Details of the experiment are reported in the Annual Review 1999. The number of days taken for the induction of branches varied from 21 to 57.

The effect of the treatment on the number of branches induced was not significant. However, the control trees had a significantly lower, number of branches. The effect of branches on the tree growth is being monitored (P Seneviratne and U S Weerakoon).

### Polybag plants

Polythene bags (9" x 18") of the following types and colours were tested for the effect on plant growth and its durability.

Type
1. Black polythene – gauge 500
2. Black polythene – gauge 300
3. Ordinary polythene* – black – double layers
4. Transparent polythene – gauge 300
5. Ordinary polythene* transparent – double layers
6. Ordinary polythene* – white

7. Ordinary polythene* – silver colour
8. Polypropylene – transparent

(*Ordinary polythene is coloured house hold polythene of gauge 250 – 300 available in grocery shops).

Almost all the bags of types 4.7 and 8 degraded after a period of 10 months (Table 1).

Table 1. *The percentage of degraded bags after 10 months*

| Bag type | Degraded % |
|---|---|
| 1 | 0 |
| 3 | 0 |
| 2 | 12 |
| 6 | 28 |
| 5 | 68 |
| 4 | 100 |
| 7 | 100 |
| 8 | 100 |

(P Seneviratne and M N de Alwis)

**Root stock nurseries**

The effect of different uprooting methods of budded stumps on the scion growth was tested. Treatments were as follows;

T1 Current recommendation. Uproot after 1 month of grafting and cut back of stock plant leaving 6" snag and plant in polybags.

T2 Same as T1 but leaving the plants in the nursery until the grafted bud starts to sprout.

T3 Same as T1 but leaving the plants in the nursery until the grafted bud grows upto about 4".

T4 Same as T1 but leaving the plants in the nursery until the first whorl is mature.

Mean sprouting time for the plants of T1 was 25 days and the period is significantly higher than the plants of rest of the treatments, *i.e.* plants left in the nursery. They all took, about17 days to sprout.

Percentage casualties for treatments 1,2,3,4 were 8, 60, 28 and 44 respectively indicating higher percentage of casualties in treatments 2,3 and 4.

Mean height of the plants of treatment 1,2,3 and 4 were 42, 34 38 and 46 cm respectively (P Seneviratne and U S Weerakoon).

**Budwood nurseries**

Different sources of budwood, *i.e.* of overaged nurseries, mature budwood, budwood of field grown trees *etc.* were compared with that of well maintained budwood nurseries.

Clones RRIC 100, 121 and 130 were tested for grafting success, sprouting time and growth of the scion.

No significant differences were observed with regard to grafting success or sprouting time. The peeling quality was highest in budwood of field grown trees.

However, 4 months old polybag plants indicated a poor growth when field budwood is used (P Seneviratne and M N de Alwis).

**Crown budding**

***RRIC 110, 1994 and 1996 Replantings - Padukka (CB/98/1)***

Mean girth of RRIC 110 trees crown budded in 1997 with RRIC 100, 102, 117, 130 and *Hevea spruciana* at Padukka estate are given in Table 2.

Table 2. *Mean girth of RRIC 110 plants crown budded with different clones (The SEM is given within brackets)*

| Clearing | Crown | Girth (cm) |
|---|---|---|
| 1996 – RRIC110 | RRIC 100 | 42.3 (±.38) |
| Minnerigama Division | RRIC 102 | 46.3 (±.66) |
| | RRIC 117 | 40.9 (±1.8) |
| | RRIC 121 | 46.6 (±.44) |
| | RRIC 130 | 43.4 (±.66) |
| | *H. spruciana* | 37.2 (±.44) |
| 1994- RRIC 110 | RRIC 100 | 43.86 (±.40) |
| Main Division | RRIC 102 | 45.0 (±.50) |
| | RRIC 117 | 42.8 (±.63) |
| | *H. spruciana* | 45.7 (±1.25) |

Trees of both clearings show a similar growth, despite of age difference. Girthing is relatively better with clones RRIC 102 and 121 than with other clones tested (P Seneviratne and M N de Alwis).

***RRISL 224, 1997 Replanting – Dartonfield (CB/98/2)***

Mean girth of trees with different crowns are given in Table 2.

Table 3. *Mean girth of trees with different crown clones*

| Crown | Mean girth cm (±SEM) |
|---|---|
| RRIC 100 | 28.4 (± .5) |
| RRIC 102 | 23.4 (± 7.6) |
| RRIC 121 | 29.3 (± .5) |
| *H. Panciflora* | 28.4 (± 1.6) |
| RRIC 100 + RRIC 121 | 27.4 (± .7) |

(P Seneviratne and M N de Alwis)

***RRIC 133, RRII 105 and BPM 24 – N'kele***

In order to see the effect of crown/trunk combinations an experiment was established with three trunk clones, *i.e.* BPM 24, RRIC 133 and RRII 105 (P Seneviratne and M N de Alwis).

**Planting techniques**

Mean girth of the young buddings and polybag plants transplanted to the field as described below are given in Table 4.

T1 - Planted with the bag
T2 - Base of the bag removed
T3 - Base of the bag removed + 4 slits
T4 - Four slits on the bag (but with the base).
T5 - Recommended method (whole bag removed).

Plants transplanted with the bag but without the base (T2) have performed best as far as the growth is concerned. Removal of the base of the bag at time of planting appears to be sufficient (P Seneviratne and U S Weerakoon).

Table 4. *Mean girth at 4' from union. Means with same letter are not significantly different*

| Treatment | Polybags * | Young budding** |
|---|---|---|
| 1 | 13.4 [ab] | 11.9 [b] |
| 2 | 14.4 [a] | 13.0 [a] |
| 3 | 14.0 [ab] | 12.9 [ab] |
| 4 | 12.9 [b] | 12.5 [ab] |
| 5 | 13.8 [ab] | 12.8 [ab] |

* 17 months after planting ** 12 months after planting.

## Girth at opening

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

Experimental details are given in Annual Review 1995. The mean yield, *i.e.* g/t/t for different clones and girth classes are given in Table 5.

Table 5. *The mean yield,* i.e. *g/t/t recorded during the year for different girths and clones*

| Treatment | Clones and mean g/t/t | | | |
|---|---|---|---|---|
| | RRIC 130 | RRIC 121 | RRIC 100 | Mean |
| $T_1$ | 43.59 | 25.64 | 29.36 | 32.86 |
| $T_2$ | 32.15 | 25.86 | 31.79 | 29.30 |
| $T_3$ | 44.51 | 29.11 | 30.80 | 34.81 |
| $T_4$ | 53.16 | 25.74 | 35.64 | 37.85 |
| $T_5$ | 76.58 | 39.03 | 31.52 | 49.04 |

In all clones tested the g/t/t increased with increasing girth. However, trees that reach a higher girth later continues to yield less than those reached the same girth earlier. Therefore, in all clones tested trees with vigorous growth within a clone yields better.

Girthing of untapped trees continues to be higher than in tapped trees in all clones. Girth decline after tapping is lowest in clone RRIC 121 amongst the clones tested (Table 6).

Table 6. *Influence of tapping on subsequent girthing of clones RRIC 100, 121 and 130*

| Clone | Treatment | Initial girth (cm) | Girth increment (cm) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 1st | 2nd | 3rd | 4th | 5th |
| RRIC 100 | T1 | 41.9 | 4.5 | 3.5 | 4.8 | 4.09 | 1.57 |
| | T2 | 41.7 | 8.2 | 6.5 | 5.7 | 4.59 | 2.2 |
| | T3 | 44.6 | 4.8 | 3.5 | 4.8 | 4.5 | 1.66 |
| | T4 | 45.1 | 8.8 | 7.0 | 6.7 | 5.39 | 3.09 |
| | T5 | 50.2 | 3.7 | 4.5 | 5.1 | 5.19 | 1.81 |
| | T6 | 49.3 | 9.3 | 6.6 | 6.7 | 6.56 | 3.61 |
| | T7 | 42 | 8.3 | 3.9 | 3.4 | 4.79 | 1.88 |
| | T8 | 45 | 8.9 | 3.8 | 3.9 | 5.46 | 2.2 |
| RRIC 121 | T1 | 42.2 | 5.1 | 4.3 | 4.1 | 1.9 | 3.18 |
| | T2 | 42.6 | 6.3 | 5.5 | 4.6 | 2.44 | 4.52 |
| | T3 | 44.9 | 5.2 | 4.2 | 3.8 | 1.41 | 2.55 |
| | T4 | 44.6 | 6.6 | 5.2 | 4.4 | 2.89 | 3.2 |
| | T5 | 49.6 | 6.2 | 4.5 | 4.2 | 2.2 | 2.99 |
| | T6 | 49.6 | 7.6 | 5.8 | 4.4 | 2.23 | 4.87 |
| | T7 | 42.6 | 7.1 | 4.1 | 4.1 | 2.02 | 3.06 |
| | T8 | 44.7 | 6.1 | 4.3 | 4.3 | 1.96 | 3.02 |
| RRIC 130 | T1 | 42.9 | 4.9 | 4.2 | 2.2 | 2.77 | 1.69 |
| | T2 | 42.4 | 8.1 | 6.2 | 3.9 | 4.53 | 4.07 |
| | T3 | 44.6 | 5.7 | 5.5 | 2.1 | 4.28 | 1.48 |
| | T4 | 45.1 | 8.8 | 6.8 | 4.5 | 4.99 | 5.86 |
| | T5 | 49.5 | 5.7 | 5.0 | 1.5 | 4.36 | 3.96 |
| | T6 | 49.8 | 9.6 | 7.6 | 4.6 | 5.9 | 5.53 |
| | T7 | 42.6 | 8.2 | 3.9 | 2.0 | 3.5 | 2.79 |
| | T8 | 44.7 | 8.5 | 4.2 | 1.8 | 3.11 | 2.98 |

(A Nugawela, S Wilbert and R K Samarasekera)

***RRIC 100, 1992 Replanting – Yatadola***

Experimental details are given in Annual Review 1997.

g/t/t increases with increasing tree girth. Moreover, trees reaching higher girth levels relatively early gives a higher yield than those reaching same girth later (Table 7). Girthing is reduced by tapping and it is similar in all treatments tested.

Table 7. *The yield and girth increment at different girths of opening in genotype RRIC 100*

| Treatment | Yield (g/t/t) | Girth increment (cm) |
|---|---|---|
| $T_1$ | 21.04 | 2.0 |
| $T_2$ | - | 3.2 |
| $T_3$ | 19.9 | 1.8 |
| $T_4$ | - | 3.5 |
| $T_5$ | 26.9 | 2.3 |
| $T_6$ | - | 3.2 |
| $T_7$ | 19.7 | 1.5 |
| $T_8$ | 22.2 | 1.5 |

(A Nugawela, S Wilbert and R K Samarasekera)

**Low frequency tapping**

The objective of these trials is to reduce tapper requirement and tapping costs with no adverse effect on productivity.

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

The yield per tree per tapping and the intake per tapper are significantly high in low frequency tapping systems with stimulation. Further, the total yield per tree per annum is only marginally less in ½S d/3 +E (4/y) when comparing with conventional ½S d/2.

The annual girth increment and the percentage dry trees are similar in low frequency and conventional tapping systems (Table 8).

Table 8. *Effect of low frequency tapping with stimulation on yield growth and tapping panel dryness in clone RRIC 121*

| Treatment | Yield | | Growth (cm) | | TPD % |
|---|---|---|---|---|---|
| | g/t/t | kg/t/year | Girth | Increment | |
| ½ S d/2 | 29.8 | 3.1 | 92.9 | 1.9 | 15.0 |
| ½ S d/4 +E*(6/y) | 41.4 | 2.2 | 87.4 | 1.7 | 13.5 |
| ½ S d/3 +E*(6/y) | 36.6 | 2.8 | 86.6 | 1.4 | 12.4 |
| ½ S d/3 +E*(4/y) | 34.3 | 2.5 | 84.4 | 1.4 | 15.0 |

E* 2.3% ET.Ba1.6 (2.5) (A Nugawela, S Wilbert and R K Samarasekera)

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

The annual mean yield per tree per tapping is marginally high in low frequency tapping with stimulation. Nevertheless, the conventional ½S d/2 has recorded highest yield per tree per annum. ¼S d/2 with stimulation gives similar yields as from ½S d/2. Incidence of dry trees and girthing are similar in all treatments (Table 9)

Table 9. *Effect of low frequency tapping with stimulation on yield, growth and tapping panel dryness in clone RRIC 100*

| Treatment | Yield | | Growth (cm) | | TPD % |
|---|---|---|---|---|---|
| | g/t/t | kg/t/year | Girth | Increment | |
| ½ S d/2 | 42.5 | 4.87 | 84.1 | 1.5 | 17.1 |
| ¼ S d/3 +E*(6/y) | 43.2 | 4.95 | 93.9 | 2.5 | 9.0 |
| ½ S d/2 +E*(6/y) | 46.0 | 3.45 | 88.9 | 2.2 | 21.2 |
| ½ S d/3 +E*(4/y) | 44.6 | 3.08 | 89.8 | 2.4 | 13.8 |

E* 2.5% ET.Ba1.6(2.5)
(A Nugawela, S Wilbert and R K Samarasekera)

***RRIC 100, 1991 Replanting – Ambetenna (LFT/97/1)***

The annual mean yield per tree per tapping is similar in all low frequency tapping systems and it is higher than of conventional ½ S d/2 tapping. Moreover, the annual yield per tree is similar in the conventional and low frequency systems. Girth, girth increment and incidence of tapping panel dryness are similar in all treatments (Table 10).

Table 10. *The performance of low frequency tapping with different methods of stimulation in relation to ½S d/2 system*

| Treatment | Yield | | Growth (cm) | | TPD % |
|---|---|---|---|---|---|
| | g/t/t | kg/t/year | Girth | Increment | |
| ½ S d/3 +E*(4/y) | 26.0 | 2.32 | 58.96 | 1.64 | .3 |
| ½ S d/3 +E**(4/y) | 26.8 | 2.44 | 60.78 | 1.81 | 6.3 |
| ½ S d/3 +E*(6/y) | 23.2 | 2.18 | 59.03 | 1.44 | 6.2 |
| ½ S d/2 | 19.9 | 2.44 | 56.76 | 1.09 | 3.0 |

E* 2.5% ET.Ba1.6(2.5) E** 5.0%ET, Ba 1.6(2.5)
(A. Nugawela, S. Wilbert and R.K. Samarasekera)

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

The annual mean dry rubber yield per tree per tapping (g/t/t) and the total annual dry rubber yield per tree are highest in ½ Sd/3 tapping system with stimulation (Table 11).

The mean girth of trees is similar in both conventional and low frequency tapping systems. The incidence of TPD is high in clone RRIC 102 but it is similar in all treatments (Table 11).

Table 11. *Effect of low frequency tapping with stimulation on yield growth and tapping panel dryness in clone RRIC 102*

| Tapping system | Yield | | Growth | | TPD |
|---|---|---|---|---|---|
| | g/t/t | kg/t/y | Girth (cm) | Increment (cm) | % |
| ½ S d/2 | 19.56 | 2.69 | 76.2 | 2.3 | 27.7 |
| ½ S d/3 | 37.53 | 3.20 | 76.4 | 1.0 | 18.0 |
| ½ S d/3+E*(4/y) | 53.49 | 4.6 | 76.9 | 1.1 | 20.1 |
| ½ S d/4+E*(6/y) | 55.18 | 3.5 | 77.6 | 1.1 | 29.6 |
| ½ S d/3+E*(6/y) | 58.58 | 5.3 | 76.9 | 1.2 | 21.7 |

E* 2.5% ET, Ba 1.6 (2.5)
(A Nugawela and K A G B Amaratunge)

**Low frequency tapping of clone PB 86 in the smallholder sector**

The mean annual yield per tree per tapping (g/t/t) and the annual total yield per tree were highest in low frequency systems with stimulation using 2.5% Ethrel. With 1.0% Ethrel though the g/t/t was higher the annual yield per tree was similar to conventional tapping (Table 12).

Incidence of TPD and girth increment were similar in all treatments.

**High intensity tapping of virgin panels**

The objective of the trial and the experimental details are described in the Annual Review 1993.

*RRIC 100, 102, 121 and 130, 1998 Replanting – Dartonfield (HIT/93/1)*

The g/t/t is low with ½S d/1 tapping in all clones except RRIC 100. The treatment differences with regard to yield and growth are not consistent (Table 13). The experimental area was affected due to wind and a significant number of trees were damaged. Therefore, the trial may have to be discontinued.

Table 12. *Yield incidence of TPD and growth of clone PB 86 when tapped at low frequency with stimulation*

| District | Treatment | Yield | | Growth (cm) | | TPD % | Stimulation rounds |
|---|---|---|---|---|---|---|---|
| | | g/t/t | Kg/t/year | Girth | Increment | | |
| Ratnapura | ½ S d/2 | 19.9 | 2.1 | 67.8 | 0.5 | 6.0 | 0 |
| | ½ S d/3 +E*(4/y) | 38.1 | 3.2 | 66.8 | 1.1 | 7.0 | 4 |
| | ½ S d/3 +E*(6/y) | 40.1 | 3.3 | 71.5 | 0.8 | 8.4 | 4 |
| | ½ S d/3 +E**(6/y) | 25.5 | 2.0 | 67.1 | 1.0 | 7.1 | 4 |
| Kegalle | ½ S d/2 | 16.0 | 1.95 | | | 2.6 | 0 |
| | ½ S d/3 +E*(4/y) | 23.6 | 1.94 | | | 2.0 | 3 |
| | ½ S d/3 +E*(6/y) | 25.6 | 2.10 | | | 3.2 | 4 |
| | ½ S d/3 +E**(6/y) | 24.4 | 2.05 | | | 3.0 | 4 |

E* 2.5% ET.Ba1.6(2.5) E** 1.0%ET, Ba 1.6(2.5)
(A Nugawela, K A G B Amaratunge and S Wilbert)

Table 13. *Effect of tapping systems tested at different fertilizer levels on dry rubber yields of clones RRIC 100, RRIC 102, RRIC 121 and RRIC 130. Annual girth increment is given within brackets*

| Tapping system | Fertilizer level | Yield (g/t/t) | | | |
|---|---|---|---|---|---|
| | | RRIC 110 | RRIC 102 | RRIC 121 | RRIC 130 |
| ½ S d/1 | 1 | 39.4(2.5) | 23.9(0.6) | 18.4(1.3) | 37.8(1.9) |
| | 2 | 40.3(1.8) | 20.9(0.6) | 25.5(1.3) | 29.2(1.0) |
| ½ S d/2 | 1 | 37.6(2.1) | 42.4(1.7) | 36.4(1.6) | 45.0(2.6) |
| | 2 | 40.0(2.5) | 33.5(0.9) | 52.3(1.8) | 38.1(2.0) |
| ½ S d/2+E* | 1 | 51.7(2.4) | 32.7(0.7) | 42.2(1.4) | 36.1(1.7) |
| | 2 | 42.4(1.6) | 32.3(0.9) | 45.1(0.8) | 33.4(2.0) |
| ½ S d/3+E* | 1 | 40.5(2.0) | 40.2(1.1) | 42.4(1.3) | 42.7(1.5) |
| | 2 | 51.5(2.7) | 27.9(0.7) | 46.2(1.7) | 48.8(3.5) |

(A Nugawela and R P Karunasena in collaboration with the Soils and Plant Nutrition Department).

**Exploitation of renewed bark**

The objective of the trial is to identify suitable bark for tapping once the virgin panels, *i.e.* BO-1 and BO-2 are tapped. Tapping treatments were revised from 1999 and the previous and current tapping treatments are described in Annual Review 1999.

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

Yield from panel BI-1, rested for *ca.*6 years is similar to what obtained without a rest period. Higher panels when tapped upwards give better yields than when tapped downwards (Table 14). Puncture tapped higher panels give similar yields to higher virgin panels.

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

| Treatment | Annual mean g/t/t | |
|---|---|---|
| | ERB/93/1 | ERB/93/2 |
| 1. ¼S(↑) + ½ S(↓) d/2 | 58.4 | 54.7 |
| 2. ¼S(↑) + ½ S(↓) d/2 | 52.4 | 43.8 |
| 3. ½ S(↓)d/2 (BI-1) | 38.4 | 45.2 |
| 4. ½ S(↓)d/2 (BI-1) | 35.4 | 35.0 |
| 5. ½ S(↑)d/2 (HO-1) | 48.6 | 43.8 |
| 6. ½ S(↓) d/2 (HO-2) | 29.5 | 42.4 |

(A Nugawela and R P Karunasena)

**Exploitation of dry trees**

***RRIC 100, 1982 Replanting Neuchatle (TPD/97/1)***
***RRIC 102, 1982 Replanting Neuchatle (TPD/97/2)***

The objective and experimental details are described in the Annual Review of 1998.

Among the different tapping systems tested to exploit dry trees the ¼ S(↑) cut on higher panels continue to give highest yields (Table 15). Further the number of yielding trees are also high in treatments where higher panels are exploited.

Table 15. *The mean yield,* i.e. *g/t/t of exploited dry trees and percentage number of trees with latex (within brackets) for different treatments*

| Treatment | Tapping frequency | | |
|---|---|---|---|
| | d/2 | D/3 | D/4 |
| $T_{1a}$ ¼ S(↑) | 18.6 (50) | 29.6 (50) | 20.4 (50) |
| $T_{1b}$ ¼ S(↓) | 26.2 (25) | 22.9 (50) | 11.4 (62) |
| $T_2$ Continues tapping | 16.8 (25) | 16.3 (50) | 6.9 (88) |
| $T_3$ ½ S(↓) opp. Panel | 13.2 (62) | 5.2 (25) | 2.8 (37) |
| $T_4$ ½ S(↑) opp. Higher panel | 12.9 (88) | 13.8 (88) | 16.5 (88) |

(A Nugawela, K A G B Amaratunga and S Wilbert)

**Planting density**

This experiment was established in 1992 and details appear in the Annual Review of the same year. Girth and yield of the three clones being tested under four different densities are summarized in the Table 16 b. As was the case in year 1999, mean girth of rubber trees decreased with increase in density. Therefore, average percentage tappable trees showed a gradual decrease from 76% to 58% with the increase in density from 500 to 800 trees per hectare. However it was *vice versa* for the total number of tappable trees per hectare (*i.e.* 382, 412,442 and 463 for 500, 600, 700, 800 trees $ha^{-1}$ respectively). Values recorded for the g/t/t were comparable among the densities with an average of 24.7. Though not statistically significant, yield per hectare increased with the increase in density up to 700 trees per hectare due to the higher number of tappable trees. Casualties (percentage dead plants) were more or less same in different densities and was *ca.* 1.7- 3.4 percentage, The least percentage weak plants was recorded in lowest density 500 tress $ha^{-1}$ with the highest, 4.1%, in 700 tress $ha^{-1}$.

The clone RRIC 110 showed a poor performance with respect to girth, percentage tappable trees, percentage casualties, percentage weak plants, g/t/t and yield per hectare.

Table 16. *Effect of planting density on growth and yield parameters of rubber. a).plant girth at 150cm, bark thickness at 150cm and percentages of casualties, weak plants and tappable trees, (b) tree yield (g/t/t) and estimated YPH (kg/ha/year)*

(a)

| Density (trees/ha) | RRIC 100 | | | | | | RRIC 110 | | | | | | RRIC 121 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Girth (cm) | Bark thickness (mm) | % Casualties | % Weak plants | % Tappabilty | Tappable trees/ha | Girth (cm) | Bark thickness (mm) | % Casualties | % Weak plants | % Tappabilty | Tappable trees/ha | Girth (cm) | Bark thickness (mm) | % Casualties | % Weak plants | % Tappabilty | Tappable trees/ha |
| **500** | 55.41 | 5.71 | 0.0 | 0.0 | 85.73 | 428.65 | 51.80 | 5.34 | 8.56 | 1.42 | 53.11 | 265.50 | 57.23 | 5.58 | 1.09 | 0.0 | 90.28 | 451.40 |
| **600** | 54.48 | 5.83 | 1.67 | 0.63 | 77.02 | 462.12 | 48.42 | 4.84 | 3.79 | 5.71 | 51.02 | 306.12 | 54.95 | 5.62 | 1.67 | 0.60 | 78.16 | 468.96 |
| **700** | 51.23 | 5.39 | 0.0 | 1.16 | 70.80 | 495.60 | 46.67 | 5.15 | 5.12 | 9.49 | 39.33 | 275.31 | 53.93 | 5.58 | 0.0 | 1.74 | 79.38 | 555.66 |
| **800** | 51.74 | 5.42 | 0.84 | 2.23 | 65.04 | 520.32 | 45.38 | 4.56 | 8.54 | 4.98 | 36.91 | | 51.78 | 5.24 | 0.86 | 0.0 | 71.70 | 573.60 |

(b)

| Clone | Yield | Density (Plants/ha) | | | |
|---|---|---|---|---|---|
| | | 500 | 600 | 700 | 800 |
| RRIC 100 | g/t/t | 23.6 | 24.3 | 22.4 | 22.1 |
| | YPH | 557.3 | 605.6 | 591.9 | 622.2 |
| RRIC 110 | g/t/t | 28.8 | 29.2 | 34.5 | 441.8 |
| | YPH | 422.4 | 492.6 | 498.2 | 441.8 |
| RRIC 121 | g/t/t | 21.9 | 22.9 | 20.4 | 18.3 |
| | YPH | 544.8 | 587.2 | 617.4 | 583.3 |

(V H L Rodrigo, A Nugawela, T U K Silva in collaboration with the Genetics and Plant Breeding Department).

## Intercropping

### *Spatial arrangements*

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

Experimental details appear in the Annual Review 1992. Similar to the results shown in 1999, girth was highest in the cluster triangular system with the lowest in the triple row system. Moreover, the lowest bark thickness and percentage tappable trees were also recorded in the triple row system. A similar trend was observed for the g/t/t (Table 17).

Table 17. *Effect of different planting systems on growth and yield parameters of rubber. In (a) overall summary of treatment effect, (b) percentage trees in different girth classes*

(a)

| Spatial Arrangement | Girth (cm) | Bark thickness (mm) | Yield (g/t/t) |
|---|---|---|---|
| Single row planting system | $53.10^{cb}$ | $6.92^{a}$ | $24.19^{ab}$ |
| Double row planting system | $50.59^{cd}$ | $6.47^{ab}$ | $20.60^{bc}$ |
| Triple row planting system | $47.51^{d}$ | $6.26^{b}$ | $18.57^{c}$ |
| Triangular planting system | $57.78^{a}$ | $6.88^{a}$ | $26.63^{a}$ |
| Square planting system | $54.14^{b}$ | $6.95^{a}$ | $24.56^{a}$ |

(Values with the same letter in each category are not significantly different)

(b)

| Spatial Arrangement | <40 cm | 40-44.9 cm | 45-49.9 cm | >50 cm |
|---|---|---|---|---|
| Single row planting system | 0 | 10.67 | 17.5 | 72.17 |
| Double row planting system | 0 | 26.67 | 16.67 | 56.33 |
| Triple row planting system | 7.67 | 26.0 | 27.33 | 39.0 |
| Triangular planting system | 0 | 3.33 | 9.0 | 87.67 |
| Square planting system | 2.0 | 0 | 20.33 | 77.67 |

(V H L Rodrigo, T U K Silva and E S Munasinghe)

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

This experiment was established in 1992 and details are reported in the Annual Review of same year.

The growth of the rubber trees was not affected significantly by the spatial arrangement, *i.e.* row or contour planting, but by the intercrop. The girth of rubber in Cinnamon plots, irrespective of the spatial arrangement, was higher than those with the other two intercrops and the control. The effect of the intercrop on the yield of rubber was not significant at this stage (Table 18) but the effect of spatial arrangement was significant (Table 19).

