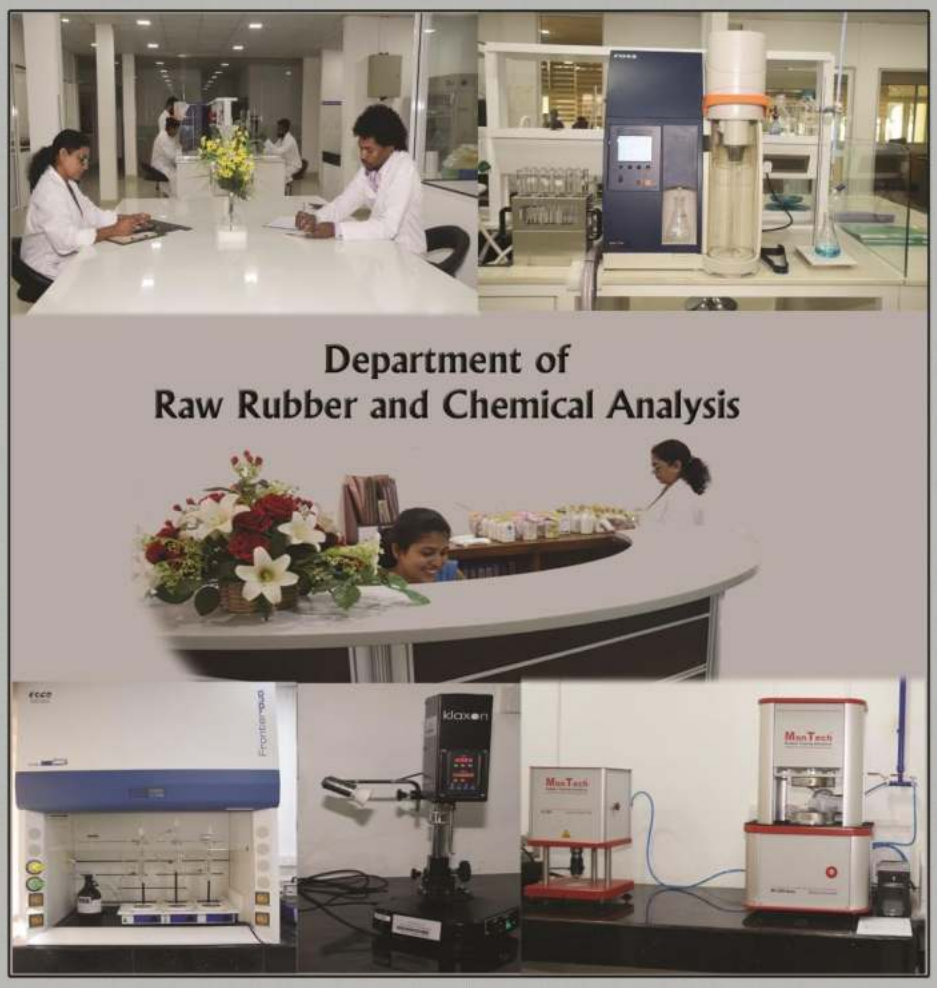
ISBN 1391-0043

RUBBER RESEARCH INSTITUTE OF SRI LANKA



Department of Raw Rubber and Chemical Analysis

Annual Review 2022

Cover Story

Rubber Research Institute of Ceylon was established in 1909 at Dartonfield, Agalawatta. Initially, Rubber Chemistry Department was established in Dartonfield. In 1965, Malaysia launched the Standard Malaysian Rubber (SMR) scheme. In this scenario, other TSR producing countries also launched rubber schemes parallel to the SMR scheme.

In 1966 Rubber Research Institute of Sri Lanka (RRISL), in collaboration with Sri Lanka Standards Institute introduced the Standard Lanka Rubber (SLR) scheme which provides incentives and duty concessions to encourage Technically Specified Rubber (TSR) manufacturers in Sri Lanka. TSR produced in Sri Lanka was exported as SLR. This transformation needed to analyze the TSR for the technical specifications to export as SLR grades.

In 1974 rubber chemistry laboratories were shifted to the premises at Telewala Road, Ratmalana, which is close to most of the rubber product manufacturing companies. First, this laboratory in the photograph was named as the Specifications Section and main mandate was to analyze for the technical specifications of TSR. Most of the machineries were received under the Colombo plan to upgrade the rubber industry in Sri Lanka.

Later, the name was changed to Raw Rubber & Chemical Analysis Department with a broad mandate for catering to the rubber industry. This laboratory is equipped with sophisticated instruments and has a competent staff to carry out testing of natural rubber latex, dry rubber & rubber processing chemicals while ensuring impartiality and confidentiality of the customer.

Raw Rubber & Chemical Analysis Department was upgraded in accordance with the requirements of international standards in 2019 under the project “Establishment of Accredited Laboratory and Enhancement of Testing Facilities for Rubber Industry in Sri Lanka” funded by the Ministry of Plantation Industries.

Rubber Research Institute of Sri Lanka

Annual Review - 2022

1st January 2022 to 31st December 2022

Editors
S Siriwardene, PhD (Malaysia)
D G Edirisinghe, PhD (Sri Lanka)
S P Withanage, PhD (Malaysia)

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
Ratmalana

CONTENTS

	Page
Board of Management	i
Staff	ix
REVIEWS	
Director	1
Susantha Siriwardena	
Genetics and Plant Breeding	8
S P Withanage	
Plant Science	26
T U K Silva	
Plant Pathology and Microbiology	47
T H P S Fernando	
Soils and Plant Nutrition	79
R P Hettiarachchi	
Biochemistry and Physiology	98
K V V S Kudaligama	
Advisory Services	113
P K K S Gunarathne	
Rubber Technology and Development	132
Dilhara Edirisinghe	
Polymer Chemistry	150
I H K Samarasinghe	
Raw Rubber and Chemical Analysis	160
Anusha Attanayake	
Raw Rubber Process Development and Chemical Engineering	169
K Adihikari	
Adaptive Research	182
E S Munasinghe	
Biometry	191
Wasana Wijesuriya and Dilhan Ratnayake	
Agricultural Economics	200
J K S Sankalpa	
Library and Publications	208
N C D Wijesekera	
Dartonfield Group	211
P A Lukshaman	
Kuruwita Sub - station	218
P A Lukshaman	
Polgahawela Sub - station	223
P A Lukshaman	
Meteorological Summary	226
Wasana Wijesuriya and Dilhan Ratnayake	
List of Publications	239

RUBBER RESEARCH BOARD OF SRI LANKA

BOARD OF MANAGEMENT

Members appointed by the Hon Minister of Plantation Industries

Prof (Mrs) Sudheera M W Ranwala, Chairperson, Rubber Research Board (up to 31.10.2022)
Mr Lakshman Abeysekera, Chairman, Rubber Research Board (w.e.f. 15.11.2022)
Mr K V D C Wimalasiri, Director (Development), Ministry of Plantation (up to 28.12.2022)
Ms Darshani De Silva, Director, National Planning Department, Ministry of Finance (up to 24.03.2022)
Dr L M K Tillekeratne, Advisor (Rubber), United Nations Organization
Mr Justin Senevirathne, Director, Lalan Rubbers (Pvt) Ltd.
Mr Udara Premathilake, Director Plantations (Rubber), Kelani Valley Plantations PLC
Prof Gamini Senanayake, Chairman, Sri Lanka Council for Agricultural Research Policy (up to 23.11.2022)
Mr V Lokunarangoda, Chairman, Thurusaviya Fund
Mr Prins Gunasekara, Chief Executive Officer, Kegalle/Namunukula Plantations PLC
Mr Ajantha Galhena, Additional Director General (Acting), Ministry of Finance (w.e.f. 24.03.2022)
Mr Senaka Alawattegama, Chairman, The Planters' Association of Ceylon (w.e.f. 11.11.2022)
Mr C C Muhandiramge, Additional Secretary, Ministry of Plantation Industries (w.e.f. 28.12.2022)

Ex-Officio Members

Mr Bhathiya Bulumulla, Chairman, Planters' Association of Ceylon (up to 11.11.2022)
Mr Madhawa Warnakulasooriya, Director General, Rubber Development Department

In attendance

Dr V H L Rodrigo, Acting Director, Rubber Research Institute

STANDING COMMITTEES

Estates Committee

Prof (Mrs) Sudheera Ranwala, Chairperson, RRB (up to 31.10.2022)
Mr Lakshman Abeysekera, Chairman, RRB (w.e.f. 15.11.2022)
Dr V H L Rodrigo, Acting Director, Rubber Research Institute, Member
Dr Susantha Siriwardena, Deputy Director - Research (Technology), Rubber Research Institute
Mr Nissanka Seneviratne, Director, Kotalagala Plantations Ltd.

Mr Jagath Hettiarachchi, Senior Manager, Arappolkanda Estate
Mr P A Lukshaman, Senior Manager, Rubber Research Institute
Mr B S S Hewage, Senior Accountant, Rubber Research Institute

Audit and Management Committee

Ms Darshani De Silva, Director, National Planning Department, Ministry of Finance (Chairman of the Committee) (up to 24.03.2022)
Mr Ajantha Galhena, Additional Director General (Acting), Ministry of Finance (w.e.f. 24.03.2022)
Mr K V D C Wimalasiri, Director (Development), Ministry of Plantations (up to 28.12.2022)
Mr Madhawa Warnakulasooriya, Director General, Rubber Development Department
Mrs Sandhya Samarasinghe, Audit Superintendent, Auditor General's Department (up to 28.12.2022)
Mr K A C Shamantha, Internal Auditor, Ministry of Plantation

In attendance

Dr V H L Rodrigo, Acting Director, Rubber Research Institute
Mr B S S Hewage, Senior Accountant, Rubber Research Institute
Ms M S I Senadheera, Internal Auditor, Rubber Research Board
Mr Susantha Dissanayake, Senior Administrative Officer, Rubber Research Institute

Scientific Committee

Members of RRISL

Prof. Sudheera Ranwala, Chairperson, Rubber Research Board
Dr V H L Rodrigo, Acting Director, RRI
Dr (Mrs) G P W P P Seneviratne, Deputy Director Research (Biology), RRI
Dr S Siriwardena, Deputy Director Research (Technology), RRI
Dr (Mrs) D G Edirisinghe, Head, Rubber Technology & Development Dept., RRI
Dr (Mrs) S P Withanage, Head, Genetics & Plant Breeding Dept., RRI
Dr (Mrs) B W Wijesuriya, Principal Research Officer, Biometry Section, RRI
Dr (Mrs) T H P S Fernando, Head, Plant Pathology & Microbiology Dept., RRI
Dr (Mrs) E S Munasinghe, Principal Research Officer, Adaptive Research Unit, RRI
Dr (Mrs) K V V S Kudaligama, Head, Biochemistry & Physiology Dept., RRI
Dr (Mrs) R P Hettiarachchi, Head, Soils & Plant Nutrition Dept., RRI
Dr (Mrs) A P Attanayake, Senior Research Officer, Raw Rubber & Chemical Analysis Dept., RRI
Dr K K Liyanage, Principal Research Officer, Genetics & Plant Breeding Dept., RRI
Dr T U K Silva, Senior Research Officer, Plant Science Dept., RRI
Mrs B M D C Balasooriya, Research Officer, Adaptive Research Unit, RRI
Dr (Mrs) D S A Nakandala, Senior Research Officer, Plant Science Dept., RRI
Dr (Mrs) M K R Silva, Research Officer, Plant Pathology & Microbiology Dept., RRI
Mr W D M Sampath, Senior Research Officer, Rubber Technology & Dept., RRI

Dr P K K S Gunarathne, Advisory Officer, Advisory Services Dept., RRI
Mr J K S Sankalpa, Senior Research Officer, Agricultural Economics Unit, RRI
Mr K Adikari, Research Officer, Raw Rubber & Chemical Analysis Dept., RRI
Mrs I H K Samarasinghe, Research Officer, Polymer Chemistry Dept., RRI
Dr W R N Alles, Senior Research Officer, Polymer Chemistry Dept., RRI
Mrs H A Ruwani Jayawardane, Research Officer, Soils & Plant Nutrition Dept., RRI
Mrs N P Surani Karunaratne, Research Officer, Biochemistry & Physiology Dept., RRI
Mrs P G N Ishani, Research Officer, Agricultural Economics Unit, RRI
Mr Yashoda Somaratne, Research Officer, Polymer Chemistry Dept., RRI
Mrs Aloka Weerasinghe, Research Officer, Rubber Technology & Development Dept., RRI
Mr Manjula Alwis, Research Officer, Plant Science Dept., RRI
Mr Sangeeth Liyanaarachchi, Research Officer, Soils & Plant Nutrition Dept., RRI
Mr Dilhan Rathnayake, Research Officer, Biometry Section, RRI
Mr P A Lukshaman, Senior Manager (Estate), RRI

Members representing the Industry and other Institutions

Mr Manoj Udugampola CEO, Agalawatta Plantations PLC, FLC Tower, No 19, Dudley Senanayake Mw, Colombo 8
Mr S Dissanayake, GM, Agalawatta Plantations PLC, Pambegama Estate, Parakaduwa
Mr K Fernando, AGM, Agalawatta Plantations PLC, Culloden Estate, Neboda
Mr D P A Perera, DGM, P.B. 06, Balangoda Plantations PLC, Palmgarden, Ratnapura
Mr B L L Prematthilake, Superintendent, Balangoda Plantations PLC, Mahawala Estate, Ratnapura
Mr D L D S Kandegama, Superintendent, Balangoda Plantations PLC, Rye/Wikiliya Estate, Balangoda
Mr B Bulumulla, CEO, Elpitiya Plantations PLC, Level 09, Aitken Spence Tower 1, Vauxhall Street, Colombo 2
Mr A G Geeth Kumara, Senior General Manager, Elpitiya Plantations PLC, Level 09, Aitken Spence Tower 1, Vauxhall Street, Colombo 2
Mr B H U Bulugahapitiya, Senior Manager, Elpitiya Plantations PLC, Talgaswala Estate, Talgaswella
Mr N M S B Nawaratne, Manager, Elpitiya Plantations PLC, Bentota Estate, Elpitiya
Mr R B S Douglas, Senior Manager, Elpitiya Plantations PLC, Elpitiya Estate, Elpitiya
Mr N T Dandeniya, Superintendent, Elpitiya Plantations PLC, Katandola Estate, Elpitiya
Mr K S Gunaratne, Senior Manager, Elpitiya Plantations PLC, Lelwala Estate, Wadurambe

Mr Rohan Wijekoon, DGM, Kegalle Plantations PLC, 310, High Level Road, Naviina, Maharagama

Mr P De S A Gunasekara, CEO, Kegalle Plantations PLC, No 310, High Level Rd, Nawinna, Maharagama

Mr Saman Doranegama, GM, Kegalle Plantations PLC, 310, High Level Road, Navinna, Maharagama

Mr A M M P Mudannayake, Superintendent, Kegalle Plantations PLC, Udapola Estate, Polgahawela

Mr N A M O Nawaratne, Superintendent, Keaglle Plantations PLC, Etana Estate, Warakapola

Mr S A A P Jayathilake, Superintendent, Kegalle Plantations PLC, Pallegama Estate, Niyadurupola

Mr B P S M Cooray, Superintendent, Kegalle Plantations PLC, Ambadeniya Estate, Aranayake

Mr S D Munasinghe, Superintendent, Kegalle Plantations PLC, Eadella Estate, Polgahawela

Mr B M J A Moonamalle, Superintendent, Kegalle Plantations PLC, Atale Estate, Atale

Mr J R Amunupura, Superintendent, Kegalle Plantations PLC, Madeniya Estate, Warakapola

Mr Dushan Ratwatte, CEO, Hapugastenna Plantations PLC, P.O. Box 2, Nambapana, Ingiriya

Mr H Mawdiwake, Superintendent, Hapugastenna Plantations PLC, Bibile Estate Bibile

Mr Buddika Weerakoon, Senior Manager, Kotagala Plantations PLC, Delkith Estate, Baduraliya

Mr Gayal Renuka, Manager, Horana Plantations PLC, Mirishena Estate, Bulathsinhala

Mr N Wijenayake, Manager, Horana Plantations PLC, Halwatura Estate, Ingiriya

Mr Buddhi Gunasekara, Manager, Horana Plantations PLC, Divithura Estate, Elpitiya

Mr V S Alahapperuma, Manager, Horana Plantations PLC, Halwatura Estate, Ingiriya

Mr P L C P Kumarasinghe, Manager, Horana Plantations PLC, Hilstream Estate, Bulathsinhala

Mr N B Seneviratne, Director - Low Country, Kotagala Plantations PLC, Regional Office, Colombo 1

Mr Udara Premathilake, CEO, Kotagala Plantations PLC, Regional Office, Colombo 1

Mr J N Hettiarachchi, Senior Manager, Kotagala Plantations PLC, Arapolakande Estate, Tebuwana

Mr L A D J Perera, Senior Manager, Kotagala Plantations PLC, Uskvelly Estate, Molkawa

Mr N Wijeratne, Manager, Kotagala Plantations PLC, Eduragala Estate, Ingiriya

Mr C Amaratunga, RGM, Kahawatta Plantations PLC, Regional Office, Pelmadulla Estate, Kahawatta

Mr T V Jayasekera, Agronomist, DGM Office, Kahawatta Plantations PLC, Godellawatta, Sannasgama, Lellopitiya

Mr Jeewantha Senaratne, Senior Manager, Kahawatta Plantations PLC, Rilhena Estate, Pelmadulla

Mr Suneth Hewagama, Senior Manager, Kahawatta Plantations PLC, Poranuwa Estate, Kahawatta

Mr Wajira Hewage, Manager, Kahawatta Plantations PLC, Opatha Estate, Kahawatta

Mr L Perera, Manager, Kahawatta Plantations PLC, Pelmadulla Estate, Kahawatta

Mr Indrajith Rukmal, Manager, Kahawatta Plantations PLC, Akarella Estate, Openayake

Mr Yajith De Silva, RGM, Kahawatte Plantations PLC, Godellawatte, Sannasgama, Lellopitiya

Mr Ranil Fenando, GM-Rubber Marketing & Ad., Kelani Valley Plantations PLC, No 400, Deans Rd, Colombo 10

Mr S F Fernando, RGM, Kelani Valley Plantations PLC, Kiriporuwa Estate, Yatiyantota

Mr R M U S Jayasundara, Manager, Kelani Valley Plantations PLC, Urumillewa Estate, Bulathkohupitiya

Mr K K A I Perera, Kelanivalley Plantation PLC, Kelani Estate, Yatiyantota

Mr Eranda Welikala, DGM, Kelani Valley Plantations PLC, Kelani Estate, Yatiyantota

Mr P K A H Thilakaratne, Senior Manager, Kelani Valley Plantation PLC, We-oya Estate, Yatiyantota

Mr W P S B Abeywardana, Senior Manager, Kelani Valley Plantation PLC, Dewalakanda Estate, Dehiowita

Mr R W U S Jayasuriya, Manager, Kalanivalley Plantations PLC, Edarapola Estate

Mr P de S A Gunasekara, CEO, Namunukula Plantations PLC, No 310, High Level Rd, Nawinna, Maharagama

Mr J B Weerasekara, Superintendent, Namunukula Plantations PLC, Pallegoda Estate, Darga Town

Mr R Ranasinghe, Superintendent, Namunukula Plantations PLC, Eladuwa Estate, Matugama

Mr P P A Peris, General Manager, Lalan Rubbers (Pvt.) Ltd., No 54, Kirulapana Avenue, Colombo 6

Mr D N P Seneviratne, DM, Lalan Rubbers (Pvt.) Ltd., No 54, Kirulapana Avenue, Colombo 6

Mr P I Fernando, GSM, Mahaoya Group, Dehiowita

Mr A Kuruppu, Actg. Senior Manager, Lalan Rubbers (Pvt.) Ltd., Sapumalkande Group, Deraniyagala

Mr C V Dias, Group Senior Manager, Lalan Rubbers (Pvt.) Ltd., Miyanawita Estate, Deraniyagala

Mr L M A C Bandara, Superintendent, Maturata Plantations Ltd., Wilpita Estate Akuressa

Mr M H P Gunarathna, Superintendent, Maturata Plantations Ltd, Diddenipota Estate, Matara

Chief Operating Officer, Pussellawa Plantations PLC, Level 11, FLC Tower, No 19, Dudley Senanayake Mw, Colombo 8

Mr Anusha Weerakon, Superintendent, Pussellawa Plantations PLC, Elston Estate, Puwakpitiya

Mr K M C Prasan, Senior Manager, Pussellawa Plantations PLC, Halpe Estate, Tummodara

Mr J A D C S Jayalath, Asst. General Manager, Pussellawa Plantations PLC, Pussella Estate, Parakaduwa

Mr L M Amarathunga, Superintendent, Pussellawa Plantations PLC, Salawa Estate, Hanwella

Mr S R L Welikala, Superintendent, Pussellawa Plantations PLC, Sunderland Estate, Ehaliyagoda

Mr W G Gunaratne, Pussellawa Plantations PLC, Ayr Estate, Padukka

Mr Chrishan Hettiarachchi, Superintendent, Pussellawa Plantations PLC, Siriniwasa Estate, Waga

Mr D Daswatte, DGM, Watawala Plantations PLC, Talangaha Estate, Nakiyadeniya

Mr Sudeera Madanayake, Actg. Manager, Watawala Plantations PLC, Talangaha Estate, Nakiyadeniya

Mr Rohana Deshapriya, Senior Asst. Manager, Watawala Plantations PLC, Nakiyadeniya Estate, Nakiyadeniya

Mr Asanga Ekanayake, Senior Asst. Manager, Watawala Plantations PLC, Hemadola Estate, Udugama

Mr Dimantha Samarasinghe, Senior Manager, Watawala Plantations PLC, Homadola Estate, Udugama

Mr C Fernando, Executive Director, Malwatte Valley Plantations PLC, No 280, Dam Street, Colombo 12

Mr M I Gourdian, Executive Director, Malwatte Valley Plantations PLC, No 280, Dam Street, Colombo 12

Mr R M V Ratnapala, Group Manager, Malwatte Valley Plantations PLC, Moralioya Estate, Ruwanwella

Mr Gaya Nakandala, Consultant, 375/26, Ratnarama Rd, 4th Lane, Hokandara North

Mr Ashoka Jayasekara, Project Consultant, Wellssa Rubber Co, C/O Tissa Jinasena Group, 57 Lake Crescent, Colombo 2

Mr S W Karunaratne, Consultant, Mallikarama Rd, Ratmalana

Mr S Seneviratne, Consultant, Seneviratne Group, D.J. Wijesiriwardana Mawatha, Mt. Lavinia

Mr N M Amaraekara, Consultant, 37/9, Terrence Av, Mt. Lavinia

Mr Jayantha P Muthutantri, Consultant, No.4/4, Nelum Mw, Sirimal Uyana, Mt. Lavinia

Provident Fund Committee

Prof (Mrs) Sudheera Ranwala, Chairperson, Rubber Research Board (up to 31.10.2022)
Mr Lakshman Abeysekera, Chairman, RRB (w.e.f. 15.11.2022)
Dr V H L Rodrigo, Acting Director, RRI, Member
Mr D M S Dissanayake, Senior Administrative Officer, Secretary
Mr B S S Hewage, Senior Accountant, RRI, Treasurer
Dr (Mrs) K V V S Kudaligama, Head of Biochemistry & Physiology Department, Elected Committee Member
Dr P K K S Gunarathna, Advisory Officer, Elected Committee Member
Mr J A S Chandrasiri, Rubber Extension Officer, Elected Committee Member

Chairman's Office & Board Secretariat

Chairperson	-	Prof. (Mrs) Sudheera M W Ranwala
Board Secretary	-	Mrs J A H Sandhya, Stenographer (Cover up duties of the Secretary)
Management Assistant	-	Miss S M D S R D A Wijerathne
Telephone Operator	-	Mrs G D D Kalamini

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

Auditors
Auditor General
Auditor General's Department
No. 306/72, Polduwa Road,
Battaramulla

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

Bank of Ceylon
Agalawatta

Contact details:
Head Office and Laboratories
Dartonfield, Agalawatta

Telephones:	
Director	034 - 2248457
Additional Director	034 - 2248458
Deputy Director Research (Biology)	034 - 2295610
General	034 - 2247426
	034 - 2247383
	034 - 2295540
	034 - 2248459

Fax:	034 - 2247427
e-mail	*dirrri@sltnet.lk*
Website	*www.rrisl.gov.lk*

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

Chairman	011 - 2635019
Fax	011 - 2605171
Director	011 - 2633351
Deputy Director Research (Technology)	011 - 2633352
General	011 - 2635851
	011 - 2635852
Administration Fax	011 - 2635142
e-mail	*dirrub@sltnet.lk*
	rubberreseach@gmail.com

Sub stations

Nivitigalakele - Substation, Matugama
Genetics and Plant Breeding Department
Telephone: 034 - 2247368, 034 - 2247199
e-mail: *rrigpb@sltnet.lk*

Kuruwita - Substation, Ratnapura
Telephone: 045 - 2262115, 045 - 3460537

Polgahawela - Substation, Polgahawela
Telephone: 037 - 2244120

Monaragala - Substation, Monaragala
Telephone: 055 - 3600707

RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

DIRECTORATE

Additional Director	V H L Rodrigo, BSc Agric. (SL), MSc (Essex), PhD (Wales)
Deputy Director - Research (Bio.)	*Mrs G P W P P Seneviratne, BSc (SL), PhD (Bath)
Deputy Director - Research (Tech.)	S Siriwardene, BSc (SL), MSc (Australia), PhD (Malaysia)

RESEARCH DEPARTMENTS

Agronomy Departments

Genetics and Plant Breeding	**(***at Nivithigalakele Substation, Matugama***)**
Head of Department	Mrs S P Withanage, BSc Agric. (SL), MSc (India), PhD (Malaysia), PDHRM (SL)
Principal Research Officer	K K Liyanage, BSc Agric. (SL), MPhil (SL), PhD (China)
Research Officer	Mrs T T D Dahanayake, BSc Agric. (SL) (up to 14.09.2022)
Experimental Officers	T B Dissanayake T M S K Gunasekera H P Peries, Dip. Agric. (Kundasale) Mrs A K Gamage, BSc (SL)
Technical Officers (Research & Development)	B W A N Baddewithana, BSc Agric. (SL), MPhil (SL) Mrs N S Jayasinghe, BSc (SL)
Management Assistant (Clerical)	Mrs S D P K L Peiris

Plant Science	**(***at Dartonfield, Agalawatta***)**
Senior Research Officers	T U K Silva, BSc Agric. (SL), MPhil (SL), PhD (SL) Mrs D S A Nakandala, BSc Agric. (SL), PhD (SL)
Research Officer	W D M N de Alwis, BSc (SL)
Experimental Officers	D L N de Zoysa P D Pathirana, BSc (SL) P K W Karunathilaka, Dip. Agric. (Ratnapura)

Technical Officers	R Handapangoda, BSc Agric. (SL)
(Research & Development)	Mrs U Dissanayake, HNDT, BSc (SL), MSc (SL)
	Miss H M Subasinghe, BSc (SL)
	Mrs W K S W Watawala, BSc (SL) (up to 07.09.2022)
	R P D Priyadharshana, BSc (SL)
	Mrs U N Udayakumari, BSc (SL)
	Miss W M D Wickremakumari, BSc Agric. (SL)
	H D H C Arunasiri, HNDT (up to 05.08.2022)
Management Assistants (Clerical)	Mrs Aruna de Almeida

Plant Pathology and Microbiology **(***at Dartonfield, Agalawatta***)**

Head of Department	Mrs T H P S Fernando, BSc (SL), MPhil (SL), PhD (SL)
Research Officer	Mrs M K R Silva, BSc Agric. (SL), MSc (SL), PhD (SL)
Experimental Officers	Mrs B I Tennakoon, Dip. Agric. (Kundasale)
	Mrs E A D D Siriwardene, BSc (SL)
	S C P Wijayaratne, NDT Agric. (Hardy)
	E A D N Nishantha, Dip. Agric. (Ratnapura), BIS Agric. (SL) M.AETM (SL)
Technical Officers	Mrs A H M N R Abeyrathna, BSc (SL),
(Research & Development)	MSc (SL)
	D A N Mallikaarachchi, BSc (SL)
Management Assistant (Clerical)	Mrs K A D Y Madushani Lanka

Soils and Plant Nutrition **(***at Dartonfield, Agalawatta***)**

Head of Department	Mrs R P Hettiarachchi, BSc (SL), MPhil (SL), PhD (SL)
Research Officers	Mrs H A R K Jayawardena, BSc Agric. (SL), MPhil (SL)
	L A T S Liyanaarachchi, BSc (SL)
Experimental Officers	Miss V U Edirimanne, BSc (SL)
	Miss A P Thewarapperuma
	P D T C Gunathilaka, NDT (Agric.)
Technical Officers	Mrs Eranga de Silva, NDT
(Research & Development)	C G Malawaraarachchi, HNDT (Hardy)
	Mrs M Kulathunga, BSc (SL)
	Mrs R M Baddevidana, BSc (SL)
	M H W Gayan, BSc (SL)
	B M K Rangana, BSc (SL)

Biochemistry and Physiology	**(***at Dartonfield, Agalawatta***)**
Head of Department	Mrs K V V S Kudaligama, BSc (SL), MPhil (SL), PhD (SL)
Research Officer	Mrs N P S N Karunaratne, BSc (SL)
Experimental Officer	M K P Perera, BSc (SL)
Technical Officers	Mrs P D T L Madushani, Diploma in Agric.
(Research & Development)	Miss N N Abeywardena, BSc (SL)
	L T B K Fernando, BSc (SL)
Management Assistant (Clerical)	Mrs H A Manoji Erandika

Advisory Services	(*at Telewela Road, Ratmalana***)**
Advisory Officer	P K K S Gunaratne, BSc Agric. (SL), PhD (SL)
Assistant Training Officer	Mrs K G P Manahari, BSC (SL)
Rubber Extension Officers	R M S Ratnayake, NDT Agric. (Hardy)
	D E P M Nanayakkara, Dip. in Agric. (Aquinas)
	Nihal Gamage, Dip. in Agric. (Angunakolapelessa)
	J A S Chandrasiri
	S M A Samarakoon, Dip in Agric. (Kundasale)
	W P G D C P K Senanayake, NDT Agric. (Hardy)
	T L Ramanayake, BSc (SL) (up to 11.12.2022)
	H G M B Jayasinghe, BSc (SL)
	K D K L Siriwardena, BSc (SL)
	Mrs K K I Jayasundera, BSc (SL)
	Mrs G R Thennakoon, BSc (SL)
	D S Dissanayake, BSc (SL)
	P V S Madubashana, BSc (SL)
	M N P de Silva, BSc (SL)
	E W S Ruwan Kumara, BSc (SL)
Management Assistants (Clerical)	R G A S Dharmaratne
	K D P Senaratne
	Mrs P Schini Ishara

Technology Departments

Rubber Technology and Development (*at Telewela Road, Ratmalana***)**

Head of Department	Mrs D G Edirisinghe, BSc (SL), MSc (SL), MPhil (UK), PhD (SL)
Senior Research Officer	W D M Sampath, BSc (SL), MPhil (SL)
Research Officer	Mrs U A Weerasinghe, BSc (SL)
Experimental Officer	Mrs G M Priyanthi Perera, BSc (SL), MSc (SL)
Technical Officers	V G M J Abeywardena, NDT
(Research & Development)	Mrs S G P Bhagayawedha, NDT

Technical Officers	Mrs P K I L Jayawardena, BSc (SL)
(Research & Development)	Miss A H D M N Gunawardena, BSc (SL)
	Mrs E N N Nanayakkara, BSc (SL)
	K N D Tillekeratne, BSc (SL)

Polymer Chemistry Department (*at Telewela Road, Ratmalana*)

Senior Research Officer	W R N Alles, MSc (SL), MSc (UK), PhD (NZ)
Research Officers	Mrs I H K Samarasinghe, BSc (SL)
	Y R Somaratne, BSc (SL), MSc (SL)
Experimental Officer	Mrs N Jayawardane, Dip. Agric. (Bibile)
Technical Officers	Mrs H M H Dhanukamalee, BSc (SL)
(Research & Development)	Mrs S V Rupasinghe, BSc (SL)
	D V D Mallikarachchi, BSc (SL)
	Mrs H L T Tharaka, BSc (SL)
Management Assistant (Clerical)	N W E C Madhuranga

Raw Rubber and Chemical Analysis (*at Telewela Road, Ratmalana*)

Senior Research Officer	Mrs A P Attanayake, BSc (SL) PhD (SL)
Research Officer	A M K S P Adikari, BSc (SL), MPhil (SL)
Experimental Officer	Mrs C S Lokuge
Technical Officers	Mrs M U D S Weerasinghe, BSc (SL)
(Research & Development)	H D M S Wijewardena, BSc (SL)
	K A S T Koswatta, BSc (SL)
Management Assistant	Miss W D Disna Samanmali (up to 30.08.2022)

Raw Rubber Process Development and Chemical Engineering (*at Telewela Road, Ratmalana*)

Experimental Officers	Mrs U M S Priyanka, BSc (SL), MSc (SL)
	Mrs V C Rohanadeepa
	A K D W Prasad
Technical Officers	R D Illeperuma, BSc (SL)
(Research & Development)	Miss P K N N Sandamali, BSc (SL)
	W A S Bandara, BSc (SL)
Management Assistants (Clerical)	Mrs H A Janani Lakshika, BSc. (Business Admin.) (SL)
	Mrs P D S Dilhani

Sections/Units

Biometry Section (*at Dartonfield, Agalawatta*)

Principal Research Officer	Mrs B W Wijesuriya, BSc Agric. (SL), MPhil (SL), PhD (SL)
Research Officer	A M R W S D Ratnayake, BSc (SL)
Experimental Officer	O V Abeywardena, Dip. in Agric. (Kundasale)

Management Assistant (Clerical)	Mrs S N Munasinghe

Adaptive Research Unit	**(***at Dartonfield, Agalawatta***)**
Principal Research Officer	Mrs E S Munasinghe, BSc Agric. (SL), PhD (SL), PDHRM (SL)
Technical Officers (Research & Development)	P M M Jayatilleke, NDT (Agric.) Mrs N M Piyasena, Dip. in Agric. (Kundasale)
Management Assistant (Clerical)	Mrs M A Randima Srimalee

Agricultural Economics Unit	**(***at Dartonfield, Agalawatta***)**
Senior Research Officer	J K S Sankalpa, BSc (SL), MSc (SL), MEcon (SL)
Research Officer	Mrs P G N Ishani, BSc Agric.

Library and Publications Unit	**(***at Dartonfield, Agalawatta***)**
Librarian & Publication Officer	Mrs N C D Wijesekera, BSc (SL) MSSc (SL)
Library Assistant & Assistant Publication Officer	Mrs R M Amaratunga, Intermediate; Lib. Sci. Doc. & Info. (SLLA)
Experimental Officer	Miss D M S Wijesekera, Dip. Rubber Tech. (PRI)
Library Assistant & Publication Assistant (Ratmalana)	Mrs D N C Amarathunga
Management Assistants (Clerical)	P M P Jayantha

Audio Visual and Information Technology Unit (*at Dartonfield, Agalawatta***)**

Network Administrator	S R D P C Peiris, BSc (SL)

Management Divisions

Administration Department (Agalawatta) (*at Dartonfield, Agalawatta*)

Senior Administrative Officer	D M S Dissanayake, BSc (Mgt.) (SL), MHRM (SL)
Assistant Medical Practitioner	M Subasinghe
Management Assistants (Clerical)	Mrs P W Neelamanie
	Mrs J A D Wijayanthi
	Mrs B D Niranjala
	Mrs O W D Namali Udayanthi
	Mrs P C Athukorala
	Mrs Thamosha Munasinghe
	Mrs O W D Nilusha Udayanthi
	Mrs M N D Perera
	Mrs B Chandralatha, BA (SL)
	Miss M G L Niroshani, BA (SL)

Management Assistant (Stenography)	Mrs J A H S Kumarie
Telephone Operator	Mrs J A D C Preethika
Administration Unit (Ratmalana)	(*at Telewela Road, Ratmalana*)
Administrative Officer	Mrs U K Akila Tharinduni, BSc (SL), PQHRM, MBM
Management Assistant (Clerical)	A T Senaratne
	Mrs A R M de Alwis
Internal Audit Unit	(*at Dartonfield, Agalawatta*)
Internal Auditor	Mrs M S I Senadeera, IFA, IPFA, IRCA, EPFA, PGDM
Management Assistants (Clerical)	M A D W K Tilakeratne
Works Section	(*at Dartonfield, Agalawatta*)
Resident Engineer	K A D K Chathuranga, BSc (Eng.). Hons, C. Eng. MIE (SL), AMSSE (SL), GREEN^{SL} AP
Engineering Assistant	Mrs W D D Prasadini, NDES
Technological Officer (Civil)	M A D K Jayasumana, NCT
Transport Officer	U L D R L Gunasinghe
Technological Officer (Mech.)	H J P Fernando, HNDE
Management Assistants (Clerical)	Mrs J A S Dharshanie (Dip. in Management)
	Mrs K K D K P Ranaweera
	Mrs M H W H Kumari, BSc (SL)
Accounts Section	(*at Dartonfield, Agalawatta*)
Senior Accountant	B S S Hewage, CPFA (UK), CBA, APFA
Accountant	Mrs A M Lasanthi, BSc (SL), MBA (SL), CBA, APFA (up to 18.08.2022)
Management Assistant (Accounting)	Mrs G P Kukulewithana
Management Assistants (Clerical)	Mrs C Dissanayake
	Mrs S I K Pathirage
	Mrs S A Niluka Harshani
	Mrs K K D Y L Ranaweera
	Miss K K T L Jayasekera
	J A J R Lakmal, Bcom. (SL)
	Mrs R P Thilini
	K A Dilan Sampath
	Mrs Erandi Kanchana Jayasinghe, BA (SL)
	Miss S R Sinhabahu
	G N K Gunasena
	Mrs K D Piyumi Hasara
Cashier	Mrs G A D D Jayawardena

Sub – stations & Estate

Kuruwita Sub-station	(*at Kuruwita*)
Management Assistants (Clerical)	D S Jayasinghe
Polgahawela Sub-station	(*at Narampola Estate, Nungamuwa, Yatigaloluwa*)
Research Officer	Mrs B M D C Balasooriya BSc (SL)
Management Assistant (Clerical)	D P N P Dissanayake
Moneragala Sub-Station	(*at Kumbukkana, Moneragala*)
Field Officers	V G D Nishantha Gunaseela
	N V U S Vijitha Kumara
Management Assistants (Clerical)	Mrs D M P Sandun Kumari
	*M M Chamath Kumara
Dartonfield Group	
Senior Manager - Estate	P A Lukshaman, BSc (SL)
Management Assistants (Clerical)	H D D Achinda
	M A N Sachith Pawinda
	T D Harsha
Field Officer	B M Siriwardena

* Contractual basis

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

Susantha Siriwardena

This reports outlines the key performance of the local rubber industry and global natural rubber demand and supply, and price fluctuations observed in 2022 and the major research and development (R&D) activities carried out by the institute. Performance in administrative and financial functions of the Institute are also included. Inability to retain the experienced and qualified technical staff due to the restrictions imposed by the government on new recruitments demands a new strategic approach to assure the satisfactory delivery of the mandatory objectives by the institute and the advisory services to the stakeholders. Other main constraints which hindered the progress of R & D activities are also briefed at the end of the report.

Rubber industry of Sri Lanka

Rubber production and consumption

As per the published statistics by the Rubber Development Department (RDD), Sri Lanka has produced 70,867 tonnes of natural rubber in main four conventional forms namely Ribbed Smoked Rubber (RSS), Centrifuged latex, Crepe rubber and Technically Specified Rubber (TSR). Of the total production, 49% of NR is produced in the form of RSS mainly manufactured by the smallholder sector, while next higher percentage (34%) was produced as centrifuged latex using field latex collected from both smallholder and plantation sectors. Total crepe rubber which was produced exclusively by the plantation sector mainly for export market was 14,466 tonnes. The balance of the total production (1.3 tonnes) was manufactured by the TSR manufacturers scattered in the country. However, according to the individual accounts of TSR manufacturers, this figure must be higher than the published data by the RDD. This demands a comprehensive study on the methodology of data collection and compilation.

It was observed that local NR production continued to further decline in the year 2022 by 7.8% compared to the previous year's production of 76,000 tonnes making Sri Lanka positioning at the 15th position among global natural rubber (NR) producing countries. This could be attributed to the reduction of normal tapping days due to adverse weather conditions, non application of fertilizer and the new Circular Leaf Fall Disease experienced in the year 2022.

Sri Lanka has consumed 117,288 tonnes of NR in 2022 while it was 128,300 tonnes in 2021. Overall, it was observed an approximately 8% reduction in demand of NR for rubber products by the local Rubber Industry. Dependence of the industry on imported NR was 40% of the local consumption.

NR exports and imports

As it has been in the previous years, Sri Lanka has exported NR in two forms namely Crepe rubber and RSS. RSS and Crepe rubber contributed to 15% and 74% of the total exports respectively while the balance was in miscellaneous types such as TSR and compounded rubber. The total NR exports from the country was recorded as 13,666 tonnes in 2022 against 15,490 tonnes of NR exports made in 2021 indicating a decline in exports.

Sri Lanka has imported around 64,459 tonnes of NR in 2022, mainly in the forms for TSR (20%), RSS (51%), Centrifuged NR latex & other latex (29%) and compounded rubber (0.3%). This record an 11% decrease in imports in 2022 compared with the figure for the year 2021.

Rubber extent

The total extent of rubber lands remained at 138,000 hectares in 2022 indicating no increase in the total rubber extent despite the launch of new cultivation programs such as Small Tea and Rubber rehabilitation (STaRR) program. This alarms on the zero rate replanting or some weaknesses in the statistic data collection methods adopted. It was also recorded that the rubber extent is made up of 123,000ha of mature rubber lands and 16,000 ha of immature rubber lands as at the end of the year 2022. Of this extent, about 68% of rubber lands are occupied by the smallholder sector in Sri Lanka and the rest of the area is managed by the large plantation companies. The country's average yield has also declined in line with the average production decrease. It was 621.5kg per ha in 2022. With the rapid expansion of rubber in non-traditional rubber growing countries in African region, it is important to take immediate measures to increase the local rubber productivity through proper nursery management, immature up keeping and application of good agricultural practices.

Natural rubber prices

Sri Lanka enjoyed a fairly reasonable price for both RSS and Crepe rubber during the first three quarters in 2022. The average price of rubber smoked sheet category 3 was US $ 1.74 in 2022 while it was as high as US $ 2.29 per kg in the middle of the year. The price of Latex Crepe rubber went up to US $ 3 per kg during the year 2022 which was a historic moment for the crepe rubber manufacturing industry in Sri Lanka. However, the prices of both these grades dropped heavily at the fourth quarter up to an average price~~s~~ of US$ (1.29) Rs.473 and US$ (1.70) Rs.625 per kg of RSS (no 3) and crepe (1X) respectively. However, special grades of crepe rubber (sole crepe) which has a low market volume fetched higher prices. According to local rubber product manufacturers, natural rubber market was hindered mainly by reduced rubber product consumption by the consumers due to the global economic crisis and the weak oil prices making large rubber product manufacturers compelled to halt their production and operate at sub-production rates. However, low

rubber prices prevailed in the country made pressure on smallholders, plantation management companies, researchers and policy makers to find alternatives ways to meet this challenge. It is clear that effective nursery management system, immature up keeping and adoption of good agricultural practices are of utmost importance to overcome this perennial low price challenge through enhancing the income generation per hectare of rubber land without sticking to bargain for higher prices for unit mass of rubber manufactured. As an attempt for possible immediate action to have a fair price for rubber produced by the smallholder farming, a weekly guidance price was announced by RRISL in its official website. This guidance price could be used by all stakeholders including buyers and sellers on various rubber platforms as it was developed considering weekly average international prices in concurrence with most of the local NR buyers.

Export earnings from raw rubber and rubber products

Export earnings from raw rubber has been increased from Rs.8.3 bn in 2021 to Rs.12 billion while the quantum of rubber exported reduced from 15,490 tonnes in 2021 to 13, 666 tonnes in 2022. Total export earnings from dry rubber based products and latex products recorded Rs.203 billion and Rs.87 billion in 2022 against Rs.135 billion and Rs.72 billion respectively earned in the previous year. As such, Sri Lanka has earned Rs.314 billion in the year 2022 against Rs.208 billion in the year 2021 recording an increase of about 39% against the previous year. This increase may be mainly due to the advantage gained by the devaluation of the local currency against US$ in the second half of the year. Export earnings from semi-processed rubber have been reported as 1.05 billion in the year 2022, while it was Rs.0.62 billion in the year 2021. Accordingly, total export earnings from the rubber industry remained at Rs.327.28 billion showing a 51% improvement from the previous year. Sri Lanka maintained its position as the largest contributor to the world Solid tyre trade and about 6% retardation was observed in this segment in 2022. In US$ terms, total exports earning from both raw rubber and rubber products exceeded US $ 1.01 billion in 2022 which was almost same (US$ 1.09) compared to the export earnings made in the previous year

Global Rubber Industry Review

Natural rubber supply

According to the statistics of Association for Natural Rubber Producing Countries (ANRPC), total world NR production was increased to 14,360 thousand tonnes in 2022 from 14,073 tonnes in the previous year 2021 recording a 2% annual increase. This is mainly due to the favourable NR price in the major markets in the Asia Pacific region during the year and tapping operations around the world became normal in the midst of overcoming the barriers imposed during the Covid-19 pandemic. The NR demand-supply gap has further narrowed down to 396 thousand tonnes in 2022 which was about 456 thousand tonnes in 2021.

NR average yield

NR average yield (YPH) in (ANRPC) countries varied between 624 kg/ha/year to 1720 kg/ha/year. Vietnam has recorded the highest national average while Sri Lanka has recorded the lowest. With this lowest national average of 624 kg/ha/year coming down from 679 kg/ha/year in the year 2021. Whilst most other ANRPC countries also have shown a declining trend in their national yield, Cambodia, India, Myanmar and Vietnam have shown an increasing trend.

Rubber extent

Total Rubber Extent in ANRPC countries has reduced by 2500ha in 2022 compared to the previous year. Of the total extent of natural rubber in ANRPC countries, 76% falls under tapped area. Study of distribution of plantations in the world signals that it is moving towards the countries with low Gross Domestic Product (GDP). With the limited lands available, it is very clear that Sri Lanka needs to take appropriate immediate measures to improve the productivity.

Global natural rubber demand

Total NR demand has increased to 14,756 thousand tonnes in 2022 showing a 1.5% increase from the previous year which was amounted to 14,529 thousand tonnes according to ANRPC. The NR demand-supply gap has further narrowed down to 396 thousand tonnes in 2022 which was about 456 thousand tonnes in 2021.

World NR price movement

Despite the declining trend prevailing in most of the markets starting from the year 2011 up to 2018, prices experienced a gradual decline for the year 2021 and 2022. Global rubber prices were slightly lower throughout the year 2022. In Sri Lanka, the annual average RSS3 price in 2022 was US$ 1.71 per kg which remained at US$ 2.20 in the year 2021. Though the market have seen an increase in rubber prices in local currency terms due to currency depreciation against US dollar, it saw a decrease in dollar terms. The average price of RSS3 was recorded as US$ 1.91 in 2022 in Bangkok against the previous year average value of US$ 2.02. Average Indian RSS4 has decreased to US$ 2.07 in year 2022 from US$ 2.29 per kg against the previous year. According to the predictions of ANPRC countries, global natural rubber prices are likely to remain stable around US$ 1.6 due to the weak global economic situation

Research and development focus

In a situation where imports had been curtailed, attention was paid to develop sustainable and safe latex coagulant from the locally available natural resources. Investigation into potential of rubber effluent water as a partial nutrient source for short-term crops as well as rubber nurseries was continued during the year 2022 with promising results. It is expected to offer dual advantages by providing solutions to waste water disposal and cutting down of fertilizer cost.

A low cost modified natural rubber latex based alternative for the currently used high cost imported synthetic polymer based binder was developed to manufacture papers using the fibres of the "Mana" weed. Environmentally and user-friendly sesame oil was used as an alternative to petroleum based aromatic processing oil in development of tyre tread compounds. Crepe rubber based products such as fishing bait, eraser, yoga mat and dental devices were developed in collaboration with industrialists with the aim of capturing local and foreign markets. Waste mica obtained from the mica mining industry was successfully exfoliated and introduced to natural rubber as a green filler. Three accelerator systems were identified as potential nitrosamine-safe accelerator systems for efficient sulfur vulcanization of NR. Rubber plants produced using root-balled technique (a new technique) and those produced using traditional stump budding method were compared and a 30% growth increment in the plants produced using the new technique was observed. With the aim of increasing productivity of rubber lands, efforts were made to introduce low intensity harvesting systems using commercially available ethephon as well as a locally formulated ethephon as the stimulant. This will offer additional benefits in managing the skilled latex harvester shortage, reducing the cost of production and enhancing the economic life span of rubber trees.

Newly developed, environmentally friendly and economically viable slow release fertilizer technique with 50% recommended fertilizers showed better growth parameters of immature plants up to the 2nd year. Due to a price increase of rubber-based porous tubes, coir based bricks (ECB) and a Reusable Fertilizer Porous Bag (RFPB) were introduced. These techniques reduced the initial preparation cost by 90% and fertilizer cost by 50%. Short term, mid term and long term strategies have been identified and recommended to minimize the effect of Circular Leaf Spot Disease. An interim chemical controlling system was also recommended to control the disease. Two microbe based bio pesticides have been introduced to control the white root disease, reducing the import volume of chemical fungicides to the country. In the process of expanding rubber cultivation to the drier climates, area specific rubber based farming models were introduced in North-Central province of the country. The available carbon credits that could be gathered from 3000 ha of new rubber smallholdings in Ampara district were validated by a third party accredited body in order to verify the carbon units.

Under the development projects, Two departments namely Raw Rubber and Chemical analysis (RRCA) department and Raw Rubber Process Development and Chemical Engineering (RRPD&CE) department established laboratory procedures as per ISO 17025 Laboratory accreditation protocol. The RRCA department also participated in the proficiency testing programme conducted by Malaysian Rubber Board and displayed outstanding performance among 15 international latex testing laboratories. The program of discarding the weak plants from nurseries was initiated in order to assure a supply of good quality plants to the growers. All the research departments provided testing and troubleshooting services to all categories of

stakeholders in the industry while providing training and research facilities to undergraduate and postgraduate students.

Hindrance of research activities

Vacancies at the permanent cadre of the institute in the research, technical and management categories were 47, 26 and 30 as at 01st January, 2022 and rose to 50, 33 and 38 as at 31st December, 2022. Retirement of the staff and increased number of resignations along with the government restrictions on the requirements are the main reasons for the above situation. As a research institute with mandatory obligations to cater to a specific industry (Rubber industry), maintaining an experienced technical staff is of great importance to deliver quality service to the stakeholders. If making of new requirements continues to be delayed, it questions the possibility of quality and efficient delivery of services to the stakeholders in the future. However, it is a pleasure to note that the cabinet of ministers has considered to establish an agrarian-technical University for both agriculture and plantation in response to the cabinet proposal made by the Hon. Minister of Plantations to form a university through amalgamation of crop research institutes and it is expected to provide a permanent solution to the said issue while strengthening the Research and development in the plantation sector. The progress of some of the development projects slowed down and extended to 2023 due to the unavailability of funds and high inflation rate connected issues. In addition, lack of experienced research and supporting staff, poor performing vehicle fleet and the economic crisis prevailed in the country hampered the progress of research and development activities to a certain extent.

Administrative and financial functions

Institute managed to offer advisory, troubleshooting activities and prioritized research and development work at a satisfactory level despite the financial and transport constraints prevailed in the country during the year. Extension and training programs were conducted virtually where ever possible through meeting the challenges. Two plant pathologists participated in two workshops conducted on management of "Pestalotiopsis" with the assistance of partial funding ~~a~~ from the Government and International Rubber Research and Development Board funds in addition to their personal funds. 100% of the approved annual budget was received; of which 100% was utilized. It was compelled to halt some of the development projects scheduled for the year following the guidelines given by the government due to poor financial situation and restrictions imposed.

Appreciation

The Ministry of Plantation Industries and Rubber Research Board are appreciated for the motivation, guidance and support extended to attend the prioritized activities despite the difficult situation prevailed in the country in the year. It is also appreciated the services rendered by the technical and non-technical staff of

the institute for their determinant contribution made unconditionally to deliver the services during the difficult periods of the year. The contribution made by the batch of 19 retired staff members including three senior scientists who retired on 31st December, 2022 is also appreciated.

The contributions made by Acting Additional Director, Acting Deputy Director (Biology), all Heads of the scientific and non-scientific departments/divisions in compiling this Annual Review are gratefully acknowledged. In particular, special appreciations are extended to the Economic Unit for providing required data in furnishing this report and to the staff in the Library and Publication Unit for compiling the materials and finally building up the Annual Review 2022.