Table 18. *Effect of intercrop on the growth and yield of rubber*

| Treatments | Yield g/t/t | Girth of rubber (cm) |
|---|---|---|
| Rubber + Cinnamon | 40.0[a] | 61.4 [a] |
| Rubber + Coffee | 39.1[a] | 58.5 [ab] |
| Rubber only | 36.1[a] | 57.9 [bc] |
| Rubber + Grass | 33.1[a] | 55.4 [c] |

(Values with the same letter in each category are not significantly different)

The growth of coffee was unaffected either by the spatial arrangement, or by the closeness to the rubber row. But the yield was greater in east-west oriented rubber row treatment than on contours. The yield of cinnamon was greater in contour rubber row treatments than in the row planting treatment. Though the growth of grass was poor in all treatments its yield followed the same trend as those of cinnamon (Table 19) (L S S Pathiratna and M K P Perera).

Table 19. *The effect of spatial arrangement on the yield of rubber, coffee, cinnamon and grass*

| Treatment | Rubber yield g/t/t | Dry bean yield of coffee, g/row | Bark yield of cinnamon g/bush | DM yield of grass kg/ha. |
|---|---|---|---|---|
| Row planting of rubber | $33.3^{b}$ | $352.2^{a}$ | $61.2^{b}$ | 1303.8 |
| Contour planting of rubber | $40.9^{a}$ | $242.9^{b}$ | $79.0^{a}$ | 1266.8 |

(Values with the same letter in each category are not significantly different)

***Intercropping systems***
*Rubber and timber*

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

Experimental details were reported in Annual Review 1992.

Alstonia was the most successfully established timber crop, and has shown the highest competition to growth and yield of rubber (Table 20a). Although bark thickness and percentage of tappable trees were not significantly affected by timber species, girth and yield of rubber in Alstonia plots were poor. The timber crop density in the double row system is greater when compared to that of single row system, hence the effect of Alstonia on growth and yield of rubber was more prominent in the former (Table 20b). Moreover, growth and yield of rubber recorded in the Alstonia timber plots were less than in corresponding high density rubber plots indicating that competitive effect of Alstonia is greater than that of rubber.

Table 20a. *Effect of timber crops on growth and yield parameters of rubber*

| Timber species | Girth (cm) | Bark thickness (mm) | % Trees in tapping | Yield (g/t/t) | Yield (kg/ha/yr) |
|---|---|---|---|---|---|
| No timber | $51.95^{b}$ | $5.95^{a}$ | $92.81^{a}$ | $20.74^{b}$ | $940.98^{a}$ |
| Halmilla | $52.00^{b}$ | $5.86^{a}$ | $87.10^{a}$ | $20.91^{b}$ | $898.53^{ab}$ |
| Alstonia | $47.78^{c}$ | $5.34^{a}$ | $80.84^{a}$ | $17.36^{c}$ | $710.27^{b}$ |
| Teak | $51.90^{b}$ | $6.87^{a}$ | $93.32^{a}$ | $20.76^{b}$ | $954.93^{a}$ |
| Mahogani | $54.54^{a}$ | $6.31^{a}$ | $92.01^{a}$ | $23.91^{a}$ | $1071.74^{a}$ |

(Values with the same letter in each category are not significantly different)

Table 20b. *Performance of rubber under different cropping systems. Since Alstonia was the most successfully established timber crop, out of all intercrops only the rubber/Alstonia was included in the statistical analysis*

| Cropping system | Girth (cm) | Bark thickness (mm) | % Trees in tapping | Yield (g/t/t) | Yield (kg/ha/yr) |
|---|---|---|---|---|---|
| Single row system (sole crop) | 53.68[a] | 6.14[a] | 100.0[a] | 22.05[a] | 1067.6[ab] |
| Double row system (sole crop) | 50.22[a] | 5.76[ab] | 85.62[a] | 19.42[ab] | 814.3[ab] |
| Alstonia intercrop in single row system | 50.12[a] | 5.52[b] | 80.77[a] | 19.50[ab] | 827.5[ab] |
| Alstonia intercrop in double row system | 45.44[b] | 5.16[b] | 80.90[a] | 15.22[b] | 593.0[b] |
| High density rubber-single row intercropping system | 51.55[a] | 5.42[b] | 88.21[a] | 20.36[ab] | 1410.9[a] |
| High density rubber-double row intercropping system | 50.70[a] | 5.24[b] | 78.98[a] | 19.84[ab] | 1460.8[a] |

(Values with the same letter within each category are not significantly different)
(V H L Rodrigo, T U K Silva and E S Munasinghe)

*Rubber and Cardamom*

The details of the experiment are described in the Annual Review 1999. No effect on either the growth or yield of rubber is evident. In general, per plant cardamom yield showed no difference across the two densities, hence higher the density, greater the yield per hectare (Table 21). Selected varieties of cardamom for the low elevation have out performed the control type EC1/700. The yields of the medium scale demonstration plot established at Elston estate with the selected varieties and planted in high density leaving only *ca.* 2 m radius for rubber were comparable with those in double row system of other trials.

**Intercropping project on rubber/banana and smallholder on-farm trials**

The details of this study appeared in the Annual Reviews of 1998 and 1999. This project is funded by the Department for International Development (DFID) UK and conducted in collaboration with Universities of Wales and Durham in UK and University of Sri Jayawardenapura, Sri Lanka.

Table 21. *Estimated yields (kg/plant/ year) of selected cardamom varieties at different planting densities and sites*

| Cardamom variety | Dartonfield | | Hapugastenna | | Morontota | | Elston |
|---|---|---|---|---|---|---|---|
| | Single row | Double row | Single row | Double row | Single row | Double row | High density |
| EC1/100 | 19.8 | 53.4 | 20.6 | 41.0 | 22.4 | 45.4 | 49.5 |
| EC1/101 | 22.8 | 54.8 | 22.4 | 47.0 | 22.8 | 46.6 | 43.5 |
| EC1/102 | 22.9 | 53.4 | 19.6 | 44.0 | 23.0 | 48.6 | 58.2 |
| EC2/400MT | 22.0 | 56.0 | 18.6 | 42.0 | 24.6 | 48.4 | 57.9 |
| EC1/700 | 8.0 | 19.2 | 7.2 | 16.8 | 6.7 | 11.4 | |

(V H L Rodrigo, L S Pathiratne, T U K Silva and E S Munasinghe. This is a collaborative project between the Department of Export Agriculture and the RRISL and funded by the CARP)

## On-station experiments

### Long-term effects of intercropping on rubber growth (Rubber/banana intercropping - Kuruwita Substation)

Intercropping with banana during the early stage of rubber crop has resulted improved growth of rubber, hence achieved greater percentage of tappable trees than that of sole rubber (Table 22). Daily yield of rubber trees (g/t/t) was comparable among treatments with an average of *ca.* 22 grams/tree/tapping during the first year of tapping, However due to the higher percentage of tappable trees, the highest yield per hectare per year, *i.e.* 455kg was recorded in the highest density BBBR treatment with lowest of 357kg for the sole rubber.

Table 22. *Treatment effect on % trees in tapping and overall rubber yields. Planting systems R, BR, BBR and BBBR refer to sole rubber and intercrops with one, two and three rows banana between two rubber rows, respectively*

| Planting systems | % Trees in tapping | Yield per hectare per annum (YPH) in Kg |
|---|---|---|
| R | 68.8 | 357 |
| BR | 76.76 | 416 |
| BBR | 81.11 | 433 |
| BBBR | 82.19 | 455 |

(V H L Rodrigo, A M W K Seneviratne, T U K Silva and P D Pathirana in collaboration with University of Wales UK)

**Shade experiment on rubber and banana (Dartonfield)**

Heavy shade has resulted reduced growth rates of both rubber and banana (Table 23). However decline in the Fv/Fm ratio in both crops was greater under open conditions indicating that shades alleviate the radiation stress (photoinhibition) during the midday period (Tables 24 and 25).

Table 23. *The growth of rubber and banana as indicated by increment in girth, diameter and height for the year 2000 under different shade levels*

| Shade level | Rubber | | Banana | |
|---|---|---|---|---|
| | Diameter Increment/ cm | Height Increment/cm | Girth Increment/cm | Height Increment/cm |
| Open (0%) | 3.3 | 296 | 50.9 | 201.7 |
| Low (30-40%) | 2.2 | 217 | 40.6 | 174.1 |
| Medium (50-60%) | 1.5 | 150 | 29.7 | 123.9 |
| High (70-80%) | 1.0 | 107 | 27.5 | 118.8 |

Table 24. *Diurnal variation in the Fv/Fm ratio of rubber at different shade levels. The percentage decline has been based on the values for the morning*

| Shade level | Morning | Midday | | Evening | |
|---|---|---|---|---|---|
| | Fv/Fm | Fv/Fm | % decline-Fv/Fm | Fv/Fm | % decline-Fv/Fm |
| Open (0%) | 0.831±0.002 | 0.753±0.008 | 9.4 | 0.804±0.008 | 3.2 |
| Low (30-40%) | 0.836±0.002 | 0.792±0.002 | 5.3 | 0.813±0.008 | 2.7 |
| Medium (50-60%) | 0.831±0.001 | 0.796±0.006 | 4.2 | 0.820±0.004 | 1.3 |
| High (70-80%) | 0.836±0.002 | 0.820±0.002 | 1.9 | 0.831±0.002 | 0.6 |

Table 25. *Diurnal variation in the Fv/Fm ratio of banana at different shade levels. The percentage decline has been based on the values for the morning*

| Shade level | Morning | Midday | | Evening | |
|---|---|---|---|---|---|
| | Fv/Fm | Fv/Fm | % decline-Fv/Fm | Fv/Fm | % decline-Fv/Fm |
| Open (0%) | 0.836±0.002 | 0.743±0.03 | 11.0 | 0.825±0.004 | 1.3 |
| Low (30-40%) | 0.824±0.003 | 0.794±0.02 | 3.6 | 0.825±0.004 | 0 |
| Medium (50-60%) | 0.833±0.005 | 0.796±0.007 | 4.4 | 0.831±0.005 | 0.2 |
| High (70-80%) | 0.841±0.003 | 0.820±0.006 | 2.5 | 0.835±0.002 | 0.7 |

(A M W K Seneviratne, V H L Rodrigo, P K W Karunathilake and P D Pathirana in collaboration with University of Wales UK)

**On-farm trials on rubber intercropping**

Researcher led on-farm experiment (RLE) comprises of four sites in Kegalle, three in Kalutara, eight in Monaragala and three in Hambantota. However, banana in two sites, *i.e.* each in Kegalle and Hambantota, was totally unsuccessful due to the poor interest paid by farmers. There were five farmer led on-farm experimental (FLE) sites, three in Kegalle (one was abandoned by the farmer, hence two now) and two in Monaragala region (Table 26). In general, most of farmers grow rubber as a permanent income source and more specifically, to secure the land ownership where it is loosely held (*eg.* on encroached crown lands). Full-time farmers pay greater interest to farming activities compared to those with off-farm income sources, resulting in improved growth of both rubber and banana and total land use efficiency with additional short-term crops. In contrast, more the off-farm activities lesser attention paid to crops hence poor growth. However when compared to banana, rubber is capable of withstanding poor management conditions such as less frequent weeding (Table 26a and b).

***Rubber and Cocoa/Cinnamon***

*Dartonfield - IC/CC/91/2*

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

The growth of rubber was not affected by the intercrops at this stage (Table 27) (L S S Pathiratna and M K P Perera).

Table 26. *Summary of situation of the on-farm trials a) Researcher-led and b) Farmer-led experiments*

a)

| REGION | FARMER | MAIN OCCUPATION | FREQUENCY OF WEEDING | GROWTH OF | | INTEREST TO INTERCROPPING | REASON FOR GROWING RUBBER | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | RUBBER | BANANA | | | |
| KEGALLE (Village Pannila) | NIMAL RANJIH | Hired labourer (tapper) | High | Good | Good | High | As a permanent income source. To secure the land ownership. | Estate labourer. Works on his own land in the evening. |
| | NAYANA KUMARA | Farmer | Medium | Moderate | Moderate | Medium | As a permanent income source. Rubber needs less money compared to tea. | Do only rubber tapping on his lands. Use hired labour for other on-farm activities. |
| | JAYARATNA | Mason | Very low | Moderate | Weak | low | As a permanent income source. To secure the land ownership. Convenience in management compared to tea. | Mason. His farther looks after the on-farm activities. |
| | NISANTHI | Hired labourer (Tea plucker) | Very low | Moderate | No plants | low | As a permanent income source. Rubber needs less money compared to tea. | Casual tea plucker. Her husband works outside. |
| KALUTERA (Village Kobawaka ) | ANTON | Trader | Medium | Good | Moderate | Medium | As a permanent income source. | Trader. Use hired labour for most of on-farm activities. |
| | WIJETUNGA | Hired labourer | Low | Moderate | Low | low | As a permanent income source. Has experience in rubber cultivation for over 30 years. | Do rubber tapping on his lands. Works as a hired labourer. No additional family labour. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | LIYANAGE | Farmer | Medium | Good | Moderate | Medium | As a permanent income source. Less labour requirement for rubber than for tea. | Widow. Has 2ac tea/rubber intercrop adjacent to the experiment. High mortality rate of tea. Use hired labour for all farm activities. |
| MONARAGALA (Village Pallekiruwa) | ABEYKON | Hired labourer | Low | Moderate | Low | low | As a permanent income source. Rubber needs less money compared to pepper. | Works as a hired labourer. When free, works on own land. |
| | LOKUBANDA | Trader | low | Good | Low | low | As a permanent income source. Convenience in management. Convenience in management. | Has started own boutique since December 2000, hence no interest in farming activities. |
| | PUNCHIBANDA | Farmer | Medium | Good | Moderate | Medium | As a permanent income source. | Pepper is been grown in a part of the rubber land. |
| | SIRIWARDANA | Farmer | High | Good | Good | High | As a permanent income. Convenience in management. To secure the land ownership. | The land is far away from home (over 1km). |
| | CHANDRADASA | Farmer | High | Good | Moderate | Medium | As a permanent income source. To secure the land ownership. | The land is away from home (over 0.5 km). |
| | SHANTHA | Farmer | High | Good | Moderate | Medium | As a permanent income. Convenience in management. To secure the land ownership. | The land is away from home (over 0.5 km). |
| | DINGIRIBANDA | Farmer | High | Good | Good | High | As a permanent income source. To secure the land ownership. | Cereals and pulses are grown with the rubber/banana intercrop. |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | WIJEPALA | Farmer | Medium | Good | Low | Low | As a permanent income source. To secure the land ownership. | His son who works on gem mining, involves in labour intensive farming activities. |
| HAMBANTOTA (Village Bookedayaya) | ARIYADASA | Farmer | Medium | Moderate | Moderate | Medium | As a permanent income source. Preferred rubber over the Citronella (traditional crop) based on price fluctuation. | Keeps Citronella grasses with rubber/banana intercrop. in the land, they don't remove them because of the low maintaining cost. |
| | DAYAPALA | Trader | Low | Moderate | No plants | Low | To secure the land ownership. | The land is away from home (ca. 1 km). Engaged more on coconut based products. |
| | PERIS | Farmer | Medium | Moderate | Good | Medium | As a permanent income source. Preferred rubber over cinnamon due to less capital requirement. | Sons do farming activities while sawing timber. |

b)

| REGION | FERMER | MAIN OCCUPA-TION | FREQUENCY OF WEEDING | GROWTH OF | | INTEREST TO INTERCROPPING | REASON FOR GROWING RUBBER | REMARKS |
|---|---|---|---|---|---|---|---|---|
| | | | | RUBBER | BANANA | | | |
| KEGALLE (Village Vegantale) | APPUHAMI | Farmer | High | Good | Good | High | As a permanent income source. Has experience in rubber cultivation for over 50 years. | Highly intensified rubber intercropping with different types of crops. Used mainly the family labour for farming activities. |
| | ABEYRATHNA | Hired labourer (Rubber tapper ) | Low | Moderate | Low | Medium | As a permanent income source. Has experience in rubber cultivation over 20 years. | Gives less priority to own land and act as a caretaker to an adjacent land. |
| MONERAGALA (Village Mediriya) | BANDARA MENIKE | Farmer | High | Good | Good | High | As a permanent income source. | More depends on short term crops. |
| | JAYAWATHI | Farmer | Low | Good | Moderate | Medium | As a permanent income source. | More depends on short term crops. The land is away from home (over 0.5 km). |

(V H L Rodrigo, A M W K Seneviratne and P D Pathirana in collaboration with Universities of Wales and Durham in UK and University of Sri Jayawardenapura, Sri Lanka.)

Table 27. *Effect of intercrops on the growth of rubber*

| Treatments | Girth of rubber (cm) |
|---|---|
| 1. Rubber only | 62.2 |
| 2. Rubber + Cinnamon (spacing 1) | 59.4 |
| 3. Rubber + Cinnamon (Spacing 2) | 64.1 |
| 4. Rubber + Cinnamon (Spacing 3) | 62.8 |
| 5. Rubber + Cocoa (Spacing 1) | 57.1 |
| 6. Rubber + Cocoa (Spacing 2) | 59.0 |
| 7. Rubber + Cocoa (Spacing 3) | 56.4 |

***Rubber - Rattan/intercropping trial - Kuruwita Sub-station***

This intercropping trial was established in October 1996 with three indigenous species of rattan (Annual Review 1996). The growth of rattan is satisfactory as evident by stem height (Table 28).

Table 28. *The stem height and annual height increment of rattan*

| Rattan | Height of stem (cm) | Annual increase (cı |
|---|---|---|
| Species 1 | 87.7 | 49.9 |
| Species 2 | 138.8 | 76.4 |
| Species 3 | 94.3 | 56.8 |

(L S S Pathiratna and M K P Perera)

***Possibilities of intercropping cinnamon under rubber***

These experiments were established at the Kuruwita Sub station, RRISL and in a smallholder plot at Kamburupitiya. The experimental details are given in Annual Review 1998.

The growth of rubber and cinnamon was satisfactory in these experiments and either the growth of rubber or cinnamon did not show any treatment effect at this stage.

The girth of rubber plants was measured and cinnamon was harvested in the two main experiments (IC/RC/98/1 and 2).

Either girth of rubber or the yield of cinnamon did not show any significant treatment differences in the experiment IC/RC/98/1.

The mean girth of rubber and the yield of Cinnamon were 20.0cm and 67.5g/bush. The weight of bark per unit length of shoot also remained unaffected by the treatments

In the experiment where cinnamon was established under mature rubber (1984 clg.) at Kuruwita Substation, the growth of cinnamon was poor compared to the monocrop cinnamon under full sunlight. In cinnamon under rubber the .91 m x .61m treatment had a better yield compared to the conventional spacing of 1.2 m x .91 m (Table 29).

Table 29. *Effect of spacing on the yield of cinnamon grown under rubber and full sunlight*

| Treatment Cinnamon Spacing | Under Rubber Bark yield (g/bush) | Under full sunlight Bark yield (g/bush) |
|---|---|---|
| .91 m x .61m | 34.7[a] | 114.3 |
| 1.2 m x .91 m | 25.1[b] | 85.5 |
| 1.7 m x 1.2 m | 29.5[ab] | 97.4 |
| 1.1m Δ lar spacing | 25.5[b] | 108.6 |

(Values with the same letter in each category are not significantly different)

The growth of both crops in the smallholder plot at Kamburupitiya is poor (Table 30).

Table 30. *Growth of rubber and cinnamon*

| Treatment (rubber spacing) | Height of rubber (cm) | Height of cinnamon (cm) |
|---|---|---|
| 8.2m x 2.4 m | 220.3 | 161.5 |
| 2.4 m triangular spacing with paired rows. Inter row space 13.2m | 169.5 | 113.5 |

**Propagation techniques and nursery practices for three species of medicinal plants**

A contract research project of the Sri Lanka conservation and sustainable use of medicinal plants project, to develop propagation techniques and nursery practices for three species of medicinal plants *viz*: *Indigofera tinctoria* (Nil avariya), *Solanum virginianum* (Katuwelbatu) and *Aerva lanata* (Polpala) were undertaken. The work was completed and the terminal report was forwarded (L S S Pathiratna and P Seneviratne).

# PLANT PATHOLOGY AND MICROBIOLOGY

C K Jayasinghe

## SUMMARY

The conducive weather conditions experienced during refoliation period caused severe secondary leaf fall in clones RRIC 121, PB 28/59, RRIM 712, PB 217 and BPM 24. Flowers were also severely affected with *Oidium* and as a consequence *Phytophthora* leaf fall and bark rot were extremely mild during SW monsoon period.

The molecular weights of the polygalacturonase produced by five different isolates of *Phytophthora meadii* were shown to be 62 to 85 KDa. Studies on enzyme production by *Botryodiplodia theobromae* revealed that this fungus is capable of secreting pectin lyase, β-glucosidase and cellobiase in culture. Pectin lyase was shown to play a significant role in the pathogenicity of *Thanatephorus cucumeris*, a pest of quarantine importance to Sri Lanka. Hexaconazole (Contaf) and tebuconazole (Folicur) were found to be very effective in inhibiting the mycelial growth of four different isolates of *Rigidoporus microporus* at concentrations of 200 and 800 µg/ml respectively when screened using "soil fungicide screening test".

## DETAILED REVIEW

### Staff

Dr C K Jayasinghe, Head of the Department, Dr R Jayaratne, Plant Pathologist, Mr W Amaratunge, Audio Visual Production Officer were on duty throughout the year. Mr K E Jayasuriya, Plant Pathologist continued his post graduate studies with the collaboration of University of Colombo. Miss W P K Silva, Plant Pathologist submitted her PhD thesis to the University of Colombo on 23rd November and left overseas on special leave on the 28th November. She is expected to resume duties on 1st March 2001.

Mrs J L P C Wettasinghe, Experimental Officer and Mrs U M S Priyanka, Technical Officer left Plant Pathology and Microbiology Department to join Rubber Technology & Development Department and Raw Rubber & Chemical Analysis Department respectively with effect from 5th July.

Mr E B Fernando and Mrs B I Tennakoon, Experimental Officers; Mrs D Wijeratne and Mr C Wijeratne, Technical Officers continued to work in the Department. Mrs T H P S Fernando, Experimental Officer successfully completed her MPhil degree at the University of Colombo with effect from 1st March. Clerk Typist Mrs P Amarasekera was on duty throughout the year.

Mr S R D P Peiries and Mrs N Dharmadasa joined the Department on 2nd May as Technical Officers. On 3rd July, Mr E A D N Nishantha joined the Department as a Technical Officer. Mr T Widyawardana, Temporary Technical Officer worked for the CARP Project 12/373/299 since 8th May 2000.

**Research students**

(a) Production of cell wall degrading enzymes by the rubber isolate of *Botryodiplodia theobromae*. (Mrs Hansamala Jayawardana from University of Ruhuna. Supervisor: Dr C K Jayasinghe)

(b) Screening of fungicides and study of biodegradation of root biomass to control white root disease (Mr S T G C de Silva from University of Ruhuna. Supervisor: Dr R Jayaratne)

**Seminars/Conferences/Meetings**

Dr C K Jayasinghe attended the International Rubber Research Development Board workshop on *Corynespora* leaf fall as a resource person from 6th to 14th June, held in Kuala Lumpur, Malaysia and Sungei Putih, Indonesia.

Miss W P K Silva attended an international training course on crop protection from 4th May to 4th July, conducted by South China Agricultural University in China.

Dr C K Jayasinghe continued to serve in several National Committees; Steering Committee on National Plant Quarantine (present Chairman), Pesticide Technical Advisory Committee and Specialist Committee on Plant Protection.

**Training programmes**

Dr C K Jayasinghe and Dr R Jayaratne served as resource personnel in following training programmes.

| Client | No. of programmes |
|---|---|
| Diploma in Plantation management | 3 |
| Estate Managers | 6 |
| Field Staff | 10 |
| Worker level | 4 |
| Officers of the Rubber Development Department | 2 |
| N.D.T. | 3 |

Mr E B Fernando, Mrs T H P S Fernando and Mrs I Tennakoon covered the practical aspects of above programmes while all the staff members extended their fullest cooperation in educating students from Universities, Technical Colleges and Schools on the Department activities.

Dr C K Jayasinghe continued to be a Visiting Lecturer in the University of Ruhuna while Dr R Jayaratne served as a Visiting Lecturer in the University of Colombo.

**Advisory visits**

Department staff made 38 Advisory visits.

## GENERAL

The incidence of secondary leaf fall was extremely heavy during the year perhaps the heaviest for the last decade. During the refoliation period, the weather conditions were ideal (*i.e* intermittent showers and high humidities maintained throughout the night) for the propagation of the fungus, causing *Oidium*. This resulted in at least two secndary defoliations and hence thin canopies on highly susceptible clones like RRIC 121, PB 28/59, RRIM 712, PB 217 and BPM 24.

*Phytophthora* leaf fall and bark rot were extremely mild. This was due to the poor pod set resulted by *Oidium* infection on flowers during the refoliation period.

No *Corynespora* infections were reported on any of the other recommended clones in Sri Lanka. Anyhow, some selections of artificial hand pollination programmes, *i.e.* 98/130, 98/52, 98/06, 98/208, 98/170, 98/128, 98/173 and 98/165 were affected. However, the disease situation in the world has become alarming as the majority of the outstanding and widely cultivated clones namely RRIM 600, RRII 105, PB 260, RRIC 110, GT 1 and IAN 873 in the natural rubber growing countries succumbed to the disease during the last few years. With this background Pathologists from IRRDB countries met in Kuala Lumpur, Malaysia and Sungei Putih, Indonesia in June to review the latest situation. The writer attended this workshop and got an opportunity to discuss the situation with regard to clones recommended in Sri Lanka in other rubber growing countries. The view of the foreign scientists in this regard is presented under the subheading "Screening of rubber clones" in this report and a descriptive article will appear in the March-April issue of "Rubber Asia".

The white root disease caused by *Rigidpoorus microporus (lignosus)* continues to be a major hazard in both mature and immature clearings. Estate Managers showed a keen interest in applying soil drenching chemical, hexaconazole instead of "Collar Protectant", the traditional grease/bitumin based fungicide formulation which should be applied on the root surface after exposure and cleaning.

The printing of publication entitled "Check List of Rubber Pathogens in Sri Lanka" was undertaken by the National Science Foundation. Two other publications namely "A Literature Guide to Rubber Pathology in Sri Lanka" and "Prevent, Diagnose and Control Rubber Diseases" are in the final proof stage. Preparation of a new publication entitled "Maladies of Non-parasitic Origin and Pests of Rubber Plantations" was commenced during the year.

## LABORATORY AND FIELD INVESTIGATIONS

### Chemical control of *Hevea* diseases (CC/89/1)

***Screening of fungicides against* Rigidoporus microporus *(in vivo)***

The field experiment carried out at Malaboda estate, Matugama to further establish the efficacy of fungicide "Folicur" was completed. Results of this experiment further confirm the high efficacy of "Folicur" in controlling the white root disease if detected at an earlier stage (R Jayaratne, C K Jayasinghe and P C Wettasinghe).

***Screening of fungicides against* Rigidoporus microporus (in vitro)**

Four systemic fungicides namely, Folicur, Daconil, Bayfidan and Contaf were screened against four different isolates which were shown to be genetically distinct to each other. Screening was carried out using different techniques, *i.e.* Poisoned Food Test (PFT) and Soil Fungicide Screening Test (SFST) in the laboratory. Out of the four fungicides, Contaf (hexaconazole) and Folicur (tebuconazole) were found to be very effective in controlling all four isolates of *R. microporus* at low concentrations of 200 µg/ml and 800 µg/ml respectively using SFST (R Jayaratne, C K Jayasinghe, D Siriwardene and D G de Silva).

***Screening of fungicides against* Corynespora cassiicola**

The long term experiment initiated in 1997 to find an economical management system to control *Corynespora* leaf fall was continued at four locations namely: Dartonfield, Lagos, Salawa and Kuruwita estates. Three rounds of fungicides were sprayed during refoliation period (from February to early April) and another three applications were done during the rest of the year (C K Jayasinghe, R Jayaratne, E B Fernando and C Wijeratne).