GENETICS AND PLANT BREEDING

To enrich the Hevea breeding pool, sixty-eight new genotypes were raised in the annual hand pollination programme at Nuechattle Estate. Two non-Wickham germplasm selections were successfully used as the female parent for the first time in the local hybridization history. Comprehensive data collection from the 2009 ECT trial at the Eladuwa Estate trial continued to develop yield indexes for commercial-scale clonal evaluation. The previous year's hand-pollinated (HP) progenies (Small Scale Clone Trials) were maintained, evaluated and monitored during the year. Annual girth measurements and monthly latex volume data of Estate/RRI collaborative clone trials (ECTs) were taken from all registered and unregistered clones. Annual girth measurements were taken to evaluate the adaptability and performance of new promising clones at the clone trials established at non-traditional rubber growing areas under sub-optimal conditions.

The new Estate/RRI collaborative trial was established at the Eladuwa Estate with two selections of HP 98-132 from the 1998 HP evaluation at Nivitigalakele and the 2002 HP evaluation at Pallegoda Estate (HP 2002-201). 15 genotypes from 2012 and 15 genotypes from 2013 hand-pollinated progeny were selected and planted at Eladuwa Estate for small-scale evaluation.

Adaptability trials for foreign clones established at Galewatta Estate, Dartonfield Group and Neuchattle estate under the multilateral clone exchange programme were evaluated for their girth performance. The highest girth was recorded in the clones RRIT 3904, RRII 422, and ARCPC 2/4 from Thailand, India, and Myanmar, respectively.

The genotypes 1995HP-55, 1995HP-41, and 1995 HP-01 from the ECT trial at Yatadola Estate were used to study Ref gene expression and the yield performances reference to the clone RRISL 203. The quantitative gene expression proved that the Ref gene expression and yield were significantly higher than the control clone RRISL 203.

To study the drought tolerance of clones RRIC 121, RRIC 208, RRISL 2001, RRISL 2005, and RRISL 2006, relative quantification of the expression of eight genes under water-stressed conditions was compared with drought-tolerant clone RRIM 600. The clones RRISL2001, RRIC 121 & RRIC 208 showed significantly higher levels of expression compared to the clone RRIM 600. The clone RRISL2001 showed the highest drought tolerance considering physiological and molecular analysis.

GENETICS AND PLANT BREEDING

S P Withanage

DETAILED REVIEW

Staff

Dr (Mrs) S P Withanage, Head of the Department, Dr K K Liyanage, Principal Research Officer, Mr T B Dissanayake, Mr H P Peiris, Mr T M S K Gunasekera, Mrs A K Gamage, Experimental Officers, Mr B W A N Baddewithana, Mrs N S Jayasinghe, Technical Officers (Research and Development) and Mrs S D P K L Peiris, Management Assistant were on duty throughout the year.

Resignations & Retirements:

- Mrs T T D Dahanayake, Research Officer, resigned from duties with effect from 14th August. Her valuable contribution during this short period to the department is highly appreciated.

- Mr T B Dissanayake, Experimental Officer, retired from the service from the 31st of December. His 37 years of excellent service to RRISL and the legacy of hard work and commitment he left behind are highly appreciated. His true professionalism inspired everyone to be more, being a fantastic coworker and an even better friend. I wish him good health, delight, and success as he moves forward.

Research students

Four students from the Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, carried out their final year research projects under the supervision of Dr (Mrs) S P Withanage, as listed below:

- Ms S A C Sathsarani - Early detection of high-yielding genotypes (*Hevea brasiliensis*) based on the expression of Rubber Elongation Factor (Ref) gene
- Ms L U Pelagewaththa - Characterization of selected *Hevea brasiliensis* genotypes at early stage of the breeding cycle using morphological & Physiological parameters
- Ms R E H Lenora - Study the gene expression of GPX (Glutathione Peroxidase) & CAT (Catalase) genes in newly developed Rubber (*Hevea brasiliensis*) genotypes
- Ms D S K R Dewapriya - Screening the molecular diversity of selected interim clones in Rubber (*Hevea brasiliensis*) using SSR molecular markers

Meetings/Seminars and Workshops attended

Officer/s	Subject/Theme	Date	Organization
SP Withanage	Workshop on Writing quality paper	24th Mar.	RRISL
	Technology update Meeting	14th Sep.	RRISL
	Workshop on Procurement Procedures	3-4th Nov.	RRISL
	Estate Committee Meeting	19th Dec.	RRISL
SP Withanage & KK Liyanage	Workshop on Bark Auditing	06th Sep.	RRISL
	Scientific Committee Meeting	29th Sep.	RRISL
	Technology Update	25th Oct.	RRISL
	Scientific Committee Meeting	08th Dec.	RRB, Ratmalana
	Understanding of fundamentals of GIS & Remote Sensing in Rubber Plantation Management	21-22nd Dec.	IRRDB & RRISL

RESEARCH

Early Detection of promising Rubber genotypes (Hevea brasiliensis) precisely to reduce the period of the breeding cycle

In conventional breeding approaches, the long breeding cycle is one of the major limiting factors for the genetic improvement of rubber. Studies have been undertaken to select promising genotypes early in the breeding cycle using molecular strategies and morphological and physiological parameters. Four superior genotypes of 2011 HP selections were chosen from the Estate Collaborative Trial 2018 at Eladuwa Estate. They were characterized for different parameters such as girth, bark thickness, first branching height, photosynthesis rate, chlorophyll content, stomatal conductance, and leaf area at the age of four years. The principal component and cluster analyses were performed to identify the diversity and promising parameters. Three potential parameters (girth, bark thickness, and stomatal conductance) were identified as early selection criteria. The genotypes 2011HP42 and the clone RRISL 2006 showed significantly higher performances compared to other genotypes tested.

Previous studies have proven a positive relationship between *Ref* gene expression and latex yield performance. Three genotypes, *i.e*. 1995HP-55, 1995HP-41, and 1995 HP-01 from the Estate collaborative Trial at Yatadolawatta, were used to study *Ref* gene expression and the yield performances, reference to the clone RRISL 203. The Livak method ($\mathbf{2^{-\Delta\Delta CT}}$) was used to analyze quantitative gene expression, and it proved that *Ref* gene expression and yield were significantly higher than the control clone RRISL 203. Therefore, this study confirmed the potential for selecting high-yielding genotypes by using *Ref* gene expression at the early stage of the rubber breeding cycle (S P Withanage, A K Gamage and N S Jayasinghe).

Screening of Drought/Stress tolerant Hevea clones for sustainable rubber cultivation in marginal areas

The experiment was conducted to study the drought tolerance of recommended *Hevea* clones. This year, five clones (RRIC 121, RRIC 208, RRISL 2001, RRISL 2005, and RRISL 2006) were selected.

The relative quantification of the expression of eight genes under water-stressed conditions was compared to the already identified drought tolerant clone, RRIM 600.

The clones RRISL 2001, RRIC 121 and RRIC 208 showed significantly higher levels of expression compared to the clone RRIM 600. The clone RRISL 2001 showed the highest drought tolerance capacity considering both physiological and molecular analysis.

Hand pollination programme

The annual hand pollination programme was done at Neuchatel Estate, and 68 new genotypes were raised. Two non-Wickhamm germplasm selections were successfully used as the female parent for the first time of the local hybridization history. Two clones were used as male parents to develop genetically diverse high – yielding, vigorous genotypes. Details of new genotypes and crosses made are given in Table 1.

Table 1. *Details of parentage and the number of genotypes obtained in the 2022 hand pollination programme*

Cross	No. of genotypes obtained	Progeny numbers
MT 11-76 I x RRISL 2006	46	2022 HP 01 - 46
MT 11-76 I x RRISL 211	15	2022 HP 47 - 61
MT 11-76 I x Illegimate	03	2022 HP 62 - 64
MT 11-76 II x RRISL 2006	04	2022 HP 65 - 68
Total	**68**	

(S P Withanage, K K Liyanage, T T D Dahanayake, B W A N Baddewithana and T M S K Gunasekara)

Multilateral Clone Exchange Programme

A Memorandum of understanding was signed in 2015 by the fifteen member countries of the International Rubber Research and Development Board (IRRDB) to exchange materials under the multilateral clone exchange programme. Objectives are to promote international cooperation and capacity building in the IRRDB member countries for the betterment of the natural rubber industry and to evaluate the performance of all the exchanged clones in different agro-climatic conditions in the member countries.

The filling of vacancies at the second adaptability trial established at Galewatta and Dartonfield Group was done. The average girth of clones after the second year, in the adaptability trial established at Neuchattle Estate, is given in Table 2. The highest girth was recorded in the clones RRIT 3904, RRII 422, and ARCPC 2/4, received from Thailand, India, and Myanmar, respectively.

Table 2. *Average girth of foreign clones established at Neuchatel Estate*

Country of origin	Clone	Number of plants	Average girth (cm)	
			2021	2022
Thailand	RRIT 251	24	10.9	16.3
	RRIT 3904	24	13.3	21.7
	RRIT 3604	24	6.0	8.1
	RRIT 226	24	9.4	17.0
	RRIT 408	24	9.7	14.0
India	RRII 414	24	11.6	16.7
	RRII 417	24	11.4	16.0
	RRII 422	23	12.5	18.7
	RRII 429	24	10.1	17.9
	RRII 430	23	8.1	16.1
Myanmar	ARCPC 2/4	20	13.3	22.2
	ARCPC 6/22	26	11.2	17.0

(S P Withanage, K K Liyanage, T T D Dahanayake, T B Dissanayake T M S K Gunasekara and B W A N Baddewithana)

Evaluation of mother plant nursery

Evaluation of mother plant nurseries was not done due to the prevailing weather conditions.

Evaluation of the previous hand-pollinated (HP) progenies in Small-Scale Clone Trials

The summary of the small-scale clone trial maintained and monitored during the year under review is given in Table 3.

Table 3. *Summary of Small Scale Trials*

HP year	Site	Planting season	Current status
2001	Kuruwita SS	Nov 2007	8th year of tapping
2002	Pallegoda I	July 2007	8th year of tapping
2002	Eladuwa II	May 2009	7th year of tapping
2004	Eladuwa Trial I	July 200	7th year of tapping
2005	Monaragala	Nov 2014	Immature
2006	Payagala	Aug 2012	4th year of tapping
2007	Kuruwita SS (seedlings)	July 2009	6th year of tapping

HP year	Site	Planting season	Current status
2010	Eladuwa	Nov 2016	Immature
2011	Eladuwa	Oct 2018	Immature
2012	Eladuwa	Nov 2022	Immature
2013	Eladuwa	Nov 2022	Immature

(S P Withanage, K K Liyanage, T T D Dahanayake, T B Dissanayake, H P Peiris, T M S K Gunasekara, A K Gamage, B W A N Baddewithana and N S Jayasinghe)

Evaluation of 2001 HP clones, Kuruwita Sub-station (GPB/BST/HPS/2001/02)

The eighth-year mean yield of the topmost promising 2001 HP entries at Kuruwita Substation is given in Table 4b, and their fifteenth-year girth values are shown in Table 4a. Top-ranked HP entry (2001 HP-183) had yielded 79.0 g/t/t and greater than the control clone RRISL 203. As some of the selections of this trial show TPD symptoms, it is decided to wind up the trial after selecting the best-performing clone for small-scale evaluation.

Table 4a. *The mean girth of the best performing HP entries of the 2001 HP progeny planted in 2006 in Kuruwita Sub-station*

Clone	Mean girth (cm)
2001 HP-220	76.6^{a}
RRIC 121	73.8^{ab}
2001 HP-185	69.9^{abc}
2001 HP-205	66.9^{bcd}
2001 HP-179	66.4^{bcd}
2001 HP- 183	65.8^{bcd}
2001 HP-227	65.7^{bcd}
2001 HP-207	64.5^{bcde}
RRISL 203	64.5^{bcde}

Table 4b. *Mean yield of the best performing HP entries of the 2001 HP progeny planted in 2006 in Kuruwita Sub-station*

Clone	Yield (g/t/t)
2001 HP-183	79.00^{a}
RRISL 203	33.57^{b}
2001 HP-185	32.45^{b}
2001 HP-205	29.82^{bc}
RRIC 121	29.71^{bc}
2001 HP-207	26.31^{bc}
RRISL 203	24.05^{bcd}

(T T D Dahanayake, S P Withanage, K K Liyanage and H P Peiris)

***Evaluation of 2002 HP clones, Pallegoda Estate* (*GPB/BST/HPS/2002/01*)**

Fifteenth-year girth measurements were taken, and the mean girth of clones was grouped using Duncan's multiple range tests, and the results are given in Table 5. Genotypes 2002 HP-96 and 2002 HP-18 have performed better in comparison to the control clone RRISL 203. Yield data collection was disturbed due to bad weather.

Table 5. *The mean girth of best-performing HP entries selected from the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002 HP-96	81.3^{a}
2002 HP-18	77.1^{ab}
RRISL 203	76.7^{abc}
2002 HP-14	76.5^{abc}
2002 HP-17	73.0^{bcd}
2002 HP-11	72.8^{bcde}
2002 HP-71	71.5^{bcdef}
2002 HP-69	70.8^{bcdef}
2002 HP-77	70.5^{bcdef}
2002 HP-24	70.4^{bcdef}

(S P Withanage, K K Liyanage, T T D Dahanayake and B W A N Baddewithana)

***Eladuwa - trial II* (*GPB/BST/HPS/2002/02*)**

Thirteen genotypes from 2002 hand pollination progeny were planted with two control clones, RRIC 121 and RRISL 203. A randomized Complete Block Design was used with four replicates per genotype. The replicate size was six. The thirteenth-year girth was taken at 150cm from the bud union, and mean girth values are shown in Table 6a. Seventh-year tapping data were collected from the above progeny, and mean yields of the best-performing genotypes are given in Table 6b. The progenies, 2002 HP-138 and 2002 HP-78, recorded the highest yield (g/t/t) compared to the best-perform g control clone RRIC 121.

Table 6a. *Mean girth at thirteenth-year of best performing HP entries and control clones selected from the 2002 HP progeny planted in 2009 at Eladuwa*

.

Clone	Mean girth (cm)	Clone	Mean girth (cm)
2002 HP-138	88.0^{a}	2002 HP-19	64.3^{ef}
2002 HP-93	77.8^{b}	2002 HP-9	64.0^{ef}
2002 HP-66	75.7^{bc}	2002 HP-62	59.8^{fg}
2002 HP-30	73.5^{bcd}	RRISL 203	59.5^{fg}
2002 HP-139	70.3^{cde}	2002 HP-78	55.9^{hg}
RRIC 121	68.2^{de}	2002 HP-52	54.5^{hg}

(S P Withanage, K K Liyanage, T T D Dahanayake and T B Dissanayake)

Table 6b. *Mean yield at seventh-year of best performing HP entries and control clones selected from the 2002 HP progeny planted in 2009 at Eladuwa*

Clone	Mean yield (g/t/t)	Clone	Mean yield (g/t/t)
2002 HP-138	82.84[a]	2002 HP-93	26.35[b]
2002 HP-78	66.44[a]	2002 HP-66	24.36[b]
RRIC 121	27.78[b]	2002 HP-62	22.34[b]
2002 HP-9	27.58[b]	RRISL 203	22.20[b]
2002 HP-58	27.50[b]	2002 HP-139	22.04[b]

Evaluation of 2004 HP clones

Twenty-two genotypes from 2004 hand pollination progeny were planted at Eladuwa Estate in 2009. The clone RRIC 121 was used as the control clone. A Randomized Complete Block Design was used with four replicates per genotype.

Eladuwa Estate trial II (GPB/BST/HPS/2004/02)

The thirteenth-year girth was taken. The HP entry 2004-347 showed significantly higher girth, and four entries were ranked as similar to the clone RRIC 121 (Table 7).

Table 7. *The mean girth of the 13th year of the best performing HP entries selected from the 2004 HP- progeny planted at Eladuwa Estate. Mean values with the same letter are not significantly different*

Clone	Mean girth (cm)
2004 HP-347	68.3[a]
RRIC 121	65.2[ab]
2004 HP-456	65.0[ab]
2004 HP-48	65.0[ab]
2004 HP-107	64.9[ab]
2004 HP-164	64.6[abc]
2004 HP-178	64.5[abc]
2004 HP-50	63.6[abcd]
2004 HP-228	63.1[abcd]
2004 HP-190	60.5[bcd]

(S P Withanage, K K Liyanage, T T D Dahanayake and B W A N Baddewitana)

Evaluation of 2006HP- progeny - Payagala Estate (GPB/BST/HPS/2006)

Sixteen genotypes selected from 2010 HP progeny were planted in Payagala Estate in Complete Randomized Design with control clones, RRISL Centennial 1 and RRISL 203. All agronomical practices were done according to RRISL recommendations. The tenth-year girth was taken, and the mean girth values of only the best-performing genotypes higher than the control clone (RRISL Cen 1) are given in Table 8.

Table 8. *Mean girth for the tenth year for HP-entries of best-performing genotypes with their control clones of the 2006 HP- progeny planted at Payagala Estate*

Clone	Girth (cm)
2006 HP-23	71.6[a]
2006 HP-128	67.3[ab]
2006 HP- 135	66.6[ab]
2006 HP-119	64.1[bc]
2006 HP-33	63.0[bcd]
2006 HP-237	61.7[bcde]
2006 HP-85	60.1[cdef]
RRISL 203	59.5[cdefg]
RRISL Cen. 1	58.6[cdefg]

(T T D Dahanayake, S P Withanage, K K Liyanage and T B Disanayake)

Evaluation of 2007 HP- progeny - Kuruwita Sub Station (GPB/BST/HPS/2007/01)

Thirteenth-year girth data were collected for the seedling progeny, and family means are given in Table 9a. Family RRIC 130 x GP 21-163 recorded the highest girth. Fifth-year tapping data were collected from the above progeny, and family means are given in Table 9b. Family RRIC 130 x GP 44-24 recorded the highest yield (g/t/t).

Table 9a. *Family mean girth of 2007 HP - progeny at the Kuruwita Substation planted in 2008*

Clone	Mean girth (cm)
RRIC 130 x GP21-163	72.2
RRIC 130 x 1-2	72.0
RRIC 130 x GP22-137	70.7
PB 260 x IAN 45-710	66.0
IAN 45-710 x PB 260	64.8
RRIC 130 x GP10-154	63.3
IAN 45-717 x PB 260	58.2
RRIC 130 x GP44-24	54.4

Table 9b. *Family mean yield of 2007 seedling HP progeny planted in 2008*

Clone	Yield (g/t/t)
RRIC 130 x GP44-24	33.09[a]
RRIC 130 x GP21-163	29.07[a]
PB 260 x IAN 45-710	26.09[a]
RRIC 130 x GP22-137	23.85[a]
RC 130 x GP10-154	20.74[a]
IAN 45-710 x PB260	16.49[a]
IAN 45-717 x PB 260	20.72[a]

(T T D Dahanayake, S P Withanage, K K Liyanage and H P Peiris)

Evaluation of 2005 HP progeny planted in 2014 at Monaragala GPB/BST/HPS/2005/01

Thirty-five genotypes from 2005 hand pollination progeny which were raised by double selfing of *Corynespora* susceptible clone RRIC 103 and resistant clone RRIC 100 were established at Monaragala substation with parental clones RRIC 100, RRIC 103, grandparents, RRIC 52 and PB 86, and RRISL 201 as a check clone in the year 2014. A Complete Randomized Design was used with ten replicates per genotype. The progeny performed below average; the eight-year average girth was around 34cm (Table 10). Trees are to be prepared for the pollination programme to develop pseudo hybrids and pure lines concerning clones RRIC 100 and 103.

Table 10. *Mean girth at eight-year of best performing HP entries parental clone and control clones from the 2005 HP progeny planted in 2014 at Monaragala*

Clone	Mean girth (cm)	Clone	Mean girth (cm)
RRIC 103	50.5^{a}	PB 86	39.3^{abc}
RRIC 52	45.0^{ab}	2005 HP-17	39.3^{abc}
2005 HP-07	43.8^{ab}	RRIC 100	38.6^{abc}
2005 HP-27	43.1^{ab}	2005 HP-11	38.4^{abc}
2005 HP-58	42.6^{ab}	2005 HP-02	38.2^{abc}
2005 HP-48	42.0^{ab}	2005 HP-09	38.1^{abc}

(S P Withanage, K K Liyanage, T T D Dahanayake and T B Dissanayake)

Evaluation of 2010 HP progeny planted in 2016 at Eladuwa GPB/BST/HPS/2010/01

Sixteen genotypes selected from 2010 HP progeny were planted in the Eladuwa Estate in Complete Randomized Design with control clones, RRIC 121 and RRISL 2001. All agronomical practices were done according to RRISL recommendations. The sixth-year girth was taken, and the mean girth values of only the best-performing genotypes higher than the control clone (RRIC 121) are given in Table 11.

Table 11. *Mean girth for the sixth year for HP-entries of best-performing genotypes with their control clones of the 2010 HP- progeny planted at Eladuwa Estate*

Clone	Girth (cm)
2010 HP-38	46.0^{a}
2010 HP-4	45.4^{ab}
2010 HP- 9	42.9^{abc}
2010 HP-35	42.7^{abc}
2010 HP-22	42.0^{abc}
2010 HP-44	41.8^{abcd}
2010 HP-41	41.0^{abcde}

Clone	Girth (cm)
2010 HP-11	40.9^{abcde}
RRISL 121	40.8^{abcde}

(S P Withanage, T T D Dahanayake, K K Liyanage and A K Gamage)

Evaluation of 2011 HP progeny planted in 2018 at Eladuwa GPB/BST/HPS/2011/01

Sixteen genotypes selected from 2011 HP progeny were planted in Eladuwa Estate in Complete Randomized Block Design with control clones, RRIC 121 and RRISL 2001. All agronomical practices were done according to RRISL recommendations. The fourth-year girth was taken, and the mean girth values of the best-performing six genotypes are given in Table 12 with the control clone RRIC 121.

Table 12. *Mean girth for the fourth year 2011 HP-entries of best performing six genotypes with their control clones planted at Eladuwa Estate*

Clone	Girth (cm)
2011 HP-236	34.1^{a}
2011 HP-75	33.5^{a}
2011 HP-198	32.9^{ab}
2011 HP-302	32.8^{ab}
2011 HP-71	32.7^{ab}
2011 HP-300	32.7^{ab}
RRIC 121	32.1^{ab}

(S P Withanage, T T D Dahanayake, K K Liyanage and A K Gamage)

Estate/RRI collaborative clone trials (ECT's) GPB-01c

Annual girth measurements were taken from all the trials. Table 13a (registered clones) and 13b (unregistered clones) show the planting sites, year of planting, and girth measurements at 150cm for the year under review and the previous two years.

Table 13a. *Mean annual girth measurements for registered clones of ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Mean girth (cm)		
			2020	2021	2022
RRISL 201	Dammeria B	2010	51.1	51. 9	54.0
	Eladuwa	2009	60.8	61.7	62.2
RRISL 203	Wewassa	2011	57.3	61.5	64.5
	Lagos	2011	58.7	59.7	60.5
	Lagos	2013	54.5	57.3	58.2
	Muwankanda	2010	NT	56.5	-
	Dammeria B	2010	41.5	41.8	42.7
	Kamburupitiya	2011	67.1	68.0	68.6

Clone	Site	Year of planting	Mean girth (cm)		
			2020	2021	2022
RRISL 208	Lagos	2013	54.0	56.5	57.3
	Moralioya	2010	60.6	62.6	63.4
	Eladuwa	2009	70.5	58.8	59.5
RRISL 219	Kuruwita	2008	55.5	56.4	57.0
RRISL 2000	Kuruwita	2005	74.6	75.8	76.4
RRISL 2001	Dammeria B	2010	58.8	60.2	62.6
	Muwankanda	2010	NT	65.2	
	Wewassa	2011	52.5	56.9	58.8
	Lagos	2013	53.7	56.4	57.5
RRISL 2003	Lagos	2013	55.6	58.4	59.3
RRISL 2006	Lagos	2013	50.7	53.6	55.0
	Eladuwa	2009	62.3	63.5	64.1
	Moralioya	2010	63.0	65.9	66.7
RRISL 2100	Edalla	2010	57.8	61.2	62.5
	Kuruwita	2011	53.6	54.9	56.1
	Notinghill	2021	-	-	6.0
RRISL Centennial 2	Eladuwa	2009	67.9	68.7	69.2
RRISL Centennial 3	Kuruwita	2009	61.8	62.3	63,3
	Eladuwa	2009	68.4	69.0	69.5
	We-oya	2010	62.5	63.6	65.2
	Edalla	2010	64.5	69.0	70.7
	Kuruwita	2011	59.8	61.6	62.4
	Siriniwasa	2011	61.6	62.1	63.0
	Lagos	2013	56. 7	58.9	59.7
RRISL Centennial 4	Kuruwita	2007	59.1	60.3	60.6
	Eladuwa	2009	57.13	60.0	60.4
	Lagos	2011	61.73	63.1	64.8
RRISL Centennial 5	Eladuwa	2009	61.61	62.2	62.8
	Kuruwita	2007	65.3	66. 4	67.0

*girth is taken at 1.5m height as commenced the tapping in this year

Table 13b. *Mean annual girth measurements of un-registered entries selected to ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2020	**2021**	**2022**
GPS II	Kuruwita	2005	58.2	58.7	59.5
HP 86-10	Kuruwita	2009	53.0	53.1	54.1
HP 86-87	Kuruwita	2009	55.8	56.6	57.5
HP 87-235	Kuruwita	2008	57.3	58.7	60.0
HP 92-129	Kuruwita	2007	61.6	83.5	63.9
HP 95-55	Lagos	2013	57.9	61.1	62.6
RRIC 100 seedlings	Kuruwita	2005	75.0	75.4	76.3
MT 11-76i	We-oya	2021	-	-	5.5
MT 11-76ii	We-oya	2021	-	-	5.2

(S P Withanage, K K Liyanage, T T D Dahanayake, T B Dissanayake, H P Peiris, T M S K Gunasekara, A K Gamage, B W A N Baddewithana and N S Jayasinghe)

Monthly latex volume data was collected from the following trials. Table 14a represents the planting sites, year of planting and g/t/t values for the year of registered clones, and Table 14b illustrates the above value for unregistered clones.

Table 14a. *Yield (g/t/t) values of clones evaluated*

Clone	Tapping system	Site	Year of planting	Average yield (g/t/t)	Year of tapping
RRIC 100 (Seedling trial)	S2 d3	Kuruwita	2005	13.36	11th
RRISL 201	S2 d2	Eladuwa	2009	18.81	6th
RRISL 203	S2 d2	Dammaria B	2010	33.41	4th
	S2 d2	Lagos	2011	55.58	6th
	S2 d2	Eladuwa	2009	31.43	6th
RRISL 208	S2 d2	Eladuwa	2009	40.70	6th
	S2 d3	Kuruwita	2008	15.91	6th
RRISL 2001	S2 d2	Dammaria B	2010	30.04	4th
Centennial 2	S2 d2	Eladuwa	2009	13.01	6th
Centennial 4	S2 d2	Kuruwita	2007	20.27	7th
	S2 d2	Lagos	2011	49.12	6th
	S2 d2	Eladuwa	2009	33.16	6th
Centennial 3	S2 d2	We-Oya	2010	41.32	6th
	S2 d4	Siriniwasa	2011	41.95	5th
	S2 d2	Eladuwa	2009	26.15	6th
	S2d3	Kuruwita	2011	18.77	5th
	S2d2	Kuruwita	2009	9.67	6th
RRISL 2006	S2 d3	Moralioya	2010	NT	4th
	S2d2	Eladuwa	2009	52.36	6th
Centennial 5	S2 d2	Eladuwa	2009	28.15	6th
	S2 d2	Kuruwita	2007	17.9	7th
RRISL 2000	S2 d3	Kuruwita	2005	13.75	11th
RRISL 2100	S2d3	Kuruwita	2011	19.64	5th

(S P Withanage, K K Liyanage, T T D Dahanayake, T B Dissanayake, T M S K Gunasekara, H P Peiris, A K Gamage, B W A N Baddewithana and N S Jayasinghe)

Table 14b. *The mean annual yield of un-registered entries selected to ECTs (Estate/RRISL Collaborative Trials)*

Clone	Tapping system	Site	Year of planting	Average yield (g/t/t)	Year of tapping
GPS II	S2d3	Kuruwita	2005	17.94	10th
HP 86-10	S2d3	Kuruwita	2009	15.34	6th
HP 86-87	S2d3	Kuruwita	2009aq	10.52	6th
HP 87-235	S2d2	Kuruwita	2008	7.43	7th
HP 92-129	S2d2	Kuruwita	2007	20.32	7th
HP 95-55	S2d2	Lagos	2013	-	-

(S P Withanage, K K Liyanage, T T D Dahanayake, T M S K Gunasekara and H P Peiris)

New establishments

ECT/RRI collaborative trials were established at Eladuwa Estate, Eladuwa. The details of the clones established are given in Table 15.

Table 15. *Details of clones, the month of plating and the number of plants established*

Estate and Agro-climatic Zone	Clone	Month of planting	No. of plants established
Eladuwa Estate - Eladuwa (WL 1a)	HP 98-132	December	150
	HP 2002-201	December	150

(S P Withanage, K K Liyanage and A K G Gamage)

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

Multiplication, establishment, and scientific evaluation of the *Hevea* germplasm collection continued to enhance productivity through genetic improvement and management of the genetic resources of *Hevea.* Preparation of plants for the filling vacancies in last year's establishment was done. Trees of two germplasm selections, *i.e*. MT 11-76 I and MT 11-76 II, were used as the female parent in the hand pollination programme (S P Withanage, K K Liyanage, T T D Dahanayake, B W A N Baddewithana and T M S K Gunasekara).

Testing of promising clones for sub-optimal conditions

The project's objective is to evaluate the adaptability and performance of new promising clones in non-traditional rubber growing areas (sub-optimal conditions).

Smallholder/RRI collaborative clone trial – Eastern province and control trial established at Kalutara district - 2012 planting

Seven experimental plots were established in Padiyathalawa/Mahaoya areas in the Eastern Province. Their control (reference) plot was established at Bandaragama, which belongs to traditional rubber growing regions. Details of these trials are given in Table 16.

Table 16. *Details of smallholder/RRI collaborative trials at Eastern Province and the ninth-year mean girth data*

Trial	Smallholder and location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)*
SRT-EP 12/1	SM Wirawardana Marawa Padiyathalawa	IL2	> 1600	RRISL 2001	55.41
				RRISL 203	54.03
				RRISL 2005	57.01
				RRISL 2006	50.98

Trial	Smallholder and location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)*
SRT-EP 12/2	Indrani Kusumalatha Marawa Padiyathalawa	IL2	>1600	RRISL 203 RRIC 121 RRISL 2001 RRISL 2006	60.1 59.80 58.96 55.73
SRT-EP 12/3	AM Sumanawathi Helakomana Padiyathalawa	IL2	> 1600	RRISL 203 RRIC 100 RRISL 2005 RRISL 208	55.12 55.36 58.39 53.21
SRT-EP12/4	HM Wimalasena Kudaharasgala Mahaoya	IL2	> 1600	RRISL 208 RRISL 2005 RRIC 100 RRISL 203	59.45 58.8 56.10 51.88
SRT-WP 12/8	Ranjith Thambawita Bandaragama Panadura (Kalutara district - Control Trial)	WL 1a	>3300	RRISL 208 RRISL CEN 3 RRISL 2001 95HP - 55 RRISL 203 RRIC 100 RRISL 211 RRISL 2005	64.17 66.06 67.13 70.28 66.5 69.94 61.11 66.15

*****As the trees are open for tapping, girth measurements were taken at 150cm height

(S P Withanage, K K Liyanage, T T D Dahanayake, T B Dissanayake and T M S K Gunasekara)

Smallholder/RRI collaborative clone trial – Eastern Province (Ampara district) -2013

Planting

The eighth-year mean girth of three experimental plots established in Ampara area in the Eastern Province is given in Table 17. Tapping panel marking and latex processing were practiced as the trials were at the tappable girth.

Table 17. *Details of smallholder/RRI collaborative clone trials planted in 2013 in the Eastern Province and the eighth-year mean girth data*

Trial	Smallholder & Location	Agro-climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones planted (No. of trees)	Mean girth (cm)
SRT-EP 13/1	HM Jayarathna 17-1 C, Lathugala Warankatagoda	DL2a	> 1300	RRIC 121(210)	57.63

Trial	Smallholder & Location	Agro -climatic Region	75% expectancy value of Annual Rainfall (mm)	Clones planted (No. of trees)	Mean girth (cm)
SRT-EP 13/4	HM Saman Kumara 17/1 B, Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	61.32
SRT-EP 13/5	M Chandrani Ranasingha 51 B - 2, Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	56.44

(S P Withanage, T T D Dahanayake, K.K Liyanage and T M S K Gunasekara)

Smallholder/RRI collaborative clone trials – Eastern Province established in 2014

Details of four experimental plots that were established in the Mahaoya area, with three RRISL 2000 series clones and clone RRIC 121 in October 2014, are given in Table 18. The eight-year girth was not taken due to the travelling difficulties. However, we decided to terminate these trials due to poor support received from the smallholders.

Table 18. *Details of smallholder/RRI collaborative clone trials planted in 2014 in the Eastern Province*

Trial	Smallholder & Location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)
SRT-EP 14/1	G Senevirathne Mahaoya	IL2	>1600	RRIC 121	Not taken
SRT-EP 14/2	M Senevirathne Mahaoya	IL2	> 1600	RRISL 2001	Not taken
SRT-EP 14/3	AM Jayasekara Mahaoya	IL2	>1600	RRISL 2006	Not taken
SRT-EP 14/4	TM Amarasena Mahaoya	IL2	>1600	RRISL 2005	Not taken

(K K Liyanage, S P Withanage, T T D Dahanayake, T M S K Gunasekara and T B Disanayake)

Smallholder/RRI collaborative clone trial planted in 2015 - Uva Province

Four experimental sites were established in the Bibile area in collaboration with the World Vision Organization. Seventh-year girth data were taken and are given in Table 19. One trial was established in Kataragama, and the sixth-year girth data were taken, and details are shown in Table 20.

Table 19. *Details of smallholder/RRI collaborative clone trials planted in 2015 in Uva Province and seventh-year mean girth data*

Trial	Smallholder & Location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones & the number of plants	Mean girth (cm)
Bibile					
SRT-UP 15/1-WV	HM Punchibanda Ilukpathana	IL1c	>1300	RRISL 2001 (215)	38.74
SRT-UP 15/2-WV	AM Karunawathie Ilukpathana	IL1c	>1300	RRISL 2001 (215)	Not Taken
SRT-UP 15/3-WV	HMW Wijekumara Kudumirisketiya Ilukpathana	IL1c	>1300	RRISL 2001 (430)	40.55

Table 20. *Details of smallholder/RRI collaborative clone trials planted in 2016 in Uva Province and sixth-year mean girth data*

Trial	Smallholder and Location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones & the number of plants	Mean girth (cm)
Kataragama					
SRT-UP 15/5	GK Chaminda Diyawaragmmana Junction, Sella Rd Kataragama	DL 5	>650	RRISL2001 RRISL 203 (215)	32.71 34.62

(S P Withanage, K K Liyanage, T B Dissanayake and T M S K Gunasekara)

Smallholder/RRI collaborative clone trial planted in 2015 - North Central Province

One experimental trial was established in the Polonnaruwa district; details are given in Table 21. The seventh-year girth was not taken due to the travelling difficulties. However, we decided to terminate this trial due to poor support received from the growers.

Table 21. *Details of smallholder/RRI collaborative clone trials planted in 2015 in North Central Province*

Trial	Smallholder and Location	Agro-ecological region	75% expectancy value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)
SRT-NCP 15/1	Army Camp Kandakaduwa Polonnaruwa	DL1c	>900	RRISL 2001 (500) RRISL 2006 (500)	Not taken

(S P Withanage, K K Liyanage and T B Dissanayake)

PLANT SCIENCE

The effect of row arrangements of root-stock nurseries on the growth of rubber resulted in more than 80% of higher success rates in three and four-row systems when compared to single and double-row systems. Promising results were obtained from the rapid and juvenile bud grafting techniques. The study "The exogenous application of Salicylic Acid on the growth performance of rubber nursery plants" revealed that the decrease in stem diameter could be alleviated under water stress conditions. Application of 0.2mM Salicylic acid would be the most effective concentration for plants that were under water stress conditions. Root-balled plants planted with coir pith in different quantities would result in a high growth rate during the immature period when introduced to drier areas.

New tapping systems have been studied in Sirikandura Estate, Mathugama to optimise the tapping and Out of the six treatments i.e.; S/2D d6 5% ET (Monthly) (T6), S/4U d3 2.5% ET + S/2D d3 2.5%ET (Panel changing year by year, alternatively) (T5) and S/2 d2 + Recommended number of Recovery Tappings per month (Control) (T1) were recorded higher g/t/t values due to the lower tapping intensity when compared to other treatments. S/4 d1 + With Rainguards (No Recovery Tapping) (T3) recorded the lowest value due to the effects of both higher frequency and shorter cut length and half spiral daily tapping (T2) recorded a moderate value due to the absence of rain guards. The treatment which has an additional tapping cut for the holidays (T4) recorded a total value of 49.3 g/t/t in holidays to cover the additional cost to be paid for the tapper for holiday tappings. Intercropping trials were assessed in Wet and Intermediate Zones and the trial on the "effects of different spacing systems of Rubber x Cardamom" was continued at a smallholding farmer field at Labugama. The growth, yield and physiological data of rubber and fruit crops were gathered and the performance of all inter-crops much better in the wider spatial arrangements of rubber, i.e., 2.5m x 12.0 m compared to other spacing systems.

Two hundred and thirty one nursery inspections were done, and about 312,943 plants were certified in RDD nurseries. Approximately, 551,055 in RPCs and 326,780 plants in private nurseries have been certified. Around 289,674 weak plants were discarded at RDD nurseries in collaboration with Rubber Development Department. Around 517,216 and 55,500 weak plants were discarded at RPCs and private nurseries respectively. Thirty advisory visits and 30 training programs were conducted on nursery management and tapping.

PLANT SCIENCE

T U K Silva

DETAILED REVIEW

Staff

Mr T U K Silva, Dr (Mrs) D S A Nakandala, Senior Research Officers, Mr W D M N de Alwis, Research Officer, Mr D L N de Zoysa, Mr P D Pathirana and Mr P K W Karunatilaka, Experimental Officers, Mr R Handapangoda, Mrs E U M D Z Dissanayake, Miss H Subasinghe, Mr D Priyadarshana, Mrs U N Udayakumari and Miss W M D Wickramakumari, Technical Officers and Mrs P D A H M A de Almeida, Management Assistant were on duty throughout the year.

Mrs S Watawala, Technical Officer who joined the Department on 2017.01.02, resigned from RRISL with effect from 07.09.2022 after five years of remarkable service.

Dr T U K Silva was awarded his PhD in Crop Science with effect from 14.10.2022 at the Post Graduate Institute of Agriculture, University of Peradeniya, Sri Lanka.

Resignations & Retirements:

Mrs P D A H M A de Almeida, Management Assistant, joined to the Rubber Research Institute on 16.07.2003 and served for more than 19 years. She assisted the Department activities in numerous ways, mainly typing and compiling nursery inspection reports more efficiently and reliably. Her valuable contribution towards the betterment of the Department is greatly appreciated.

Research students

- Ms K B M V M T M Muhandiram, a Research Student of Faculty of Animal Science and Export Agriculture, Uva Wellassa University started her research project titled "Effect of high density planting on timber production and structural changes of rubber trees (*Hevea brasiliensis* Muell. Arg.)" under the supervision of Dr T U K Silva.

- Ms K M U Madhusankhani, a Research Student of Faculty of Animal Science and Export Agriculture, Uva Wellassa University started her research project titled "Performance of intercropping Soursop (*Annona muricata L*), Orange (*Citrus sinensis L*) and Guava (*Psidium guajava*) under two spatial arrangements of Rubber (*Hevea brasiliensis* Muell. Arg.) in the Low Country Intermediate Zone of Sri Lanka" under the supervision of Dr T U K Silva.

- Ms Ishadini Swarnamali, a research student at the Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka started her research project titled "A study of exogenous application Salicylic Acid on the growth performance of rubber nursery plants under water stress condition" under the supervision of Dr (Mrs) D S A Nakandala.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Nursery Management	07	Sapumalkanda Estate, NIPM, Uwa wellassa University and J'Pura University	WDMN de Alwis L De Zoysa, R Handapangoda, EUMDZ Disanayake UN Udayakumarie, WMD Wickrama kumarie
Bud grafting training Programmes	14	RDD, RPC's and Private	WDMN de Alwis L De Zoysa R Hadapangoda EUMDZ Disanayake UN Udayakumarie WMD Wickrama kumarie
Webinar on crop diversification	01	NIPM	TUK Silva WDMN de Alwis

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
TUK Silva DSA Nakandala WDMN de Alwis	Scientific Committee Meeting	Rubber Research Institute
TUK Silva	Final report on Oilpalm cultivation	Ministry of Plantation
TUK Silva WDMN de Alwis	Nursery Meeting	Ministry of Plantation
TUK Silva DSA Nakandala	International Workshop on GIS, Remote sensing and Geospatial applications	International Rubber Research and Development Board with partnership of RRISL

Services

Testing the quality of polythene

Polybag samples for government rubber nurseries and polythene samples for rainguards were checked for quality and specifications in order to select bidders (T U K Silva, P Seneviratne and P K W Karunathilaka).

Supplying of marking plates

About 10 marking plates (d2 and d3) were issued to stakeholders (T U K Silva and P K W Karunathilaka).

Issuing authentic budwood

No bud woods were issued during the year 2022 due to prevailing leaf disease conditions (T U K Silva, W D M N de Alwis, D L N De Zoysa, E U M D Z Dissanayake, U N Udayakumari and W M D Wickramakumarie).

Issuing authentic budded plants

The main purpose of this is to issue budwood plants for all RRI, and RDD nurseries in collaboration with the Genetics and Plant Breeding Department. The plants were bud-grafted from each clones in Kumbukkana, Egaloya and Gurugoda RDD nurseries as shown in Table 1.

Table 1. *Number of budwood plants issued for RRI and RDD budwood* nurseries

Kumbukkana RDD Nursery

Clone	Available plants	For RRI nurseries	For RDD nurseries
RRISL 2006	150	15	35
RRISL 208	45	15	30
RRISL Centennial 5	143	15	28
RRISL 201	75		
RRISL Centennial 5	87	15	72
RRISL 211	49	15	34
RRIC 130	56	15	41
RRISL Centennial 3	56	15	41
RRISL 217	59	15	44
PB 86	60	15	45
RRISL 219	64	15	49
RRIC 102	60	15	45
RRIC 121	161	15	46
RRISL 2001	50	15	35
RRISL 203	55	15	40
RRIC100	56	15	41

Egaloya RDD Nursery

Clone	Available plants	For RRI	For RDD	For Kuruwita Estate
RRISL2006	150		100	RRISL 2006 50+
RRISL201	100		100	+RRISL 201 50
RRISL2100	300		300	C3 50
				C4 50
				2001 50

Budwood Nurseries (*BN/2014/Gallewatta, BN/2017/Olikanda and BN/2017DF)*

Budwood nurseries at Olikanda, Gallewatta and Dartonfield were maintained throughout the year. Weeding, manuring, pollarding and application of fungicide were done at regular intervals (T U K Silva, W D M N de Alwis, D L N De Zoysa, E U M D Z Disanayake, U N Udayakumarie and W M D Wickramakumarie).

Nursery inspection

Government, RPC and Private nurseries were inspected and details are given in Tables 2,3 & 4.

Table 2. *Details of government nurseries established in Jan 2021, August 2021, January 2022 and August 2022*

Name of the Nursery	Season	No. of plants established	No. of plants certified
Egaloya	2021 Jan	52,700	9,000
	2021 Aug	400,000	5,044
	2022 Jan	100,000	
	2022 Aug	155,178	
Gurugoda	2021 Jan	56,600	35,958
	2021 Aug	261,280	36,735
	2022 Jan	171,391	
	2022 Aug	165,000	
Karapincha	2021 Jan	28,500	10,000
	2021 Aug	160,000	5,000
	2022 Jan	90,000	
Meerigama	2021 Jan	100,000	18,149
	2021 Aug	175,650	24,233
	2022 Jan	100,000	
	2022 Aug	200,000	

Name of the Nursery	Season	No. of plants established	No. of plants certified
Welikadamulla	2021 Jan	55,000	21,318
	2021 Aug	400,000	29,187
	2022 Jan	280,000	
	2022 Aug	220,000	
Middeniya	2021 Jan	100,000	4,990
	2021 Aug	150,000	42,520
	2022 Jan	72,550	
Moneragala	2021 Jan	285,000	12,000
	2021 Aug	421,000	24,944
	2022 Jan	186,898	
	2022 Aug	213,852	
Padiyathalawa	2021 Jan	16,000	8,000
	2021 Aug	184,328	25,865
	2022 Jan	50,000	
	2022 Aug	71,000	
Total		**4,921,927**	**312,943**

Table 3. *Details of RPC nurseries established in 2022*

Regional Plantation Company	Season	No. of estates having nurseries	No. of nurseries for the RPCs	No. of plants established in 2022	No. of plants certified as YB in 2022
Agalawatte	2021 Aug	4	4	210,000	95,172
Hapugasthenna	2021 Jan	1	1		10,000
	2021 Aug				13,500
Kegalle	2021 Jan				16,100
	2021 Aug	9	11	100,700	62,330
Kelanivally	2021 Jan				93,462
Lalan	2021 Aug				65,000
Pussellawa	2021 Aug	5	6	229,635	151,016
Elpitiya	2021 Aug	2	2	63,900	11,734
Namunukula	2021 Aug	1	1	125,000	2,892
Kahawatte	2021 Aug	1	1		900
Total		**23**	**26**	**731,235**	**551,055**

Table 4. *Details of private nurseries established in 2022*

Region	Season	No. of nurseries	No. of plants established	No. of plants certified
Kegalle	2021 Jan			49,500
	2021 Aug	19	317,260	98,780
Rathnapura	2021 Aug	4	90,000	74,000
Moneragala	2021 Jan			8,000
	2021 Aug	3	24,000	20,000
Kalutara	2021 Jan			25,000
	2021 Aug	2	170,000	51,500
Total		**28**	**601,260**	**326,780**

(T U K Silva, W D M N de Alwis, D L N de Zoysa, R Handapangoda, E U M D Z Dissanayake, N Udayakumari and W M D Wickramakumari).

Inspection of budwood nurseries

All budwood nurseries belong to Rubber Development Department, RPCs and Private nurseries were inspected (T U K Silva, W D M N de Alwis, D L N de Zoysa and R Handapangoda).

Discarding weak plants in rubber nurseries

Discarding weak young budded plants and unsuccessful seedling plants in RDD nurseries was done in the presence of officials from both RRISL and RDD. This program was started in the year 2022 to avoid the issuing poor quality plants to the field. Details are given in Table 5.

Table 5. *Number of weak plants discarded from 2021 August nurseries*

Description	No. of established plants	No. of plants discarded
RDD nurseries	2,073,495	289,674
RPC nurseries	1,045,030	517,216
Private nurseries	211,000	55,500

The number of plants issued by RDD, RPCs and Private nurseries without certification of RRISL given in Table 6.

Table 6. *The number of budded plants issued without certification*

Nursery		No. of budded plants issued without adhering discarding weak plants programme	Total
RPC	Agalawatta	119,230	
	Kegalle	14,354	
	Hapugasthenna	1,890	
	Pussellawa	40,655	176,129
RDD	Egaloya	38,164	
	Karapincha	16,187	
	Gurugoda	60,730	
	Meerigama	61,113	
	Padiyathalawa	49,200	
	Moneragala	180,453	
	Welikadamulla	117,432	523,279
Private	Kegalle	73,930	
	Rathnapura	6,000	
	Monaragala	22,879	102,809

(T U K Silva, W D M N de Alwis, D L N de Zoysa, R Handapangoda, E U M D Z Dissanayake, N Udayakumari and W M D Wickramakumari)

Visits

Advisory	- 15
Experimental	- 77
Nursery inspection	- 231
Total	- **323**

LABORATORY INVESTIGATIONS

Tissue culture

Renovation of the tissue culture laboratory was completed, and research work will be planned to commence by next year (T U K Silva, D S A Nakandala and P Seneviratne).

FIELD EXPERIMENTS

Nursery techniques

Effect of row arrangements of rootstock nurseries on the growth of rubber in the Intermediate Zone of Sri Lanka (NT/RA/2022/Mon)

The experiment was carried out at Moneragala Substation in 2021. Details were given in Annual Review 2021. Treatments were as follows;

T1 : Single row
T2 : Two rows
T3 : Three rows
T4 : Four rows

Seedling plants from each treatment were bud grafted in 2021 and the grafting success of the plants was recorded. The success rate of each treatment is given in Table 7. More than 80% of success rate was recorded by three and four-row systems when compared to single and two-row systems (Table 7).

Table 7. *Bud grafting success rate of plants under different plant row arrangement*

Treatment	No. of plants grafted	Success plants	Success rate (%)
T1 – Single row	198	105	53
T2 – Two rows	468	365	78
T3 – Three rows	713	599	84
T4 – Four rows	950	779	82

Soil moisture content in the polybag plants on a volume base, under each row arrangement was recorded (Table 8) and the difference was not significant. The trial will be repeated to confirm the results.

Table 8. *Average soil moisture content (v/v%) of different treatments after four months of transplanting into polybags*

Treatment	The soil moisture content at different time interval (v/v/%)		
	8.00 a.m.	12.00 noon	4.00 p.m.
T1	16.9±0.5	13.3±0.5	12.3±0.4
T2	17.5±0.5	14.0±0.6	12.1±0.5
T3	17.9±0.6	14.8±0.5	13.8±0.5
T4	18.4±0.6	15.1±0.5	13.5±0.5

Development of rapid bud grafting technique

This experiment was started in the Meerigama and Padiyathalawa RDD nurseries in the year 2022 to give a feasible solution for the tapper shortage. Details of new technique compared to the traditional method are given in Tables 9 and 10.

Table 9. *Bud grafting success rate of plants under different bud grafting methods*

Nursery	Treatment	Total no of plants grafted	No of success plants	Success %
Padiyathalawa	Traditional method (Control) (T1)	500	478	96
	Rapid method (T2)	500	485	97
Meerigama	Traditional method (Control) (T1)	500	486	97
	Rapid method (T2)	500	488	98

Table 10. *Bud grafting speed of plants under different budgrafting methods*

Nursery	Treatment	No. of hours taken	No of plants budgrafted	Speed of bud grafting (plants/hour)	No of Success plants	Success %
Padiyathalawa	Traditional method (Control) (T1)	7	220	31	211	96
	Rapid method (T2)	7	520	74	495	95
Meerigama	Traditional method (Control) (T1)	7	350	50	343	98
	Rapid method (T2)	7	520	74	510	98

Juvenile budgrafting method

The experiment was started last year at Meerigama and Padiyathalawa RDD nurseries with one and half months old seedling plants. The objective is get ready the two whorled budded plants with on set of the planting season will increase the establishment and survival rate at field.

Table 11 and 12 shows the success rate of Juvenile bud grafting technique compared to Traditional bud grafting technique.

T1- Tradition bud grafting method (Control)

T2- Juvenile bud grafting method

Table 11. *Bud grafting success rate of different budgrafting methods*

Nursery	Treatment	Total number of plants bud grafted	number of success plants	success plants (%)	No of sprouted plants	Sprouted plants (%)
Meerigama	T1	1000	977	97.7	977	100
	T2	1000	996	99.6	996	100
Padiyathalawa	T1	500	478	95.6	478	100
	T2	500	485	97	485	100

Table 12. *Bud grafting speed of plants under different budgrafting methods*

Nursery	Treatment	No. of hours taken	No of plants budgrafted	Speed of bud grafting (plants/hour)	No of Success plants
Meerigama	T1	7	350	50	343
	T2	7	520	74	510
Padiyathalawa	T1	7	220	31	211
	T2	7	520	74	495

The juvenile bud grafting method has a faster rate of bud grafting than the traditional method.

There were no significant differences observed for growth attributes of seedlings (Table 13) (W D M N de Alwis, U N Udayakumari and W M D Wickramakumari).

Table 13. *Diameter of stock plants after budgrafting - Meerigama RDD Nursery*

	Diameter (mm)	
Treatment	**Before cutback**	**After cutback**
1	12.3 ± 0.8^{a}	15.7 ± 0.8^{a}
2	14.1 ± 0.5^{a}	15.6 ± 0.7^{a}

Direction of row planting systems for rubber nursery plants

A nursery experiment was initiated to investigate the effect of row direction arranged in the nursery on plant growth, bud grafting success and disease susceptibility. This study was conducted at Dartonfield Nursery in two different directions *i.e*.; T1- East-West oriented (Control) and T2- North – South oriented.

However, all measured growth parameters were not significantly different when compare the two treatments (Table 14).