### Biology of common pathogens (BCP/90/1)

***Morphological studies of* P meadii *isolates obtained from petiole infected sites of different* Hevea *clones***

Two *P meadii* isolates, MAD 86 (IMI 385259) and DF 600(IMI 385260) were authenticated as *P meadii* McRae by CABI, UK (K E Jayasuriya, R L C Wijesundera, C K Jayasinghe and B I Tennakoon).

***Studies on molecular variation of* P meadii *isolates obtained from different* Hevea *clones***

Several primers were screened with *P. meadii* DNA samples using RAPD-PCR analysis. Experiments are in progress (K E Jayasuriya, D P S T G Attanayake and R L C Wijesundera).

***Studies on cell wall degrading enzymes produced by* P meadii *isolates***

Seven *P meadii* isolates having varying levels of virulence produced polygalacturonase (PG) enzyme *in vitro*. Five isolates produced PG having molelcular weights of 62-85 KDa. The most virulent isolate (MAD 86 – IMI 385259) produced two forms of PG including a form having a lower molecular weight (48 or 21 KDa). The low molecular weight PGs were produced only by MAD 86 isolate and the isolates having the next highest virulence. No Pectin lyase (PL) was produced by any isolate. PG nor PL was detected in infected tissues (K E Jayasuriya, R L C Wijesundera and B I Tennakoon).

***Studies on the accumulation of pathogenesis related proteins (PR protein) in Hevea petioles at* P meadii *infection sites***

SDS-PAGE technique is in progress for quantifying the proteins (K E Jayasuriya, R L C Wijesundera and B I Tennakoon).

***Pathogenesis of* Botryodiplodia theobromae**

*Botryodiplodia theobromae* Pat. is a common and widespread fungus in tropical areas, where it is well-known as a wound parasite on a wide range of host plants including *Hevea brasiliensis*. Die-back of *Hevea* and blue stain on rubber wood are caused by this fungus. Morphology and biology of *Botryodiplodia theobromae* have been extensively studied. However, no literature on the production of cell wall degrading enzymes by the rubber isolate of the pathogen is available. Therefore, the objective of this new investigation was to study these aspects.

Both isolates of *B. theobromae* examined showed a similar pattern of growth in both media (two carbon sources; citrus pectin and carboxy-methyl-cellulose). When the fungus was grown on ammonium tartrate liquid medium with citrus pectin or carboxy-methyl-cellulose as the main source of carbon, the fungus showed the maximum growth rate in the initial period (during the first 3 to 4 days). A similar pattern of pH values of culture filtrates were shown by both isolates in both media and increased with the mycelial growth. The optimum pH value for the mycelial growth was around 8 in both media. *B theobromae* isolates secreted the pectolytic enzyme, pectin lyase (PL) and the cellulolytic enzymes, β-glucosidase and cellobiase in culture. However, polygalacturonase (PG) was not produced by the isolates in culture. Pectin lyase of all isolates tested had a similar pattern of production with the incubation period. All isolates had two markedly high peaks in the production. A significant amount of PL production was noticed three days after inoculation and this trend continued until termination of the experiment on 20$^{th}$ day. Similar patterns of secretion of both enzymes, cellobiase and β–glucosidase were observed by both isolates tested in culture. Cellobiase and β–glucosidase enzyme activity increased initially and then continued until the termination of the experiment. Activity of β–glucosidase had two peaks. When the rubber leaves were inoculated with *B. theobromae*, only a slight pectin lyase activity was detected. Extracts of the healthy

leaves did not show PG and PL activity. β–glucosidase was present in both healthy and infected leaves (C K Jayasinghe, H Jayawardena and T H P S Fernando).

***Biology and pathogenecity of* Colletotrichum acutatum *and* Colletotrichum gloeosporioides*: a comparative study***

After the discovery that two *Colletotrichum* species are responsible for the *Colletotrichum* leaf disease of rubber in Sri Lanka, investigations were initiated to compare the biology and pathogenicity of both species. Initial studies on the authentification of isolates with the collaboration of CAB International were completed. Experiments are to be commenced on spore production, viability of spores, spore germination, enzyme production and involvement of toxins in pathogenesis during the year 2001 (C K Jayasinghe, T H P S Fernando and N Dharmadasa).

***Survey of crop plants grown in and around rubber plantations for* Corynespora *infection***

Disease samples were collected from Kalutara and Ratnapura districts and several isolates were purified from papaya and manihot. Samples from other rubber growing districts will be collected in future (W P K Silva and N Nishantha).

***Studies on pectic enzymes produced by* Corynespora cassiicola *collected from hosts other than rubber***

Four isolates were selected and study is in progress (W P K Silva and N Nishantha).

***Production of toxin by* C cassiicola *which are not pathogenic on rubber***

An isolate from papaya, which is not pathogenic on rubber, was selected for this study. It was shown that although this isolate could not cause the disease on any of the rubber clones tested, it produced a toxin in MAM medium which can produce characteristic symptom in all the rubber clones tested (W P K Silva and N Nishantha).

***Cell wall degrading enzyme production by* Thanatephorus cucumeris**

Results of the investigations carried out to find the key factors involved in the pathogenesis of *T cucumeris*, a pest of quarantine importance to Sri Lanka revealed that pectin lyase plays a significant role in its pathogenecity (C K Jayasinghe, C Wijeratne and T H P S Fernando).

**Screening of *Hevea* clones for leaf and panel diseases (SC/89/1)**

***Secondary leaf fall***

Secondary leaf fall incidence, specially *Oidium* leaf fall reached the epidemic

proportions during the year 2000 due to the conducive weather condition experienced during refoliation period. Most of the late wintering clones except RRIC 130 succumbed to the disease severely. Under the light of this situation an island wide survey was conducted to determine the field susceptibility of the recommended clones. The survey revealed that clones namely RRIC 100, RRIC 102, RRIC 130, RRIC 117, RRIC 133, RRIC 203, PB 235, PB 260 and PR 255 tolerate the disease while RRIC 121, PB 217, PB 28/59 and BPM 24 are susceptible (Table 1). As the epidemic in 2000 was the heaviest for the last several years the disease incidence in each year for the last 50 years was tabulated in the Fig. 1 (C K Jayasinghe, E B Fernando and T H P S Fernando).


Fig. 1. The incidence of *Oidium* leaf fall from 1950 to 2000

**Corynespora *leaf fall disease***

Several outstanding clones in the world namely RRIC 110, RRIM 600, RRII 105, IAN 873, GT 1 and BPM 24 have become susceptible to *Corynespora* leaf fall during the recent past posing a grave threat to the natural rubber industry. With this background the disease situation of clones recommended in Sri Lanka in other rubber growing countries were studied. The table 2 presents the disease severity of the locally recommended clones in the Asian and African continents (C K Jayasinghe, Courtesy: Dr Ismail Hashim, Malaysia, Dr Simon M Gobina, Cameroon; Mr Irwan Suhendry, Indonesia).

Table 1. *Field screening of recommended clones against* Oidium & Colletotrichum *infections in year 2000 (an year which had conducive weather condition for the development of* Oidium and Colletotrichum *infection in Ratnapura and Kalutara districts)*

| Clone | Disease Severity | |
|---|---|---|
| | *Level of infection on leaves** | Condition of the canopy* |
| RRIC 100 | Mild infection of *Oidium* & *Colletotrichum* | 0 - 25% defoliation |
| RRIC 102 | Mild to moderate *Oidium* | No defoliation |
| RRIC 121 | Moderate to severe *Oidium* & *Colletotrichum* | 75 - 100% defoliation |
| RRIC 130 | Mild *Oidium* & *Colletotrichum* | 0 - 25% defoliation |
| PB 217 | Moderate to severe *Oidium* & *Colletotrichum* | 75 - 100% defoliation |
| PB 28/59 | Moderate to severe *Oidium* & *Colletotrichum* | 50 - 75% defoliation |
| RRIC 117 | Moderate to severe *Oidium* & *Colletotrichum* | 25% defoliation |
| RRIC 131 | NA | |
| RRIC 133 | Mild *Oidium* infection | No defoliation |
| RRISL 201 | NA | |
| RRISL 202 | NA | |
| RRISL 203 | Mild *Oidium* infection | No defoliation |
| RRISL 205 | NA | |
| RRISL 206 | NA | |
| RRISL 210 | NA | |
| RRISL 211 | NA | |
| RRISL 215 | NA | |
| RRISL 217 | NA | |
| PB 235 | Moderate to severe *Oidium* & *Colletotrichum* | 25% defoliation |
| PB 260 | Moderate to severe *Oidium* & *Colletotrichum* | 25 - 50% defoliation |
| BPM 24 | Moderate to severe *Oidium* & *Colletotrichum* | 50 - 75% defoliation |
| RRISL 200 | NA | |
| RRISL 204 | NA | |
| RRISL 208 | NA | |
| RRISL 218 | NA | |
| RRISL 220 | NA | |
| RRISL 221 | NA | |
| RRISL 222 | NA | |
| RRISL 225 | NA | |
| RRISL 226 | NA | |
| RRISL 227 | NA | |
| RRIM 717 | NA | |
| PB 255 | NA | |
| PR 255 | Moderate *Oidium* Severe *Colletotrichum* | 25% defoliation |
| PR 305 | NA | |
| RRII 105 | NA | |
| PR 261 | Moderate *Oidium* & Severe *Colletotrichum* | 75% defoliation |
| RRIM 712 | Moderate *Oidium* & Severe *Colletotrichum* | 75 - 100% defoliation |
| RRIM 600 | Moderate *Oidium* & Severe *Colletotrichum* | 0 - 25% defoliation |

(1) * a range is given depending on sites (2) clones not recommended by RRISL
(2) NA, data can not be obtained, as mature clearings are not available.

Table 2. *Disease scenario of the locally recommended clones in Asian and African continents*

| | |
|---|---|
| RRIC 100 | Resistant clone in Malaysia, Indonesia, Thailand, Vietnam and Cote D'ivoire. Regarded as a susceptible clone in Cameroon. However, no defoliation and recommended for large scale planting in Cameroon. |
| RRIC 102 | Resistant clone in Indonesia. No reports from other countries. |
| RRIC 121 | No reports from other countries. |
| PB 28/59 | Mild infections are reported from Malaysia but moderately susceptible in Africa specially in Cote D'ivoire. Resistant clone in Thailand. |
| PB 217 | Resistant clone in Indonesia and Thailand. Became susceptible in Malaysia and removed from the recommendation list. |
| PB 235 | Resistant clone in Thailand. Mild infections are recorded in Malaysia. Became susceptible in Cameroon. |
| PB 260 | The best clone in Indonesia. But mild infections are reported from certain localities in Indonesian islands. Moderate infections in Malaysia. A resistant clone in Thailand. Succumbed to the disease severely in Africa causing die-back. |
| BPM 24 | Resistant clone in Indonesia. Mild infections are recorded in Malaysia. However, removed from the recommendation list in Malaysia due to poor performance. |
| PR 255 | Resistant clone in Indonesia. Mild infections in Malaysia. African situation not known |

***Maintenance of recommended and potential clones in different agroclimatic zones***

Weeding, fertilizer application and numbering were done at Atale, Polatagama, Padukka, Pitiyakanda, Nakiyadeniya, Bibile, Hapugastenna and Dartonfield estate nurseries. No new clones succumbed to *Corynespora* leaf fall disease in these nurseries (C K Jayasinghe and C Wijeratne).

**Studies on arbuscular mycorrhiza (M/86/1)**

The field experiment initiated to ascertain the effect of inoculating arbuscular mycorrhiza on the natural populations was continued. The growth of the plants were monitored during this period (Table 3).

Table 3. *Mean girth (cm) of the field established plants after 40 months (Mean of 5 replicates with each replicate consisting of 10 plants)*

| Mycorrhizal type | +P (addition of P) | -P (No addition of P) |
|---|---|---|
| *Gigaspora margarita* | 24.97 [a] | 24.91 [a] |
| *Acaulospora* sp. | 20.14 [b] | 23.37 [b] |
| Natural population | 21.29 [c] | 22.89 [b] |
| Non-mycorrhizal (initially) | 19.89 [c] | 17.27 [c] |

(Means with the same letter are not significantly different at P = 0.05 using DMRT).

*Gigaspora margarita* inoculated plants still continues to grow at a significantly higher rate than other treatments (R Jayaratne and D Siriwardena).

## MISCELLANEOUS

**Poisoning of stumps to improve the methods of clearing of old stand during replanting**

Poisoning of stumps cut at 1½ feet above the ground level was carried out using four chemicals at Sapumalkanda estate. A visual assessment on the rate of decaying of roots was taken after 6 months of treatment (Table 4) (R Jayaratne, C K Jayasinghe, B Fernando, Albert Peiris and N Madawela).

Table 4. *Visual assessment taken on decaying of different sizes of roots after 6 months of treatment*

| Treatment | Above ground | | Below ground | | | |
|---|---|---|---|---|---|---|
| | Cut surface | Side | Collar & Tap root | Main laterals (circumference in inches) 2-4 | 5-7 | 8-10 |
| 2-4D | 2 | 2 | 2 | 2 | 3 | 2 |
| Urea | 2 | 1 | 0 | 0 | 0 | 0 |
| Triclopyr | 2 | 3 | 3 | 2 | 3 | 2 |
| Glyphosate | 2 | 2 | 2 | 2 | 2 | 2 |
| Grammaxone | 2 | 2 | 2 | 2 | 1 | 2 |
| Control | 1 | 1 | 0 | 1 | 1 | 1 |

Visual assessment guide to scores
0 – Alive
1 – Hard Rot
2 – Fairly hard rot
3 – Fairly soft rot
4 – Soft rot
5 – Advanced rot
6 – Humus

The experiment initiated at N'kele division of Dartonfield estate, to determine the decaying rates of split roots after poisoning with same chemicals used in the above experiment was continued (Annual Review 1999). Two assessments were taken at 6 monthly intervals by determining their weight loss (Table 5).

Table 5. *Comparison of decaying rates of split roots after treatment*

| Treatment | % Weight loss | |
|---|---|---|
| | Assessment 1 (After 6 months) | Assessment 2 (After 12 months) |
| Urea | 20.52 ±2.50 | 39.98 ±1.81 |
| Grammoxone | 7.97 ±4.18 | 30.74 ±3.95 |
| Triclopyr | 12.55 ±5.84 | 36.27 ±4.31 |
| Decaying fungi (Artificially inoculated) | 27.80 ±1.11 | 54.02 ±6.92 |
| *Rigidoporus* infected (Naturally infected) | 10.62 ±7.86 | 36.81 ±7.26 |
| Control | 26.37 ±5.72 | 56.80 ±5.11 |

± - Std. Error of the mean

**Poisoning of live white root infected trees before uprooting**

An experiment was initiated at Reucastle estate, to evaluate the best method of poisoning live trees which are "Fomes" infected before the uprooting for replantings. The chemical used was triclopyr (Garlon).

The following methods were tested:

1. Drenching round the base of plants.
2. Ring bark few inches above collar region and dripping the chemical for 2-3 hours through a small plastic tubing connected to an old saline bottle.
3. Direct tree injection method using special tree injectors.
4. Ring Bark few inches above collar region as in treatment (2) and brush application of chemicals.
5. Poisoning of the trees as in case of poisoning of healthy stumps (stem poising).

The aim of this experiment is to kill live trees along with the *Rigidoporus* fungus on roots before felling the trees. The effectiveness of the each method will be evaluated by periodical examination of the root system for live *R. microporus* fungal hyphae (R Jayaratne, C K Jayasinghe and B Fernando).

**Mock exercise**

During the mock exercise [500 g of triclopyr (2 litres of "GARLON 250 EC") in 40 litres of diesel per ha] carried out in 1997, it was noticed that defoliant causes the shoot die-back (Annual Report 1998, p.70). However, trees completely recovered from the damage during the refoliation periods of the subsequent years (C K Jayasinghe, R Jayaratne and E B Fernando).

# SOILS AND PLANT NUTRITION

## Lalani Samarappuli

### SUMMARY

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

The data reveals that application of K fertilizers increase yield during early mature stage. The studies on use of organic manure in nursery stage of rubber suggested that application of organic manure is very effective in increasing the root growth of young budded poly bag plants.

The site specific fertilizer recommendation programme for mature rubber provided data for fertilizer recommendations for 20,000 hectares in the estate sector. The soil and foliar survey programme for the smallholder sector was not commenced as an economy measure due to the poor trading condition prevailing in the country.

### DETAILED REVIEW

**Staff**

The Head of the Department, Dr (Mrs) Lalani Samarappuli, Soils Chemist, Dr D M A P Dissanayake and Assistant Soils Chemist Mr D N P Wickramasinghe were on duty throughout the year. Assistant Soils Chemist, Mr R S Dharmakeerthi continued his post graduate studies in Canada.

Experimental Officers, Messrs G de Mel, H D S P Perera, Rasika Hettiarachchi, Chitra Maheepala, S N Silva, P Karunadasa, U Mitrasena, A N Yakandawela and T B Dissanayake were on duty throughout the year. Technical Officers, Messrs Vishani Edirimanne, Anoma Thevarapperuma, P R Puhambugoda, Kumari Jayanetti and J A S Chandrasiri and the English Stenographer Mrs Lakshmi Rupasinghe were on duty throughout the year. Mr T Gunatilleke joined the Department in July as a Technical Officer.

**Research students**

- Miss M D C Senadheera, an undergraduate student from the University of Ruhuna, completed her final year project on "Effects of application of sludge on nutrient status of rubber (*Hevea brasiliensis*)" under the supervision of Dr Lalani Samarappuli.
- Mr Nimal Shantha Abeysinghe, an undergraduate student from the University of Ruhuna, completed his final year project on "Effect of growing different cover crops between rows of rubber on some physical properties and their influence on the performance of immature rubber (*Hevea brasiliensis*)" under the supervision of Dr Lalani Samarappuli.

- Mr J A D C S Jayalath, an undergraduate student from the University of Peradeniya, completed his final year project on "Use of Rubber Factory effluent as a source of fertilizer for young rubber" under the supervision of Dr D M A P Dissanayake.

**Seminars/Conferences/Meetings/Work-shops attended**

| Officer | Subject | Organization |
|---|---|---|
| Lalani Samarappuli | Technical Committee Meeting of the Tender Board | Rubber Development Department |
| Lalani Samarappuli | Working Group on Organic Fertilizers | Sri Lanka Standards Institution |
| Lalani Samarappuli and D M A P Dissanayake | Scientific Committee Meeting | Rubber Research Institute |
| D M A P Dissanayake | Nuclear Agriculture Committee Meetings | Atomic Energy Authority |
| D M A P Dissanayake | Advantages of using Eppawala Rock Phosphate for Plantation Crops | Lanka Phosphate Ltd. |
| D N P Wickramasinghe | Formation of action programme on the control of *Pathenium* weed | Dept. of Agriculture |
| D N P Wickramasinghe | Analytical Instruments | Analytical Instruments (Pvt) Ltd. |

**Training programmes**

| Client | No of programmes |
|---|---|
| Plantation Monitoring Officers | 01 |
| Estate Managers | 10 |
| Field Officers | 12 |
| Estate Workers | 06 |
| Rubber Development Officers | 02 |
| Smallholders | 02 |
| University Students | 04 |
| NDT Students | 03 |

**Advisory visits**

| Client | No of visits |
|---|---|
| Plantations | 20 |
| Smallholdings | 05 |

## LABORATORY AND FIELD INVESTIGATIONS

### 1. Soil fertility and moisture conservation

#### 1.1 *Agronomic practices in relation to moisture conservation*

##### 1.1.1 *Use of live and dead mulch*

1.1.1.1 Comparison of different management practices

In experiment SMC-Ag/M/88/1, mulching was continued during mature phase. Continuation of mulching in comparison with the discontinuation of mulching on yield of rubber plants is given in Table 1. No significant difference was observed between the two treatments for yield (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 1. *Effect of different soil management practices on yield*

| Treatment | Yield | |
|---|---|---|
| | (g/t/t) | (kg/ha/yr) |
| Legumes | 26.77[a] | 1686[a] |
| Mulching discontinued | 27.91[a] | 1758[a] |
| Mulching continued | 29.34[a] | 1848[a] |

1.1.1.2 Different mulching materials

A field experiment (SMC-Ag/M/97/1) is in progress at Sapumalkanda estate, Deraniyagala to study the effect of different quantities of refused tea and wood ash on growth of *Hevea* plants. Treatments consisted of three quantities of refused tea and wood ash /plant/annum; no refused tea (T0), refused tea, level 1 (T1), refused tea, level 2 (T2), no wood ash (W0), wood ash, level 1 (W1) and wood ash, level 2 (W2). Plant girth at three and a half years after planting is given in Table 2 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Another field experiment (SMC-Ag/M/99/1) is in progress at Nottinghill estate, Kahapathwela to study the effect of different mulching materials on growth of *Hevea* plants in a comparatively drier area. Treatments consisted of four mulching materials

and a control; no mulching (M0), paddy straw (M1), coir dust (M2), paddy husk (M4) and green manure (M5). Girth at one and a half years after planting is given in Table 3 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 2. *Effect of refused tea and wood ash on girth (cm) of rubber plants*

| Level of tea dust | Level of wood ash | | |
|---|---|---|---|
| | $W_0$ | $W_1$ | $W_2$ |
| $T_0$ | 22.4[a] | 23.6[a] | 20.9[a] |
| $T_1$ | 19.4[a] | 22.1[a] | 20.7[a] |
| $T_2$ | 22.1[a] | 21.9[a] | 20.4[a] |

Table 3. *Effect of different mulching materials on girth of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| No mulch | 13.25[a] |
| Paddy straw | 14.30[a] |
| Coir dust | 14.60[a] |
| Paddy husk | 14.85[a] |
| Green manure | 15.45[a] |

1.1.2 *Fertilizer practices for overcoming moisture stress*

A field experiment (SMC-Ag/F/88/3) is in progress at Nalanda Estate, Ulpotha to study the effect of different levels of potassium on growth and yield of *Hevea* plants in a comparatively drier area. The effect of different K levels on girth and girth increment is given in Table 4 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 4. *Effect of different K levels on girthing of* Hevea

| Treatment | Girth (cm) | Girth increment (cm) |
|---|---|---|
| $K_0$ | 60.8 | 2.5 |
| $K_1$ | 61.2 | 2.5 |
| $K_2$ | 61.1 | 2.9 |
| LSD | 3.9 | - |

In experiment SMC-Ag/M/88/1, with and without K, yield data indicated higher yield (Table 5) with potassium at K1 level (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 5. *Effect of potassium on yield of rubber plants*

| K levels | Yield | |
|---|---|---|
| | (g/t/t) | (kg/ha/yr) |
| $K_0$ | 26.88 | 1693 |
| $K_1$ | 30.13* | 1898* |
| LSD | 3.67 | 231 |

In field experiment (SMC-Ag/F/95/1), the effect of both potassium and mulching on moisture stress and growth of *Hevea* was studied. Treatments consisted of three mulching techniques; no mulch (M0), surface mulching (M1) and sub surface mulching (incorporation) (M2) and four potassium levels; half the recommended level (K1), recommended level (K2), one and half the recommended level (K3) and double the recommended level (K4). Girth measurements and tappability percentage at five and a half years after planting are given in Tables 6 and 7, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 6. *Effect of potassium and mulching on girth (cm) of rubber plants*

| Mulching | Level of K | | | |
|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ |
| $M_0$ | 47.93[a] | 48.95[a] | 47.73[a] | 47.08[a] |
| $M_1$ | 48.23[a] | 49.05[a] | 49.78[a] | 48.18[a] |
| $M_2$ | 47.63[a] | 48.30[a] | 48.93[a] | 47.68[a] |

Table 7. *Effect of potassium and mulching on tappability (%) of rubber plants*

| Mulching | Level of K | | | |
|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ |
| $M_0$ | 62 | 75 | 72 | 93 |
| $M_1$ | 73 | 92 | 96 | 90 |
| $M_2$ | 71 | 83 | 94 | 82 |

Another two field experiments (SMC-Ag/F/98/1 and SMC-Ag/F/99/1) are in progress at Bibile estate, Bibile and Nottinghill estate, Kahapathwela to study the effect of both potassium and mulching on moisture stress and growth of *Hevea* plants in

comparatively drier areas. Treatments consisted of two mulching techniques; no mulch (M0) and surface mulching (M1) and four potassium levels; half the recommended level (K1), recommended level (K2), one and half the recommended level (K3) and double the recommended level (K4). Girth at two years in experiment, SMC-Ag/F/98/1 and girth at one and a half years in experiment, SMC-Ag/F/99/1 are given in Tables 8 and 9, respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 8. *Effect of potassium and mulching on girth (cm) of rubber plants at two years after planting (SMC-Ag/F/98/1)*

| Mulching | Level of K | | | |
|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ |
| $M_0$ | $10.30^{a}$ | $10.30^{a}$ | $10.98^{ab}$ | $10.33^{a}$ |
| $M_1$ | $12.11^{b}$ | $10.93^{ab}$ | $10.48^{a}$ | $11.30^{ab}$ |

Table 9. *Effect of potassium and mulching on girth (cm) of rubber plants at one and a half years after planting* (SMC-Ag/F/99/1)

| Mulching | Level of K | | | |
|---|---|---|---|---|
| | $K_1$ | $K_2$ | $K_3$ | $K_4$ |
| $M_0$ | $13.78^{a}$ | $14.95^{a}$ | $13.98^{a}$ | $14.23^{a}$ |
| $M_1$ | $13.60^{a}$ | $14.18^{a}$ | $14.00^{a}$ | $13.83^{a}$ |

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

An experiment is in progress at the RRI Sub Station in Kuruwita (SMC-Ag/I/93/1) to study the water use efficiency of rubber plants when multicropped with tea. This experiment was continued (Lalani Samarappuli, S M Iqbal, P Karunadasa and U Mitrasena).

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

An experiment (SMC-Ag/D/96/1) was started at Mucalana Division, Sirikandura Estate to study the fertilizer and soil moisture requirement of rubber under different densities. Treatments consisted of (a) Four different densities; (i) 500 trees/ha [4.5m x 4.5m], (ii) 600 trees/ha [4.2m x 4.2m], (iii) 700 trees/ha [3.8m x 3.8m] and (iv) 800 trees/ha [3.5m x 3.5m] (b) Three fertilizer treatments; (i) recommended level (F1), (ii) reduced level (F2) and (iii) 1st three years recommended level and thereafter reduced level (F3). Effect of different fertilizer treatments on girth of rubber plants at the end of four and a half years from planting is presented in Table 10. No significant difference was

observed between densities tested (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Table 10. *Effect of different fertilizer treatments on girth of rubber plants*

| Fertilizer levels | Girth (cm) |
|---|---|
| Recommended level (F1) | 41.66[a] |
| 1st 3 yrs. recommended level then reduced level (F3) | 40.69[ab] |
| Reduced level (F2) | 39.75[b] |

Another experiment (SMC-Ag/D/97/1) was also started at Dorset Division, Clyde Estate to study the fertilizer and soil moisture requirement of rubber under different densities with same treatments. Effect of different densities on girth of rubber plants at the end of three and a half years from planting is presented in Table 11. No significant difference were observed between the levels of fertilizer, tested (Lalani Samarappuli, P Karunadasa and U Mitrasena in collaboration with the Plant Science Department).

Table 11. *Effect of different plant densities on girth of rubber plants*

| Planting densities | Girth (cm) |
|---|---|
| 500 trees/ha [4.5m x 4.5m] | 31.8[a] |
| 600 trees/ha [4.2m x 4.2m] | 31.9[a] |
| 700 trees/ha [3.8m x 3.8m] | 30.8[b] |
| 800 trees/ha [3.5m x 3.5m] | 30.9[b] |

1.2 ***Feasibility of growing rubber in drier areas***

Field experiments (SMC-Ag/F/88/3), (SMC-Ag/F/98/1), (SMC-Ag/F/99/1), (SMC-Ag/M/99/1), (SMC-GC/TL/98/1) and (SMC-GC/C/99/1) are in progress at Nalanda Estate, Ulpotha, Bibile Estate, Bibile, Nottinghill estate, Kahapathwela, Kumarawatta estate, Monaragala and Nottinghill estate, Kahapathwela, respectively, to study the same with different soil management and fertilizer practices (Lalani Samarappuli, P Karunadasa and U Mitrasena).