Table 14. *Shoot attributes (mean values) of seedlings of rubber after one month of transplanting into poly bag nursery*

Treatment	Diameter (mm)	Height (cm)	No of leaves	Chlorophyll
T1	3.9±0.1	41.7±1.0	3.9±0.2	44.9±2.3
T2	3.9±0.1	41.6±1.1	4.1±0.2	48.1±2.4

(W D M N de Alwis, E U M D Z Disanayaka and U N Udayakumari)

Impact of stock – Scion interaction on growth and rubber yield of Hevea brasiliensis

The aim of this experiment was to study the impact of stock-scion interaction on the growth performance of young rubber nursery plants and the yield performance of rubber when transplanting them in the fields under Wet and Dry climatic conditions. A test trial was commenced in September, 2022 at the Plant Science Department nursery to study the clonal variation of stock-scion interaction according to morphological and physiological attributes under nursery conditions. Seeds from isolated fields of three clones *i.e.;* RRISL 203, RRIC 121 and RRIC 102 were collected with the onset of August seed fall. The seedling nursery was established according to Randomized Complete Block Design with three replications. Unselected mixed clone seedlings were kept as a control treatment (Table 15).

Table 15. *Growth attributes of stock plants after two months of establishment*

Treatment	Clone	Diameter (cm)	Height (cm)	No. of leaves	Chlorophyll (SPAD index)
T1	RRIC 121	5.0^{a}	46.7^{a}	5.6^{a}	62.2^{a}
T2	RRISL 203	4.9^{a}	46.0^{a}	4.5^{ab}	64.1^{a}
T3	RRIC 102	4.7^{a}	43.7^{a}	3.3^{b}	67.3^{a}
T4	Unselected	4.8^{a}	42.1^{a}	4.5^{ab}	63.8^{a}

Results revealed that there was no significant differences in plant stem diameter, height, and chlorophyll content when compared to unselected seedlings (Table 15) (D S A Nakandala and U N Udayakumari).

A study of exogenous application of Salicylic acid on the growth performance of rubber nursery plants under water stress conditions

The present study was to investigate the effect of the exogenous application of Salicylic acid on the growth performance of rubber nursery plants under water stress conditions in the Intermediate Zone of Sri Lanka. A split-plot experimental design was applied with different drought severity levels; Non-stress, Mild stress, and Severe stress, and different concentrations of Salicylic acid; 0.0mm, 0.1mM, and 0.2mM. Treatments are as follows:

Main plot: different water stress levels

I0 - No stress daily irrigation
I3 - Mild stress - irrigation done at three-day intervals
I5 - Severe stress - irrigation done at five-day intervals

Sub plots: Salicylic acid at different concentrations.

S0 - 0.0 mm
S1 - 0.1 mm
S2 - 0.2 mm

Seedlings were treated with 100ml of Salicylic acid as a soil drench in monthly applications. Physiological parameters *viz*. chlorophyll content, stomatal conductance, and plant growth parameters *viz.* stem diameter, leaf area, dry matter content, and root length were recorded before and after treatments (Fig. 1).

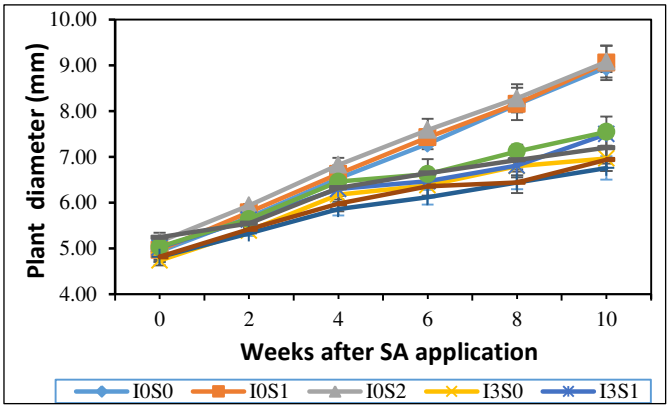


Fig. 1. Effect of exogenous application of Salicylic Acid on diameter of rubber seedlings

The results revealed that the decrease in stem diameter could be alleviated with the application of Salicylic acid resulting the beneficial effects. 0.2mM concentration of Salicylic acid under mild water stress (I3S2) has been identified as the most effective concentration of Salicylic acid in alleviating adverse effects of water stress conditions in rubber nurseries in the Intermediate Zone in Sri Lanka (D S A Nakandala and W M D Wickramakumari).

Irrigation systems for rubber nurseries and immature plants

Micro-irrigation systems for immature rubber plantings in Intermediate Zone of Sri Lanka (PT/MI/2020/Moneragala)

A porous tube micro-irrigation system was installed at Moneragala in 2020 with an objective of minimizing the drought stress of immature rubber plants under

sub-optimum conditions in the Intermediate zone of Sri Lanka. Introducing different techniques of porous irrigation systems to immature rubber plants provides sufficient amount of irrigation to plants to tolerate the water stress under drought conditions. Three types of porous irrigation systems were installed at the two immature rubber fields in Moneragala. Different treatments are as follows,

T1 : One porous tube unit at 1foot depth from the surface of the soil
T2 : One porous tube unit at 2 feet depth from the surface of the soil
T3 : Two porous tube units at 1 foot and 2 feet depths from the surface of the soil
T4 : Manual watering (Control)

Plant growth in relation to average annual girth is given Table 16. Results showed that the girth of two-year plants is higher in each treatment on different porous irrigation systems when compared to the control (T4).

Table 16. *The annual girth of irrigated plants with porous irrigation systems*

Treatment	Girth at 120cm height (cm)
T1	14.7
T2	14.5
T3	14.1
T4	13.9

(D S A Nakandala and P K W Karunathilaka)

Effect of size of the polybag on the growth of rubber nursery plants

Young budding plants raised in different sizes of polybags were established at Dapiligoda of Dartonfield Estate. Regular maintenance was done throughout the year. The annual girth of plants in different treatments was recorded at 120 cm height from the bud union (Table 17).

Table 17. *Effect of size of polybags on the growth of plants after one year of field establishment*

Treatment	Girth at 120cm height (cm)
T1 (5"x13")	14.2 ± 0.5^{b}
T2 (5"x15")	15.3 ± 0.6^{a}
T3 (6"x13")	15.8 ± 0.6^{a}
T4 (6"x15")	15.0 ± 0.6^{a}

The growth of all treatment plants in relation to the girth of the plant at 120cm height from the bud union was satisfactory after two years of planting except T1 treatment (5”x13”) (D S A Nakandala, R Handapangoda and U N Udayakumari).

Effect of colour of the polybag on the growth of rubber nursery plants

Young budding plants established in two different colour of polybags (Black and transparent) in the standard size (6"x15") were field planted in 2020 at Dapiligoda of Dartonfield Estate. Regular maintenance, including manuring and circle weeding, was done throughout the year. The annual girth of treatment plants was recorded at 120cm height from the bud union (Table 18).

Table 18. *Effect of colour of polybags on the growth of plants after one year of field establishment*

Treatments	Girth at 120cm height (cm)
Black (Control)	16.2 ± 0.5^{a}
Transparent	14.4 ± 0.6^{b}

Results show that the annual girth of plants was significant with poly bag color and the higher girth was given recommended black (Table 18) (D S A Nakandala, R Handapangoda and E U M D Z Dissanayaka).

Planting techniques

Stumped budding experiment (SB/2016/Moneragala)

A stumped budding experiment was established at Moneragala Substation in November 2016. Regular maintenance, including manuring and circle weeding, was done throughout the year. The annual girth and girth increment were compared in the treatment plants *i.e.;* Normal budded stumps (Control) and whole plants with root balled (Table 19).

Table 19. *Mean annual girth of stumped budded plants, root boled plants and initially established plants*

Treatment	Girth (cm)	Girth increment (cm)
Whole plants with root boles	32.0±1.8	5.0±0.8
Stumped budded plants	28.0±1.5	4.0±0.7

Root balled plants have shown a higher girth increment compared to normal stumped budded plants (control) and it can be predicted that the root balled plants will reach the tappable girth of 45cm after two years at the tapping commence of normal plants (D S A Nakandala, W D M N de Alwis and D L N de Zoysa).

Different types of planting materials for drier areas (PT/SP/Anuradhapura/2019)

This experiment was commenced at a farmer's field at Kekirawa, in Anuradhapura District in 2019. The objective of the study is to increase field establishment rate of immature rubber under sub-optimal climatic conditions.

Different potting media were used to form root balled plants as stated in Table 20. The control (T6) was selected as two-whorl young budding plants.

Table 20. *Composition of the media used to prepare root balled plants*

	Composition	
Treatment	**Coir dust (v/v%)**	**Top soil (v/v%)**
T1	0	100
T2	25	75
T3	50	50
T4	75	25
T5	100	0

Routing maintenance and fertilizer application were done according to the RRISL recommendations. The annual girth was recorded at the 120cm height from the bud union (Table 21).

Table 21. *The annual girth of rubber plants at two years after planting*

Treatment	**Girth at 120cm**
T1	11.95
T2	13.27
T3	16.63
T4	15.58
T5	14.11
T6	(Control)
12.57	

Table 21 shows that the girth of treatment plants varied according to the added amount of coir pith to root-balled plants. The highest girth was recorded by the root-balled plants arranged with 50:50 of coir pith and topsoil mixture (T3). The plants without coir pith (T1) have not shown a significant difference compared to young budding plants (Table 21). Results revealed that root-balled plants with coir pith in different quantities would result in vigorous growth of plants during the immature period (W D M N de Alwis, D S A Nakandala, D L N de Zoysa, R Handapangoda and W M D Wickramakumari).

Cultural practices during the immature phase

Planting at high density (PT/1992/1/Kuruwita)

This experiment was established in 1992 and yield data was not recorded from 2020, considering the age of the plantation. However, a Research Student of Faculty of Animal Science and Export Agriculture, Uva Wellassa University completed her research project titled “Effect of high density planting on timber

production and structural changes of rubber trees (*Hevea brasiliensis* Muell. Arg.)" using this trial field. Total assessments of timber, fuel and biomass are to be conducted in next year (T U K Silva, V H L Rodrigo and H Subasinghe).

Morphological, physiological and molecular level variation of different rubber clones grown under wet and dry climates in Sri Lanka (PT/2020/Galewatta)

The experiment was established at the Galewatta Division of the Dartonfield Group in July 2020 with the onset of South-West monsoon rains. The objective of this study was to evaluate the growth, physiological and molecular biological variations of different rubber clones *viz.,* RRISL 201, RRISL 2006, Centennial 4 and RRIC 121 under wet and dry climates. The same trail was established at Moneragala under a dry climate with all clones as in the Wet Zone. The growth of the plants in Galewatta Division was recorded after two years of planting in terms of stem girth at a height of 120cm from the base of the bud union (Table 22).

Table 22. *Variation of stem girth of different clones under wet climatic conditions*

Clone	Stem girth at 120cm height (cm)
RRISL 201	8.1±0.9
RRISL 2006	8.0±1.2
Centennial 4	7.3±0.9
RRIC 121	7.7±0.9

(D S A Nakandala, U N Udayakumari and D L N de Zoysa)

Mechanization of planting hole cutting (PT/HE/2020/Moneragala*)*

An experiment was set up to introduce a new tractor-mounted auger (a digger machine) to the farmer fields in Moneragala District for the first time in Sri Lanka. The main objective of this experiment was to evaluate the growth performance of rubber plants that were planted in planting holes prepared by using a new digger machine. The experiment was established at three fields of Kumarawatta Estate in Moneragala District with the onset of North-East monsoon rains in 2020.

The experiment was designed with two methods of holing *i.e.;* using a new digger machine (T1) and manual holing as a control (T2). Details of the experimental design and methodology were discussed in Annual Review 2020. Regular maintenance, including the application of fertilizer and circle weeding, was done according to RRISL recommendations. The girth of plants that were planted in the holes made by the new digger machine was not significantly different when compared to manual planting (Table 23).

Table 23. *Initial basal girth (average) and mean annual girth at 120 cm height of plants grown in different types of planting holes*

Treatment	Girth at 120cm height (cm)
T1– New digger machine	14.8[a]
T2– Manual holing (Control)	14.2[a]

(D S A Nakandala and P K W Karunathilaka)

Exploitation

A novel approach to optimize the bark management of rubber plantations *(BCR/2017/Sirikandura)*

The objective of this experiment was to investigate the possibilities of increasing the productivity of rubber plantations through the proper management of bark consumption. A rubber field established in 2006 with RRIC 121 clone at Sirikandura Estate was selected for the study. Six tapping systems were employed as treatments (Table 24). The experiment was designed according to a Randomized Complete Block Design (RCBD) with three replications of each treatment. Growth and yield data were recorded (Table 24). Out of the six treatments T6, T5 and T1 were recorded with higher g/t/t values than the other treatments due to the lower tapping intensity (Table 25). The T3 recorded the lowest value due to the effects of both higher frequency and shorter cut length. However, the half spiral daily tapping (T2) recorded a moderate value due to a lesser number of tapping days than T3 due to the absence of rainguards. The treatment which has an additional tapping cut for the holidays, *i.e.* T4, recorded the total value of 49.3 g/t/t in holidays to cover the additional cost to be paid for the tapper for holiday tapping.

Table 24. *Description of tapping systems employed as treatments*

Treatment	Tapping system
T1	S/2 d2 + Recommended number of Recovery Tappings per month (Control)
T2	S/2 d1 + Without Rainguard or Recovery Tapping (Smallholder Practice)
T3	S/4 d1 + With Rainguards (No Recovery Tapping)
T4	S/2 d2 (RG), No RT + Supplementary Holiday Tappings per month (S/4 U d7)
T5	S/4U d3 2.5% ET + S/2D d3 2.5%ET (Panel changing year by year, alternatively)
T6	S/2D d6 5% ET (Monthly)

Table 25. *Mean girth, bark thickness and yield (g) per tree per tapping (g/t/t) under different tapping systems*

Treatment	Mean girth (cm)	Mean bark thickness (mm)	Yield (g/t/t)
T1	73.1	8.5	31.7
T2	76.0	8.8	26.1
T3	76.4	8.4	21.4
T4	72.8	8.3	28.4
T5	71.9	7.8	42.7
T6	73.0	8.1	42.8

(T U K Silva, H Subasinghe and D Priyadarshana)

Intercropping

Intercropping demonstration field (IC/DP/2011) – Moneragala

This intercropping field was established as demonstration plot of intercropping at the RRISL substation in Moneragala. The growth of rubber trees in terms of girth under different planting systems is given in Table 26.

Table 26. *The girth of rubber trees under different intercropping systems and spacing arrangements*

Intercropping system	Spacing of rubber (m)	Girth of rubber (cm)
Rubber x Pineapple	Single row system	66.6
Rubber x Banana	2.5m x 7.75m	64.5
Rubber x pomegranate/Guava	Single row system	58.8
Rubber* x pomegranate*/Guava*	2.5m x 12m	50.8
Rubber x Cinnamon	Paired row system	64.5
Rubber x Mango/Rambutan	(3m x 3m) – 18m	60.7

*Planted in the year 2012
(T U K Silva, D Priyadarshana and H Subasinghe)

Rubber x Intercropping trials in Moneragala and Ampara districts

Rubber x *Fruit crops trial in Moneragala (IC/FC/2018/1)*

Four fruit crops *i.e.* Orange, Soursop (Anoda), Guava and Papaya were planted under rubber with 2.5m x 7.75m and 2.5m x 12.0m spatial arrangements. Planting of both rubber and fruit crops were done as per the recommendations given by RRISL and the Department of Agriculture. The growth of rubber in terms of girth at 4 feet height after four years of planting is shown in Table 27. Growth of intercrops after five years is shown in Table 28.

Table 27. *Mean girth at four feet height (cm) of rubber trees under different treatments and under different spatial arrangements*

Main treatment (spatial arrangement of rubber)	Sub treatment (intercrop)	Girth of rubber (cm)
2.5m x 12.0m	Soursop	20.7
	Orange	19.5
	Guava	17.5
2.5m x 7.75m	Soursop	19.2
	Orange	18.6
	Guava	16.3

Table 28. *Mean basal girth (cm) of intercrops under different spatial arrangements of rubber*

Main treatment	Sub treatment (intercrop)	Basal girth (cm)
2.5m x 12.0m	Soursop	42.7
	Orange	29.9
	Guava	25.7
2.5m x 7.75m	Soursop	41.1
	Orange	28.8
	Guava	27.8

(T U K Silva, N M C Nayanakantha, H Subasinghe and D Priyadarshana)

Rubber x Short term crops trial in Ampara (IC/ST/2018/3)

Two hectares of land were selected from each farmer's field at Hingurana and Mahaoya in Ampara District to establish intercropping trials with short-term crops. Three short-term crops, *i.e.* Thibbatu, Thumbakaravila and Maize were selected and established under rubber with a 2.5m x 7.75m spacing system. Only Mahaoya field has been continued and the girth values are shown in Table 29. However, short-term crops did not established this year.

Table 29. *Mean girth (cm) of rubber at 120cm height in Mahaoya field*

Area	Tree girth (cm)
Replicate 1	21.74
Replicate 2	19.38
Replicate 3	18.64
Control	22.7

(T U K Silva, N M C Nayanakantha, H Subasinghe and D Priyadarshana)

Rubber x Ginger/Turmeric trial – Kuruwita Substation and Siyabalanduwa

Two inter-crop trials with rubber, ginger and turmeric were planted in Kuruwita and Siyabalanduwa. Raised beds and poly bag methods were used in the

inter- row of rubber. The planting of ginger and turmeric was done in January 2022. Objective is to find the most suitable planting method for ginger and turmeric with rubber (T U K Silva, P D Pathirana, D Priyadarshana and H Subasinghe).

Testing different cinnamon spacing's under two spatial arrangements of rubber

One hectare field from the Kuruwita Substation of RRISL was selected to conduct the above trial. The objective of this experiment was to identify the best rubber x cinnamon intercropping system to optimize cinnamon yield throughout the economic lifespan of rubber. Two spatial arrangements of rubber were taken as main treatments and three spatial arrangements of cinnamon were taken as sub-treatments. Details of the treatments are given in Table 30.

Table 30. *Main and sub-treatments of rubber and cinnamon*

Main treatment	**Sub treatment**
Rubber	Cinnamon
(I). 2.5m x 7.75m	(I). 0.6m x 1.2m
(II). 2.5m x 12.0m	(II). 0.9m x 1.2m
	(III). 1.2m x 1.2m

(T U K Silva, P D Pathirana and D Priyadarshana

PLANT PATHOLOGY AND MICROBIOLOGY

Incidence of Powdery mildew and Colletotrichum leaf disease were mild to moderate during the refoliation period except for a few disease vulnerable sites. Powdery mildew was severe in Akuressa and Badulla areas. The newly reported leaf fall disease was named as the "Circular Leaf Spot Disease". The disease is primarily caused by four new Colletotrichum species namely; Colletotrichum siamense, C. fructicola, C. gigasporum and C. tropicale. And secondarily attacked by three Pestalotioides genera: Pestalotiopsis spp. Neopestalotiopsis spp. and Pseudopestalotiopsis spp. which have been regarded as opportunistic, weak parasites. This disease is regarded as a secondary leaf fall disease. During the year 2021, CLSD reached a severe condition mainly in the wet rubber growing districts. The studies on the biology and epidemiology of the pathogen isolates are in progress and a revised interim recommendation was issued by the RRISL for chemical controlling. Two systemic fungicides carbendazim (10g per liter) and hexaconazole (10 ml per liter) were recommended to be used alternatively, only if the leaf fall exceeds 60% during October – November 2021. Three rounds of fungicide applications were recommended as two carbendazim rounds and one hexaconazole round. It has been reported that the disease had been effectively controlled in India using copper oxychloride and a sample has already been ordered for testing. Since the vigour of the plants affected the severity of the disease incidence, application of the fertilizer and the adoption of all the other recommended agronomic practices were recommended. Short term, medium term and long term strategies were introduced. Based on the Corynespora screening programme, there was no disease reports from new clones. The disease remained at a mild level in traditional rubber growing areas and the severity of the disease in the nontraditional areas was comparatively higher. Incidence of Phytophthora diseases was also mild except for a few disease vulnerable sites. White root disease had become destructive and played an important role in reducing the tree stand in rubber plantations. Seventy demonstration plots established among the Plantation Companies and Smallholdings to demonstrate the efficiency of new and revised recommendations were further monitored. White root disease patches were rehabilitated using integrated disease management systems: mechanical, biological and chemical methods. After rehabilitation plant types such as banana, pineapple, ginger and cassava were identified to be used as indicator plants while providing some additional income to the grower. The disease severity index for the Corynespora leaf fall disease on tested clones have been introduced to be considered in the breeding programmes. Antagonistic fungi isolated from Sri Lankan rubber growing soils and healthy leaves were evaluated against the circular leaf spot disease pathogens. Two Trichoderma based products were forwarded to the Registrar of Pesticides, Department of Agriculture for the registration. The product is currently tested under commercial level. The national level culture collection was generally checked. The department conducted 12 training programmes on the new leaf fall disease management.

PLANT PATHOLOGY AND MICROBIOLOGY

T H P S Fernando

DETAILED REVIEW

Staff

Dr (Mrs) T H P S Fernando, Head, Department of Plant Pathology and Microbiology and Dr (Mrs) M K R Silva, Research Officer were on duty throughout the year. Experimental Officers, Mrs B I Tennakoon retired on duties with effect from 31st December 2022, Mr E A D N Nishantha left the country for Japan on no-pay leave with effect from 15th December 2022. Mrs E A D D Siriwardene and Mr S C P Wijayaratne worked throughout the year. Mrs A H M N R Aberathne and Mr D A N Mallikarachchi, Technical Officers and Mrs K A D Y Madushani Lanka, Management Assistant, was on duty throughout the year. Mrs K L K Shehani worked as a Temporary Research Assistant under the WRD Project resigned from duties on May 2022 and Mrs W A K S Wijesooriya and Mrs B P Kariyawasam, Temporary Research Assistants under the Pestalotiopsis Project resigned from duties on September 2022. Mr G K S Madhusanka and Miss H R G N Peiris, Technical Assistants were on duty throughout the year under the Pestalotiopsis Project.

Research Grants received

Source and Grant No.	Duration	Title of the Project	Allocation (Rs. Mn.)	Status
Ministry of Plantation Industries **Development Project – 23/1/17**	2018-2022	Improvement of strategies to manage white root disease in rubber plantations (Funds were not received during the year 2022)	42.99	Not completed
Ministry of Plantation Industries **Development Project –** Pestalotiopsis	2021-2025	Studies on the biology and epidemiology of the Pestalotiopsis Leaf fall disease and to develop effective management strategies. (Budget cut in the year 2022)	49.46	

Research students

Dr (Ms) T H P S Fernando supervised the final year research projects of the following undergraduate students and postgraduate students. Eight number of

students from Universities and Technical Colleges were trained at the department on basic and applied plant protection and microbiological activities.

Name	Study Programme	Duration	University	Project Title
HTT Dewmini De Zoysa	Research	2021-2022	KAATSU International University Sri Lanka	Identification of free living nitrogen fixing bacteria inhabiting in rubber growing soil
SAC Sandamali	Research	2022	Uva Wellassa University	Isolation of endophytic fungi from *Hevea brasiliensis* and investigation of their antagonism against the circular leaf spot disease pathogens of rubber
MNN Zainab	Research	2022-2023	Sabaragamuwa University	Isolation of endophytic fungi from rubber (*Hevea*) leaves and to test their pathogenicity

Commettes attended

Officers	Subject	Organization
THPS Fernando MKR Silva	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
THPS Fernando	Pesticide Technical's Advisory Committee	Department of Agriculture
THPS Fernando	Pesticide Sub-committee	Department of Agriculture
THPS Fernando	Bio pesticides sub committee	Department of Agriculture
THPS Fernando	Task Force on the management of new leaf fall disease (Pestalotiopsis)	Ministry of Plantations

Training programmes attended

Officers	Subject	Organization
THPS Fernando MKR Silva	International Workshop on New *Hevea* Leaf Diseases, 20^{th}-24^{th} September 2022 in Kottayam, India, Organized by IRRDB	India
THPS Fernando	Meeting of the IRRDB Plant Protection Experts on Pestalotiopsis leaf disease North Sumatra (Medan), 11^{th}-14^{th} December 2022 Malaysia, 15^{th}-17^{th} December 2022, organized by IRRDB	Malaysia

Training programmes conducted

Dr (Mrs) T H P S Fernando and Dr (Mrs) M K R Silva served as the resource personnel in training Rubber Development Officers, Rubber Extension Officers, Estate Managers, Assistant Superintendents and Field Officers. Mrs B I Tennakoon, Mrs E A D D Siriwardene, Mr S C P Wijayaratne, Mr E A D N Nishantha, Mrs Nadeeshani Aberathne and Mr Akila Mallikaarachchi covered the practical aspects of the above programmes while all the staff members extended their fullest cooperation in educating students from Universities and Technical Colleges on departmental activities.

Experimental/Advisory visits

Purpose	No of visits
Experimental	687
Advisory	71
Other	10
Total	**768**

LABORATORY AND FIELD INVESTIGATIONS

Chemical Control of *Hevea* Diseases (23/P/01)

White Root Disease Management – Trials undertaken as demonstration plots

Demonstration plots to test the efficacy of chemical controlling and the disease management of white root disease were established in different rubber growing areas during the year 2021. These trials were monitored during the year 2022 (Tables 1 & 2) (T H P S Fernando, B I Tennakoon and E A D D Siriwardena - Funded by the Development Project - Grant 23/1/17).

Rehabilitation of White root disease patches - Demonstration plots

The white root disease patches rehabilitated at Galewatta, Nivithigalakale, Dartonfield Estate, Kuruwita Substation and Galatura Estate were monitored. Sulphur sprinkling was carried out to make conditions unfavorable for the growth of the fungus *Rigidoporus microporus.* Later, indicator plants were established (*Gliricidia and Croterlaria*) to trace out any remaining inocula (Table 3). The project could not be continued due to lack of funds (T H P S Fernando and S C P Wijayaratne: Funded by Development Project 23/1/17).