1.3 ***Ground cover management and nutrient recycling***

1.3.1 *Ground cover management*

1.3.1.1 Comparison of different cover types

Experiment, SMC-Ag/M/88/1, started to study the influence of creeping, bush and tree legumes on some soil characteristics and their effects on the performance of rubber in *Boralu* series soils was terminated (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Another field experiment was in progress at Perth Estate, Horana to compare the effectiveness of tree legumes with the conventional creeping type *Pueraria phasioloides.* This experiment was also terminated (Lalani Samarappuli, P Karunadasa and U Mitrasena).

1.3.1.2 Comparison of different tree legumes

Field experiment (SMC-GC/TL/96/1), started to study the comparative efficiency of *Tephrosia vogellie, Crotolaria anagyroides and Flemingia congesta* as successful tree legume species that can be grown between the rows of rubber plants which could provide enough material for mulching was terminated (Lalani Samarappuli, P Karunadasa and U Mitrasena).

1.3.1.3 Phosphate fertilizers for cover crops

A field experiment, (SMC-GC/P/97/1) was started in Weniwella estate, Kegalle to study the effectiveness of Eppawela rock phosphate as a source of P for leguminous ground covers, both creeping and bush/tree types. The study consisted of three P treatments: no P, ERP and IRP and two cover types: *Mucuna bracteata and Flemingia congesta.* Effect of these treatments on girth of rubber plants at the end of three and a half years from planting is presented in Table 12 (Lalani Samarappuli, A Dissanayake, P Karunadasa and U Mitrasena).

Table 12. *Effect of different sources of phosphate on girth of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| No P for rubber and covers | 26.5 |
| No P for rubber, IRP for covers | 26.4 |
| No P for rubber, ERP for covers | 27.0 |
| IRP for rubber, no P for covers | 29.0 |
| IRP for rubber, IRP for covers | 29.5 |
| IRP for rubber, ERP for covers | 28.5 |
| ERP for rubber, no P for covers | 27.3 |
| ERP for rubber, IRP for covers | 29.6 |
| ERP for rubber, ERP for covers | 27.4 |

1.3.1.4 New cover crop species

At Perth estate, Horana an experiment (SMC-GC/C/96/1)) was started to study the efficiency of *Mucuna bracteata*, on growth, nutrient enrichment and other desirable characteristics in comparison with *Pueraria.* This experiment was terminated (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Another experiment was started at Pembroke Division, Payagala estate to study the establishment success of *Mucuna bracteata.* The treatments consisted of 3 different planting materials; seeds (P1), stem cuttings (P2) and rooted cuttings (P3) and 3 planting densities; 450 plants/ha (D1), 240 plants/ha (D2) and 120 plants /ha (D3). The blocking of the experimental plots were completed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

At Sapumalkanda estate, Deraniyagala an experiment (SMC-GC/C/97/1)) was started to study the efficiency of *Wedelia biflora* (Arunadevi), on growth, nutrient enrichment and other desirable characteristics in comparison with *Pueraria.* Effect of this cover crop on girth of rubber plants at the end of three and a half years from planting is presented in Table 13 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 13. *Effect of* Wedelia biflora *(Arunadevi) on girth of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| *Pueraria phaseoloides* + P | 23.9[a] |
| *Wedelia biflora* + P | 21.3[a] |
| *Wedelia biflora* + NPKMg (level 1) | 25.3[a] |
| *Wedelia biflora* + NPKMg (level 2) | 23.0[a] |

Another field experiment (SMC-GC/C/98/1), was started to study and identify leguminous cover crop species with multiple advantages and would satisfy a dual function of being a cover crop and a cash crop at the same time. Effect of these treatments on girth of rubber plants at the end of two and a half years from planting is presented in Table 14 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 14. *Effect of different legume species on girth of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| *Pueraria phaseoloides* | 12.3[a] |
| *Mucuna bracteata* | 13.2[a] |
| *Flemingia congesta* | 11.9[a] |
| *Crotolaria anagyroides* | 12.9[a] |
| *Flemingia + Crotolaria* | 12.5[a] |
| Legume cash crop | 11.9[a] |

1.3.2 *Nutrient recycling*

1.3.2.1 Sludge as a potential fertilizer for *Hevea*

An experiment was started at Payagala estate to evaluate sludge as a fertilizer for

immature rubber (SMC-GC/RC/93/2 & SMC-GC/RC/93/3), and for legume covers (SMC-GC/RC/93/1). Although different levels of fertilizers and sludge were applied according to the design through the immature period, application of sludge was stopped after the commencement of tapping. Test tapping was not done during the year (Lalani Samarappuli, U Mitrasena, Anoma Thevarapperuma and S Chandrasiri).

1.4 ***Soil conservation and development of degraded lands***

This project was continued (Lalani Samarappuli, N Yogaratnam, P Karunadasa and U Mitrasena).

1.5 ***Weeds and weed control***

A field experiment was planned to study the performance of different types and different concentrations of Glyphosates on weed control during the immature stage of rubber. The blocking of the experimental plots were completed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

## 2. Fertilizer use and plant nutrition

### 2.1 *NPKMg requirement of rubber*

#### 2.1.1 *Fertilizers to nursery plants*

2.1.1.1 Application frequency

An experiment was carried out to evaluate the efficiency of a more soluble fertilizer mixture for young budding at the Eladuwa estate. Following treatments were allocated in a Randomized complete block design with 25 poly bags per treatment and 4 replicates.

Treatment 1 - no fertilizer (control)
Treatment 2 - 50g RP + biweekly application of currently recommended liquid formulation
Treatment 3 - 50g RP + monthly application of currently recommended liquid formulation
Treatment 4 - 75g RP + biweekly application of SA/SOP/CES liquid formulation
Treatment 5 - 75g RP + Monthly application of SA/SOP/CES liquid formulation

(R S Dharmakeerthi, Lalani Samarappuli and S N Silva)

2.1.1.2 Requirement of a basal application when young buddings are planted in the field

This experiment was continued (R S Dharmakeerthi, Lalani Samarappuli, S N Silva and A Yakandawela).

2.1.2 *Fertilizer requirement of new clones*

This experiment was continued (R S Dharmakeerthi, Lalani Samarappuli, S N Silva and A N Yakandawela)

2.2 ***Phosphate nutrition***

This project was continued (A Dissanayake, P Perera, T Dissanayake, Chitra K Maheepala and R Puhambugoda).

2.2.1 *ERP as a source of P for nursery, immature and mature plants*

2.2.1.1 Poly bag nurseries

The experiment started at Dartonfield to study the suitability of Eppawala rock phosphate (ERP) and Imported rock phosphate (IRP) in comparison with Fused magnesium phosphate (FMP), "YOORIN", a Japanese product for polybagged plants was completed.

Application of ERP, IRP, Triple super phosphate (TSP) and FMP does not have a significant influence on plant growth in comparison with no phosphorous (No P) fertilizer application. But, plant growth in terms of stem diameter was significantly higher ($P<0.05$) with ERP than application of it together with FMP (Table 15) (A Dissanayake, Chitra Maheepala and R Puhambugoda).

Table 15. *Plant diameter at the age of 8 months*

| Treatment | Plant diameter (cm) |
|---|---|
| No P | $1.58^{ab}$ |
| IRP | $1.50^{ab}$ |
| ERP | $1.68^{a}$ |
| TSP | $1.43^{ab}$ |
| FMP | $1.40^{ab}$ |
| IRP + FMP | $1.26^{b}$ |
| ERP + FMP | $1.32^{B}$ |

2.2.1.2 Immature rubber

2.2.1.2.1 Effect of different sources and levels of Phosphorous

a. Assessment of yield and chemical analysis of leaf and soil samples were completed to represent the experimental plots that were divided into two sub plots to study the residual effects of rock phosphates applied during the immature period. This experiment (P/IM/87) was continued (A Dissanayake, T Dissanayake and P Perera).

b. The experiment started at Vogan estate to study the possibility of using both Eppawala and Imported rock phosphates in different combinations was continued. Fertilizer was applied as per the treatments and nutrients present in both soil and leaf samples collected from experimental blocks were analyzed.

Girth and yield data indicated that there is no significant difference between fertilizer treatments (Table 16) (A Dissanayake, P Perera, S Chandrasiri and T Dissanayake).

Table 16. *Effect of different P sources on girth and yield*

| P source | Girth (cm) | Average yield (g/t/t) |
|---|---|---|
| No phosphate | 59.6 | 19.7 |
| IRP | 61.3 | 21.2 |
| ERP | 59.3 | 20.8 |
| IRP + ERP (50:50) | 58.61 | 20.9 |

2.2.2 *Evaluation of clonal differences in phosphate utilization*

Experiments started at Devalakande (P/IM/93/-01), Payagala (1/IM/94-01) and Ambadeniya (P/IM/96-01) estates to study the ability of different RRIC clones (RRIC 100,102,110 and 121) in utilization of ERP were continued. P fertilizers were applied according to the experimental treatments (A Dissanayake, T Dissanayake, P Perera and Chitra Maheepala).

2.2.3 *Availability of P from ERP*

2.2.3.1 Mulching and liming

The experiment started to study the effect of different agronomic practices on availability of P from ERP at Culloden estate (P/Ag/93) was continued. The recommended amount of rice straw and lime were also applied in two applications. Soil and leaf samples were analyzed for N,P,K, Ca and Mg. Girth of rubber plants was recorded. It was observed that application of lime does not influence the plant girth, average yield and leaf P content significantly in relation to different P sources (Table 17) (A Dissanayake, Lalani Samarappuli, P Perera and S Chandrasiri).

Table 17. *Effect of lime application on girth, average yield and leaf P content in relation to different P sources*

| P source | Girth (cm) | | Yield (g/t/t) | | Leaf P (%) | |
|---|---|---|---|---|---|---|
| | W L | No L | W L | No L | W L | No L |
| IRP | 61.00 | 59.50 | 25.83 | 24.30 | 0.16 | 0.17 |
| ERP | 57.15 | 58.75 | 24.44 | 24.58 | 0.19 | 0.18 |
| IRP + ERP | 59.65 | 60.10 | 23.83 | 24.72 | 0.19 | 0.19 |
| No phosphate | 57.65 | 57.70 | 25.66 | 23.49 | 0.17 | 0.18 |

W L - With lime application
No L - No lime application

2.2.3.2 Suitability of ERP to cover crops (Mycorrhizal aspect)

The experiment started to study the effect of mycorrhiza on the efficiency of P uptake from Eppawela rock phosphate by rubber plants grown in poly bags was completed. Soil samples were analyzed to determine pH, exchangeable cations and phosphorus content and statistical analysis are in progress (A Dissanayake, R Jayaratne, Chitra Maheepala and R Puhambugoda).

2.2.3.3 Use of isotopic technique to evaluate the agronomic efficiency of ERP

Arrangements have been made to collect soil samples from the experimental plots, which received different sources of phosphates for a considerable period of time. These soils are to be used for a glass house pot experiment to assess the agronomic efficiency of rock phosphates by using isotopic dilution technique under the Technical Corporation Project CRL/5/032 (A Dissanayake, T Dissanayake and L L W Somasiri, CRI).

## 2.3 *Sulphur nutrition*

### 2.3.1 *Effect of sulphur on growth of young rubber*

The experiment started at Pallegoda estate to study the effect of three different sources of Sulphur on the performance of young rubber was continued. Fertilizers were applied according to the treatments and soil, leaf samples were collected and girth measurements were recorded. Generally, girth was poor in plants of clone RRIC 100 in relation to addition of elemental sulphur and this was not observed for clone RRIC 121. Leaf sulphur levels and plant girth are given in Table 18 in relation to different sulphur sources (A Dissanayake, P Perera, S Chandrasiri and Chitra Maheepala).

## 2.4 *Micro nutrients*

Effect of different monoculture systems including rubber plantations and that of natural forest on the contribution of micro nutrients to the soil was studied in this experiment. Soil Mn and Zn contents under different plantation systems and in natural forests are presented in Tables 19 and 20 (L Samarappuli and P Karunadasa).

Table 18. *Effect of different Sulphur sources on leaf S content and plant girth*

| Source of Sulphur | Leaf S (%) | | Girth (cm) | |
|---|---|---|---|---|
| | RRIC 100 | RRIC 121 | RRIC 100 | RRIC 121 |
| No S | 0.29 | 0.30 | 19.6 | 21.4 |
| Kieserite | 0.25 | 0.25 | 18.7 | 19.2 |
| Ammonium Sulphate | 0.20 | 0.24 | 19.1 | 20.9 |
| Elemental S - L1 | 0.17 | 0.26 | 17.9 | 22.3 |
| Elemental S - L2 | 0.27 | 0.28 | 16.3 | 20.8 |
| Elemental S - L3 | 0.29 | 0.24 | 17.7 | 21.3 |

Table 19. *Effect of different plantation systems and in natural forests on soil Mn content*

| Different systems | Soil Mn (mg/kg) | |
|---|---|---|
| | 0-15 cm soil depth | 15-30 cm soil depth |
| Natural forest | 72 | 78 |
| Mahogany | 17 | 21 |
| Pinus | 25 | 25 |
| Rubber | 71 | 80 |

Table 20. *Effect of different management systems on soil Zn content*

| Different Systems | Soil Zn (mg/kg) | |
|---|---|---|
| | 0-15 cm soil depth | 15-30 cm soil depth |
| Natural forest | 17 | 16 |
| Mahogany | 24 | 23 |
| Pinus | 09 | 11 |
| Rubber | 27 | 30 |

### 2.5 *Foliar nutrients*

A field experiment was initiated to study the effect of a foliar fertilizer; Humat 2000 on the performance of rubber plants during first and second years after planting. The blocking of the experimental plots was completed (Lalani Samarappuli, P Karunadasa and U Mitrasena).

### 2.6 *Use of rubber factory effluent*

The field experiment started at Eladuwa estate to study the possibility of using rubber factory effluent as a fertilizer was continued. One liter of rubber factory effluent was applied weekly per plant and N P K Mg fertilizers were applied according to the treatments. Soil and leaf samples were collected and girth measurements were recorded.

Samples collected from 18 factories in Kalutara District were analyzed to determine the nutrient content of rubber factory effluent and it indicated that it is a source rich in both macro and micro nutrients (Fig.1) (A Dissanayake, N Wickramasinghe, T Dissanayake and R Puhambugoda).

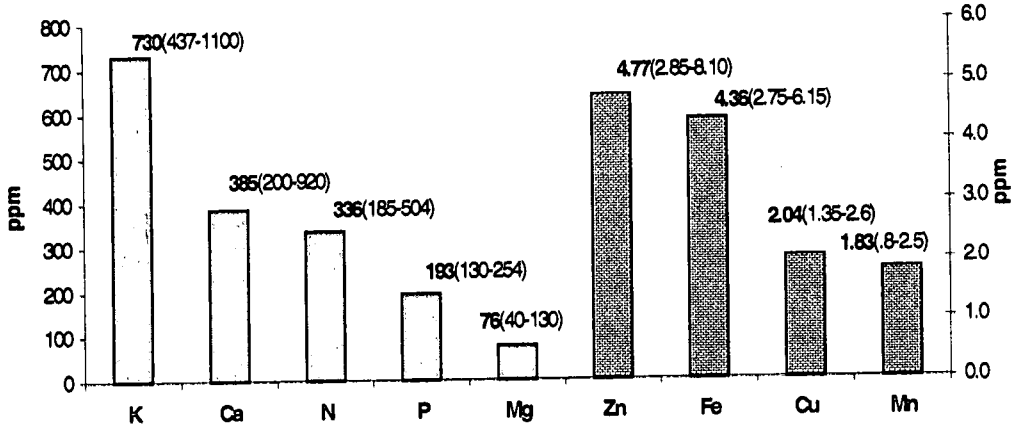



Fig.1. Macro and Micro nutrient contents in rubber factory effluent

It was clear that the application of effluent does not charge the soil pH significantly (Table 21).

Table 21. *Effect of different fertilizer treatments on soil acidity*

| | Soil – pH | | |
|---|---|---|---|
| | Years after treatment | | |
| Treatments | 2 | 3 | 4 |
| GFR | 4.140[a] | 4.526[a] | 4.756[a] |
| GFR + E | 4.542[a] | 4.266[a] | 4.812[a] |
| ½GFR + E | 4.180[a] | 4.728[a] | 4.590[a] |
| E only | 4.178[a] | 4.590[a] | 4.620[a] |

GFR – General fertilizer recommendation E – Rubber factory effluent

Application of generally recommended inorganic fertilizers were able to increase the plant girth significantly ($P<0.05$) than that of only effluent application. However, this situation was not observed with the increasing of age showing no significant differences among treatments. It indicated that application of rubber factory effluent was able to maintain the plant girth similar to that of other fertilizer treatments (Table 22).

Table 22. *Effect of different fertilizer treatments on the girth of young rubber plants*

| Treatments | Girth (cm) Months after planting | | | |
|---|---|---|---|---|
| | 18 | 27 | 42 | 47 |
| GFR | 11.32[a] | 17.22[a] | 32.05[a] | 36.11[a] |
| GFR + E | 11.17[a] | 16.45[a] | 30.78[a] | 35.85[a] |
| ½GFR + E | 11.25[a] | 16.70[a] | 30.33[a] | 35.01[a] |
| E only | 10.15[a] | 14.48[a] | 32.01[a] | 32.20[a] |

GFR – General fertilizer recommendation E – Rubber factory effluent

## 2.7 *Organic fertilizers*

### 2.7.1 *Use of organic materials in poly bagged nursery plants (young budding technique)*

An experiment (FPN-Org/99/1), was started to study the effect of using organic materials on the performance of rubber plants raised by young budding technique (poly bagged nursery plants). Treatments consisted of (T1) inorganic fertilizer (recommended level), (T2) inorganic fertilizer (recommended level) + cowdung, (T3) inorganic fertilizer (recommended level) + poultry litter and (T4) inorganic fertilizer ( recommended level) + compost. The effect of different treatments on growth of plant roots is presented in Table 23 (Lalani Samarappuli and Anoma Thevarapperuma).

Table 23. *Effect of organic manures on root growth of rubber plants*

| Treatment | Root weight (g) |
|---|---|
| Inorganic fertilizer (rec. level) only | 14.8[a] |
| Inorganic fert. (rec. level) + cow dung | 36.6[b] |
| Inorganic fert. (rec. level) + poultry litter | 41.3[b] |
| Inorganic fert. (rec. level) + compost | 31.6[b] |

### 2.7.2 *Use of animal wastes in rubber cultivations*

A field experiment (FPN-Org/An/95/3), is in progress at Dorset division, Clyde estate to study the effect of poultry litter as an organic manure for rubber. Treatments consisted of (a) Inorganic fertilizer (recommended level), (b) Inorganic fertilizer (½ recommended level) + poultry litter, (c) Inorganic fertilizer (¼ recommended level) + poultry litter, (d) Poultry litter only, (e) Poultry litter + IRP + MOP, (f) Poultry litter + IRP + paddy straw and (g) Poultry litter only with natural cover. Effects of treatments on girth and girth increment of rubber plants at the end of five and a half years are given in Table 24 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 24. *Effect of different treatments on girth of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| Inorganic fertilizer (recommended level) | 47.6 |
| Inorganic fertilizer (½ recommended level) + poultry litter | 49.6 |
| Inorganic fertilizer (¼ recommended level) + poultry litter | 50.4 |
| Poultry litter only | 50.0 |
| Poultry litter + IRP + MOP | 48.7 |
| Poultry litter + IRP + paddy straw | 50.5 |
| Poultry litter only with natural cover | 51.7 |
| No fertilizer (control) | 40.4 |

2.7.3 *Use of green manure in rubber cultivation*

Two field experiments (FPN-Org/Gm/97/1) and (FPN-Org/Gm/97/2) are in progress at Dartonfield estate (*Agalawatta* series) and Dorset Division, Clyde estate (*Boralu* series) to study the effect of plant materials as an organic manure for rubber. Treatments consisted of combinations of three sources of N *viz.* full inorganic, ½ inorganic + ½ green manure and full green manure and three sources of K *viz.* full inorganic, ½ inorganic + ½ straw and full straw. The nine different treatment combinations were applied in a randomized block design with four replicates. Effect of treatments on girth of rubber plants at the end of three and a half years for *Agalawatta* and *Boralu* series are given in Tables 25 and 26 respectively (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 25. *Effect of different treatments on girth of rubber plants in Agalawatta series soils*

| Sources of N | Sources of K | | |
|---|---|---|---|
| | K1 | K2 | K3 |
| N1 | $24.4^{a}$ | $21.5^{a}$ | $22.9^{a}$ |
| N2 | $22.6^{b}$ | $24.3^{b}$ | $23.0^{a}$ |
| N3 | $19.7^{c}$ | $22.1^{a}$ | $20.5^{b}$ |

Table 26. *Effect of different treatments on girth of rubber plants in Boralu series soils*

| Sources of N | Sources of K | | |
|---|---|---|---|
| | K1 | K2 | K3 |
| N1 | $29.5^{a}$ | $29.5^{a}$ | $29.3^{a}$ |
| N2 | $30.8^{a}$ | $28.3^{a}$ | $30.3^{a}$ |
| N3 | $28.5^{a}$ | $29.8^{a}$ | $28.8^{a}$ |

2.7.4 *Organic rubber*

An experiment is in progress to develop a sustainable and a commercially viable system for plantations as well as for small holders to produce an environmental friendly new grade of rubber (organic rubber) to meet the increasing demand for "bio-market". Effects of treatments on girth of rubber plants at the end of two and a half and three and a half years are given in Table 27 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 27. *Effect of different treatments on girth of rubber plants*

| Treatment | Girth after planting (cm) | |
|---|---|---|
| | 1½ years | 2 ½ years |
| Chemical fertilizer only | 19.2 | 26.6 |
| Organic fertilizer only | 15.4 | 22.1 |

## 2.8 *Efficiency of fertilizer utilization*

2.8.1 *Reduced frequency of fertilizer applications*

A field experiment (F/Ap/95/1), is in progress to the study the effect of reduced frequency of fertilizer applications during the immature period on the growth of rubber plants. Treatments consisted of (a) 25 applications/immature six year period (urea based), (b) 20 applications/immature six year period (SA based), (c) 19 applications/immature six year period (urea based), (d) 14 applications/immature six year period (SA based) and (e) 14 applications/immature six year period (urea based). Effects of treatments on girth of rubber plants at the end of five and a half years are given in Table 28 (Lalani Samarappuli, P Karunadasa and U Mitrasena).

Table 28. *Effect of different treatments on girth and girth increment of rubber plants*

| Treatment | Girth (cm) |
|---|---|
| 20 applications/immature six year period (SA based) | 46.8[a] |
| 25 applications/immature six year period (urea based) | 47.3[a] |
| 14 applications/immature six year period (SA based) | 46.1[a] |
| 19 applications/immature six year period (urea based) | 46.9[a] |
| 14 applications/immature six year period (urea based) | 46.7[a] |
| No fertilizer | 39.1[b] |

2.8.2 *Economics of fertilizer use in mature rubber*

This experiment was continued (Lalani Samarappuli, P Karunadasa and U Mitrasena).

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

This experiment (F/Mg/94/1), which was in progress at Dorset division, Clyde estate to study the feasibility of using Dolomite even during the mature stage was terminated (Lalani Samarappuli, P Karunadasa, U Mitrasena and Vishani Edirimanna).

2.8.4 *SUL-PO-MAG based fertilizer mixtures*

An experiment (F/SPMg/94/1), was started in Culloden estate, Neboda to study the effectiveness of SUL-PO-MAG based mixtures in comparison with the conventional mixtures 12:14:14 and 7:9:9:3 in immature rubber. SUL-PO-MAG based treatment was formulated by adding urea, rock phosphate and muriate of potash to SUL-PO-MAG to meet the nutrient ratios of N,P,K and Mg recommended for rubber in conventional mixtures. Investigation on the effects of treatments on yield will be continued (Lalani Samarappuli and J G de Mel).

2.8.5 *Slow release fertilizers*

A joint project (F/SR/95/1) with Polymer Chemistry Department was commenced to study the possibility of using encapsulated coir blocks during the first year of planting. Effect of different quantities of encapsulated fertilizers on the growth of rubber plants is studied in this experiment Data are being analysed (Lalani Samarappuli, K G Karnika de Silva, Rasika Hettiarachchi and Manel Wijesekera).

2.8.6 *Nutrient requirement of rubber based cropping systems*

Arrangements have been made to commence experiments at estate and smallholder sectors to study the nutrient requirements of rubber based cropping systems (A Dissanayake, Lalani Samarappuli, N Wickramasinghe, U Mitrasena and S Chandrasiri).

## 2.9 *Soil and foliar survey programme*

2.9.1 *Improvements to soil and foliar survey programme*

2.9.1.1 Sampling intensity

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

2.9.1.2 Storage of leaf samples before processing

A study was initiated to further investigate the earlier findings of leaf sample processing procedure. The following experiments were designed and samples were collected, processed and chemically analyzed following normal procedures.

Experiment 1. Effect of refrigeration period on analytical results.

| Treatment | Processed within (hrs) | Refrigeration time |
|---|---|---|
| 1 (control) | Just after sampling | Nil |
| 2 | 24 | 12 |
| 3 | 48 | 36 |
| 4 | 72 | 60 |
| 5 | 96 | 84 |
| 6 | 120 | 108 |
| 7 | 132 | 120 |
| 8 | 144 | 132 |
| 9 | 156 | 144 |
| 10 | 168 | 156 |
| 11 | 180 | 168 |
| 12 | 192 | 180 |

Experiment 2. Effect of sample storage time (without refrigeration) on analytical results.

| Treatments | Storage duration (hrs) |
|---|---|
| 1 (control) | nil |
| 2 | 24 |
| 3 | 36 |
| 4 | 48 |
| 5 | 60 |
| 6 | 72 |
| 7 | 84 |
| 8 | 96 |

Experiment 3. Effect of storage time before refrigeration on analytical results.

| Treatment | Refrigerated after (hrs) | Refrigeration duration (hrs) |
|---|---|---|
| 1 (control) | Just after sampling | 120 |
| 2 | 24 | 96 |
| 3 | 36 | 84 |
| 4 | 48 | 72 |
| 5 | 60 | 60 |
| 6 | 72 | 48 |
| 7 | 84 | 36 |

(N Wickramasinghe, Lalani Samarappuli, T Gunathilake and S Chandrasiri)

2.9.1.3 Sampling time

A study was initiated to find out whether improvements could be done on the earlier findings for leaf sampling time. Leaves were sampled as below and were chemically analyzed by following normal procedures.

| Treatments | Sampling time | Treatments | Sampling time |
|---|---|---|---|
| 1 | 7.00 AM | 5 | 2.00 PM |
| 2 | 9.00 AM | 6 | 3.00 PM |
| 3 | 11.00 AM | 7 | 4.00 PM |
| 4 | 1.00 PM | 8 | 5.00 PM |

(N Wickramasinghe, Lalani Samarappuli, T Gunathilake and S Chandrasiri)

2.9.2 *Soil and foliar survey programme - Fertilizer recommendation*

**Estate sector**

The site specific fertilizer recommendation programme for mature rubber provided data for fertilizer recommendations for 20,000 hectares in the estate sector.

**Small holder sector**

The soil and foliar survey programme for the small holder sector was not commenced as an economy measure due to the very poor trading condition prevailing in the country.

2.10 ***Survey on agronomic practices in rubber lands***

2.10.1 *Model fitting on factors affecting fertilizer utilization*

A field level survey was carried out with the aim of modeling the factors affecting fertilizer adoption in the Estate sector. Social, economic, institutional and other

factors were included for this study and statistical analysis of data collected from seventy estates under 19 plantation companies are in progress.

Around 300 immature rubber fields of these estates were inspected to investigate the effect of major agronomic practices on performance of rubber plants.

2.10.2 *Planting hole fertilizer application*

It was observed that several incorrect practices are adopted during planting hole application of fertilizer. The following are the most commonly adopted incorrect practices.

i. Application of rock phosphate only (**R**)
ii. Application of rock phosphate + kieserite + NPK mixture, in incorrect quantities (**RKM(±RQ)**)
iii. Application of kieserite and NPK mixture only. No rock phosphate is added. (**KM**)
iv. Application of rock phosphates and kieserite only. No NPK mixture is added. (**RK**)
v. Application of NPK mixture only. Kieserite and rock phosphate are not added. (**M**)
vi. Application of rock phosphate and NPK mixture only. No kieserite is added. (**RM**)

Out of all these incorrect practices 40% represented application of only rock phosphate to planting holes (Fig.2).

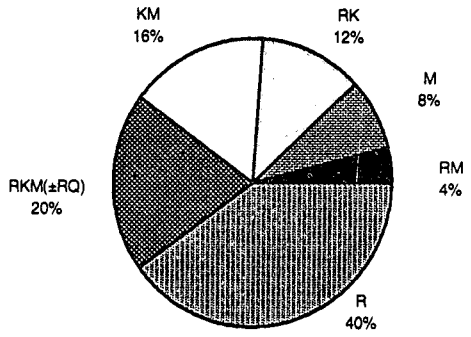



Fig.2. Incorrect practices adopted during planting hole application of fertilizer

2.10.3 *Method of fertilizer application*

Although, forking (**F**) is the best way of manuring rubber plants, it was practiced only in 21% of immature clearings. Several incorrect practices adopted were identified and following are the most commonly used incorrect methods (Fig.3).

i. Fertilizer application by digging with mammoty (**DM**)
ii. Fertilizer application by digging with crow bar (**DC**)
iii. Mixing fertilizer with soil without using agricultural tools (**MS**)
iv. Fertilizer broadcasting (**B**)

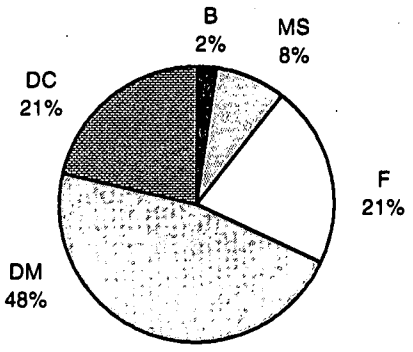



Fig.3. Different methods adopted for fertilizer application

## 3. Land use planning

### 3.1 *Soil survey and classification*

Soil samples were collected from locations to represent four major rubber growing soils. Further, arrangements have been made to collect samples from remaining soil series and also from Bibile, Moneragala areas (A Dissanayake, N Wickramasinghe and Chitra Maheepala).

### 3.2 *Land selection and suitability for rubber cultivation*

Land and soil properties to be considered in selecting lands for commercial rubber cultivation and a broad range of suitability indices for each parameters have been identified. Arrangements have been made to incorporate these information to develop a computer programme to assess the feasibility of land for rubber cultivation (L Samarappuli, N Wickremasinghe and W Wijesuriya).

## 4. Analytical services and techniques

### 4.1 *Analytical service*

Routine chemical analysis of soil, leaf, latex and fertilizer samples collected for experimental and advisory purposes were carried out. Samples from other Departments and Organizations were also analyzed. Details are presented in Table 29.

Table 29. *Details of the analysis done during the year 1999* samples

| Source | No. of analyses | | | | |
|---|---|---|---|---|---|
| | Plant | Soil | Fertilizer | Other* | Total |
| Experimental | 2000 | 800 | - | - | 2800 |
| Soil and Foliar survey | 4400 | - | - | - | 4400 |
| Other Departments of RRI | 24 | - | - | - | 24 |
| Research Institutes | 50 | 30 | - | 40 | 120 |
| Rubber Development Department | - | - | 125 | - | 125 |
| Plantation Management Companies | - | 25 | 330 | 16 | 371 |
| Other Private Companies | - | - | - | 66 | 66 |
| Total | 6474 | 855 | 455 | 122 | 7906 |

* water/bleaching agents/chemicals/rubber

4.2 ***Analytical techniques***

Work on preparation of a Laboratory Manual for the Soils and Plant Nutrition Department was continued (N Wickramasinghe and Lalani Samarappuli).

# BIOCHEMISTRY AND PHYSIOLOGY

W M Thurul

## SUMMARY

The main focus of the department was on development of appropriate technology for environmentally friendly management of rubber factory waste.

## DETAILED REVIEW

### Staff

Assistant Biochemist, Mr W M Thurul was on duty through out the year. Miss K V V S Kudaligama, Experimental Officer, Mr P D J Rodrigo and Mr D Ramawikrama, Technical Officers, were on duty through out the year. Mr G D W Kulathunga, assumed duties as a Laboratory Attendant on 21st September with effect from 1st November, 1999.

### Awards

Mr W M Thurul won a Presidential merit award for his invention on coconut fiber media for high rate biological wastewater treatment.

### Research students

Miss D J Liyanage, MSc student from Sri Jayawardenapura University continued the research work in rubber factory effluent treatment under the supervision of Mr W M Thurul and Dr P A J Yapa. The completed thesis, titled "Possibility of using coconut fibre pieces as stationary media in high rate anaerobic treatment of Rubber factory waste", was submitted to the University as a partial fulfillment of the degree.

### Research and Development

#### *Bio-Brush media*

Several technological improvements were incorporated to coconut fiber based Bio-Brush media production machinery. A leap frog improvement in production efficiency was achieved (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

Further research was continued to improve the efficiency of Bio-Brush media for rubber wastewater treatment. An improved configuration for laying the media in CAD systems was implemented in a commercial scale treatment system at Eladuwa rubber factory. Possibility of using materials other than coconut fibre was

also investigated (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Odour filter*

Further research on development of coconut fiber based odour filter was continued. All the odour filters implemented are performing well. Possibility of using materials other than coconut fiber was also investigated (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Low cost treatment system configurations and low cost construction materials*

Possibility for upgrading the construction procedure of "Covered Activated Ditch (CAD)" system at low cost was tested. Testing of materials and developing construction equipment were also of consideration (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Deammoniation and continuous coagulation of skim latex*

Developing appropriate techniques for removing ammonia from skim latex and continuous coagulation of skim latex with organic acids were continued. A bench scale system was tested. Designing a commercial scale system was of consideration (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Biological and biochemical treatment of rubber wood*

Studies on biological and biochemical treatment of rubber wood were continued (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Chemical bleaching of rejected treated rubber wood*

Further development of techniques for bleaching treated rubber wood, rejected due to fungal staining was continued (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

*Biological and biochemical carving of rubber wood*

Research work on this was continued (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

**Implementation and monitoring of new developments**

*Rayigam Estate Crepe Rubber Factory*

Monitoring and the analytical assessments were made. The system was functioning satisfactorily. A major maintenance operation was recommended for the

nearly four-year-old system (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Pallegama Estate Sole Crepe Rubber Factory***

The effluent treatment system of the factory was functioning satisfactorily. Monitoring and the analytical assessments were carried out (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Kiriporuwa Estate Centrifuge Factory***

Monitoring and the analytical assessments were made. The system was running satisfactorily at higher waste loads than that of the designed capacity (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Yatadola Estate Crepe Rubber Factory***

Monitoring and the analytical assessments were made. The system was functioning satisfactorily (W M Thurul, K V V S Kudaligama, P D J Rodrigo, D Ramawikrama).

***Eladuwa Crepe Rubber Factory***

A Covered Activated Ditch system with several improvements was constructed for treatment of effluent (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Ketandola Rubber Factory***

Detailed engineering design and relevant documents were submitted to the Management Company for construction of the effluent treatment system for the factory (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Pallegoda Estate Crepe Rubber Factory***

A treatment system was designed to suit the site available at the factory (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Neuchatle Estate Crepe Rubber Factory***

Detailed engineering design and relevant documents were submitted to the Management Company for construction of the effluent treatment system for the factory (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

***Delshan Auto Service, Kuliyapitiya***

Bio-Brush based novel type of air filtration system was designed for minimizing the air pollution from the Auto Service center. The new facility has been performing satisfactorily (W M Thurul, K V V S Kudaligama, P D J Rodrigo and D Ramawikrama).

# RUBBER TECHNOLOGY AND DEVELOPMENT

**N M V Kalyani Liyanage**

## SUMMARY

Use of various electrolytes as coagulants in latex dipping formulations to enhance the extractability of water-soluble proteins was evaluated.

Application of NR latex as a binder for coir and coir dust based articles used in horticultural practices was looked into.

Suitable techniques for manufacture of toy balloons resembling English alphabet using tefflon moulds were developed.

Use of water-soluble polymers as extractable protein removers was investigated.

Some trials were performed to increase the percentage incorporation of Carbon black in Latex/Carbon black masterbatches.

A tyre paint suitable for improving the glossy appearance of tyre retreads was developed.

A study on the influence of mixing conditions as well as the technique of blending on technological properties and swelling resistance of Carbon black filled NR/NBR blends was initiated.

Technological properties of Interpenetrating Polymer Networks (IPNs) based on NR and various monomers synthesized under various experimental conditions were determined.

## DETAILED REVIEW

### Staff

Dr (Mrs) N M V Kalyani Liyanage, Head, Rubber Technology and Development Department was on duty throughout the year. Dr Mohamed Rizmi, Assistant Rubber Chemist, resigned from the Institute on 11$^{th}$ August. Mrs D G Edirisinghe, Assistant Rubber Chemist, resumed duties of the Department on the 15$^{th}$ of August after completing her postgraduate studies at the University of Loughborough, UK and she went on maternity leave with effect from 3$^{rd}$ of October. Mrs M M Jayasooriya, Rubber Chemist, left for UK on 28$^{th}$ of January to carryout the initial part of her postgraduate studies at the University of Loughborough and returned to the Institute on 29$^{th}$ of August.

Mrs Manel Mahanama, Experimental Officer, followed a training at the Rubber Research Institute, India from 24$^{th}$ of January to 20$^{th}$ May. Mr K M U Mithrananda, Experimental Officer, resigned from the Institute in April. Mrs Sriyani Yapa, Experimental Officer, was on duty throughout the year. Mrs P C

Wettasinghe, Experimental Officer, was transferred to the Department on the 5th of July. Miss Nadeeja Wickremarachchi, Research and Development Assistant, and Mr Asela Siriwardena, Technical Officer, assumed duties of the Department on the 11th of February and the 6thof September respectively.

**Research students**

- Four undergraduates from University of Colombo underwent vacation training.
- An undergraduate from University of Moratuwa was trained under the Apprenticeship in-plant training scheme.

**Meetings, Seminars, Lectures and Courses**

Dr (Mrs) N M V Kalyani Liyanage[1] and Dr A C M Rizmi[2] participated in the following;

- A workshop on 'Research Performance Evaluation' organised by The National Science & Technology Commission (NASTEC) on the 1st of February at Galadari Hotel, Colombo[1].
- A meeting on the 'Current Position of RVNRL' with Mr Wan Manshol, an expert in the field of RVNRL from Malaysia, on the 21st of March at the Atomic Energy Authority[1]. Also a discussion on the same subject with Mr Wan Manshol was organized for the RRI scientists on the 23rd of March at RRI.
- The staff of the Department involved in organising and conducting 4 practical classes for the MSc course on 'Polymer Technology' organised by the University of Sri Jayawardenapura.
- Two meetings of "Rubber & Plastics Sub-sector Working Group Meeting on Draft Master Plan on Rubber & Plastics" held at the Ministry of Industrial Development on the19th of May and the 28th of June[1].
- A Seminar on "Masterplan on Industrialisation and Investment Promotion in Sri Lanka" organized by the Ministry of Industrial Development held at Hotel Galadari on the 24th& 25th of May[1].
- Meetings of the Sri Lankan research group on "Radiation Prevulcanisation of Natural Rubber Latex" held at the Atomic Energy Authority[1].
- A meeting of working group on Rubber Examination gloves held at SLSI on the 10th of July[1].
- A discussion on "Testing facilities available for the rubber industry at PSP organised by the SLAMERP on the 1st of August[1].
- A meeting on the "Masterplan on Industrialisation & Investment Promotion In Sri Lanka." organised by the JICA at Galadari Hotel on the 3rd of August[1].

- A meeting on the "Manufacture of small rubber products at provincial level" held at the Provincial Minister's office at Ruwanwella on the12th of August[1].
- Five meetings of working group on Master Plan on Industrialisation and Investment Promotion in Sri Lanka" held at RRISL on the 3rd & the 14th of July and at the Ministry of Industrial Development on the 6th & the 21st of September & the15th of November [1]

## LABORATORY INVESTIGATIONS

### 1. Latex technology

### 1.1 *Radiation prevulcanisation of natural rubber latex*

1.1.1 *Development of suitable antioxidant/antioxidant systems for RVNRL*

Suitability of some commercially available antioxidants in RVNRL was evaluated at various levels of addition. Antioxidants such as Antioxidant 2246, TNPP, and Irganox were used in this evaluation. At the 0.25pphr level of addition, Irganox. was found to give the best room temperature ageing resistance to the RVNRL films. However, at 100°C, samples containing TNPP showed the optimum ageing resistance (N M V K Liyanage, L Karunanayake, H N K K Chandralal, M Rizmi, K G S Ranmohotti and M H C R de Silva - University of Colombo and S S Kulathunge - Atomic Energy Authority).

1.1.2 *Extractable protein content of RVNRL*

The study on the total extractable protein content of the NR latex matured to various time intervals and irradiated to similar dose levels was repeated. The physical properties of resultant films were also determined.

It was observed that as the latex matures the physical properties of the films after leaching increases and the extent of the increase depends upon the nature of the leaching medium. The extractable protein content of the resultant films are yet to be measured (N M V K Liyanage, L Karunanayake, H N K K Chandralal, M Rizmi, S I Yapa and S S Kulathunge -Atomic Energy Authority).

1.2 ***NR latex coated fabric gloves***

A request came from Hanwella Rubber Products for a suitable technique to reduce the penetration of latex into the interior surface of latex coated fabric gloves during the coating process. Several suitable techniques developed by the Department were proposed (N M V Kalyani Liyanage).

1.3 ***Techniques for reducing extractable protein content of latex films***

Several techniques were tested for reducing the total extractable protein content in NR latex dipped films. Techniques suitable for denaturing and thereby reducing the extractability of latex proteins as well as those suitable for increasing the solubility of proteins, thereby removing the extractable proteins during the leaching process were tried out. Some of the techniques were found to produce very promising results (N M V K Liyanage, Nadeeja Wickramarachchi and Ruwani Balasooriya. -University of Colombo ).

1.4 ***Use of water soluble polymers as extractable protein removers***

Suitability of water soluble polymers such as Polyvinyl acetate(PVA) of different molecular weights as agents for removing the extractable proteins in NR latex films were evaluated. PVA was found to be a very effective agent in removing the extractable proteins (Upul Rathnayake, N M V K Liyanage, Nirosha Kalupahana - NDT student).

1.5 ***Latex based cement for tyre retreading***

The major drawback of the latex cement was the premature coagulation of the cement. Several attempts were made to prepare the latex based cement with a longer storage stability. Lab scale trials on some latex based cement formulations were found to possess excellent peel strength characteristics. Some of the formulations were found to outperform the peel strength characteristics of currently used solvent dry rubber based cement (N M V Kalyani Liyanage, M Rizmi, D G Edirisinghe S I Yapa and A M U Gayani - University of Colombo).

1.6. ***Latex /carbon black masterbatches***

A new set of samples of latex carbon black masterbatches synthesised as a preliminary study produced some useful results. New stabilizers are being used in the preparation of carbon black dispersions with a view to increase the percentage of incorporation of carbon black into rubber (N M V K Liyanage and M K Mahanama).

1.7 ***Rubberised coir***

A request came from the Rubberised Coir Manufacturing Factory of SRMC for developing their currently used latex compound as they had experienced a severe sagging problem in their thick rubberised coir mattresses. A suitable modification for their latex compound was recommended after a factory inspection. It was reported that the RRI formula helped them to overcome the problem successfully (N M V Kalyani Liyanage and Nadeeja Wickramarachi).

1.8 ***Use of latex in horticulture practices***

A systematic study on the use of rubber latex as a binder for coir dust based articles used in horticulture was initiated. Suitability of rubberised coir and

coir dust in making items such as flower pots, pot covers, creeper bars and hanging baskets etc. was looked into using various types of latex concentrates. Normal prevulcanised latex concentrates, room temperature vulcanising latex concentrates, post vulcanisable concentrates as well as irradiated latex concentrates, were used in this evaluation RVNRL may be an ideal latex binder for this purpose as it does not contain Zn (N M V K Liyanage, P C Wettasinghe, and Nadeeja Wickramarachchi).

1.9 ***Production of toy balloons by using tefflon moulds***

A request came for a suitable technique as well as for a suitable latex compound for the manufacture of toy balloons resembling the English Alphabet. A series of trials were conducted and suitable formulations for latex compound as well as for coagulant solution were developed. Relevant details of the same were passed on to the interested party who was willing to invest to manufacture these balloons for the export market (N M V K Liyanage and M K Mahanama).

## 2. Dry rubber technology

### 2.1 Tyre paints for retreading industry

A request came from the Associated Motorways Ltd. for a suitable tyre paint which would impart a glossy appearance to the final retread. Several trials were conducted with their current paint and a suitable modification for the same paint was developed (N M V Kalyani Liyanage and Nadeeja Wickremarachchi).

### 2.2 Protein analysis of crepe rubber

Total extractable protein content of 3 types of UFUB crepe rubber produced by varying the chlorine content in the water used in final stages of the washing of laces at C W Mackies was determined by the BCA method. The extractable protein content of the samples was found to depend on the extent of chlorination (N M V Kalyani Liyanage and M Rizmi).

### 2.3 Blends of NR with NBR

A study on the influence of mixing conditions as well as the technique of blending on technological properties and swelling resistance of carbon black filled NR/NBR blends was initiated. The objective of this study is to select mixing conditions and the technique of blending in the Brabender PL 2000 Plasticorder for optimum properties of NR/NBR blends. Work was also commenced to identify curing systems which would give an even distribution of cross links within the two phases of the NR/NBR blends (D G Edirisinghe, M K Mahanama and A I Siriwardena).

2.4 ***ENR/NBR blends***

A 4 month research project was carried out on 'Studies on Blends of Acrylonitrile Butadiene Rubber and Epoxidised Natural Rubber (NBR/ENR)' at Rubber Chemistry Physics and Technology Division of Rubber Research Institute of India, Kottayam, Kerala. NBR/ENR blends showed self vulcanisable characteristics as evident from rheometric as well as volume fraction (Vr) estimation data. The gum vulcanizates of blends containing lower proportion of ENR (10-15 parts) showed better technological properties compared to those of the nitrile rubber gum vulcanizate. The swelling characteristics of nitrile rubber was not adversely affected by the incorporation of a lower proportion of ENR. However blends containing more than 20 parts of ENR showed reduced technological properties and increased oil swelling (M K Mahanama and K Mariamma George - Rubber Research Institute of India, Kottayam).

2.5 ***Inter penetrating polymer networks (IPNs)***

A literature survey was carried out on Modification of Natural Rubber & IPNs. A series of IPNs based on NR & monomers were prepared under various experimental conditions. These blends are found to be of satisfactory physical properties. Morphological studies done using SEM indicated that phase separation has occurred in some IPNs. Miscibility of these IPNs were determined using DMTA and MDSC methods (M M Jayasooriya and D J Houston (University of Loughborough).

**Industrial extension**

The following services were provided by the Department in product development and testing.

| Test | No. of industries |
|---|---|
| Rubber compound testing | 8 |
| Product testing | 4 |
| Protein analysis | 2 |

# POLYMER CHEMISTRY

K G Karnika de Silva

## SUMMARY

Development of blends of NR/EPDM, with the aim of combining the excellent physical properties of NR with the ozone resistance EPDM was initiated. This study was important to cut down the high cost of EPDM rubber used in certain products.

Initial trials were carried out with latex samples from different clones treated to different conditions to denature the extractable proteins. Films of blends of NR/NBR lattices with compatibilizers were also tested for proteins. The effects on vulcanization methods were also monitored. Quantitative analysis of proteins in latex gloves were carried out using BCA method.

An adhesive was developed using general purpose neoprene and grafted neoprene using polymethylmethacrylate as the grafting agent. Attempts were also made to develop an adhesive using ENR latex and polyvinyl acetate emulsion and their blends.

Variation of MST at different conditions such as temperature variations, storage time, preservative system *etc.* was studied using centrifuged latex. Different types of Neem stabilized centrifuged latex samples were prepared and the properties were evaluated. Samples were sent to the industry to turn out gloves for comparison of physical properties, protein content etc. against standard glove samples.

A comparative study was carried out to analyze the chemical and physical properties of creamed latex and centrifuged latex.

A low cost, heat resistant mould out of NR latex was developed successfully at the department.

An improved formulation was suggested to produce good quality coco peat dusted rubber latex based sacks. These are used in horticulture industry. Mould design and quality improvement were successfully completed and the technical know-how was transferred to the industry.

The new preservative system based on neem extract was used to prepare a large batch of centrifuged latex without using any toxic TMTD in the formulation.

A rubber based paint was successfully developed for latex based dipped products. A range of formulations, solvents etc. were tested to find out the most cost-effective formulation to satisfy the requirements of the customer.

A new project to introduce a soilless plant medium with tea dust and compounded latex was initiated in collaboration with the TRI to match an imported planting medium available in the market.

Trials were conducted with non-toxic chemicals to replace Hydroxylamine neutral sulphate (HNS) which is used to manufacture CV Rubber.

It was found that the much expensive conductive black used in the manufacture of conductive pads can be replaced with normal HAF black provided not the correct modified formulation is used.

Presently used toxic chemicals to coat metal wires used in tyre industry can be replaced by cheap and non-toxic latex compounds.

## DETAILED REVIEW

### Staff

Dr K G Karnika de Silva, Deputy Director Research/Technology continued to supervise the activities in the Polymer Chemistry Department.

Mrs Champa Wellappili and Mrs Nilminie Liyanage, Assistant Rubber Chemists were on duty through out the year.

Mrs Indra Denawaka Experimental Officer reported for duty on 20.05.2000 after completing four months training at RRII.

Messers H N K K Chandralal, S S Warnapura, Mrs W C M Kuruppu, Messers R S Wijesundara, S L G Ranjith and Ananda Samaraskoon, Experimental Officers, Mrs Renuka Wijeratne, Clerk/Typist, Messers Sunil Weerasekara, P R Sigera, L L Piyasena, W D S Dharmawardena Laboratory Attendants were on duty throughout the year.

### Research students

Nine undergraduates were provided with short term training during the year.

### Meetings/Visits/Seminars/Discussions

Dr K G Karnika de Silva participated at the following meetings/seminars/discussions.

- One Scientific Committee meeting held at SLAAS Auditorium and did a presentation on Value Additions in Rubber Industry
- Five Board Meetings held at Ceyesta as a Board Member
- Served as a committee member in the implementation of Industrial Master Plan initiated by the Ministry of Industrial Development
- Committee on setting up of Standards for Examination Gloves held at SLSI
- Committee on Personnel Development Project under ADB grants held at the Ministry of Science and Technology
- Served as a member for Open University curricular development
- A workshop on Research Performance Evaluation held at Galadari Hotel organized by the Ministry of Science and Technology.
- Participated at the exposure visit to Australia and industrial Rubber Conference – 2000 held in Melbourne.

**Training programmes conducted**

- The department organized a full day workshop on "All Aspects of Centrifuged Latex Manufacture" at the RRISL Auditorium, Telawala Road, Ratmalana for Centrifuged latex manufactures.
- The department staff served as resource personnel in training programs conducted by NIPM.

**Advisory visits**

Eight advisory visits were under taken during the year.

## LABORATORY INVESTIGATIONS

**NR/EPDM blends**

Development of blends of NR/EPDM, with the aim of combining the excellent physical properties of NR with the ozone resistant EPDM was initiated on a request made by a rubber based product manufacturer. These blends are mainly used in weather resistant applications and different polymer ratios with different accelerator systems were used to get optimum properties of the blends. This study was important to cut down the high cost of EPDM. Physical properties and other relevant properties were tested for further improvements of the blends. Better results were obtained with some specific types of accelerator systems and new mixing methods. According to the physical properties, it was evident that the polymer blends with new mixing methods give better results, compared to conventional mixing methods (K G Karnika de Silva, Champa Wellappili and Rajitha Dharmawardana - NDT student).

Determination of crosslinking density was carried out in different solvents. This study revealed that the crosslinking density in EPDM phase could be improved by polymer cross blending using upside down mixing (K G Karnika de Silva, Champa Wellappili, H N K K Chadralal and R Darmawardana NDT-student).

**Blends with acrylonitrile/NR graft NR/NBR copolymer**

A study was undertaken to standardize the optimum concentration of ACN-g-NR to compatabilize NR/NBR blends. Evaluation of mechanical properties and investigation of formation of interfacial crosslinks in the presence of compatabilizers by swelling methods were carried out.

It was found that in binary blends of NR and NBR the addition of a small amount of acrylonitrile graft NR (ACN-g-NR) could compatabilize improving the molecular level mixing due to the possible polar - polar interactions between ACN-g-NR. As a result the physical and technological properties of NR/NBR blends could be improved considerably (Indra Denawaka – project carried out at RRI, India).

**NR/NBR blends for brake pads**

Different ratios of NR and NBR were milled with and without compatibilizers. The results showed that NR without any NBR is a good material to turn out brake pads as the brake fluids are based on polyethleneglycols (K G Karnika de Silva, Champa Wellappili and Shiral Fernando-Trainee -University of Kelaniya).

**Plant based fatty acid derivatives as activators**

Research to find out the suitability of using plant based fatty acid derivatives in rubber compounds were conducted. Plant extracts were made in solid form using saponification methods. One of the plant extract out of many tested showed excellent properties and it was decided to continue the project using this particular fatty acid based derivative. Two rubber based industries have shown interest in using this new compound after in depth study in collaboration with RRI (K G Karnika de Silva, Nilmini Liyanage and Gayani Koddippili - Trainee - University of Colombo).

**Conductive rubber**

The project on conductive rubbers was reactivated on a request made by a manufacturer of rubber pads for the electronic industry. Natural Rubber was compounded with normal HAF black using a modified formulation and the results were compared with samples of conductive black. The results show that the required specifications including the conductivity could be achieved with the new formulation. Commercial scale trials were also conducted at a factory. It was shown that the cost involved with costly conductive blacks could be reduced considerably by using ordinary blacks with the right modification in the formulation (K G Karnika de Silva, Champa Wellappili and Thanuja Abenayaka – Trainee University of Colombo).

**NR protein allergy**

Project on latex proteins supported by the NSF Grant No RG/99/C/07 was continued. The initial trials were carried out with different latex samples and subjected to different conditions to denature the extractable proteins. Films of NR/NBR blends were also tested for proteins. BCA method was used for protein analysis. The effect on vulcanization *eg.* Prevulcanization and Post vulcanization methods was monitored by introducing new vulcanization methods. Latex samples collected from different clones (*eg.* RRIC 100, 102, 130, 121) were subjected to deprotenisation. The extractable protein content of them were determined. Different types of coagulation and vulcanisation systems were also studied to see their effect on extractable protein content in the end product (K G Karnika de Silva, Champa Wellappili, S L G Rangith, Madana Sorupe and Kumudinie Chandrasekara).

**Neem stabilized latex**

Properties of different types of Neem stabilized centrifuged latex were evaluated. A sample was sent to a latex glove manufacturer to manufacture gloves for comparison of physical properties, protein content *etc.* with those of the standard glove samples (K G Karnika de Silva, Champa Wellappili and Chitra Kuruppu).