Table 1. *Details of the White root disease demonstration plots established*

	District	Area	Contact	No of affected plants	Chemical application	Sulphur
01	Kegalla	Ruwan-wella	Nalanda Estate	42	1st Application 2nd Application	100kg
02	Kalutara	Maggona	Shantha Visenthi	60	1st Application 2nd Application	100kg
03	Kalutara	Millewa	Koshan	70	1st Application 2nd Application	50kg
04	Kalutara	Millewa	Hemachandra	18	1st Application	--
05	Gampaha	Delgoda	KGH Dharmawardena	42	1st Application	50kg
06	Galle	Baddegama	Sarath Amarasiri	52	1st Application 2nd Application	50kg
07	Kalutara	N' Kele	N'Kele	Patch WRD	Rehabilitation	100kg
08	Kalutara	Galewatta	D/F	Patch WRD	Rehabilitation	100kg
09	Kalutara	Rannagala	Rannagala Estate	12	1st Application	--
10	Kalutara	Yatadola	Premasiri	32	1st Application	500kg
11	Kalutara	Bulath-singhala	NG Jayasena	23	1st Application	--
12	Kalutara	Lihiniyawa	Sarath Fernando	170	1st Application	150kg

Table 2. *Details of the White root disease demonstration plots established*

District		Area	Smallholders	No of affected plants	Chemical application	No of recovery plants
01	Galle	Pitigala	Upali Galaboda	92	1st Application	90
		Pitigala North	WA Chandrasiri	21	1st Application	21
		Urapola	Sunil	189	1st Application 2nd Application	189
02	Kegalle	Rambukkana	Upali Seneviratne	39	1st Application	39
		Kotiyakumbura	SD Karunasena	75	1st Application 2nd Application	74
03	Matara	Morawaka	Gunapala	200	1st Application 2nd Application	200

District		Area	Smallholders	No of affected plants	Chemical application	No of recovery plants
04	Rathnapura	Kiriella	Hettiarachchi	75	1st Application	75
		Ayagama	Sisira Kumara	75	1st Application 2nd Application	75
		Ayagama	Nimal Kumara	82	1st Application 2nd Application	81
		Pelmadulla	GM Gayan Kumara	75	1st Application	75
05	Kalutara	Horana	Samila	100	1st Application	100
		Horana	MD Dharmasena	30	1st Application	30
		Welimanana	KK Siril	20	1st Application	20
		Thebuwana	HD Premarathne	35	1st Application	35
		Thebuwana	Sunil Ranasinghe	16	1st Application	16
		Meegahathenna	Duminda	100	1st Application	100

Table 3. *Details of the demonstration plots established for the rehabilitation of White root disease patches*

Trial	Rehabilitation crops	Location/Estate
1	Gliricidia/Pineapple	Gallewatta, Dartonfield Estate
2	Banana	Nivithigalakale, Dartonfield Estate
3	Banana	Kuruwita Substation, RRISL
4	Turmeric	Galathura Estate

Development of new adhesives for chemical repellant, development of new chemical formulations against mammalian pests and introduction of alternative physical methods

The data on the incidence of mammalian pest attacks was collected. The timing for the repellant application was being tested. The trial is being monitored for progress (M K R Silva, T H P S Fernando, Dammika Balasooriya collaboratively with the Adaptive Research Unit).

Chemical management of Circular Leaf Spot Disease in rubber plantations

Screening of potential fungicides and their concentrations against the Circular Leaf Spot Disease was further carried out with different techniques.

a) *In vitro* screening of the potential fungicides against Circular Leaf Spot Disease (CLSD)

i. Soil Fungicide Treatment Test (SFST) of the fungicides

Three potential fungicides which were previously tested for their efficacy using the Poison Food Technique (PFT) were tested with the *in vitro* technique: Soil Fungicide Screening Test (SFST) against the same four *Colletotrichum* isolates: C1, C5, C15 and C24 (Table 4). The fungicides were tested under a series of concentrations: 10, 50, 75, 100 and 200ppm.

Table 4. *Details of the fungicides under investigation*

Fungicide	Product details	Systemic/Contact in action
carbendazim 50% w/w	Billet, carbendazim, - Plantchem	Systemic
hexaconazole 50g/l EC	Hayleys hexaconazole, Hayleys	Systemic
mancozeb 80% w/w	Dynamic mancozeb, Oasis	Contact

A completely randomized design with four replicates was adopted. The analysis of the variance of the diameter reduction values over the control at different concentrations of the fungicides and the pathogen isolates was carried out using the statistical software SAS and subsequently, mean separation was done with Duncan's Multiple Range Test (DMRT). The variation in the diameter reduction of the fungus values (DR) at different concentrations of the fungicides is shown in Tables 5, 6, 7 and 8 (fungal isolates C1, C7, C15, C24 respectively).

Table 5. *Effect of fungicides and their concentration on the growth of Colletotrichum isolate C1* in vitro *conditions*

Concentration	The mean score value of the DR*		
	carbendazim	Hexaconazole	Mancozeb
10 ppm	8.45^{a}	11.14^{a}	0.00^{b}
50 ppm	22.96^{a}	7.64^{b}	14.46^{ab}
75 ppm	100.00^{a}	1.80^{c}	8.04^{b}
100 ppm	100.00^{a}	2.04^{b}	7.54^{b}
200 ppm	100.00^{a}	17.18^{b}	3.89^{c}

* Values in the same raw followed by the same letters are not significantly different at DMRT at P=0.0001

Table 6. *In vitro effect of fungicides and their concentration on the growth of Colletotrichum isolate C7*

Concentration	The mean score value of the DR*		
	Carbendazim	Hexaconazole	Mancozeb
10 ppm	25.71[a]	7.86[b]	4.76[b]
50 ppm	21.63[a]	3.75[b]	15.71[a]
75 ppm	18.93[a]	2.22[b]	4.29[b]
100 ppm	100.00[a]	3.021[c]	16.79[b]
200 ppm	100.00[a]	0.00[c]	3.21[b]

* Values in the same raw followed by the same letters are not significantly different at DMRT at P=0.0001

Table 7. In vitro *effect of fungicides and their concentration on the growth of Colletotrichum isolate C15*

Concentration	The mean score value of the DR*		
	carbendazim	Hexaconazole	Mancozeb
10 ppm	94.05[a]	100.00[a]	28.97[b]
50 ppm	100.00[a]	100.00[a]	73.7[b]
75 ppm	100.00[a]	100.00[a]	87.95[a]
100 ppm	100.00[a]	100.00[a]	63.09[b]
200 ppm	100.00[a]	100.00[a]	100.00[a]

* Values in the same raw followed by the same letters are not significantly different at DMRT at P=0.0001

Table 8. *In vitro effect of fungicides and their concentration on the growth of Colletotrichum isolate C24*

Concentration	The mean score value of the DR*		
	carbendazim	Hexaconazole	Mancozeb
10 ppm	33.94[b]	83.22[a]	100.00[a]
50 ppm	67.43[b]	100.00[a]	100.00[a]
75 ppm	100.00[a]	100.00[a]	100.00[a]
100 ppm	100.00[a]	100.00[a]	100.00[a]
200 ppm	100.00[a]	100.00[a]	100.00[a]

* Values in the same raw followed by the same letters are not significantly different at DMRT at P=0.0001

According to the results, at all the pathogen isolates, fungicides and concentrations showed a significant variation in DR value and significant interactions were present among fungicides and concentrations.

ii. Poison Food Technique (PFT) for new pathogen isolates

In addition to the four fungal isolates tested previously, ten new *Colletotrichum* isolates were tested for the reaction towards the two effective fungicides: carbendazim and hexaconazole. A completely randomized design with four replicates was adopted. Five concentrations of the commercial fungicides namely: 0.5, 1, 5, 10 and 25ppm were tested. The analysis of the variance of the diameter reduction values over the control at different concentrations of the fungicides and the pathogen isolates was carried out using the statistical software SAS. Subsequently, mean separation was done with Duncan's Multiple Range Test (DMRT). The variation in the diameter reduction of the fungus values (DR) at different concentrations of the fungicides is shown in Table 9 and Figure 1.

Table 9. *Mean score values of the diameter reduction of the fungus values (DR) observed for different fungicide and concentration combinations (in nine pathogen isolates)*

Pathogen isolate	Concentration	The mean score value of the DR*	
		carbendazim	hexaconazole
C 2	0.5 ppm	0.85[b]	98.40[a]
	1 ppm	45.585[b]	96.170 [a]
	5 ppm	54.681[b]	100.00 [a]
	10 ppm	88.192[b]	98.08[a]
	25 ppm	93.46[b]	100.00[a]
C 3	0.5 ppm	13.083[b]	99.52[a]
	1 ppm	52.49[b]	100.00[a]
	5 ppm	64.884[b]	100.00[a]
	10 ppm	96.98[b]	100.00[a]
	25 ppm	96.66[b]	100.00[a]
C 4	0.5 ppm	7.59[b]	98.25[a]
	1 ppm	57.911[b]	97.31[a]
	5 ppm	65.506[b]	98.73[a]
	10 ppm	90.981[b]	100.00[a]
	25 ppm	93.829[b]	100.00[a]
C 5	0.5 ppm	4.114[b]	99.05[a]
	1 ppm	39.082[b]	98.58[a]
	5 ppm	55.22[b]	99.37[a]
	10 ppm	92.089[b]	100.00[a]
	25 ppm	94.146[b]	100.00[a]
C 8	0.5 ppm	2.406[b]	97.96[a]
	1 ppm	41.63[b]	98.74[a]
	5 ppm	54.969[b]	98.74[a]
	10 ppm	88.389[b]	98.74[a]
	25 ppm	92.155[b]	100.00[a]

Pathogen isolate	Concentration	The mean score value of the DR*	
		carbendazim	hexaconazole
C 9	0.5 ppm	2.03[b]	96.86 [a]
	1 ppm	60.77[b]	94.82[a]
	5 ppm	65.79[b]	98.74[a]
	10 ppm	92.78[b]	98.74[a]
	25 ppm	97.18[b]	100.00[a]
C 13	0.5 ppm	12.29[b]	99.36[a]
	1 ppm	58.67[b]	96.50[a]
	5 ppm	69.17[b]	100.00[a]
	10 ppm	91.42[b]	100.00[a]
	25 ppm	94.44[b]	100.00[a]

*Values in the same raw followed by the same letters are not significantly different at DMRT at P=0.0001

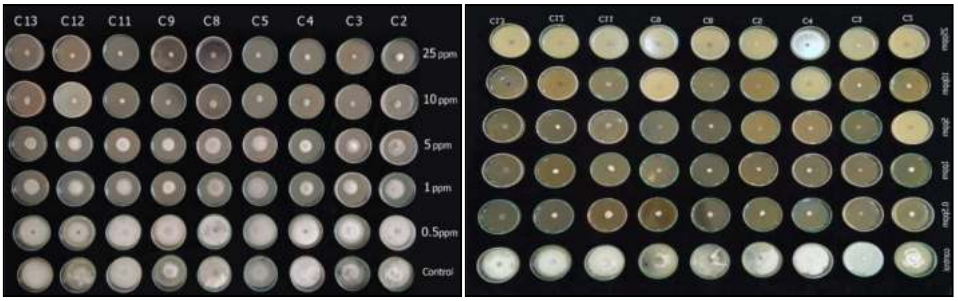


Fig. 1. Growth of *Colletotrichum* under different concentrations of **a)** carbendazim **b)** hexaconazole

b) Screening of the potential fungicides against the CLSD under field conditions

The field experiments on the chemical management of CLSD were carried out during the refoliation stage of 2021. Following treatments were adopted to have approximately 3 replicate sites for each treatment (Table 10). Each replicate consisted of mature rubber in a land area of 1ha.

Table 10. *Treatments adopted in the field experiments on the chemical management of CLSD*

Treatment	Fungicide/Fungicide combination	Quantity
T1	carbendazim (commercial product-50% w/w)	10g/l
T2	carbendazim (commercial product-50% w/w)	15g/l
T3	hexaconazole (commercial product-50g/l EC)	10ml/l
T4	hexaconazole (commercial product-50g/l EC)	15ml/l
T5	carbendazim (commercial product-50% w/w) x hexaconazole (commercial product-50g/l EC) Alternatively	10g/l x 10ml/l
T6	carbendazim (commercial product-50% w/w) x hexaconazole (commercial product-50g/l EC) Alternatively	15g/l x 15ml/l
T7	mancozeb (commercial product-80% w/w) - (paraffin-oil based)	10g/l
T8	mancozeb (commercial product-80% w/w) -(paraffin-oil based)	20g/l
	Control	-

In comparison to the previous year's treatment conditions, the fungicide application was initiated in the latter phase, and the leaf maturity stages of the three fungicide applications were approximately at the late apple green stage, semi-mature stage and mature stage; before the appearance of the symptoms. The fertilizer application was carried out in treatment plots. In all the treatments, the fungicide applications were carried out with a commercial spreader and two applications of a commercial foliar nutrient solution were carried out during the refoliation phase. At the initial stage of the experiment at each location, the litter was treated with 10g/l Mancozeb (commercial product-80% w/w). The experiments were carried out at the following stakeholder's rubber fields (Table 11).

Table 11. *Details of the field experiments on the chemical management of CLSD*

Location	No. of treatments	Officer
Newchattle Estate	2 Treatments	B I Tennakoon
Pallegoda Estate	2 Treatments	
Miriswatta Estate	2 Treatments	
Mahaoya Estate		
Sapumalkanda Estate		
Eladuwa Estate	4 Treatments	E A D D Siriwardena
Arappolakanda Estate	1 Treatment	
Siriniwasa	2 Treatments	
Thalgaswala Estate	2 Treatments	S C P Wijayaratne
Galatura Estate	2 Treatments	
Halpe Estate	4 Treatments	
Salawa Estate	2 Treatment	E A D N Nishantha,
Newchattle Estate	2 Treatments	D A N Mallikarachchi

In monthly intervals, the CLSD severity of each plot (Average Disease Severity Index-ADSI) was evaluated based on the leaf fall status of a random set of trees as follows:

ADSI of the treatment plot = $\frac{[(0 * n1) + (1 * n2) + (2 * n3) + (3 * n4) + (4 * n5)]}{N}$

n1 = No. of plants representing score index 0
n2 = No. of plants representing score index 1
n3 = No. of plants representing score index 2
n4 = No. of plants representing score index 3
n5 = No. of plants representing score index 4
N = Total number of trees

The disease severity data of the fungicide spraying experiments showed slight changes in the disease development curve at different fungicide applications. However, it was observed that the reduction of the ADSI was not persistent throughout the disease active period (Figs. 2, 3, 4, 5 and 6) (M K R Silva, T H P S Fernando, B I Tennakoon, E A D D Siriwardena, S C P Wijayaratne, E A D N Nishantha and D A N Mallikarachchi).

c) Screening of the higher concentrations of potential fungicides against the CLSD

A polybag nursery-level experiment was initiated at the Dartonfield Estate to evaluate the effectiveness of higher concentrations of fungicides on the management of CLSD. The data recording is in progress. The treatments are summarized in Table 12.

d) Evaluation of the effectiveness of using paraffin oil as a spray base for fungicide spraying against CLSD

Based on the previous studies to evaluate the phytotoxicity of using different oils as a base of fungicide application (oil-based fungicide application), castor oil, mustard oil, lubricating oil and paraffin oil (white oil) showed no phytotoxicity at foliar application onto immature leaves of rubber. However, based on the price and the market availability, paraffin oil (white oil) was selected for further evaluation under field conditions. However, among the effective fungicides, only Carbendazim (commercial product-50% w/w) and mancozeb (commercial product-80% w/w) were found to be soluble in paraffin oil.

The effectiveness of spraying mancozeb (commercial product-80% w/w) (10g/l) using paraffin oil as a spray base for spraying was tested at three locations. In the experiment carried out at Mohomadi Estate, the fungicide spaying was carried out three times. The disease progression pattern is shown in Figure 7 (the fungicide application points are denoted in the time axis as arrows).

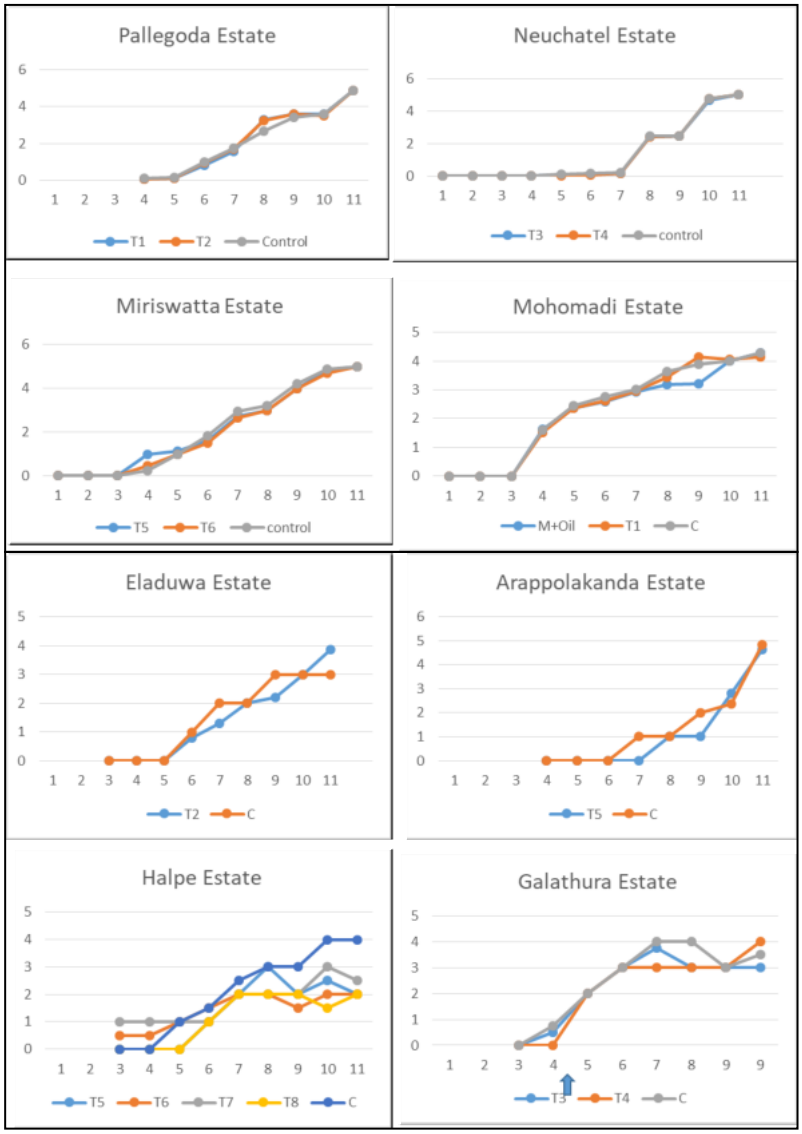


Fig. 2 - 6. Disease progression in the experimental plots

(M K R Silva, T H P S Fernando, B I Tennakoon, E A D D Siriwardena, S C P Wijayaratne, E A D N Nishantha and D A N Mallikarachchi)

Table 12. *Treatments of the nursery-level experiment on the effectiveness of higher concentrations of fungicides on the management of CLSD*

Treatment No.	Fungicide	Concentration	Base	Sprayed foliar stage
01	carbendazim (commercial product-50% w/w)	50g/l	Water	Copper brown
02	carbendazim (commercial product-50% w/w)	50g/l	Water	All stage
03	carbendazim (commercial product-50% w/w)	50g/l	Water	Apple green
04	carbendazim (commercial product-50% w/w)	50g/l	Water	Semi mature
05	carbendazim (commercial product-50% w/w)	50g/l	Water	Mature
06	hexaconazole (commercial product-50g/l EC)	50ml/l	Water	Apple green
07	CuOCl	50g/l	Paraffin oil	Apple green
08	copper Hydroxide (commercial product-57.6 % w/w)	50g/l	Water	Apple green
09	control			

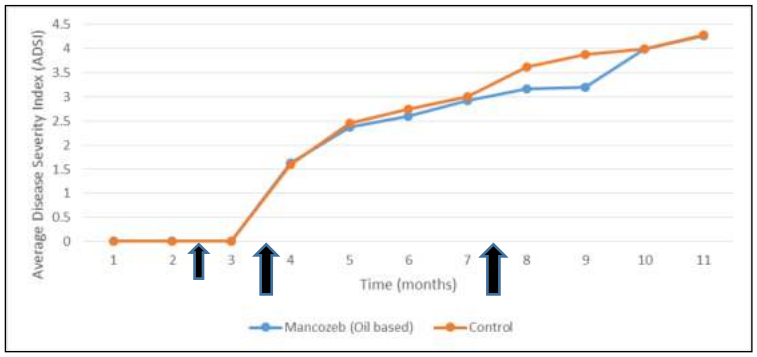


Fig. 7. Disease progression pattern of spraying oil-based mancozeb (the fungicide application points are denoted in the time axis as arrows)

At the Sirikandura Estate, where the mancozeb (commercial product-80% w/w) (10g/l) was applied once in paraffin oil, the Average Disease Severity Index (ADSI) of the treatment plots showed no difference from that of the control plots. At the Dartonfield Estate too where the carbendazim (commercial product-50% w/w) (10g/l) was applied once in paraffin oil, the Average Disease Severity Index (ADSI) of the

treatment plots showed no difference from that of the control plots (M K R Silva, T H P S Fernando and D A N Mallikarachchi).

e) Evaluation of the effective refoliation stage of fungicide application against CLSD

The study on the effective refoliation stage of fungicide application against CLSD was carried out at the nursery and field levels. At the nursery-level experiment carried out at the Dartonfield Estate, five treatments were maintained under a heavily infested tuber field to estimate the natural was used and the plants were cut back once to get an even refoliation. The treatments consisted of carrying out fungicide applications (Carbendazim- 4g/l) covering each of the refoliation stages: bud bursting, copper-brown leaf stage, apple green, semi-mature leaf stage and mature leaf stage. In the control set of plants, the fungicide application was carried out covering all stages (approximately in one week intervals according to the nursery recommendation). At the leaf maturity, the remarkable disease incidence was observed from the plants of all five treatments and no significant variation of was observed among the treatments.

Two parallel experiments were carried out at the Dartonfield Estate and the Mohomadi Estate to evaluate the possibility of managing CLSD with a single fungicide application at the late refoliation stage (semi-mature to early-mature). Carbendazim (commercial product-50% w/w) (10g/l, water-based), Carbendazim (commercial product-50% w/w) (10g/l, oil-based) and a new chemical mix containing Carbendazim and Mancozeb (commercial product-80% w/w) (10g/l, oil-based) were tested and the results are summarized in Figure 8 (the fungicide application point is denoted in the time axis as an arrow).

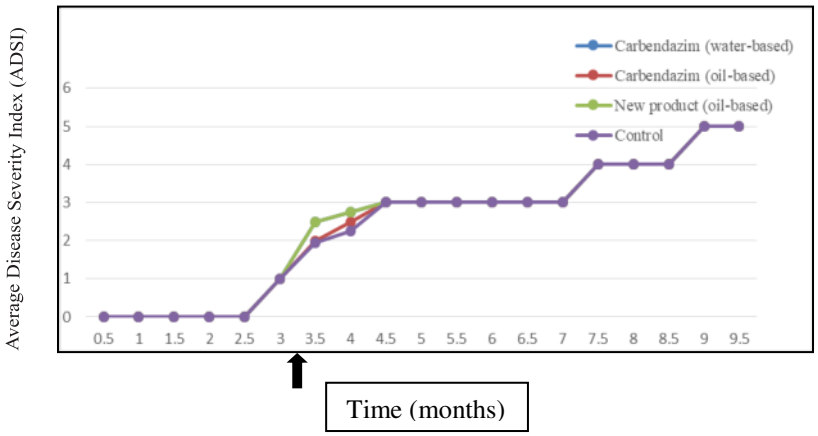


Fig. 8. Disease progression pattern of carrying out the late application of fungicides (the fungicide application point is denoted in the time axis as an arrow)

At the disease onset, the ADSI values showed a non-significant increase in treated plots while the disease progression curve had no displacement thereafter. This showed that the late application of these two fungicides at the tested concentration may cause a sudden boost up of the disease inoculum resulting in the symptom expression (M K R Silva, T H P S Fernando and D A N Mallikarachchi).

f) Evaluation of the curative action of the effective fungicides against CLSD

A polybag-level study evaluated the curative action of fungicides on the fungi *Colletotrichum* and *Pestalotiopsis*. Carbendazim (commercial product-50% w/w) and Hexaconazole (commercial product-50g/l EC) at the concentrations of 10g/l and 10ml/l, respectively were sprayed onto developed CLSD lesions. At four and seven days of spraying, fungal isolations were made from the margin of the foliar lesions of the respective treatment onto the artificial growth medium. During the isolation, surface sterilization was carried out for 30 seconds with 70% ethanol. Out of total number of isolation points, the percentage of points getting *Colletotrichum/ Pestalotiopsis* grown was calculated (Table 13). Carbendazim showed a significant reduction in the germination percentage at both readings ($\alpha = 0.05$)

Table 13. *Percent germination of Colletotrichum/Pestalotiopsis from inoculation points after fungicide treatment*

	Percent germination under each fungicide treatment		
	carbendazim	hexaconazole	Control
Germination % (4 days)	33.3	13.3	75.5
Germination % (8 days)	36.6	51.6	63.3

g) Chemical management of Circular Leaf Spot Disease using drone technology

In the management of Circular Leaf Spot Disease, experiments were initiated to determine the prospects of using drone technology in spraying fungicides. With the outsourcing of the drone service, the fungicide application was initiated in rubber plantations: Haldummulla, Halpe Estate and Diurumpitiya Estate. Treatments were designed to optimize the fungicide and the concentration, spray volume to cover a unit land area and timing of fungicide application. However, the planned programme was disturbed due to the rainfall lasting up to the end of the year (T H P S Fernando, M K R Silva and S C P Wijayaratne).

h) Evaluation of the CLSD development on the yield parameters

A study was initiated at the Dartonfield and Sirikandura Estates to evaluate the effect of the development of the disease on the yield parameters: latex volume and DRC. A series of test tapping is being carried out in a set of trees severely and mildly affected by the disease.

i) Evaluation of the effect of the fungicide Copper hydroxide in the oil-water mix

A nursery-level experiment was conducted to evaluate the efficacy of applying the concentration of 200g/l of Copper Hydroxide (commercial product-57.6 % w/w) onto immature leaves. Copper Hydroxide was prepared in a 1:1 paraffin oil-water mix. The fungicide application was carried out at the semi-mature stage of the foliage. A severe scorching was observed in treated leaves after one week.

A field experiment was initiated at the Dartonfield Estate to evaluate the efficacy of applying Copper Hydroxide in the concentration of 100g/l in a 1:1 paraffin oil-water mix. The fungicide application was carried out at the semi-mature stage of the foliage.

Poison Food Technique (PFT)

Poisoned food technique was performed for the *Colletotrichum* spp. cultures (C15, C24) isolated in CLSD. The concentrations of 0.5, 1, 5, 15, and 25ppm of fungicides were used for carbendazim, topsin, tebuconazole and hexaconazole, while the concentrations of 100, 250, 500, 750, 1500ppm of fungicides were used for champ, mancozeb and S. five replicated were maintained for each treatment including the control for each isolate (M K R Silva, T H P S Fernando, A H M N R Aberathne and S C P Wijayaratne).