**CV rubber**

A project was initiated to manufacture constant viscosity (CV) rubber using non-toxic chemicals. A literature survey was carried out to find out alternatives to match the function of Hydroxylamine neutral sulphate (HNS) and to see the possibilities of replacing HNS from the method of CV rubber manufacturer. Initial trials were conducted with non-toxic chemicals found in the literature (K G Karnika de Silva, Nilmini Liyanage, S S Warnapura, L P Vitharana and Ananda Samarakoon).

**Rubber based adhesives**

A new adhesive based on grafted neoprene was developed and was compared with a general-purpose neoprene based adhesive. Methylmethacrylate was used as a grafting reagent and also to introduce a polar nature to neoprene. Peel strength was used as the physical parameter to compare strength of these two types of adhesive samples (K G Karnika de Silva, Nilmini Liyanage, Keerthi Senevirathna -Trainee-University of Kelaniya and Dishni Dayaratne - Trainee-University of Colombo).

A study was carried out to develop an adhesive using MG- latex, ENR latex and polyvinyl acetate emulsions and their blends with NR and neoprene lattices on a request made by an adhesive manufacturer. Peel strengths of the samples in leather and paper were tested (K G Karnika de Silva, Nilmini Liyanage and D G Sanjeewa – NDT Trainee - University of Moratuwa).

A study was carried out to develop an adhesive using polychloroprene rubber, NR and SBR blends on a request made by a manufacturer of natural rubber based strips (K G Karnika de Silva, Nilmini Liyanage and S S Warnapura).

**Epoxidized natural rubber**

The project on epoxidized natural rubber was reactivated in view of using it in some valuable end product manufacture. High stability is a requirement for this product and attempts were made to keep the epoxidized latex for a long period of time. 20% and 50% ENR were prepared and tested for adhesive applications. These samples were blended with other suitable lattices, *eg.* MG latex samples to increase adhesion properties. Evaluations of results are in progress (K G Karnika de Silva, Champa Wellappili and Ananda Samarakoon).

**Dewebbers and defoamers**

Samples of dewebbers and defoamers sent by Crusader Chemical Co, Inc. USA were tested for their dewebbing activity with the assistance of two glove manufactures in Sri Lanka to see the performance in glove manufacture. Surface tension of the lattices with and without these modifiers were tested and compared (K G Karnika de Silva, Nilmini Liyanage and H N K K Chandralal).

**Bicycle tyres - Rubber coated wires**

Generally metal wires coated with a dry rubber compound are used in tyre building operations. This process involves dipping the wires in a toxic solution to enhance rubber-metal bonding and coating the wire with an extruded rubber compound. This operation was found to be time consuming and labour intensive. Hence an alternative method, to introduce a latex dipping step to coat the wires with rubber was suggested. The main advantage is that no toxic chemical solutions are involved in this process. Different latex compounds were prepared. When they were passed through thick latex compound they were coated successfully (K G Karnika de Silva, Champa Wellappili and Chitra Kuruppu).

**Coco peat dusted natural rubber latex based sacks**

An improved formulation was suggested to produce good quality coco peat dusted rubber latex based sacks for exports. These are used in horticulture. Mould design and quality improvement was successfully completed and the technology developed was given to the interested party (K G Karnika de Silva, Nilmini Liyanage and H N K K Chandralal).

**Rubberised coir based pots/mattresses**

An improved formulation was suggested to produce good quality rubberized coir with out sagging. The new formulation introduced was able to produce good quality rubberized coir mattresses. Samples of thin rubberized coir sheets were introduced for the German market through a public sector firm producing rubberized coir (K G Karnika de Silva, H N K K Chandralal and Chitra Kurruppu).

**A flexible paint for latex based dipped products**

A new rubber based paint was successfully developed for latex based dipped products on a request made by a balloon manufacturer. A range of formulations, solvents etc. were tested to find the most cost effective formulation to satisfy the requirement of the customer. The best formulation was selected and the technology developed was given to the customer (K G Karnika de Silva and S S Warnapura).

**Extrusion of latex tubes**

Heat sensitive gelation was used to extrude latex tubes. Further trials with different types of heat sensitizes are in progress (K G Karnika de Silva, Champa Wellappili, H N K K Chandralal and Kenath Mathusingha – NDT Trainee – University of Moratuwa).

**MST variation**

Variation of MST under different conditions i.e. temperature, storage time, preservative system etc. was studied using centrifuged latex (K G Karnika de Silva, Nilmini Liyanage, Chitra Kuruppu and E W P Jayathunga – NDT Trainee - University of Moratuwa).

**Comparison of different lattices**

A comparative study was carried out to analyse the chemical and physical properties of creamed and centrifuged latex (K G Karnika de Silva, Nilmini Liyanage and E W P Jayathunga - NDT Trainee – University of Moratuwa)

**Nitrile rubber**

A request was made by IDB to assist them to analyze nitrile rubber from a local supplier. This was required to evaluate a tender for supplying Nitrile Rubber to IDB. Standard samples were requested to plot a calibration curve to find the composition of the acrylonitrile and butadiene in NBR using FTIR. An officer from RRPD/CE Department participated at the evaluation committee and indicated the need of requesting specifications of the raw materials based on the above study (K G Karnika de Silva and Nilmini Liyanage).

**Mould design**

A request was made by partners of a BOI joint venture project to develop a low cost mould out of natural rubber to manufacture decorative candles. Several trials were carried out to develop a successful low cost, heat resistant mould out of NR latex. This development helped the industry to save on the high cost on silicone moulds used earlier (K G Karnika de Silva, Champa Wellappili, Nilmini Liyanage and H N K K Chandralal).

**Soil-less plant medium with tea dust and compounded latex**

This project was initiated on a request made by the TRI to match an imported medium available in the market for growing plants with one of their byproducts using compounded latex as a binder. Information from electronic media was used in developing a suitable plant base to suit our context (K G Karnika de Silva, Dr Mohotti – TRI and S S Warnapura).

**Industrial extension**

The following services were provided by the department during the year.

| Test | Number of industrialists |
|---|---|
| Elastomer analysis | 40 |
| Quantitative analysis | 10 |
| Qualitative analysis | 5 |
| Bloom analysis | 10 |
| Kinetic study of the polymerization reactions | 2 |

# RAW RUBBER AND CHEMICAL ANALYSIS

**L M K Tillekeratne and H S Weeraman**

## SUMMARY

The following activities were performed during the year:

(a) Testing, grading and issuing shipping certificates for all TSR produced in the country.
(b) Recommendation of chemicals to the industry and testing their purity.
(c) Testing of latex, latex crepe, sole crepe and sheet rubber produced in the country for local industries and shippers.
(d) Analysis of chemicals and water used in the rubber processing and rubber products manufacturing industry for purity.
(e) Testing of finished products such as
    1. Rubber gloves for sodium pentachlorophenate content
    2. Rubber content in vulcanized products
    3. Rubber and other polymer contents in foam rubber
    4. Contamination of dipped products with metal ions.
(f) Participation in Round Robin cross check on standard dry rubber testing for regional laboratories conducted by Rubber Research Institute of Malaysia. Organizing and participation in inter laboratory cross check programme for latex testing laboratories owned by the private sector or the state.
(g) Organizing demonstrations and work shops on preparation of new brushable rainguard sealant for plantation companies and smallholder sector.
(h) Analysis of dry rubber, latex, chemicals, finished products, *etc* on requests made by the other research departments.

Following research projects were in progress.

1. New brushable sealant for fixing rainguards
2. Use of nitrile rubber latex in the grout applications
3. Effect of latex storage temperature on latex properties
4. Improving the hardness of sole crepe by incorporating nitrile latex.

## DETAILED REVIEW

### Staff

Dr L Karunanayake, Specifications Officer was in service until May 22$^{nd}$ and resigned from the post to take up duties at University of Sri Jayawardenapura, Kotte. Since then Mrs H S Weeraman was in-charge of the overall activities of the department.

Experimental Officers H S Weeraman, L Wanigatunga, H V K Gamage, C Lokuge and Mr P L Perera, were on duty through out the year.

Mr L P Vitharana, Experimental Officer was on duty until May 19th and was transferred to Biometry section for seven months and on his request re-joined the department on 4th December.

Miss P Perera, resumed duties as Development and Research Assistant on 14th February. Mrs N Baduge, Graduate Assistant (Technical) - was on duty through out the year. Miss M Wijesekera, Messrs B Gunasiri, W Vithanage, W W Nandasena, N Karunatilake, Technical Officers were on duty through out the year.

Mrs Geethani Rajapakse, Technical Officer was on leave due to ill health until her demise on 5th June.

Mrs Shirani Priyanka transferred from Plant Pathology and Microbiology Department on 3rd July was on Maternity leave until 3rd November.

Mr L G P Lelwela, Instrument Technician was on duty through out the year. Mrs I Wijesinghe, Clerk/Typist was on duty through out the year. Messes S Gallege, G H Somasiri and P Vithana, Laboratory Attendants were on duty through out the year.

**Meetings attended**

- A workshop on research performance evaluation organized by the National Science and Technology Commission.
- Committee meeting of PVNRL organized by Atomic Energy Authority.
- Scientific Committee Meeting.

**Training programmes**

21 demonstrations on rainguard fixing were carried out during the year using modified brushable sealant (N Karunatilake, L P Vitharana and W W Nandasena).

A training programme on latex were arranged for 8 representatives from industry.

**Advisory visits**

An inspection visit was made to the following factory during the year.

| Place | Type of sample | Purpose |
|---|---|---|
| Finlay Chemicals Ware House | Formic acid | To issue a recommendation letters for the introduction of a new supplier of formic acid |

(P L Perera and W W Nandasena).

**Round robin cross check**

Round robin cross check under the international contract for TSR was carried out on half yearly basis for blended and unblended rubbers. Results were forwarded to RRIM for analysis. All results shown in the exercise were in good agreement with the results from the other international laboratories (Leela Wanigatunga, H V K Gamage, Champa Lokuge, Lional Perera, B Gunasiri and W W Nandasena).

An inter laboratory cross check organized by RRISL was carried out for centrifuged latex test methods used in industries . The results were analysed according to ISO 5752 standard and distributed among the laboratories (K G K de Silva, N M V K Liyanage, Priyanthi Perera, H S Weeraman and Wasana Wijesooriya).

## LABORATORY INVESTIGATIONS

**1. New brushable sealant for fixing rainguards**

Instructions were given to the manufacturer to produce it in a commercial scale, under the guidance of the department (L M K Tillekeratne and N Karunatilake).

**2. Use of nitrile rubber latex in the grout applications**

It was found that Nitrile latex can be used to reduce the water absorption of grout used to fix floor tiles (Table 1).

Table 1. *Percentage water absorption with centrifuged, pre-vulcanized and nitrile latex*

| Concentration of the latex mix | % water absorption using centrifuged latex | % water absorption using Pre vulcanized latex | % water absorption using Nitrile latex |
|---|---|---|---|
| 3% | 45 | 41 | 38 |
| 6% | 48 | 49 | 29 |
| 10% | 62 | 66% | 48 |
| 15% | Unable to mix | Unable to mix | Unable to mix |

% water absorption is reduced with nitrile rubber. Further discolouration can be minimised and a good finish can be obtained. Further in order to find out the linear shrinkage of this mixture according to ASTM designation c531-85, preparing of a type of mould is in progress (L Karunanayake, P Perera, N M V Kalyani Liyanage and P L Perera).

**3. Effect of latex storage temperature on latex characters**

A research project was initiated to find out the variation of viscosity and mechanical stability of latex with storage temperature. First trial was carried out using centrifuged latex. Storage temperatures tested were room temperature 0, 35, 40, 45, 50, 55 and 60 °C. The project is in progress (N M V Kalyani Liyanage, Priyanthi Perera, S Weeraman and Medavi Wijesekera).

4. **Improving the hardness of sole crepe by incorporating nitrile latex**

In order to increase the IRHD hardness to above 30 as required by the buyers, of sole crepe samples of sole crepe were made by incorporating between 10-30 % of nitrile latex into NR latex. Although there is an improvement in the hardness with the incorporation of nitrile rubber, there is no consistency in the value obtained. Experiments are under way to improve this method of manufacture of sole crepe (L M K Tillekeratne, N M V Kalyani, M Jayasooriya, N Wickramaarchchi and S Weeraman).

**Analytical services**

The number of TSR samples tested during this year is as follow.

| Producer | No. of samples |
|---|---|
| Statcon Block Rubber Factory, Getahetta | 139 |
| Ceymac Block Rubber Factory, Horana | 1563 |
| Total | 1702 |

Other samples tested during the last year were,

| Producer | No. of samples |
|---|---|
| Rubber samples | 587 |
| Latex samples | 159 |
| Chemical samples | 96 |
| Masterbatch samples | 23 |
| Gloves samples | 53 |
| Water samples | 17 |
| Bleaching agent | 186 |
| Total | 121 |

Besides calibration and maintenance of electronic repair unit the following services were extended to the instruments in the other departments.

- Major breakdown in MDR 2000 Rheometer
- Shaw Robinson two roll mill.
- Electrical breakdown in UPS.
- Damage of air filter system of viscometer.
- Mematte waterbath.

# RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

**W M G Seneviratne**

## SUMMARY

Twelve advisory visits were made to rubber factories to solve the problems associated with the crepe rubber manufacture. Effluent treatment mechanism to treat rubber and industry waste water developed by the department has gained considerable recognition over the years locally as well as internationally. Our services in this field was extended to the RRI of Thailand to support their ongoing activities.

Thirty one, rubber and other industries were visited to look into the problems connected with environmental pollution created with the discharge of waste water from their manufacturing processes. Proposals to construct effluent treatment plants in some of those factories were already forwarded. Pilot project on implementing a waste water treatment facility at Sanhinda Desiccated mill has completed and commenced operation successfully during the year.

The NSF funded project on Bio Gas generation from skim rubber effluent was continued as scheduled.

Waste water testing laboratory at the department has already gained reputation as one of the recognized effluent water quality testing laboratory in Sri Lanka and various industries have obtained it's services during the year, 88 waste water testing certificates have been issued. Work on implementation of ISO 25 quality certification scheme implemented for this laboratory is being done.

Assistance was extended to implement ISO 9002 - quality assurance scheme to Ms Busan and Boseang, leading rubber product manufacturing industries in the country, having BOI status.

A project on suitability of white rice husk ash as filler for rubber compounds has been initiated to use it as an alternative to Silica filler.

## DETAILED REVIEW

### Staff

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

Mr Susantha Siriwardena, Rubber Chemist, is continuing his Postgraduate studies at University of Science in Penang, Malaysia.

Mr Upul Ratnayake, Assistant Rubber Chemist obtained a Postgraduate Diploma in Chemical Analysis from the University of Colombo.

Mr P H Sarath Kumara, Assistant Rubber Chemist, Mr P P Jayasinghe, Development Officer, Messrs C D Senanayake and T A S Siriwardane, Experimental Officers, Mrs Chandrika Nalini, Mr A K D Warnajith and Miss V C Rohanadeepa, Technical Officers, Mrs L Rukmanie, Store Keeper and Mrs Anusha Paranavitane, Typist/Clerk were on duty throughout the year.

Mrs Imali Koralage, Temporary Research Assistant of research project RG/98/EP/01 funded by National Science Foundation (NSF) resigned in September. Miss N Subasinghe, was recruited with effect from 1st October as a Temporary Research Assistant to work on the research project.

Messrs U Dharmasena and N L D Priyantha laboratory attendants were also on duty throughout the year.

**Research students**

Following students were trained in the Department during the year.

*NDT students*

1. Miss R M Liyanage - University of Moratuwa
2. Mr P K Ratnayake - - do -
3. Miss K T Kumari - - do -

*Undergraduates*

1. Miss P Salwatura - University of Colombo

**Seminars/Meetings and conferences**

Dr W M G Seneviratne[1] Messrs Upul Ratnayake[2] and P H Sarath Kumara[3] T A S Siriwardena[4] attended the following:

- PRI Educational Sub Committee meetings and 3 PRI Management Committee meetings[1]
- One National Accreditation Committee meeting (NLAC) at the SLSI[1]
- One Scientific Committee meeting[1]
- A seminar on Research priorities organized by the SLAAS and PRI at the SLAAS auditorium[1].
- A two day workshop on Research methods organized by the National Library of Sri Lanka[1].
- A seminar on Rubber Technology conducted by Dr. H. Fries in association with the PSP. (A German Project)[1].
- Two meetings on the IRC Melbourne conference and the rubber exposure visits at the TIPS office Colombo[1].

- A meeting to discuss about the professional course on rubber manufacture at NIPM[1].
- International Rubber Conference (IRC) 2000 held in Melbourne, Australia between the period 30th October to 2nd November. He also participated in the Rubber products exports and Industrial exposure mission in Perth, Sydney and Melbourne[1].
- Visit to RRI Thailand between the period 7th October - 13th October on invitation to help the raw rubber manufacturing industries to implement waste water treatment system developed by RRISL.[1]
- A meeting to discuss the provision of Technical Assistance and training by Sri Lanka for developing countries at the Ministry of Foreign Affairs.[2]
- A committee meeting on Radiation Vulcanization of Natural Rubber Latex held at the Atomic Energy Authority[2].
- A seminar on FLYGHT waste water pumps and aerators at the institute of Engineers organized by the Swedish Trading Company Limited.[1,2,4]
- Technical evaluation committee held at Industrial Development Board, Katubedda[3].

**Training programmes**

The departmental staff was involved in the following training programmes.

***Plantation Sector - For Managers***

- All aspects of Raw Rubber Processing for three plantation companies at a training programme organized by RRI[1,2,3]
- Lectures on Seventh Professional examination in Rubber manufacture and factory practices organized and held at NIPM[1,2,3]
- Lectures on Raw Rubber Processing for plantation monitoring officers from the Ministry of Plantation[1,2,3]

***Plantation Sector - For Factory Officers and Field Officers***

- Addressed field staff of Vogan estate to educate them on maintaining quality of field latex[3]
- Lectures on Quality processing of raw rubber for Factory Officers at a training programme organized by NIPM[2,3]
- A lecture on preservation of latex and DRC estimation for Field Officers at a training programme held at Dartonfield organized by NIPM[3].

- Lectures for Factory Officers of Pussella Plantation Limited on Quality processing of raw rubber organized by NIPM[2,3]

***Plantation Sector - For Factory workers***

- Addressed the factory workers of Clyde estate at the workers skill development programme conducted by NIPM[3]
- Lectures for rubber factory workers of Pussellawa Plantations Limited at a training programme organized by NIPM and held at Halpe, Penrith, Eheliyagoda and Elston estates[3,4]

***Rubber Development Department***

- Addressed Regional secretaries of Rubber Development Department from Galle and Matara districts on role of the RRISL at a seminar organized by Regional office, Galle[3]
- Lecture on concentrated latex manufacture for R.D.O.'s at the Training Centre, RDD[3]

***For undergraduates and other students***

- Lectures for MSc in Polymer Chemistry and Technology, University of Jayawardanepura[1]
- Lectures for DPRI course conducted by Plastics and Rubber Institute of Sri Lanka[1,3]

**Advisory visits**

- Twelve estates and rubber factories were visited during the year in connection with factory development and quality improvement of raw rubber.
- Thirty one factories were visited during the year to look into waste water disposal problems. Suitable treatment methods were suggested for required factories and necessary advice were given to improve the efficiency of the existing treatment plants.

**Sample testing**

- 88 waste water analysis certificates were issued by analysing the samples from waste water treatment plants as well as from factory discharge from various industries such as rubber, textile, paints, pesticide, food *etc.*

**Waste water treatment and disposal**

The developed treatment system based on anaerobic septic tank coupled with aeration system has gained considerable recognition over the last couple of years due to its cost effectiveness and satisfactory performance. Around 32 commercial scale plants have already been installed in rubber factories and in few other industries such as desiccated coconut processing, textile processing and in weedicide and pesticide bottling industries.

Requests for assistance to install treatment plants for rubber factories have increased considerably during the year mainly due to pressure from the Central Environmental Authority.

Plant at Morontota crepe rubber factory designed to treat effluent generating from their skim rubber processing has been satisfactorily commissioned.

Construction work of the following treatment plants were commenced during the year;

1. Sunnycroft Crepe rubber factory
2. Thalduwa Crepe rubber factory
3. Glenross Centrifuged latex factory
4. Vincit Centrifuged latex factory
5. Neuchatal Crepe rubber factory

Plants at Dewalakanda and Panawatta rubber factories are nearing completion and expects to commence operation early.

**ISO 9002 Quality Assurance Scheme**

Two management review committee meetings were conducted at Director's office at Dartonfield.

Four internal quality audits were carried out by the officers of the department at Dartonfield rubber factory. In-house training programmes for the staff and the factory workers were also conducted as scheduled. Mr K A D Warnajith Prasad is being internally trained as an internal auditor.

Only one surveillance audit was carried out by the SLSI during the year although two audits were scheduled and they have decided to conduct only one surveillance audit per year from year 2001.

Assistance was extended to Padukka rubber factory to rectify the NCR's (non-conformities) raised at the surveillance audit carried out by the SLSI. Assistance was also extended to carry out two internal audits.

Assistance was also extended to implement ISO 9000 Quality Assurance System at Boseang Lanka Ltd. and Busan Dipping Ko-Lanka Ltd. in Negombo. These two companies will soon apply for the certification of the quality systems.

**Draft quality manual for waste water testing laboratory**

Preparation of draft quality manuals as per the ISO guide 25 laboratory accreditation scheme has been completed and the implementation as per the manuals is now underway.

**Educational video film on manufacture of centrifuged latex**

The NIPM produced a video film on manufacture of centrifuged latex under the technical guidance and assistance of the department. The film has been approved by the Board of Management of the NIPM and now ready for the viewers. This film can be made use of the education of planters, factory officers and personnel working in centrifuged latex manufacturing industry. Video is available both in Sinhala and English presentation.

## LABORATORY AND FIELD INVESTIGATIONS

**Generation of bio - gas from skim rubber**

The project titled "To develop an efficient and cost effective treatment system for the serum water that is discharged when latex is centrifuged and also to use the Bio - gas generated in the process of treatment as an energy source" funded by National Science Foundation was continued throughout the year.

Applicability of the anaerobic coupled aerobic treatment system for skim serum has been evaluated and the optimum conditions were found for the treatment of skim serum using the same treatment technique.

Optimum flow rate of sulphate rich influent to the anaerobic digester was found and the pH changes inside the anaerobic digester was also observed.

As shown in the figure1 the pH inside the anaerobic digester maintains to the required level until the flow rate is 80 litres/day. However 50 - 60% COD and BOD removal efficiency could be effectively achieved only up to 60 litres/day of flow rate. Therefore the optimum flow rate of sulphate rich skim serum to the anaerobic digester is about 50 - 60 litres/day.

Treatment efficiencies of anaerobic digester was compared using sulphate rich (4000 - 8000 mg/l) and sulphate less (500 - 800 mg/l) skim serum.

Highest removal efficiency (55%) of sulphate rich effluent could be obtained at a loading rate of 4 kg COD/$m^3$ reactor volume/day whereas highest removal efficiency (75%) of sulphate less effluent could be obtained at a loading rate of 6 kg/$m^3$ reactor volume/day. Sulphate less skim effluent could be treated more effectively in comparison with sulphate rich effluent using this high rate anaerobic digester. Reduced efficiency of treatment of sulpahte rich effluent in mainly due to high level of sulphate in the serum.

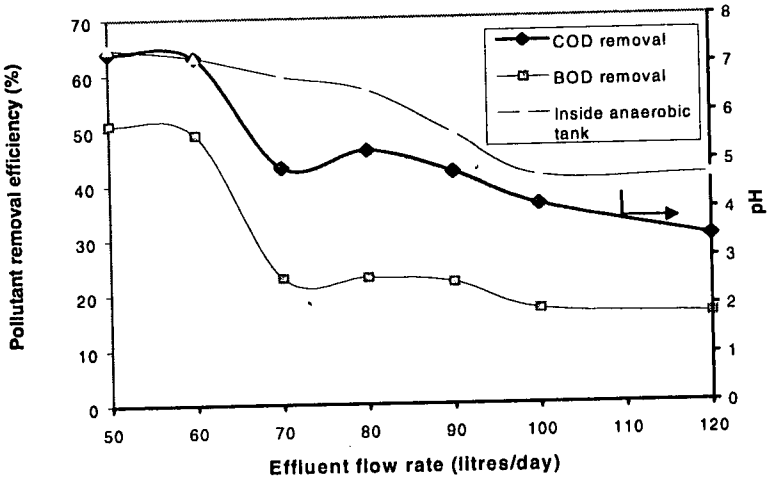



Fig. 1. Effect of effluent flow rate on anaerobic treatment and pH changes inside the aerobic digester

Experiments are in progress to analyse the composition of Bio - gas generated when skim serum digested anaerobically and to find out a method to remove the $H_2S$ accumulated inside the anaerobic digester (W M G Seneviratne, Upul Ratnayake, T A S Siriwardena, N Subasinghe - Temporary Research Assistant for the project).

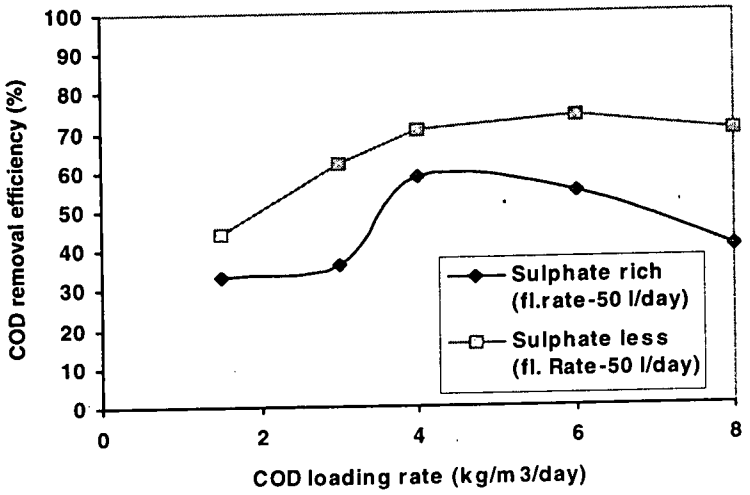



Fig.2. Treatment efficiency of anaerobic digester

**Effects of metal ions on crepe rubber**

Effect of metal ion contamination on discolouration of crepe rubber as well as its physical properties was studied. Studies were mainly carried out to ascertain the maximum levels of each metallic ion that could be present in crepe rubber without causing any discolouration. Experimental results revealed that when the total iron (Fe) content of rubber was less than 50 ppm, no discolouration appears on bleached crepe rubber. Further trials should be carried out to find out the optimum iron content that can be present in crepe rubber as well as in the processing water (W M G Seneviratne, Upul Ratnayake, T A S Siriwardena and W Prasad).

**Monitoring of effluent treatment plants**

Collecting and analysing of waste water samples from waste water treatment plants at Atale, Kiriporuwa and Pusella estates are being carried out. Samples are being collected once a month from each treatment plant (W M G Seneviratne, Upul Ratnayake, T A S Siriwardena, C Nalini and C Rohanadeepa).

**Use of water soluble polymers to remove extractable protein from centrifuged latex**

Suitability of water soluble polymers to remove extractable proteins from centrifuged latex has been evaluated.

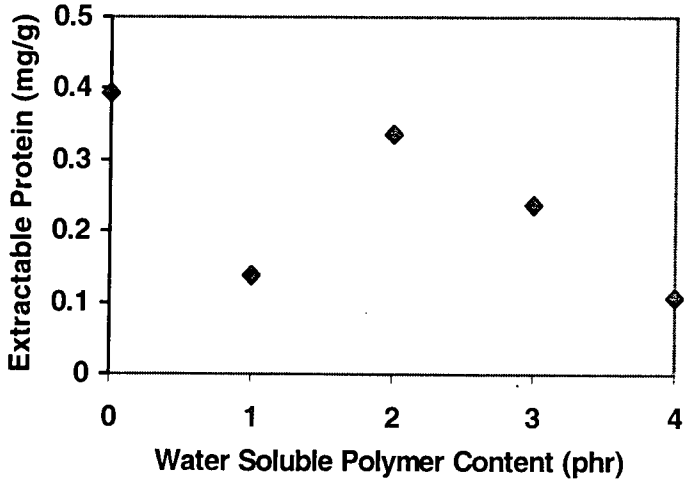



Fig. 3. Effect of water soluble polymer on extractable protein in centrifuged latex

Fig. 3 shows that water soluble polymer has a significant effect in removing extractable proteins from centrifuged latex. Properties such as MST and viscosity of

water soluble polymer added centrifuged latex have to be checked in order to develop this method further (Upul Ratnayake, N M V K Liyanage and W Prasad).