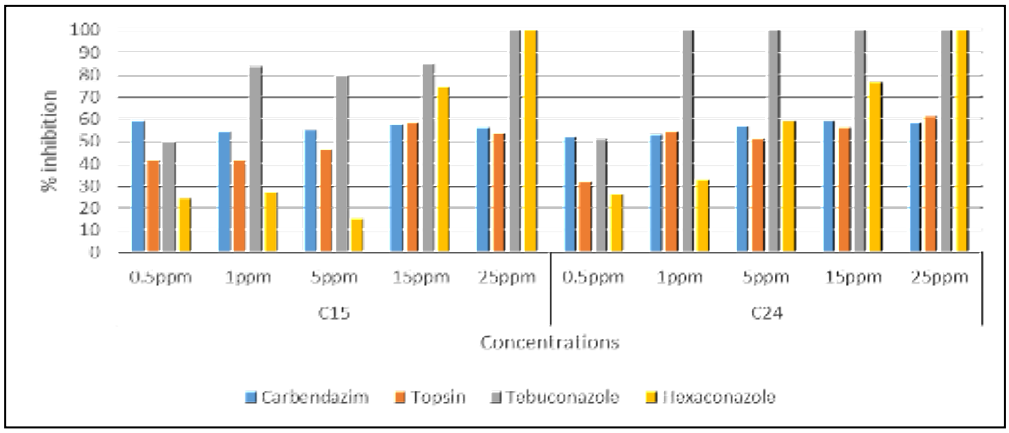


Fig. 9. Percentage inhibition of each isolate in each concentration of carbendazim, topsin, tebuconazole and hexaconazole

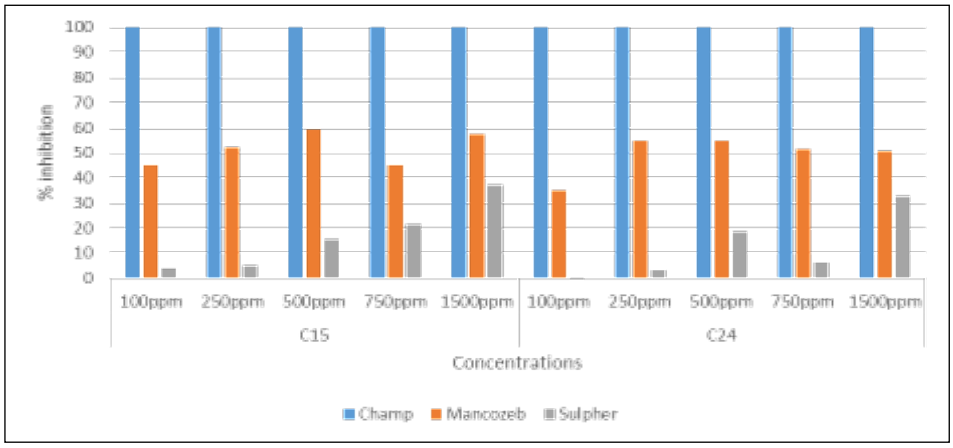


Fig. 10. Percentage inhibition of each isolate in each concentration of champ, mancozeb and sulphur

Biology of Pests (23/P/02)

Identification of causative organisms associated with the Circular Leaf Spot Disease

A foliar disease spreading in the many rubber growing countries was reported from Sri Lanka in the August 2019. Approx. 500 number of disease leaf samples were collected from different rubber growing agro-climatic regions. The symptoms were recorded and the causative pathogens were isolated onto Potato Dextrose Agar. More than 100 pathogen isolates were obtained and Kock's postulates were also proven using the isolates. The cultures were subjected to morphological studies and later for molecular identification. Majority of the isolates were Pestalotioides. The other main pathogen was Colletotrichum. Among the isolates nearly 70% represented Pestalotioides pathogens – three genera, *Neopestalotiopsis* spp., *Pestalotiopsis* spp. and *Psuedopestalotiopsis* spp. Although the *Colletotrichum* were low in number, they were more pathogenic. Some of the Pestalotioides showed a very mild pathogenicity assayed by detached rubber leaf method. Cultural and reproductive characteristics showed significant variability among the isolates. Based on morphological characters, 13 pathogen isolates were selected for further studies. DNA isolation was performed, and PCR using the primers ITS 1 and 4 was subjected. Sequencing revealed that there were three main species such as; *Colletotrichum siamense, C. fructicola* and *C. gigasporum*. Koch's postulates were proven with the three *Colletotrichum* species on rubber seedlings. This is the first report of *C. siamense, C. fructicola* and *C. gigasporum* associated with the newly spreading leaf fall disease of rubber plantations. *C. gigasporum* was identified as a poor sporulator compared with the other two species. According to the pathogenicity studies, *C. gigasporum* showed the

highest Disease Index value. A detailed study to investigate the biology and pathogenicity has been undertaken, as the information is essential of formulating effective disease management strategies (T H P S Fernando, M K R Silva, A H M N R Aberathne, E A D N Nishantha and E A D D Siriwardena).

The name of the newly spreading leaf fall disease as circular leaf spot disease

The new leaf fall disease is caused by two fungal pathogens: Colletotrichum and Pestalotioides. Many new species are being reported. All the other affected countries also report different pathogen species. Hence it seems that the pathogen populations associated with this disease are different from country to country. Hence instead of using the names of pathogens, use of the symptom was suggested. All the rubber growing countries have agreed on this. Hence the name "Circular Leaf Spot Disease (CLSD) was accepted (T H P S Fernando and M K R Silva).

Effect of leaf stage on the establishment of the CLSD - Trial 01

Five leaf stages (A - initial copper brown; B - later copper brown; C - apple green; D - semi matured; E - matured) were subjected to the observations. Five sets of rubber plants which having initial copper brown leaves were selected and they were closed using polythene bags after the application of initial carbendazim treatment (3g/l). Five plants were maintained as replicates for each set. One set was opened initially at initial copper brown stage and others were closed. Another set was opened when the rest of the plants became later copper brown leaf stage. Likewise, the set of plants was opened at apple green, semi matured and matured stages. Then they were allowed to natural inoculum potential allowing the development of lesions. Lesion percentage in both day 1 and day 2, were high in treatment D, which was opened at their semi matured stage. According to the results (Fig. 11), semi mature stage may be considered the most susceptible stage for the infection of the pathogen. However, in the third day, the lesion percentage has increased rapidly in B which was exposed at their later copper brown stage. There was confusion with the third day data. The experiment has to be repeated for better conclusion (T H P S Fernando, M K R Silva, A H M N R Aberathne, E A D N Nishantha and C Wijeyarathne).

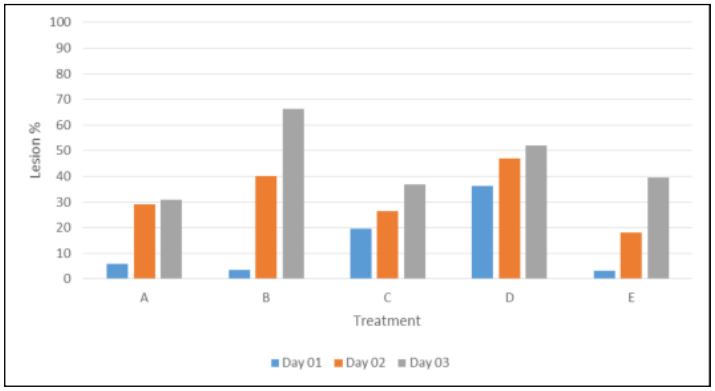


Fig. 11. The effect of leaf maturity stage on the establishment of the disease

Effect of leaf stage on the establishment of CLSD - Trial 02

The experiment was conducted by using fungicide spray: carbendazim – 5g/liter and later opened the flush for the natural inoculum potential. The set – up of the experiment was as given below and the observations made after two weeks of incubation period were as follows (Table 14). Number and size of lesions are higher in opened leaves in semi matured stage. However, the experiment should be repeated as negative results were obtained in the control (T H P S Fernando, M K R Silva, A H M N R Aberathne, E A D N Nishantha and E A D D Siriwardena).

Effect of leaf stage on the establishment of the CLSD - Trial 03

This trial was conducted to reveal the stage of the leaves that are susceptible to the disease. The tender leaves appearing from the bud burst were kept covered until the relevant leaf stage passed, and the plants were later exposed to the normal environment. The results were noted as the presence or absence of disease symptoms. Since the disease lesions were not observed even in open control (Table 15), the trials need to be repeated (T H P S Fernando, M K R Silva, A H M N R Aberathne, E A D N Nishantha and E A D D Siriwardena).

Table 14. *Effect of leaf stage on the establishment of the CLSD - Trial 02*

Date	A	B	C	D	E	F	Control
01.06.2022	Spray & open	Spray	Spray	Spray	Spray	Spray	-
04.06.2022		Spray & open	Spray	Spray	Spray	Spray	-
07.06.2022			Spray & open	Spray	Spray	Spray	-

Date	A	B	C	D	E	F	Control
10.06.2022				Spray & open	Spray	Spray	-
13.06.2022					Spray & open	Spray	-
Activity	Sprayed till copper brown	Sprayed till apple green	Sprayed till semi matured	Sprayed till matured	Sprayed even after matured	Continue spraying	No spraying
Observation after 14 days	Slight lesions	Mild lesions	Mild to moderate lesions	No lesions	No lesions	No lesions	No lesions

Table 15. *Six plant sets which having unopened leaves were selected and grouped as A, B, C, D, E and F*

A	B	C	D	E	F
Open at copper brown stage	Open at Apple green stage	Open at semi mature stage	Open at mature stage	Always closed	Control always opened
A high amount of lesions	Moderate amount of lesions	Mild amount of lesions	No lesions	No lesions	No lesions

Isolation of the fungi in Hevea phylloplane

Un-opened healthy rubber leaves were collected and cut in to small pieces. The isolations were done using the leaf with and without surface sterilizing. They were inoculated on to PDA plates and incubated to observe the appearance of colonies (Fig. 12). Different types of fungal cultures arising from leaf pieces were counted separately. The number of resulted *Colletotrichum* spp. is higher than Pestalotioides in both surface sterilized and non- sterilized leaves (T H P S Fernando, M K R Silva and A H M N R Aberathne).

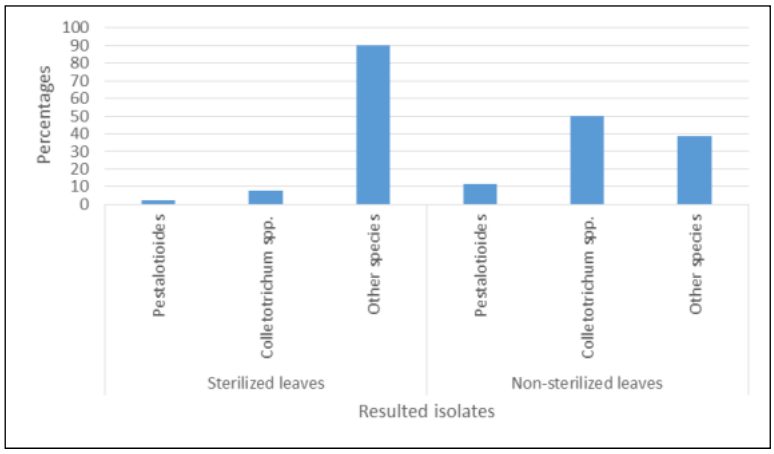


Fig. 12. Resulted microorganism percentages in both sterilized and non- sterilized leaves

Isolation of the fungi from Hevea phylloplane in different stages

Healthy rubber leaves from different stages (copper brown, apple green, semi-mature, mature) were selected and cut in to small pieces. Isolation of the micro-organisms were isolated with and without surface sterilization. They were inoculated on to PDA plates and incubated to observe the resulting microbes. Different types of fungal cultures observed from leaf pieces were counted separately (Fig. 13). *Colletotrichum* spp. are high in immature leaf stages while Pestalotioides are high in mature leaf stages (T H P S Fernando, M K R Silva and A H M N R Aberathne).

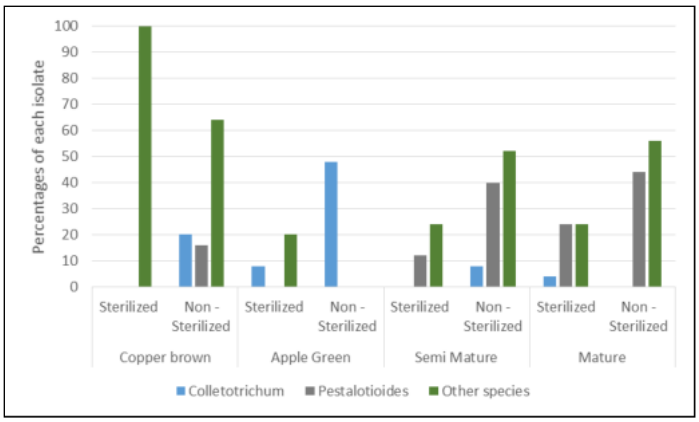


Fig. 13. Percentage micro-organisms observed in different healthy rubber leaves

Establishment of the pathogenicity for the Colletotrichum spp. associated with the CLSD

Four cultures of *Colletotrichum* spp. isolates (C1, C7, C15, C24) were used in the study. Conidia suspensions (5 x 10^4 conidia/ml) were prepared from each isolate. Detached rubber leaves (rubber clone RRIC 121) were inoculated with the conidial suspensions prepared as given above. One set of leaves from each stage was wounded and other set was without wounding. They were incubated at laboratory providing 100% RH for 3 days and the symptom development was observed. Copper brown and apple green stages are the most sensitive leaf stage for isolate C1, C7 and C24 even in non-wounded stages. However, C15 can't behave as a pathogen in non-wounded stages figure 14 (T H P S Fernando, M K R Silva, A H M N R Aberathne and E A D N Nishantha).

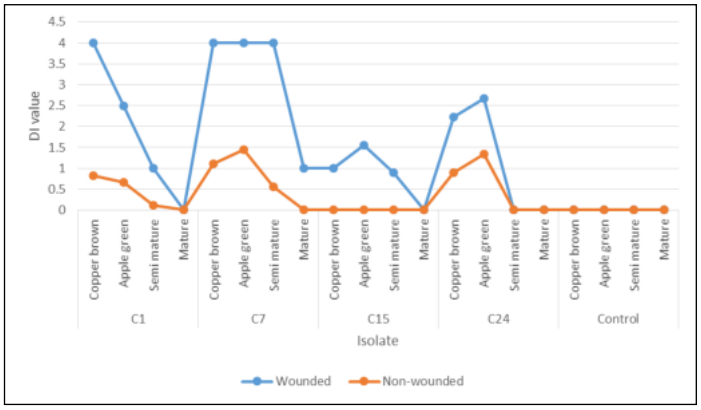


Fig. 14. DI value of each wounded and non- wounded leaves

Pathogenicity test for Colletotrichum spp. Pestalotioides and their combination

The pathogen cultures were used for artificial inoculation as given below and the development of lesions were observed after 72 hours. *Colletotrichum* spp. showed the highest pathogenicity in both wounded and non-wounded leaves and *Colletotrichum* spp. showed the highest pathogenicity than Pestalotioides isolates. In wounded leaves, *Colletotrichum* spp. showed a higher pathogenicity than in the non-wounded leaves. In non-wounded leaves, there were no lesions noted accept *C. gloeosporioides, C. gigasporum, C. fructicola, C. tropicale, C. fructicola* + P44, *C. gloeosporioides* + P20, *C. tropicale* + P20. After mixing *Colletotrichum* spp. with Pestalotioides, the pathogenicity has reduced in non-wounded leaves. After mixing *C. gloeosporioides* and *C. gigasporum* with Neopestalotiopsis (P44), the pathogenicity was reduced in wounded leaves than using pure *Colletotrichum* spores. But after mixing *C. fructicola* with *Neopestalotiopsis* (P44), the value has increased than using pure *C. fructicola.* But after mixing *C. tropicale* with *Neopestalotiopsis*

(P44), the value has not changed than using pure *C. tropical.* After mixing *Colletotrichum* spp. with *Pseudopesalotiopsis* (P20), the pathogenicity has reduced in wounded leaves than using the pure *Colletotrichum* spores figure 15 (T H P S Fernando, M K R Silva, A H M N R Aberathne and E A D N Nishantha).

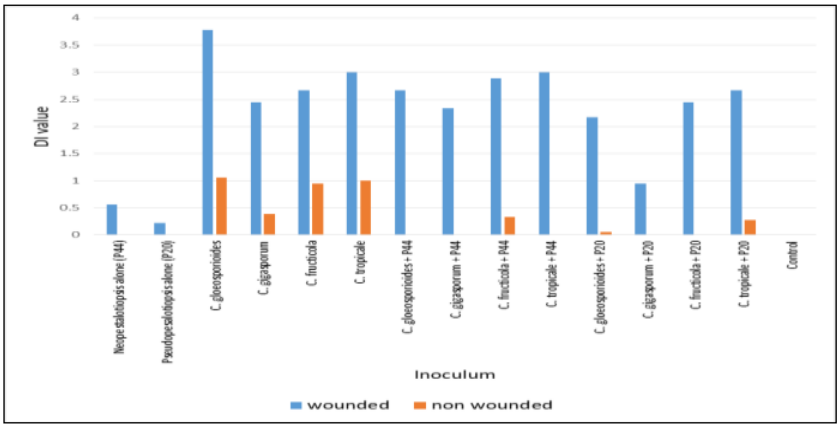


Fig. 15. DI values of the artificial inoculations on detached rubber leaves using *Colletotrichum* spp. and Pestalotioides pathogens

Effect of soil nutrition on the development of CFLD - Case study carried out at a location with low CLSD incidence

In the rubber clearing with low disease incidence which was reported in the Welgama area of Kalutara district (the specific location of the rubber plantation had been used as a threshing ground), while the adjoining area of the same plantation was showing drastic devastation due to the disease, the disease progression was further evaluated. It was revealed that the same pattern continued this year too. In the previous year, an investigation was undertaken to find out whether any relationship exists between the development of the CFLD and the soil nutrient status of the respective field (M K R Silva, T H P S Fernando, D A N Mallikarachchi – collaboratively with the Department of S & PN).

Effect of soil nutrition on the development of the CFLD under field conditions

Field experiments were initiated at Sirikandura Estate and a medium-level rubber plantation in Maggona to evaluate the effect of soil nutrition on the development of CLSD. The experiment was designed to evaluate the effect of adding higher doses of recommended fertilizer elements and using micronutrients such as Silicon. The ADSI of the experimental plots is being recorded (M K R Silva, T H P S Fernando and D A N Mallikarachchi – collaboratively with the Department of S & PN).

Testing the pathogenicity of wood degrading fungi

Pure cultures of each isolate were prepared on PDA. They were inoculated on to sterilized rubber root pieces after growing on the full Petri dishes. They were incubated to grow on the surface of the root pieces. They were inoculated separately into the soil which growing the rubber seedlings. They were labelled and allowed to test the pathogenic features. Five replicates for each treatment was maintained with the control. There were no pathogenic features observed in inoculated seedlings even after 06 months (Fig. 16) (T H P S Fernando and A H M N R Aberathne).

Fig. 16. Steps of inoculation of isolates into seedling pots

Rubber latex coagulation bacteria

Six bacteria and six fungi were isolated from coagulated rubber latex in the field. Pure cultures of them were obtained. They were grown in malt extract broth medium and the pH changes of each media were measured. The experiment is still continuing (T H P S Fernando, A H M N R Aberathne and Lahiru collaboratively with S Siriwardena).

Cell wall degrading enzyme production by *Colletotrichum* spp. and *Pestalotioides* associated with the circular leaf spot disease

Four isolates of *Collectotrichumn spp. (C. tropicale, C. accutatum, C. siamense, and C. fructicola)* and three isolate of *Pestalotiopsis* (Isolate P7, P20, P44) were used. The isolates were grown in Ammonium Tartrate Medium with either citrus pectin, carboxymethyl cellulose (Sigma) as the main source of carbon (for the assays on pectinolytic enzymes, cellulolytic enzymes respectively). The fungus was

grown in citrus pectin as the sole carbon source. Growth of the four *Collectotrichum* isolates in the ammonium tartrate liquid medium with citrus pectin as the main sources of carbon. *C. fructicola* showed a significant growth rate after 4 days. Other inoculates showed comparatively slower growth rates than the *C. fructicola* isolate.

The cultures incubated with citrus pectin, and carboxy methyl cellulose as the carbon source were subjected to the assays on pectinolytic enzymes,and cellulolytic enzymes respectively. Three replicate cultures were used to harvest target incubation interval of each experiment. So, the fungal mats were harvested by filtering through Whatman no. 1 filter papers and the resulting culture filtrates were subjected to enzyme assays. Time-course studies were carried out to detect the course of enzyme production by the above mentioned four isolates of *Collectotrichum* and three isolate from *Pestalotiopsis.* Furthermore, the variation in the pH of the culture filtrate was recorded throughout the incubation period.

To determine Polygalacturonase activity, two methods: namely the cup plate method and the viscosity reduction method were used. When assayed by the cup plate method PG production of the four isolates showed peaks after 2 days of incubation. *C. tropicale* showed the highest PG activity than the other three isolates *(C. acutatum, C. siamense, and C. fructicola).* At the viscosity reduction method *C. tropicale* and *C. fructicola* showed higher PG production after 2 days of incubation. All the three isolates of Pestalotioides gave higher PG activity after 2 days of incubation assayed by viscosity reduction method and cup plate method. However, isolate P7 and P44 showed a significantly higher PG level than P20. In addition, all the isolates produced PG. The *Colletotrichum* isolates showed in a pH level varying from 4.3 to 8.6 throughout the incubation period when citrus pectin was the primary carbon source. The production of pectic enzymes showed a similar trend to the variation of the pH level of the medium. The three *Pestalotioides* isolates showed a pH varying from 4.4 to 7.6 throughout the incubation period when citrus pectin was the primary carbon source (T H P S Fernando, W A K S Wijesooriya and E A D N Nishantha).

Toxic metabolite production by *Colletotrichum* spp. & *Pestalotioides* associated with the circular leaf spot disease

Detection of toxic metabolite production by pathogen isolates

Pathogen isolates of *Colletotrichum; C. acutatum, C. siamense, C. tropicale, and C. fructicola* produced phytotoxins in culture media under laboratory conditions. The cultures were maintained on PDA. Erlenmeyer flasks (250ml) each containing 25ml of Czapek Dox liquid media were inoculated with three mycelial plugs, 8mm in diameter, taken from 7-day old colonies of *Colletotrichum* spp. grown on potato dextrose agar (PDA) at room temperature (28±2°C). The cultures were incubated at RT under normal light and dark regimes as stationary cultures. The cultures were harvested 9 d after incubation by filtering Through Whatman No. 1 paper and then

through a 0.22µm millipore filters. The resulting culture filtrate was stored at 4°C in small aliquots of 10ml and used as the source of toxins.

Detached apple green staged leaves from *Hevea brasiliensis* (clone RRIC 121) were used to detect the toxic activity of the culture filtrates. Three needle-point injuries were made on either side of the mid-rib of each leaf and 0.02 ml droplets of the culture filtrate were placed on these pin-point wounds. Subsequently, these inoculated *Hevea* leaves were incubated for 72hrs at RT under 100% RH in trays lined with moist blotting papers. At the end of the incubation period, the inoculated drops were removed by using a blotting paper and the lesions were ranked from class I–V based on the size of the lesions. Filtrates from uninoculated media served as controls. According to the *C. acutatum* was the lowest producer. In this study, *C. tropicale* produced more toxic substances. The time course experiment was completed (T H P S Fernando, D P Kariyawasam and E A D N Nishantha).

Screening of Clones for Leaf and Panel Diseases (23/P/03)

Screening of* Hevea *clones against Corynespora leaf fall disease (CLFD)

The incidence of Corynespora leaf fall disease was mild during the year 2022 (Table 16).

Table 16. *Results of the Survey on Corynespora leaf fall disease conducted in 2022*

Clone	ADSI *	Clone	ADSI *
RRIC 121	0	RRISL221	0
RRIC 102	0	RRISL222	0
RRIC 130	0	RRISL 202	1.0
RRISL 203	0	RRISL2000	0
PB 260	0	RRISL2002	0
RRIC 133	0.6	RRISL2004	0
RRISL 201	0.8	RRISL2005	0
RRISL 205	0	RRISL2006	0
RRISL206	0	GPS 1	0
RRISL210	0	PB 255	0.6
RRISL211	0	PR 255	0
RRISL215	0	PR 305	0
RRISL216	0	RRII 105	0.6
RRISL217	0.4	PB235	0
RRISL219	0	BPM 24	0
RRISL2001	0	Centennial 2	0
RRISL2003	0	Centennial 3	1.0
RRISL 218	1.2	Centennial 4	0
RRISL 204	0	Centennial 5	0
RRISL 220	0		
RRISL 208	1.2		

*ADSI- Average Disease Severity Index

ADSI; 0-free from the disease; 0.01-1.0, slight infections; 1.01-2.0, moderate infections; 2.01-3.0, severe infections

Maintenance of nurseries for screening purposes – Ratnapura District

Fifty *Hevea* clones have been established at the Kuruwita substation Ratnapura for clonal evaluation against Corynespora leaf fall disease and the other foliar diseases. Corynespora leaf disease was reported from RRIC 121 plants. The cultures are being studied for the variability (T H P S Fernando, M K R Silva and E A D N Nishantha).

Establishment of a nursery for screening purposes - Moneragala

Fifty *Hevea* clones have been established at the Moneragala substation, Moneragala for clonal evaluation against Corynespora leaf fall disease and the other foliar diseases (T H P S Fernando, M K R Silva and S C P Wijayaratne).

Establishment of a nursery for screening purposes – Padiyathalawa

Fifty *Hevea* clones have been established at the Padiyathalawa Rubber Development Department premises for clonal evaluation against Corynespora leaf fall disease (T H P S Fernando, M K R Silva and E A D D Siriwardena).

Establishment of a nursery for screening purposes – Sapumalkanda Estate

Forty eight *Hevea* clones have been established at Sapumalkanda Estate for clonal evaluation against Corynespora leaf fall disease and other potential diseases (T H P S Fernando, M K R Silva and B I Tennakoon).

Establishment of a nursery for screening purposes - Dartonfield

Fifty *Hevea* clones have been established at the Dartonfield Estate, RRISL for clonal evaluation against Corynespora leaf fall disease and the other potential diseases (T H P S Fernando, M K R Silva, E A D D Siriwardena and A Mallikarachchi).

Screening of* Hevea *clones against Circular Leaf Spot Disease (CLSD)

Screening of 15 *Hevea* clones were completed at eight experimental sites. The incidence of the disease was observed in all the nursery plants (poly bag plants) immaterial of the clone. The screening of the bud wood nursery type of experiments in five sites revealed that the clones RRIC 100, RRIC 130, RRISL 2006 and del Cen 4 showed a moderately tolerance towards the disease (T H P S Fernando, M K R Silva, E A D D Siriwardena and A Mallikarachchi).