**Effect of white rice husk ash (WRHA) as a filter for rubber compounds**

The project was started by a MSc student under the supervision of the Head of the Department. Literature survey of the project has been completed. Experiments will be carried out with the addition of WRHA at different percentages to the natural rubber compounds. Physical properties of the compounds will be evaluated (W M G Seneviratne, Upul Ratnayake and Suraj Ratnayake - MSc student).

# ADAPTIVE RESEARCH

S M M Iqbal

## SUMMARY

Experiments on interplanting of rubber with tea and bee keeping under rubber plantations were in progress. A survey was initiated to investigate the adoption level of RRI recommendations in the rubber smallholder sector.

## DETAILED REVIEW

### Staff

Mr S M M Iqbal, Research Assistant in Agronomy, Messers P P Jayasinghe, A M A Perera, R B Gunaratna and D S Wettasinghe Research Assistants and E A T Senadeera, Experimental Officer were on duty throughout the year.

### Training programmes

- Lectures for NIPM Diploma Course on Plantation Management
- Lectures for NIPM training program for Field Officers.

### Advisory visits

Four advisory visits were undertaken to the plantation sector.

## FIELD INVESTIGATIONS

### Adaptive Research Programme

***Adoption level of RRI recommendations in the rubber smallholder sector***

Preliminary surveys were conducted in Kalutara (Agalawatta range), Kegalle and Ratnapura regions. Five smallholdings of different extents and ages were selected. According to data collected the formal questionnaire was prepared. Detailed survey in these areas are in progress (R B Gunaratne, W A D D S Wettasinghe, E A T Senadeera and A M A Perera).

### Bee keeping in rubber smallholdings and plantations

Three estates, *i.e.* Dartonfield, Salawa and RRISL substation, Kuruwita and five smallholdings were selected for the study. One bee colony and three bee boxes were supplied to each site (W A D D S Wettasinghe and L M K Tillekeratne, in

collaboration with Training and Extension Division, Department of Agriculture, Peradeniya).

**Interplanting of rubber lands with tea**

***Observation trials***

Trials initiated at Kalutara and Kegalle regions are in progress (S M M Iqbal).

***Productivity in rubber/tea systems (Kuruwita/TR 1)***

A detailed study was initiated with following objectives.

- To determine the relative limitations to dry matter production and yield in tea by competition for light, soil nutrients and water through the quantification of resource capture under a range of intercrop planting densities.
- To determine the extent of anatomical and physiological adaptation to shade that occurs in tea grown under a range of intercrop planting densities and main crop canopy densities.

Productivity measurements are in progress in a rubber tea intercrop system planted in N-S direction.

The following measurements were done in relation to the intercrop planting density treatments.

- Growth and yield
  Growth and yield data of rubber and tea were collected.
- Biomass production
  A detailed growth analysis for tea was conducted through destructive sampling.
- Light interception
  Fixing of solarimeters in the field to quantify the radiation use of tea crop is in progress.
- Water use
  To monitor the environmental conditions for the water use study, an automatic weather station manufactured by the National Engineering Research and Development (NERD) centre was installed at the experimental site.
- Pruning of tea
  Pruning of tea in accordance with pruning cycle was completed.

In another study the effects of shade and competition of roots on the growth, yield and yield parameters of tea is being monitored. 2.4 m x 12 m and 2.4 m x 18 m planting systems in unconditioned soil and planted N-S direction is used for this study.

Installation of root barriers to separate the shade effect on tea crop from the effects of edaphic environment was done. Thinning of the canopy cover of rubber to simulate different shade levels, *i.e.* extreme shade (zero defoliation), intermediate shade (approx. 50% defoliation), low shade (approx. 80% defoliation) were completed.

Under this experiment the following activities were done.

- Pruning of tea in accordance with pruning cycle.
- Growth analysis to assess pretreatment effect.
- Fixing of solarimeters to assess the radiation use of tea crop.

Rapid Rural Appraisal (RRA) is also in progress to assess the present status of rubber/tea intercroping in Sri Lanka with respect to,

a. how local farmers would be prepared to introduce tea as an intercrop with rubber.
b. difficulties faced by local rubber growers with respect to rubber/tea intercropping.

The followings were completed with respect to RRA,

- Preparing check list/questionnaire
- Selecting farmers for interviews based on the information available at the Rubber Development Department of Sri Lanka.
- 60% of the farmer interviews in Kalutara region were completed.

(S M M Iqbal, A M A Perera and S Wettasinghe in collaboration with TRI).

***Productivity in rubber/tea systems (Agalawatta/TR 2 )***

The above experiment was continued. Yield and Growth of rubber were monitored. Yield data of Tea is presented in Table 1.

***Productivity in rubber/tea systems (Perth estate/TR 3 )***

Experiment started at Perth estate was terminated as the estate was acquired by the BOI for a housing and industrial development project.

***Productivity in rubber/tea systems (Vogan estate/TR 4 )***

Growth assessments of both tea and rubber were recorded. Routing maintenance work, *i.e.* weeding, supplying vacancies and manuaring were done according to the treatments. Girth of the rubber plants in 1999 is presented in Table 2. Experimental details were given in the Annual Review 1998 (S M M Iqbal and R B Gunaratna).

Table 1. *Made tea yield during the year (Rubber stand, as a percentage of monocrop stand is given within brackets)*

| System | Made tea yield kg/bush/year |
|---|---|
| 1.Tea Only 12'x 18' (100%) | 0.1107[a] |
| 2. Rubber 8'x 27' (100%) + Tea | 0.1446[a] |
| 3. Rubber 8'x 32' (85%) + Tea | 0.1432[a] |
| 4. Rubber 8'x 36' (75%) + Tea | 0.1095[a] |
| 5. Rubber 8'x 40' (70%) + Tea | 0.1427[a] |
| 6. Rubber 8'x 40' (65%) + Tea | 0.0937[a] |

(Means with the same letter are not significantly different)
(S M M Iqbal and A M A Perera)

Table 2. *Growth of rubber in tea rubber systems*

| System | Rubber girth (cm) |
|---|---|
| 1. F1- ½ of the recommended fertiliser level to Rubber | 6.147[a] |
| 2. F2- recommended fertiliser level to Rubber | 5.941[a] |
| 3. F3- 1½ of the recommended fertiliser level to rubber | 6.103[a] |
| 4. Rubber only 12' x 18' | 6.073[a] |
| 5. Rubber 8'x 8' x 46' + Tea | 6.184[a] |
| 6. Rubber 8'x 8' x 60' + Tea | 5.933[a] |

(Means with the same letter are not significantly different)

***Smallholder sector***

Smallholder trials in Kegalle and Ratnapura Regions were in progress (S M M Iqbal, A M A Perera and E A T Senadeera).

# BIOMETRY

## Wasana Wijesuriya

### SUMMARY

Biometry section provided necessary research support to the other Research Departments. These include design of experiments, analysis and interpretation of results. The main research focuses during this year were; development of statistical techniques for on-farm participatory research, development of a sampling guide for accurate measurement of girth for immature rubber holdings, studies on climatic variability at Dartonfiled, statistical quality control and determination of partial and total factor productivity values for different nutrients in mature rubber holdings.

Database and the meteorological station at Dartonfield were maintained satisfactorily. The personnel and project summary databases of the RRI scientists were updated. NR and SR data for different countries from the year 1968 were entered in a database. The database on auction prices for all rubber grades is updated for the year 2000.

### DETAILED REVIEW

#### Staff

The staff of the Biometry section Ms Wasana Wijesuriya (Biometrician), Ms Chintha Munasinghe (Experimental Officer) and Mr Vidura Abeywardene (Technical Officer) were on duty throughout the year. Mr L P Vitharana, an Experimental Officer from the Department of Raw Rubber Processing and Chemical Analysis was transferred to the Biometry section with effect from 22$^{nd}$ May and returned back to the same department from 01$^{st}$ of December. Ms Wijesuriya continued her postgraduate studies while attending to the services of the Biometrician. Mr J A D Nishantha Pushpakumara (Laboratory Attendant) was on duty throughout the year.

#### Seminars, Conferences and Meetings

Wasana Wijesuriya

- Scientific Committee Meetings
- Management Review Meetings of the Dartonfield rubber factory
- National Committee of Socio – Economists and Policy Analysts

Vidura Abeywardene

- Seminar on environmental, botanical and meteorological equipment conducted by SKYE instruments of UK

## Training programmes conducted

Wasana Wijesuriya

- Plantation Monitoring Officers
- Managers and Assistant Managers of Management Companies
- NIPM Diploma Courses

## Training programmes attended

Wasana Wijesuriya

- Training on INFORM-R at PGIA, Peradeniya

## Services

***Statistical analysis and interpretation***

Biometry section assisted other research departments in designing of experiments, statistical analysis and interpretation of experimental results. Statistical assistance is also provided to undergraduate and postgraduate students.

***Database management***

a) *Meteorological*

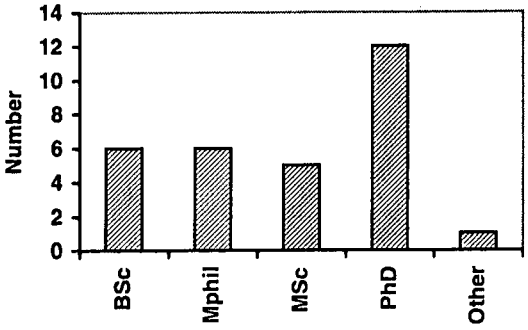
Meteorological station at Dartonfield was maintained properly and daily measurements were entered in a database. Monthly reports were prepared and sent to the Central Meteorological Station. These data were used by researchers as well as the Agrarian Service Centers and schools in the vicinity of the station (Wasana Wijesuriya, Chintha Munasinghe and Vidura Abeywardene).

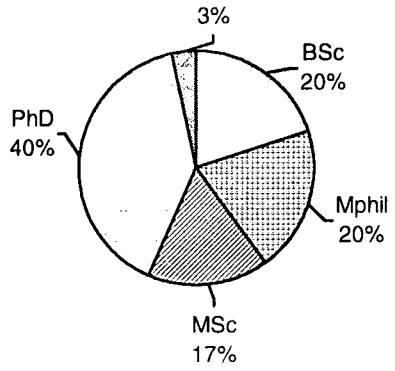
b) *Management information*

The personnel and project summary databases were updated for the year 2000. The collected information was transferred to CARP to be included in the database of National Agricultural Research System (NARS).

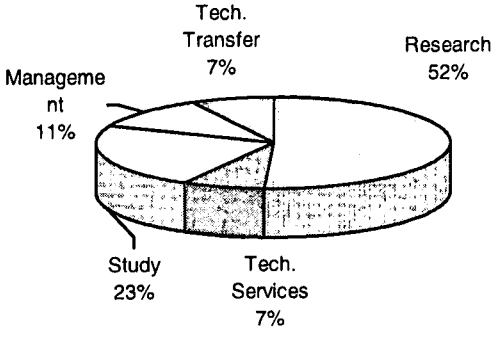
The following are some of the important features of the research system at RRI.

**Scientists by highest qualification as at December 2000**

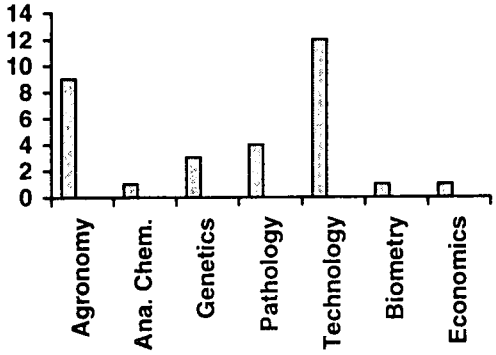



**Time spent on different activities by scientists**




**Number of scientists in each discipline**




c) *Rubber data*

NR and SR data for different countries from the year 1968 were entered in a database. The database on auction prices for all rubber grades is updated for the year 2000.

## RESEARCH

The following studies are in progress.

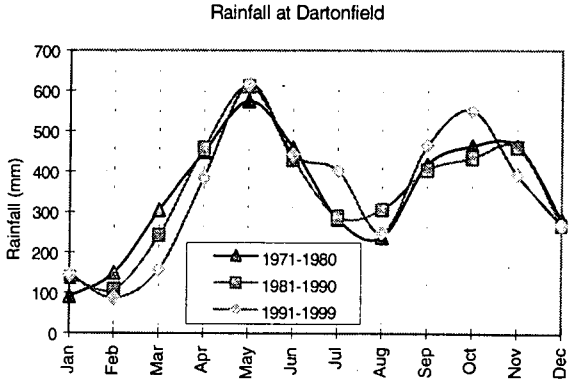
1. **Development of statistical techniques for on-farm participatory research**
   In previous studies logistic regression approach was successfully employed in modeling the adoption behavior in immature rubber holdings. Further, rank correlations were employed to identify the likelihood of adopting different combinations of technologies.

The present study was carried out to develop adoption indices for rubber farming. A questionnaire covering all technical recommendations for the immature stage was prepared. A technical evaluation form was designed to evaluate the holdings. The idea will be to collect relevant information from small holders in the Kalutara region to develop adoption indices and subsequently test for statistical assumptions (Wasana Wijesuriya and Vidura Abeywardene).

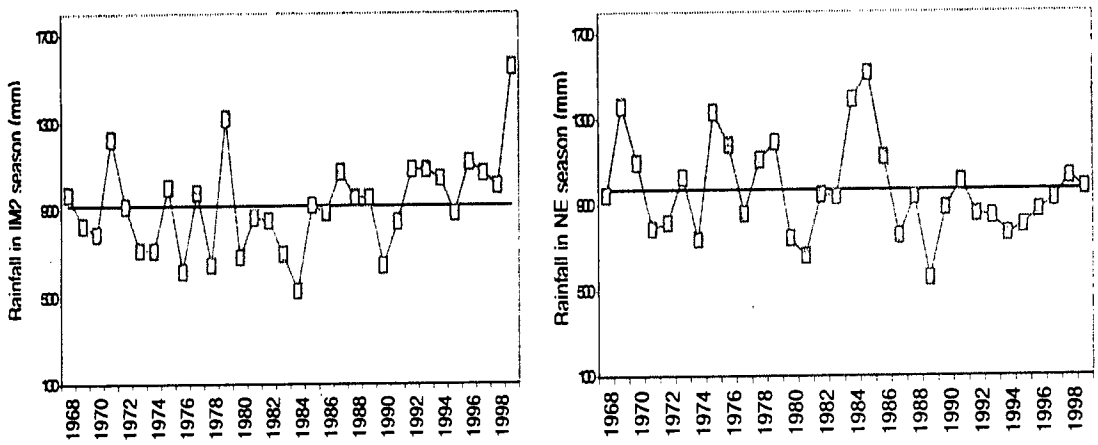
2. **Agronomic survey on adoption of fertilizer practices**
This study was carried out in collaboration with the Soils and Plant Nutrition department. The appropriate statistical analyses were done on different segments of this study. Different approaches were made to develop awareness scores for individual personnel in estate senior management level (Wasana Wijesuriya and A Dissanayake).

3. **Sample size for estimation of girth in immature rubber holdings**
Determination of the sample size for accurate estimation of girth records is a basic necessity in sampling plans. This study was focused on the above objective and analyses were carried out using secondary data on girth from the agronomic survey, obtained from immature rubber holdings covering seven rubber growing districts. The coefficients of variation (CV) for girth were calculated for each rubber holding and averaged accordingly, to study the change in CV (i) with age (ii) in different districts (iii) with the varying extents (iv) with the type of clone (v) with the type of planting material, and (vi) with the stand per ha. in a rubber holding. Subsequently, a sampling guide is proposed based on the average CV for varying conditions and the accuracy needed on the estimation of girth (Wasana Wijesuriya, A Dissanayake, V Abeywardene and R Puhambugoda).

4. **Climatic variability in the Dartonfield estate**
A database is being maintained for all measured meteorological factors at Dartonfield recorded since 1968. Descriptive and time series analyses of these records were completed. Further analysis on probability of onset of rains is in progress (W Wijesuriya).
Monthly rainfall for 3 different decades commencing from 1971 is depicted in the following figure. The patterns observed during 1971-1980 and

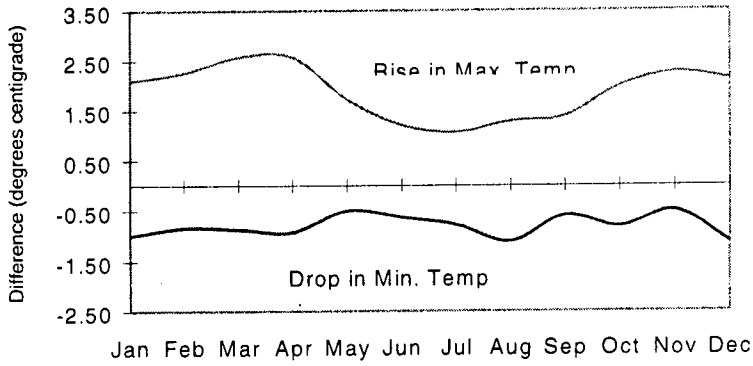


1981-1990 are similar. During the 9 year period of 1991-1999, average rainfall observed during July and October is comparatively higher when compared to other 2 decades. As far as the rainfall experienced in different seasons are concerned, an upward trend was observed in rainfall during the 2nd inter-monsoon season while below average values were observed during North-East rainy season. This suggest a shift in rainfall towards September-October period. The long-term variability of rainfall in these 2 seasons are shown in figures below.




During the last decade, a considerable deviation was observed in Relative Humidity (RH) recorded at 9.00 a.m. The average RH also deviated to a certain extent (2-4%), during the period of May to December. The maximum temperature showed a rise, while the minimum showed a drop during 1991-1999. The monthly variation of this phenomena is presented in the figure below (Wasana Wijesuriya, Chintha Munasinghe and V Abeywardene).

**Monthly variation in deviation from the previous decade**



5. **Studies on statistical quality control**

An EXCEL work sheet carrying different formulas was developed to support calculation of various statistics documented in ISO Standards handbook. A document was prepared to provide guidelines for statistical analysis and interpretation of precision experiments. Results of the Inter Laboratory Cross Check analysis conducted annually by the Raw Rubber Process and Chemical Analysis Department were analyzed according to the ISO 5752 standards (Wasana Wijesuriya).

6. **Factor productivity of applied nutrients in mature rubber holdings**

Total Factor Productivity (TFP) indices are useful as indicators of the long term sustainability of agricultural systems. Partial Factor Productivity (PFP) indices are also considered important as they provide useful information about the efficiency of individual inputs used. The initial study employed yield data and data on inputs of the experiment SM 83/1 carried out by Soils and Plant Nutrition Department. This experiment had 3 levels each of N, P and K. The PFP trends for different nutrients were plotted but no further modeling could be done since only 6 years of yield data were available in this experiment.

A similar study is in progress covering 9 estates in the Kalutara region. This study employs soil and foliar survey data and estate yield records to study PFP indices and also to identify any lag effects of applied fertilizer to rubber yield using time series approaches (Wasana Wijesuriya and Lalani Samarappuli).

# LIBRARY AND PUBLICATIONS

S U Amarasinghe 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 rubber and related areas have been carried out throughout the year 2000.

## DETAILED REVIEW

### Staff

Mr S U Amarasinghe was appointed as the Librarian and Publications Officer with effect form 2nd June, 2000. Mrs Thilaka Dantanarayana (Colombo Office) and Mrs Ramani Amaratunga, Library Assistants and Assistant Publications Officers, Mr P M Prema Jayantha, Clerk/Typist and two Library Attendants were on duty throughout the year.

Mr W D Kumaradasa, Library Attendant expired in a sudden heart attack on 10th November.

### Seminars and workshops

Librarian and Publications Officer attended the following:

- The AGM of the Sri Lanka Library Association at Hotel Galaderi on 28.06.2000.
- Two AGRINET meetings at CARP Office on 14.07.2000 and 15.12.2000.
- SLISTINET meeting at NSF on 30.08.2000.

### Resource development activities

The book strength increased up to 5030. The Library subscribed to 76 journals and nearly 30 were received on an exchange basis.

### Publications

The following publications have been processed and published during the year.

Annual Review 1999
RRISL Bulletin Vol.41, 2000
Rubber Puwath, Vol.21, 1998
6 Advisory circulars

**Equipment**

The following equipment were purchased during the year.

- Ladder
- Electric Kettle (For Colombo Library)
- Vacuum Cleaner

**SDI Service**

Twenty five articles were sent to various agricultural libraries at their request and vice versa 15 articles were requested for the benefit of RRISL library users. Literature surveys bases on *Hevea*/rubber were done using CD-ROM databases available at CARP library.

**Inter-Library co-operation activities**

The computerized bibliographic data of the year 2000 were sent to the National Library and the CARP Library for compilation of the National Union Catalogue and Sri Lanka Agricultural Bibliography respectively.

Meanwhile, content pages of 55 journal titles were received on the request of the RRISL Library and content pages of 12 titles were sent to AGRINET libraries.

# DARTONFIELD GROUP

## Jehan Perera

### SUMMARY

A crop of 152,346 kgs was harvested which is a 10% increase over last year from an extent of 185.69 hectares.

The yield per hectare achieved was 820 kgs an increase of 92 kgs over last year.

The average intake per tapper was 6.9 kgs. The intake decreased by 0.8 kgs over last year.

The annual rainfall was 3586.2 mm with 176 wet days as against 4903.9 mm with 194 wet days during last year.

The Cost of Production and Net Sale Average for the year were Rs.49.20 and Rs.58.44 per kg. respectively. The profit per kg, was Rs.9.24 and profit made for the year was Rs.1,407,677.04. The total profit inclusive of sundry income was Rs.3,790,374.04.

### DETAILED REVIEW

**Staff**

Mr Jehan Perera, Estate Superintendent, Mr P Kannangara, Chief Clerk, Mr K K P Gunawardena, Senior Clerk, Mrs C Dissanayake, Mr A K D A Wickramasinghe and Mrs S I K Pathirage, Junior Clerks, Mr D S K Ranaweera, Rubber Factory Officer, Mr W D D Senanayake, Assistant Factory Officer, Mr J A Wimalasena, Mr S K S de Silva, Mr T Somaratne and Mr N L D Reggie, Field Officers, Mr H M J Premalal, Assistant Field Officer, Mr J K Nakandala, Mr K A Sarath Kumara, Mr B M Siriwardena, Mr N L D Nihal, Junior Assistant Field Officers, Mrs C S Hettiarachchi, Creche Attendant, Mr N V Premawanse, Tractor Driver were on duty throughout the year.

Mr S R Vadivel, Assistant Field Officer retired with effect from 29th March, Mr N L D Premachandra was appointed as Office Peon with effect from 01st November. Mr A B Nakandala and Mr N V U S Vijitha Kumara were appointed as Junior Assistant Field Officers with effect from 01st December.

The group cadre stood at 22 at the end of the year, made as follows:

| | |
|---|---|
| Senior Staff | 1 |
| Assistant Staff | 19 |
| Minor Staff | 2 |
| Total | 22 |

## Hectarage

A summary of the hectarage is given in Table 1.

Table 1. *Land distribution (Ha.) in Dartonfield group*

| | Dartonfield | Gallewatte | Nivitigalakele | Total |
|---|---|---|---|---|
| Mature area | 29.19 | 131.91 | 24.59 | **185.69** |
| Immature area | 9.83 | 28.60 | 14.34 | **52.77** |
| Budwood nurseries | 6.54 | | 2.00 | 8.54 |
| Seedling nurseries | 0.73 | | 5.69 | 6.42 |
| Uprooting area | | 4.51 | 7.25 | 11.76 |
| Abandoned 53/54 | | | 3.06 | 3.06 |
| Difference in fields | | | 2.70 | 2.70 |
| State land taken | 0.27 | | | 0.27 |
| Paddy/Deniya | | 1.22 | | 1.22 |
| Waste land | 0.19 | 0.18 | | 0.37 |
| Earth slipped area | 3.01 | 1.26 | 2.62 | 6.89 |
| Jungles | 0.80 | | 0.71 | 1.51 |
| Rocks/Streams | 2.14 | 4.74 | 2.17 | 9.05 |
| Buildings | 18.67 | 5.07 | 7.79 | 31.53 |
| Roads | 2.92 | 6.86 | 0.32 | 10.10 |
| Others total | 35.27 | 23.84 | 34.31 | **93.42** |
| Grand total hect. | 74.29 | 184.35 | 73.24 | 331.88 |
| Grand total acrs. | 183.57 | 455.53 | 180.98 | 820.08 |

## Crop

A total crop of 152,346 kg was harvested from an extent of 185.69 hectares during the year. When compared with the crop harvested during the previous year there is an increase of 13,770 kgs.

Dartonfield Estate could have harvested further 30,000 kgs during the year, if not for 4590 (18.35%) vacant blocks (Table 2). The main reason to have vacant blocks was the scarcity of tappers specially at Gallewatte Division.

Table 2. *Vacant Blocks recorded in Dartonfield Group*

| Division | Vacant blocks | Percentage |
|---|---|---|
| Dartonfield | 516 | 14.90 |
| Gallewatte | 3363 | 20.13 |
| Nivithigalakale | 4590 | 18.00 |

The yield per hectare of the past 5 years is given in Table 3 for the entire group and separately for each division.

Table 3. T*he yield per hectare (YPH, kg) at Dartonfield group from 1996 to 2000*

| Division | Year | | | | |
|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 1999 | 2000 |
| Dartonfield | 900 | 1059 | 790 | 649 | 730 |
| Gallewatta | 1073 | 1067 | 926 | 713 | 828 |
| Nivitigalakele | 723 | 800 | 1106 | 858 | 885 |
| Group average | 953 | 1006 | 965 | 728 | 820 |
| Group estimate | 1020 | 1038 | 979 | 926 | 1093 |

When compared with last year the yield per hectare of all 3 divisions and in the group has increased slightly (Tables 3 and 4).

Table 4. *The yield per hectare recorded during the year division wise*

| Month | Dartonfield | Gallewatta | Nivitigalakele |
|---|---|---|---|
| January | 89 | 88 | 93 |
| February | 49 | 74 | 64 |
| March | 48 | 60 | 57 |
| April | 36 | 37 | 32 |
| May | 38 | 42 | 27 |
| June | 40 | 46 | 37 |
| July | 103 | 100 | 141 |
| August | 50 | 58 | 80 |
| September | 48 | 55 | 73 |
| October | 68 | 76 | 65 |
| November | 58 | 62 | 72 |
| December | 102 | 124 | 142 |

**Intake per tapper**

The average intake per tapper of the group had decreased mainly due to employing of in-experienced tappers to reduce vacant blocks. However, even after employing these workers the vacant block percentage of the group stood at 18.35% (Table 5).

Table 5. *The average intake per tapper (kg) division wise for the last 5 years*

| Division | Year | | | | |
|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 1999 | 2000 |
| Dartonfield | 6.5 | 6.9 | 7.4 | 8.5 | 6.8 |
| Gallewatta | 6.2 | 7 | 7.9 | 7.5 | 7.2 |
| Nivitigalakele | 4.5 | 4.9 | 6.5 | 5.6 | 5.0 |
| Group average | 6.2 | 6.5 | 7.3 | 7.7 | 6.9 |

**Tapping cost**

The tapping cost of the group has increased by 8% over last year due to wage increase and decline in intakes (Table 6)

Table 6. *A break-down in total tapping cost for 3 years)*

| Cost item | Cost (Rs.) | | |
|---|---|---|---|
| | 1998 | 1999 | 2000 |
| Tapping | 15.46 | 15.67 | 17.16 |
| Double tapping | .48 | .43 | .44 |
| Kanganies | .03 | .01 | .02 |
| Over kilos | .92 | .81 | .62 |
| Scrap pay | .20 | .14 | .19 |
| Incentive to Field Staff | .07 | .02 | -- |
| Total | 17.24 | 17.08 | 18.43 |

**Rainfall**

The total annual rainfall has decreased during the year (Table 7).

Table 7. *Annual rainfall and the number of wet days for the last five years*

| | Year | | | | |
|---|---|---|---|---|---|
| | 1996 | 1997 | 1998 | 1999 | 2000 |
| Rainfall (mm) | 3696.9 | 4501.2 | 5790.1 | 4903.9 | 3586.2 |
| Wet days | 165 | 164 | 184 | 194 | 176 |

## Tapping days

When compared with last year there is an increase in both normal and late tapping days. The number of non tapping days have decreased from 168 to 144 during the year (Table 8).

Table 8. *The number of tapping days, average intake per tapper and yield per hectare for the last four years in Dartonfield group*

| | | Year | | | |
|---|---|---|---|---|---|
| | | 1997 | 1998 | 1999 | 2000 |
| 1. | Tapping days | | | | |
| 1.1 | Normal | 252 | 199 | 186 | 208 |
| 1.2 | Late | 29 | 30 | 11 | 13 |
| 1.3 | Double | 7 | 12 | 25* | 6* |
| 1.4 | No | 80 | 135 | 168 | 144 |
| 2. | Average intake tapper (Kg) | 6.5 | 7.3 | 7.7 | 6.9 |
| 3. | YPH (Kg) | 1006 | 979 | 728 | 820 |

*Dartonfield division only

## Manufacture

The latex grade 1 percentage has declined by 6% when compared with previous year (Table 9).

Table 9. *The details of the crop manufactured during the year 2000*

| Grade | Quantity Kgs. | Grade % | Latex % | Scrap |
|---|---|---|---|---|
| Crepe No.1 | 120992 | 80 | 87 | |
| Crepe No.3 | 18213 | 12 | 13 | |
| Scrap Crepe No.1 | 9476 | 6 | | 72 |
| Scrap Crepe No.2 | 3285 | 2 | | 25 |
| Scrap Crepe No.3 | 379 | | | 3 |
| Smoke Sheets | | | | |

## Cost of production and profitability

The cost of production has increased by Rs.3.98 per kg. This is mainly due to wage increase. However, a profit of Rs.1,407,677.04 was made during the year (Table 10).

Table 10. *Labour rate (LR,RS) and a break down of cost of production (COP)*

| | | 1996 | 1997 | 1998 | 1999 | 2000 |
|---|---|---|---|---|---|---|
| 1. | Labour | 83.00 | 83.00 | 95.00 | 95.00 | 98.00 |
| 2. | COP | 38.72 | 39.74 | 43.25 | 45.22 | 49.20 |
| 2.1 | Tapping | 18.56 | 17.93 | 17.24 | 17.08 | 18.43 |
| 2.2 | Manufacture | 6.15 | 5.38 | 8.75 | 7.98 | 8.79 |
| 2.3 | General charges | 9.09 | 12.75 | 11.21 | 12.01 | 13.21 |
| 2.4 | Upkeep | 4.92 | 5.28 | 6.05 | 8.15 | 8.77 |
| 3. | NSA | 70.49 | 72.68 | 53.45 | 44.81 | 58.44 |
| 4. | Profit | 31.77 | 32.94 | 10.20 | (0.41) | 9.24 |

NB- Labour rate per day for the year was Rs.98/- + an additional incentive of either Rs.8/- or Rs.14/- per day according to the attendance.

Table 11. *Comparative statement of the mature extent, profit per kg and profit per hectare*

| | Year | | | |
|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 2000 |
| Mature extent | 165.59 | 163.90 | 190.26 | 185.69 |
| Total profit (Rs. Million.) | 5.48 | 1.61 | (0.06) | 1.40 |
| Profit/Ha (Rs.) | 33126.40 | 9840.00 | (298.62) | 7580.79 |

# Meteorological Summary - 2000
# Dartonfield Station

**Wasana Wijesuriya**

A total of 3740mm of rain experienced during the year 2000 compared to the long-term average of 4243mm. This accounted for an decrease of 503 mm and 1217 mm compared to the long-term average and rainfall of the preceding year respectively. The distribution showed considerable deviation from the usual bimodal pattern as shown in Fig. 1. The highest rainfall was observed in September, a difference of nearly 405 mm from the long-term average for this month. A fairly dry weather was observed during the first two months of the year. Below average rainfall values were observed during April to July and October to December when compared to long term averages of these months. The lowest rainfall was experienced in July.

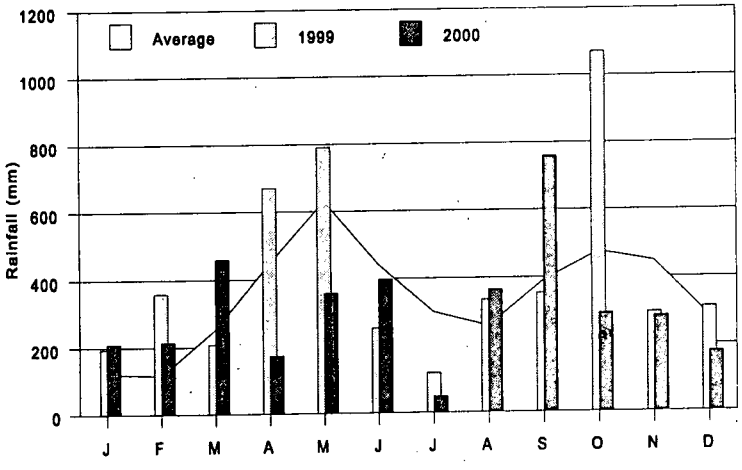



Fig. 1 Monthly variation in rainfall

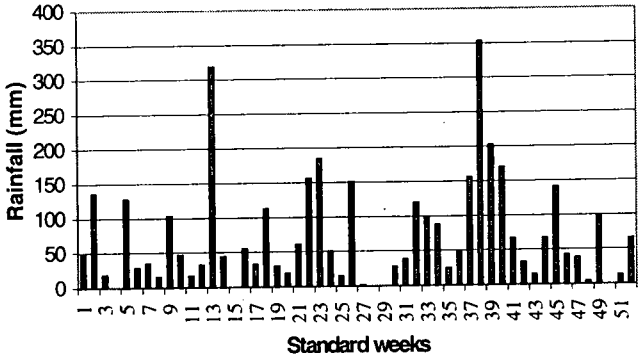



Fig. 2. Weekly variation in

The distribution of weekly rainfall is depicted in Fig. 2. Five dry weeks were observed during the year. The highest rainfall experienced during the 38th standard week (late September) coincided with the inter-monsoon season prior to North East monsoon.

The rainfall distribution in different seasons of the year also exhibit deviations from the long-term average. Slight decrease of around 3.5% was observed in South-West (SW) rains. The first inter-monsoon carried a lesser percentage of rains (2.2%) and the rainfall in second inter-monsoonal period had increased by 7.2% (Fig. 3). Percentage rain experienced in the period under the influence of the North-East (NE) monsoon was 18.6%, which is little less than the long term average for the same season.

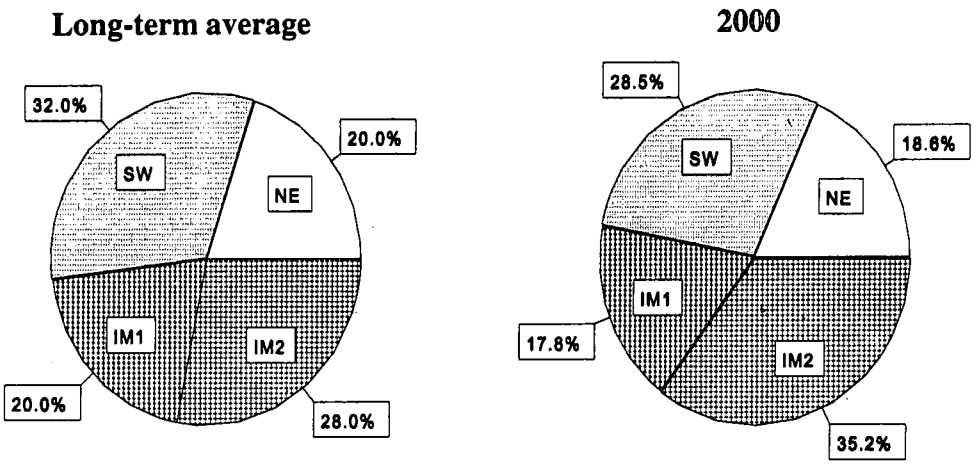



Fig. 3. Seasonal variation in rainfall

The amount of rainfall and number of rainy days under low, moderate and high rainfall categories are listed in Table 1. Number of rainy days for the year was 220 with 5 months exceeding 20 rainy days. In October, 8 days have exceeded 50 mm of rain per day.

*Intensity of rainfall*

High intensity showers with short durations were common in South-West monsoon period. The highest rainfall intensity recorded was 92.4 mm/hr, but lasted only for 5 minutes. The 3 highest intensities recorded, their duration and time of occurrence and the average intensity for each month are presented in Table 2.

Table 3 depicts the monthly values of some important meteorological observations together with averages for 1980 to 1992. Minimum temperature dropped below 20°C for 2 days in January, 1 day in February and 3 days in December. The lowest value for sun shine was observed in June due to overcast conditions resulted by heavy rains. The average morning RH was in the range of 80 to 85 %. The soil temperatures at 3 different depths are given in Table 4.

Table 1. *Monthly variations of rainfall and rainy days in 2000*

| Month | Rainfall (mm) | Average** (mm) | No. of rainy days* | Avg.** days | No. of days under each category | | | Evaporation (mm) |
|---|---|---|---|---|---|---|---|---|
| | | | | | 0.3 - 2.5 (mm) | 2.6 - 50 (mm) | >50 (mm) | |
| January | 210.3 | (121) | 15 | (10) | 01 | 13 | 01 | 2.00 |
| February | 214.8 | (116) | 19 | (09) | 07 | 11 | 01 | 2.20 |
| March | 458.9 | (252) | 18 | (17) | 03 | 10 | 05 | 2.90 |
| April | 173.4 | (449) | 08 | (21) | 01 | 07 | 00 | 2.00 |
| May | 357.8 | (629) | 22 | (24) | 06 | 13 | 03 | 2.10 |
| June | 398.4 | (440) | 26 | (24) | 05 | 18 | 03 | 2.40 |
| July | 48.2 | (299) | 10 | (22) | 06 | 04 | 00 | 1.80 |
| August | 365.0 | (257) | 25 | (21) | 07 | 15 | 02 | 2.10 |
| Septembe r | 758.9 | (391) | 23 | (22) | 07 | 12 | 04 | 1.70 |
| October | 292.9 | (476) | 21 | (22) | 08 | 11 | 02 | 1.59 |
| November | 284.0 | (448) | 20 | (20) | 05 | 14 | 01 | 2.00 |
| December | 177.7 | (282) | 13 | (17) | 02 | 12 | 00 | 2.30 |
| Total | 3740.3 | (4160) | 220 | (229) | 58 | 140 | 22 | 25.09 |

* Rainy days are defined as those with 0.3 mm or more ** Average values for 1980-1992 are shown in parentheses

Table 2. *Rainfall intensity recorded at Dartonfield Meteorological Station - 2000*

| Month | Date | 3 highest intensities (mm/hr) | Time interval | Duration (min) | Average intensity (mm/hr) |
|---|---|---|---|---|---|
| January | 15 | 49.80 | 10.35-10.45 | 10 | 8.12 |
| | 08 | 30.98 | 15.25-17.15 | 110 | |
| | 07 | 26.50 | 16.30-17.30 | 60 | |
| February | 12 | 41.14 | 20.55-21.30 | 35 | 5.30 |
| | 01 | 34.29 | 06.40-07.15 | 4 | |
| | 28 | 11.84 | 19.15-20.30 | 75 | |
| March | 03 | 54.80 | 15.00-16.00 | 60 | 11.34 |
| | 26 | 42.80 | 14.30-16.00 | 90 | |
| | 27 | 41.86 | 16.20-17.15 | 85 | |
| April | 01 | 42.00 | 21.00-23.00 | 60 | 11.31 |
| | 23 | 40.60 | 15.15-15.45 | 30 | |
| | 21 | 24.24 | 12.40-13.30 | 50 | |
| May | 18 | 45.60 | 06.30-06.35 | 5 | 6.94 |
| | 02 | 34.40 | 20.00-20.45 | 45 | |
| | 18 | 26.40 | 05.10-05.15 | 5 | |
| June | 05 | 87.60 | 06.55-07.00 | 5 | 13.19 |
| | 05 | 57.60 | 13.30-13.35 | 5 | |
| | 05 | 56.40 | 00.25-00.30 | 5 | |
| July | 01 | 92.40 | 19.15-19.20 | 5 | 11.27 |
| | 26 | 57.60 | 23.00-23.05 | 5 | |
| | 25 | 18.00 | 03.30-03.35 | 5 | |
| August | 07 | 31.50 | 07.40-08.00 | 20 | 7.57 |
| | 04 | 23.20 | 20.30-20.45 | 15 | |
| | 19 | 21.60 | 01.45-01.50 | 5 | |
| September | 14 | 32.91 | 03.40-04.15 | 35 | 8.18 |
| | 15 | 26.40 | 03.40-03.45 | 5 | |
| | 20 | 21.00 | 18.15-18.25 | 10 | |
| October | 13 | 38.40 | 17.45-17.50 | 5 | 11.72 |
| | 13 | 27.60 | 17.10-17.15 | 5 | |
| | 01 | 26.40 | 18.30-19.00 | 30 | |
| November | 11 | 36.30 | 15.30-16.30 | 60 | 6.65 |
| | 30 | 24.00 | 12.15-12.20 | 5 | |
| | 05 | 18.26 | 15.35-16.45 | 70 | |
| December | 27 | 31.20 | 20.10-20.20 | 10 | 5.48 |
| | 09 | 18.47 | 18.30-20.00 | 90 | |
| | 05 | 14.90 | 18.15-20.15 | 120 | |

Table 3. *Variations of observed meteorological factors at Dartonfield - 2000*

| *DARTON FIELD)* Month | *(Latitude 6°32'; Longitude 80.09 E; Altitude 65.50 m)* Temperature (°c) | | | | Sun shine hours | Relative Humidity (%) | | | Mean wind speed (kmph$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | Mean Max | Mean Min | Mean | No. of days min temp <20 | | 9.00 am | No. of days RH 9.00am >90% | 4.00 pm | |
| Jan | 32.1 (32.3) | 21.8 (20.8) | 27.0 (26.5) | 02 | 5.2 | 85 (87) | 01 | 66 (67) | 1.20 |
| Feb | 32.4 (33.3) | 22.2 (21.1) | 27.3 (27.2) | - | 6.0 | 82 (85) | - | 68 (64) | 1.20 |
| Mar | 32.8 (33.5) | 22.4 (21.7) | 27.6 (27.6) | 01 | 5.7 | 83 (84) | 01 | 71 (66) | 1.20 |
| Apr | 32.5 (32.9) | 23.8 (22.7) | 28.2 (27.8) | - | 6.0 | 83 (84) | 01 | 67 (73) | 1.20 |
| May | 31.8 (31.6) | 23.8 (23.3) | 27.8 (27.5) | - | 5.5 | 84 (87) | 02 | 69 (77) | 1.60 |
| Jun | 30.0 (30.8) | 23.3 (23.1) | 26.7 (26.9) | - | 3.8 | 84 (88) | 01 | 72 (76) | 2.60 |
| Jul | 30.9 (30.2) | 23.4 (22.8) | 27.2 (26.5) | - | 6.4 | 81 (88) | 00 | 65 (74) | 3.2.0 |
| Aug | 29.9 (30.2) | 22.9 (22.7) | 26.4 (26.5) | - | 4.3 | 84 (87) | 02 | 72 (74) | 2.60 |
| Sep | 30.6 (30.6) | 22.6 (22.4) | 26.6 (26.5) | - | 4.9 | 84 (86) | 03 | 72 (74) | 2.10 |
| Oct | 31.3 (30.9) | 22.6 (22.1) | 27.0 (26.5) | - | 5.9 | 82 (85) | 01 | 70 (77) | 2.00 |
| Nov | 32.1 (31.4) | 22.5 (21.8) | 27.3 (26.9) | - | 5.0 | 81 (84) | 02 | 70 (77) | 1.50 |
| Dec | 32.1 (32.0) | 21.9 (21.4) | 27.0 (26.7) | 03 | 5.1 | 80 (84) | 00 | 66 (74) | 1.90 |

** Average values for 1980-1992 are shown in parentheses

Table 4. *Soil temperatures recorded at different depths at Dartonfield - 2000*

| Month | 09 .00 hrs | | | 16.00 hrs | | |
|---|---|---|---|---|---|---|
| | 5 cm | 10 cm | 30 cm | 5 cm | 10 cm | 30 cm |
| January | 26.1 | 26.2 | 27.7 | 32.7 | 31.4 | 27.9 |
| February | 27.1 | 26.8 | 28.1 | 34.2 | 32.7 | 28.4 |
| March | 27.9 | 27.3 | 28.8 | 35.0 | 33.1 | 29.0 |
| April | 28.7 | 28.2 | 29.2 | 35.5 | 34.0 | 29.5 |
| May | 28.5 | 28.0 | 29.3 | 34.8 | 33.1 | 29.5 |
| June | 27.5 | 27.1 | 28.1 | 32.3 | 31.1 | 28.4 |
| July | 28.0 | 27.7 | 28.9 | 35.6 | 33.6 | 29.2 |
| August | 27.7 | 26.8 | 27.8 | 31.7 | 30.8 | 28.0 |
| September | 27.4 | 26.8 | 27.8 | 32.4 | 31.2 | 28.0 |
| October | 27.5 | 26.8 | 27.7 | 32.8 | 31.6 | 28.0 |
| November | 27.3 | 26.8 | 28.1 | 32.8 | 31.4 | 28.4 |
| December | 26.6 | 26.4 | 27.9 | 32.8 | 31.8 | 28.2 |

## LIST OF PUBLICATIONS

**Scientific Journals**
**(Rubber Research Institute of Sri Lanka authors are shown in bold type)**

**Attanayaka, D.P.S.T.G., Herath, S.P., Gamage, A.K.** and Karunanayake, E.H. (2000). Identification of RRIC 100 series clones and two germplasm clones of rubber (*Hevea brasiliensis*) using random amplification of polymorphic DNA (RAPD). *Journal of Plantation Crops* **28**, 160-163.

**De Silva, K.G. Karnika,** Karunanayake, L. and Mutukkrishnan, Krishanthi (2000). Blends of acrylonitrile butadiene rubber/superior processing/natural rubber and Poly (Vinyl chloride) Part I – A study of some of the technological properties of NBR/SP rubber/NR/PVC blends. *Journal of the Rubber Research Institute of Sri Lanka* **82**, 1-7.

**Fernando, T.H.P.S., Jayasinghe, C.K.** and Wijesundera, R.L.C. (2000). Factors affecting spore production, germination and viability of *Colletotrichum acutatum* isolates from *Hevea brasiliensis*. *Mycological Research* **104**, 681-685.

**Jayasinghe, C.K.** and Wijesundera, R.L.C. (1999). Cell wall degrading enzymes of *Cylindrocladium quinqueseptatum*. *Journal of the Rubber Research Institute of Sri Lanka* **82,** 47-60.

**Jayasinghe, C.K.** and Wijesundera, R.L.C. (1999). Toxic metabolite from clove isolate of *Cylindrocladium quinqueseptatum*. *Journal of the Rubber Research Institute of Sri Lanka* **82,** 61-71.

**Ratnayake, Upul,** Makuuchi, K. and Yoshii, F. (1999). Quality improvement of radiation vulcanized natural rubber latex by addition of Polyvinyl alcohol and centrifugation. *Journal of the Rubber Research Institute of Sri Lanka* **82**, 8-21.

**Seneviratne, Priyani, Witharana, L.P.P. De Alwis, M.N.** (1999). The rubber seed production in Sri Lanka: Results of an islandwide survey. *Journal of the Rubber Research Institute of Sri Lanka* **82**, 22-30.

**Silva, W.P.K., Jayasinghe, C.K.,** Wijesundera, R.L.C. and **Priyanka, U.M.S** (2000). New hosts of *Corynespora cassiicola* in Sri Lanka. *Plant Disease* **84,** 202.

**Wijesuriya, Wasana** and Thattil, R.O. (1999). Evaluation of ISO recommendation on analysis of precision experiments for statistical quality control. *Journal of the Rubber Research Institute of Sri Lanka* **82,** 31-46.

**Attanayaka, D.P.S.T.G.** (2000). Annual Review of the Genetics and Plant Breeding Department for the year 1999.

De Silva, K.G. Karnika, **Wellappili, Champa, Warnapura, S.S.** and Sugathapala, Harsha (2000). Self reinforced granular natural rubber. *Proceedings of Rubb Tec'2000,* India.

**Dissanayake, D.M.A.P., Wickramasinghe, D.N.P., Puhambugoda, P.A.C.R.** and Munasinghe, Ranjula (2000). Quality of rubber fertilizers – Deviation from standards. *Journal of the National Institute of Plantation of Management* **16** (2), 56-63.

**Dissanayake, D.M.A.P., Wickramasinghe, D.N.P., Puhambugoda, P.A.C.R.** and Munasinghe, Ranjula (2000). Quality of fertilizers in relation to public and private sector organizations. *Journal of the National Institute of Plantation Management* **16** (2), 64-71

**Fernando, T.H.P.S.** (2000). Studies on the biology of the *Hevea* isolate of *Colletotrichum acutatum* Simmonds ex Simmonds. Thesis submitted for the MPhil degree of University of Colombo, 2000.

Jayasekera, J.D.R.S., **Karunasekera, K.B.**, Jayasekera, N.E.M., Wickramasinghe, W.N. (2000). An analysis of a series of experiments on *Hevea* using repeated measures techniques. *Proceedings of the 56th Annual Session of SLAAS,* Sri Lanka.

Jayasekera, Y.S.S.C., **Wijesuriya, B.W.** and Thattil, R.O. (2000). Forecasting Natural Rubber (NR) production in Sri Lanka. *Proceedings of the 56th Annual Session of SLAAS,* Sri Lanka.

**Jayasinghe, C.K.** (2000). *Corynespora* leaf fall: The most challenging rubber disease in Asian and African continents. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 56-64.

**Jayasinghe, C.K.** (2000). *Cylindrocladium* leaf spot disease of rubber: The review on the causative agent. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 65-71.

**Jayasinghe, C.K.** (2000). *Corynespora* leaf fall of rubber in Sri Lanka: diversity of the pathogen and pathogenesis. Paper presented at the International Rubber Research and Development Board *Corynespora* leaf fall disease workshop in Kuala Lumpur, Malaysia from 6th to 9th June, 2000. Report on the CLF workshop in Malaysia, 2000, IRRDB, Hertford, London.

**Naranpanawa, A.K.B.** (2000). Natural rubber prices: Future prospects. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 22-32.

**Nugawela, A.** (2000). Improvements in total production and productivity in the rubber plantations. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 1-9.

**Nugawela, A.** (2000). Tapper shortage in Sri Lanka – Reasons, repercussions and recommendations to minimize it. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 39-40.

**Pathiratna, L.S.S.** and **Seneviratne, P.** (2000). Propagation techniques and nursery practices for *Indigofera tinctoria* (Nil Avariya). Final report of the Agronomic Research carried out by the Rubber Research Institute of Sri Lanka and funded by the Sri Lanka Conservation and Sustainable Use of Medicinal Plants Project.

**Pathiratna, L.S.S.** and **Seneviratne, P.** (2000). Propagation techniques and nursery practices for *Solanum virginianum* (Katuwelbatu). Final report of the Agronomic Research carried out by the Rubber Research Institute of Sri Lanka and funded by the Sri Lanka Conservation and Sustainable Use of Medicinal Plants Project.

**Pathiratna, L.S.S.** and **Seneviratne, P.** (2000). Propagation techniques and nursery practices for *Aerva lanata* (Pol pala). Final report of the Agronomic Research carried out by the Rubber Research Institute of Sri Lanka and funded by the Sri Lanka Conservation and Sustainable Use of Medicinal Plants Project.

**Samarappuli, Lalani** (2000). Integrated plant nutrient management in rubber nurseries. *Journal of National Institute of Plantation Management* **16** (1), 42-49.

**Samarappuli, Lalani** (2000). Importance of fertilizer application to mature rubber even during low rubber prices. *Journal of the National Institute of Plantation Management* **16** (2), 26-32.

**Samarappuli, Lalani** (2000). Developments in soil conservation systems in rubber plantations. *Journal of the National Institute of Plantation Management.* **16** (2), 33-42.

**Samarappuli, Lalani** (2000). Effect of soil-plant-water relations on drought management in rubber plantations. *Journal of the National Institute of Plantation. Management* **16** (2), 43-55.

**Samarappuli, Lalani** (2000). Rubber growing soils and their characteristics. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 10-21.

**Samarappuli, Lalani** (2000). Economics and efficiency of fertilizer utilization in immature rubber. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 1-10.

**Samarapuli, Lalani** (2000). Economics and efficiency of fertilizer utilization in mature rubber. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 11-24.

**Seneviratne, P.** (2000). The role of budwood nursery on the quality of the budded plants. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 49-51.

**Seneviratne, P., Nugawela, A., Weerakoon, U.S., De Alwis, M.N.** and **Zoysa, L.** (2000). Budwood nurseries in Sri Lanka: Condition of the nurseries in the estate sector. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 39-48.

**Seneviratne, P., Nugawela, A., Weerakoon, U.S.** and **De Alwis, M.N.** (2000). The effect of the condition of budwood nurseries on the productivity: Mixed clones. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 44-48.

**Seneviratne, P., Zoysa, L.** and **De Alwis, M.N.** (2000). The effect of method of seed sowing on percentage germination and growth of seedlings. *Bulletin of the Rubber Research Institute of Sri Lanka* **42**, 49-55.

**Seneviratne, P., Weerakoon, U.S., Alwis, M.N.** and Karunaratne, G. (2000). A short account on the number of buds on various types of budwood. *Bulletin of the Rubber Research Institute of Sri Lanka* 25-28.

**Tillekeratne, L.M.K.** and Karunanayake, Lalin (2000). Rain-guards, the rapid way to increase rubber production. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 41-43.

**Tillekeratne, L.M.K.** and **Naranpanawa, A.K.B**. (2000). What will the future of natural rubber be? *Journal of the National Institute of Plantation Management* **16** (1), 25-29.

**Tillekeratne, L.M.K.** and **Nugawela, A.** (2000). Some factors inhibiting the growth of the rubber industry in Sri Lanka. *Journal of the National Institute of Plantation Management* **16** (2), 73-78.

**Wijesuriya, Wasana, Munasinghe, Chintha** and **Abeywardene, Vidura** (2000). Seasonal variations in meteorological factors at Dartonfield. *Bulletin of the Rubber Research Institute of Sri Lanka* **42,** 29-37.

**Yogaratnam, N.** (2000). Rubber land suitability evaluation. *Bulletin of the Rubber Research Institute of Sri Lanka* **41**, 33-38.

Stirling, C.M., **Rodrigo, V.H.L**, Marzano, M., Thenakoon, Sillitoe, P., **Senivirathna, A.M.W.K.** and Sinclair, F.L. (2000). Developing rubber-based cropping systems that improve not only latex yield but also the livelihood of the rural poor; case studies in Sri Lanka, Research Highlights, Plant Science Programme of the Department for International Development, UK. P.41-45.