Surveillance of potential pests and disease outbreaks (23/P/04)

Studies on Alternative hosts Alternative hosts study for CLSD associated pathogens

Leaves of different host plants (*Pueraria* sp., Cinnamon, Tea, Chilli, Brinjal, *Mucuna* sp.) showing the typical symptoms of the circular leaf spot disease found in the vicinity of rubber plantations were selected. Isolation of the associated pathogens was done after surface sterilization using ethanol 70%. Leaf pieces were transferred onto PDA plates. They were incubated under room temperature and normal light and dark conditions. Both *Colletotrichum* spp. and Pestalotioides were resulted from each isolation. Pure cultures of each isolate were incubated till spore production. They were observed under light microscope and the conidia suspensions were prepared. Conidia concentration was adjusted to 5 x 10^4 conidia/ml using a haemocytometer. They were inoculated onto the leaves of each host plant in a humid chamber. 20µl of conidia suspension of each pathogen was inoculated to the host leaves (06 drops of each suspension). One set of leaves were injured and one set of leaves were allowed to remain without wounds. They were incubated for 72 hours and lesion development was observed. The experiment is in progress to test the Koch's postulates (T H P S Fernando, M K R Silva, A H M N R Aberathne and H R G N Peiris).

Surveillance of the circular leaf spot disease – incidence and severity and its impact on the yield

A survey was conducted in 11 Rubber Estates regarding the Circular leaf spot disease incidence, severity, yield and nutrient condition. Mature rubber plantations were selected and from each site a disease severe, moderate and mild clearings were subjected to the study. The project is in progress to analyse the data collected (P Seneviratne, T H P S Fernando, M K R Silva collaboratively with Dept. of Plant Science, Dept. of Biochemistry and Plant Physiology, Dept. of Soils and Plant Nutrition).

Surveillance of the circular leaf spot disease – incidence and severity in smallholdings

A survey was undertaken to assess the disease condition and their yields in smallholder farmers in the country. The project is in progress to analyse the data collected (P Seneviratne, T H P S Fernando and M K R Silva, collaboratively with the Economics Unit, Dept. of Plant Science, Dept. of Biochemistry & Plant Physiology, Dept. of Soils and Plant Nutrition).

Biological Control of *Hevea* Diseases (23/P/05)

Two *Trichoderma* based biopesticides have been submitted to the Registrar of Pesticides for registration.The products were prepared in two media such as compost and talc and under commercial level screening (T H P S Fernando, M K R Silva, E A D D Siriwardena, S C P Wijayaratne, A H M N R Aberathne and S Madushanka collaboratively with Biochemistry and Physiology Department).

Developing a national level Fungal culture collection – WDCM registered

A collection of fungal cultures is maintained at the Plant Pathology & Microbiology Department in view of using them for research and development purposes. These pure cultures of beneficial and pathogenic are provided for nationally and internationally important research and development purposes.

The collection mainly consists of *Colletotrichum acutatum/Colletotrichum gloeosporioides/Corynespora cassiicola/Phytophthora spp./Rigidoporus microporus/ Phellinus noxius/Xylaria thwatsii/Fusarium solani/Nattrassia mangiferae/ Thanetephorus cucumeris/Rhizoctonia solani/Pestalotiopsis spp./Phomopsis spp./ Botrodiploidea theobromae/Trichoderma* spp./*Aspergillus* spp./*Penicillium* spp./ *Trichoderma harzianum/Trichoderma hamatum/Colletotrichum siamense/ Colletotricum fructicola/Colletotrichum gigasporium/Ustulina deusta/ Botryodipoidea theobromae/Aspergillus spp.*) (T H P S Fernando, M K R Silva, A H M N R Aberathne, Gayani Peiris and the staff of Plant Pathology & Microbiology Dept.).

Experiment to test the effectiveness of bio fertilizer for the growth of short term crops

Brinjal seedling were grown in plastic pots and allowed to grow and establish. They applied the combinations of bio fertilizers as given below (Table 17). Five replicates were maintained for each treatment including the control. Growth of the plants was observed. Treatment 07, the combination of bacteria in compost and paddy husk mixture + *Trichoderma* sp. 01 in compost and paddy husk mixture showed the highest growth in brinjal plants with compared to the control. Treatments 01, 05, 07 and 08 showed a high extent of plant growth than control while the rest of the plants showed reduced growth. Among them, isolate 04 showed the lowest growth than others (Fig. 17) (T H P S Fernando, M K R Silva, A H M N R Aberathne and Shehani Liyanage).

Table 17. *Different treatments of biofertilizer under investigation*

Treatment No.	Fertilizer combination
01	*Trichoderma* sp. 01 + Compost
02	*Trichoderma* sp. 02 + Compost
03	Compost alone
04	Bacteria in liquid medium + *Trichoderma* sp. 01 in liquid medium
05	Bacteria in paddy husk + compost
06	Bacteria in liquid medium
07	Bacteria in compost and paddy husk mixture + *Trichoderma* sp. 01 in compost and paddy husk mixture
08	*Trichoderma* sp. 01 in paddy husk
09	Control – No treatment

Fig. 17. Growth of the Brinjal pants with each combination of treatments with control

Experiment to test the effect of bio pesticides against WRD

Rubber plants were grown on the flow for the application of prepared bio pesticides using most effective *Trichoderma* sp. against white root disease. One plant was planted at the middle and it was infected with white root disease artificially. Another six plants were planted around the diseased plant and they were added bio pesticides. A control set was maintained without adding bio pesticides. The experiment is in progress (T H P S Fernando & A N M N R Aberathne).

Isolation and study of bacteria from rubber serum

Two methods such as surface spread samples and mixing the samples with culture media were used to isolate inhabiting micro-organisms. The PH of the samples were recorded (Table 18). Extract Agar was used as the growth media and a dilution series was used for each sample as Crude, 10^{-1}, 10^{-2} and 10^{-3}. Three replicates were used for each dilution and they were incubated for 03 days. The resulted bacterial and fungal colonies were counted separately. Mean was calculated from each replicate and the graphs were prepared.

Table 18. *pH of the serum samples under investigation*

Sample No.	pH
Sample 01	4.492
Sample 02	2.345
Sample 03	2.120
Sample 04	7.760
Sample 05	7.420

Effect of climate change on the severity of the Circular Leaf Spot disease of rubber. Literature survey was carried out to initiate the project. (M K R Silva, T H P S Fernando, Dilhan Ratnayake)

Advisory visits and training programmes (PP– 08)

The staff of the department made 75 advisory visits mainly to handle complicated disease problems. The majority of these visits were for the Estate sector while the others were directed to the department by the Extension staff (T H P S Fernando and the staff of Plant Pathology & Microbiology Dept.).

The department conducted five training programmes on White root disease management and on the management of the new leaf fall disease to educate the Extension staff and the stakeholders of the new findings (T H P S Fernando and the staff of Plant Pathology & Microbiology Dept.).

The staff of the department served as the resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Students from Universities and Technical Colleges were also trained in departmental activities. Mr Priyantha Peiris covered all audio visual aspects with regard to the training programmes organized by the institution (T H P S Fernando and the staff of Plant Pathology & Microbiology Dept.).

SOILS AND PLANT NUTRITION

Research activities on improvement of soil fertility, increasing fertilizer use efficiency, soil, water and nutrient conservation and weed control were continued. The special capital project "Establishment of environmentally friendly, economically viable slow-release fertilizer techniques to improve crop performance and establishment of an accredited laboratory to supply good service to the rubber industry" continued. The project "Enhancing soil fertility in degraded rubber lands by combined use of agro-management practices such as inorganic fertilizer, biofertilizer, cover cropping and mulching with organic were conducted with the funds of the National Research Council. An experiment was started at Kuruwita RRISL Sub-station in the third quarter of the year 2022 for investigation of the effect of cut down of the inorganic fertilizer dosage combined with organic amendments such as compost, partially burned paddy husk, biochar and commercially available Effective Microbes (EM) as treatments. Growth parameters collected up to the bud grafting stage revealed that the application of human urine as a source of nutrients is sufficient for the young budding plants raised in polybags. The preliminary study showed promising results of using rubber effluent as a nutrient source for capsicum plants. An experiment to study the impact of different fertilizer treatments on the incidence and severity of New Leaf Fall Disease in immature rubber plants was started at Maggona and Sirikandura Estates. Fertilizer application with slow-release techniques; Fertilizer Encapsulated Coir Bricks (FECB) and Reusable Fertilizer Porous Tube (RFPT) showed significantly higher or comparable assessments related to growth/soil fertility parameters/leaf nutrients compared to conventional split fertilizer application under immature rubber. Plants treated with 50% and 75% of recommended inorganic fertilizer with good agricultural practices (GAP) showed a significantly higher plant girth at the end of the first year, compared to the control with two treatments which applied only 50% and 100 % of the recommended inorganic fertilizer respectively. However, except for the leaf potassium (K), a significant difference was not observed between treatments for other leaf nutrients; nitrogen (N), phosphorus (P) and magnesium (Mg). Hence, there is a possibility to reduce the amount of recommended inorganic fertilizer when combined with GAP to maintain fertility levels at the age of the first year. Diagnosis and recommendation integrated system (DRIS) related to dual nutrient ratios in plant material is an efficient method to determine the nutritional status of the plant and helpful for the determination of the nutrient status of the plant and their revisions accurately. The soil carbon stock of the Kuruwita experiment site was determined to identify different management zones under mature rubber plantations based on the carbon status of the soil. Site-specific fertilizer recommendation programme provided 53 fertilizer recommendation reports for the extent of 8697 hectares of mature rubber fields. Three land suitability reports were issued for 57.2 hectares under the land selection programme. Analytical service offered eight analytical reports, including 238 parameters based on 85 samples together with 14 fertilizer samples. Those fertilizer samples ensure the application of good quality fertilizer for their rubber land.

SOILS AND PLANT NUTRITION

R P Hettiarachchi

DETAILED REVIEW

Staff

Dr (Mrs) R P Hettiarachchi, Head of the Department, Mrs H A R K Jayawardana, and Mr L A T S Liyanaarachchi Research Officers were on duty throughout the year. Experimental Officers Miss V Edirimanna, Miss A Thevarapperuma and Mr T Gunathileke, Technical Officers, Mrs K E de Silva, Mr G C Malawaraarachchi, Mr M W H Gayan, Mrs K M M E K Kulatunga, Mrs R M Baddevidana and Mr B N K Rangana were also on duty throughout the year. Technical Officer, Mrs P D S D O Rathnasooriya, served the department until her resignation on 18th April.

Research students

The following students have completed their Research studies under the supervision of Dr (Mrs) R P Hettiarachchi**.**

- B W T Nethmi, a student from the Faculty of Science, the University of Colombo Sri Lanka, conducted a part of her final year research project on "Effect of home-made compost on rubber grown soil".

- K R B S Jayarathne student from the Department of Export Agriculture, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, conducted a part of his final year research project on "Influence of the Crepe Rubber Processing Wastewater on Soil Characteristics".

- H D A N Jayawardhana student from the Department of Agricultural and Plantation Engineering, Faculty of Engineering Technology, the Open University of Sri Lanka, conducted a part of her final year research project on "Evaluate the effectiveness of organic manure and inorganic fertilizer application on rubber (*Hevea brasiliensis*) plantations in non-traditional areas in Sri Lanka".

- W G Buddika student from the Department of Agricultural and Plantation Engineering, Faculty of Engineering Technology, the Open University of Sri Lanka, conducted a part of her final year research project on "Evaluate the effectiveness of organic manure and inorganic fertilizer application on rubber (*Hevea brasiliensis*) plantations in traditional areas in Sri Lanka".

- A D P Rasangika student from the Department of Agricultural Engineering and Soil Science, Faculty of Agriculture, Rajarata University of Sri Lanka, conducted a part of her final year research project on "Soil phosphorus availability in relation to organic carbon and pH in differently managed immature rubber growing soils: *Boralu* and *Homagama* soil series".

- K H D M Premarathna student from the Department of Agricultural Engineering and Soil Science, Faculty of Agriculture, Rajarata University of Sri Lanka, conducted a part of her final year research project on "Nutritional status of immature rubber in *Boralu* and *Homagama* soil series managing under different conditions".

Seminars/Training/Workshops/Conferences/Meetings conducted

Officer	Subject	Organization
RP Hettiarachchi	Fertility management for rubber plantations	Rubber Research Board
	සාර්ථක රබර් වගාවක් සඳහා පසෙහි සරුබව කළමනාකරණය	Rubber Development Dept
HARK Jayawardana	Bio-efficacy Reports of weedicide samples	Office of Registrar of Pesticide
TS Liyanaarachchi	Land suitability analysis for rubber *via.* GIS	IRRDB and RRI

Seminars/Training Programmes/Workshops/Exhibitions attended

Officer	Subject	Organization
RP Hettiarachchi	Fertilizer Advisory Committee Meeting	Ministry of Agriculture
	Task force for optimizing the use of organic and inorganic fertilizer	Presidential Secretariat
RP Hettiarachchi, HARK Jayawardena & LATS Liyanaarachchi	Scientific Committee Meeting	Rubber Research Institute
HARK Jayawardena & LATS Liyanaarachchi	Laboratory Accreditation (1)	Consultant- Mrs S Jayasinghe
	Laboratory Accreditation (2)	HORDI, Gannoruwa
	Workshop of Statistics	University of Peradeniya
	GIS and Spatial Mapping	IRRDB and RRISL

Visits

Advisory	05
Experimental	67
Others	57

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Rehabilitation of degraded lands

Identify degraded lands and promote their fertility levels by using organic, inorganic and biofertilizer

Activities of the above project funded by NRC began in 2020 and consisted of different fertility levels (50% recommended fertilizer only, 100% recommended fertilizer only, 50% recommended fertilizer with Good Agricultural Practices (GAP) and 75% recommended fertilizer with GAP). At the end of the first year, the plant girth was measured at four feet above the ground level and showed significant differences among treatments (Table 1). Plants treated with 50% recommended fertilizer and 75% recommended fertilizer with GAP gave significantly higher plant girth compared to inorganic fertilizer alone two treatments which included 50% and 100% of the recommended fertilizer only. Further, we could observe a significant enhancement of plant growth with 100% inorganic fertilizer treatment (T2) compared to 50% inorganic fertilizer treatment (T1). Annual Review 2021, showed no significant differences between these two treatments as there was not enough time to show differences. These results clearly show that the application of less amount of recommended fertilizer may result in a low growth rate with time.

Table 1. *Effect of different treatments on plant girth of immature rubber plants*

Treatments	Plant girth, 12 months after planting (cm)
T1-50% Recommended fertilizer	8.5^{d}
T2-100% Recommended fertilizer	8.98^{c}
T3-50% Recommended fertilizer + GAP	10.15^{a}
T4-75% Recommended fertilizer + GAP	9.67^{b}

Values in the column followed by the same letter are not significantly different at p = 0.05

Also, soil fertility parameters measured at the end of the 18 months showed no significant differences among treatments for soil pH, total nitrogen (N) available phosphorus (P), exchangeable magnesium (Mg), and calcium (Ca). Soil potassium (K) showed significant differences between inorganic fertilizer-only application treatments; T1 and T2 (Table 2).

Table 2. *Different soil fertility parameters in the top 0-15cm soil layer in respect of different treatments at the end of 18 months*

Treatments	pH	N%	P (ppm)	K (ppm)	Mg (ppm)	Ca (ppm)
T1-50% Recommended fertilizer	5.26[a]	0.108[a]	23.5[a]	64.26[b]	31.3[a]	98.6[a]
T2-100% Recommended fertilizer	5.35[a]	0.111[a]	26.6[a]	80.88[a]	30.9[a]	88.2[a]
T3-50% Recommended fertilizer + GAP	5.30[a]	0.101[a]	22.8[a]	72.05[ab]	25.16[a]	86.16[a]
T4-75% Recommended fertilizer + GAP	5.51[a]	0.108[a]	25.0[a]	72.43[ab]	26.83[a]	93.2[a]

Values in the same column followed by the same letter are not significantly different at p = 0.05

Leaf nutrients showed no significant differences between treatments for N, P and Mg. However, significantly higher leaf K content could be observed in 50% inorganic fertilizer with GAP treatment (T3) compared to 50% inorganic fertilizer-only treatment (T1). That type of significant enhancement could not be observed in 75% inorganic fertilizer with GAP treatment (T4) compared to 50% inorganic fertilizer-only treatment (T1) or 100% inorganic fertilizer-only treatment (T2) (Table 3). Overall results show that there is a possibility of using a reduced amount of recommended inorganic fertilizer with GAP to maintain fertility levels of first year immature rubber comparable to recommended inorganic fertilizer application (R P Hettiarachchi, V Edirimannne, T Gunathilake and K E de Silva).

Table 3. *Effect of different fertilizer application techniques on leaf nutrients at 18 months afterplanting*

Treatments	N%	P%	K%	Mg%
T1-50% Recommended fertilizer	2.33[a]	0.258[a]	0.740[b]	0.249[a]
T2-100% Recommended fertilizer	2.29[a]	0.233[a]	0.814[ab]	0.238[a]
T3-50% Recommended fertilizer + GAP	2.5[a]	0.257[a]	0.870[a]	0.222[a]
T4-75% Recommended fertilizer + GAP	2.34[a]	0.250[a]	0.819[ab]	0.234[a]

Values in the same column followed by the same letter are not significantly different at p = 0.05

Use of soil amendments and effective microbes for cutting down inorganic fertilizer application

An experiment was begun at Kuruwita RRISL Sub-station in the third quarter of the year 2022 for investigation of the effect of cutting down fertilizer dosage combined with organic amendments such as compost, partially burned paddy husk, biochar and commercially available Effective Microbes (EM) treatments on plant

growth and soil condition in immature fields with the application of treatments from planting hole applications to upwards. The treatments are as in Table 4.

Table 4. *Details of the treatments*

Treatment	Description
T1- control	100% recommended fertilizer
T2	100% recommended fertilizer + compost and other amendments
T3	100% recommended fertilizer + EM + compost and other amendments
T4	50% recommended fertilizer + compost and other amendments
T5	50% recommended fertilizer + EM + compost and other amendments

Pre-treatment soil samples were collected for nutrient analysis and plant diameter was measured 15cm above the ground level (Table 5).

Table 5. *Average plant girth (cm) recorded at the pre-treatment stage*

Treatment	Average plant diameter (cm)
T1	1.08
T2	1.21
T3	1.09
T4	1.12
T5	1.21

Evaluation of the effect of rubber processing effluent as a nutrient source for plants

A preliminary study with Salad Cucumber showed the potential of fresh serum application with reduced recommended fertilizer. Therefore a new experiment was conducted to investigate fresh serum application on *Capsicum* (*Capsicum annum* L.). Morphologically homogenous same-age seedlings of Muria F1 variety was purchased from a recognized private nursery. Yara Mix was selected as the fertilizer source and recommended dosage on the pack was used for the treatment design. For effluent treatments, the fresh serum collected from the coagulation tank was stored in a trap tank to trap the non-rubber particles. Then the serum was filtered and the pH was tested and adjusted to 6.0-6.5 using NaOH and used for the study. The average total N content in the fresh serum (500 mg/liter) and recommended fertilizer dosage per month per plant were considered when designing the treatments. It was assumed that about 50% of the total N in the serum would be readily available for the plants, and the volume of serum to be applied for compensating the reduced fertilizer dosage was calculated accordingly. Two separate trials were conducted in a plant house (Indoor) at Plant Science Department and outdoors at Soils and Plant Nutrition Department. At each trial, fifteen plants per treatment were arranged in a completely randomized design (CRD). The growth and yield parameters of the plants were

recorded at regular intervals. Serum application was done daily while fertilizer application was done once a month as recommended in the fertilizer pack. Treatments were as below in Tables 6a and 6b.

Table 6a. *Treatments (from 0 - 4 weeks of planting)*

	Percentage of yara mix fertilizer dosage (%)	Volume of fresh serum (ml)
T1- control	100	0
T2	50	150
T3	0	300

Table 6b. *Treatments (from 4 weeks of planting)*

	Percentage of yara mix fertilizer dosage (%)	Volume of fresh serum (ml)
T1- control	100	0
T2	50	300
T3	0	600

Yield parameters recorded in different treatments at indoor and outdoor experiments are presented in Table 7. The average yield per plant was greater in control plants than in T2 and T3 treatments in indoor and outdoor experiments. Serum water-treated plants (T2 and T3) showed comparatively similar yield values in the indoor experiment. Plants treated with only the fresh serum without mineral fertilizer showed the lowest yield while 100% mineral fertilizer applied plants and 50% mineral fertilizer plus serum water applied plants showed more or less similar yield values in the outdoor experiment.

Table 7. *Yield parameters recorded during the two months of the harvesting stage in different treatments at Indoor and outdoor experiments*

Treatment	Indoor experiment		Outdoor experiment	
	Avg. yield per plant (g)	Avg. pod length per plant (cm)	Avg. yield per plant (g)	Avg. pod length per plant (cm)
T1	194.5	12.7	171.5	10.7
T2	170.2	11.7	167.6	10.7
T3	166.5	11.9	105.4	11.1

Data were not statistically analyzed.

Samples were collected from the potting media at the end of the experiment and analyzed for nutrient contents and pH (Table 8). The pH of the T2 and T3 treatments which were applied with pH-adjusted serum water showed pH values just above 7, while the control treatment showed a pH of 6.4. Organic carbon percentages

and N percentages of the treatments are more or less similar among the treatments. However, treatments applied with fresh serum either with 50% of fertilizer and 0% fertilizer showed greater values of both potassium and magnesium contents compared to the control treatment (H A R K Jayawardana, L A T S Liyanaarachchi, M W H Gayan and B N K Rangana).

Table 8. *Average values of soil fertility parameters of the potting media of different treatments at the end of the experiment period*

Treatment	pH	OC (%)	N (%)	K (ppm)	Mg (ppm)
T1	6.46	2.44	0.24	734.33	509.33
T2	7.25	2.60	0.24	1214.00	856.67
T3	7.35	2.42	0.26	1230.00	845.00

Data were not statistically analyzed

Substitute of inorganic fertilizer with human urine

The overuse and misuse of chemical fertilizers are attributed to critical environmental and health problems. Therefore, there is a growing trend among present researchers to explore low-cost, effective fertilizer substitutes for inorganic fertilizers in crop production. Human urine is a liquid waste rich in essential plant nutrients such as nitrogen, phosphorous and potassium. This research was carried out under normal environmental conditions at Dartonfield estate to evaluate the effectiveness of human urine on rubber nursery plants. The study was laid out as a Completely Randomized Block Design (CRBD) with three replicates per treatment assigning twenty plants per replicate. Four different treatments were established as in Table 9.

Table 9. *Different treatments for rubber nursery plants*

Treatment	Combination
1	RRISL recommended conventional fertilizer application
2	4 applications of diluted urine (urine & water1:1)
3	6 applications of diluted urine (urine & water1:1)
4	8 applications of diluted urine (urine & water1:1)

Throughout the experimental period growth measurements; plant height, plant diameter and lateral spread were measured. At the end of three and half months, randomly selected plants were removed and some assessments were done. Data were not statistically analyzed. However, plants showed promising growth with urine application compared to the conventional fertilizer application (Table 10) (R P Hettiarachchi and K M M E K Kulatunga).

Table 10. *Different growth assessments of rubber nursery plants at the end of 3.5 months*

Treatments	Plant height (cm)	Diameter (mm)	Leaf area (cm^2)	Leaf wt. (g)	Lateral spread (cm)
T1	65	6.9	859	11.58	30.7
T2	72	9.2	860	12.15	32.5
T3	73	7.2	1029	12.55	32.25
T4	72	7.05	975	12.65	30.75

Effect of soil nutrient status on the severity of new leaf fall disease in rubber

A study was begun at Sirikandura and Maggona Estates collaboratively with Plant Pathology and Microbiology Department for investigating the correlation between applied fertilizer on the new leaf fall disease in immature rubber plants with the below-mentioned treatments (Table 11). Commercially available silicon fertilizer (powder form) was used as the silicon source while the commercially available micronutrient supplement was used as the micronutrient source which was applied as soil drenching (H A R K Jayawardana, R M Baddevidana and B N K Rangana).

Table 11. *Details of the treatments*

T1- control	100% recommended fertilizer
T2	No fertilizer
T3	150% recommended fertilizer
T4	100% recommended fertilizer plus Silicon fertilizer
T5	100% recommended fertilizer plus micronutrient supplement

Soil samples were collected to analyze the nutrient values of the sites. The disease severity is being recorded by the PP&MB Department.

Plant nutrition and fertilizer use nutrient requirement of *Hevea* grown in the low country Dry Zone

Due to Covid 19 pandemic situation in the country disturbed the continuous assessments of experimental sites and the experiment was terminated (R P Hettiarachchi, V Edirimannne, T Gunathilake and G C Malawaraarachchi). However, slow-release fertilizer techniques including Reusable Fertilizer Porous Tube (RFPT) and Reusable Fertilizer Porous Bag (RFPB) were established for first-year plants in a smallholder site in the Horowpothana in Anuradhapura district. Treatment combinations are in Table 12.

Table 12. *The treatment combination of the experiment*

T1	Recommended fertilizer application with normal split application
T2	Half of the Recommended quantity of fertilizer apply with RFPT
T3	Half of the Recommended quantity of fertilizer apply with RFPB

Slow-release fertilizer application

Application of slow-release fertilizer technique, reusable fertilizerr porous tube (RFPT) for immature rubber plants

An experiment was laid down at Ganepalla Estate, Yatiyanthota to study the effectiveness of RFPT on the growth of rubber plants. The experimental design was mentioned in the 2019 Annual Review. The growth measurements taken at the end of 48 months showed a significant enhancement of plant growth with Reusable Fertilizer Porous Tube treatments (T2 and T3) compared to conventional fertilizer application (T1) (Table 13).

Table 13. *Effect of different fertilizer application methods on plant girth at 48 months after planting*

Treatments	Girth (cm)
T1 (Control)	29.89[c]
T2 (RPT type 1, NPK mixture R/U 12:14:14 and Kieserite mixed with filling medium No.1)	32.17[b]
T3 (RPT type 2, NPK mixture R/U 12:14:14 and Kieserite mixed with filling medium No.2)	34.69[a]

Values in the column followed by the same letter are not significantly different at p=0.05

Parallel to this experiment, several experimental sites were established with first year plants at Ratnapura, Kalutara, Colombo and Kegalle districts under major Plantation Companies; Pussellawa, Agalawatta, Lalan Rubber and Kelani Valley. Growth parameters of immature plants at the end of 6 months showed significantly higher or comparable growth with slow-release fertilizer application techniques (T2 and T3) compared to conventional fertilizer application (T1) at the site of Dewalakanda Estate (Table 14).

Table 14. *Effect of different fertilizer application methods on plant diameter at 6 months after planting*

Treatments	Diameter (mm)
T1 (Control)	13.24[b]
T2 (Fertilizer Encapsulated Coir Brick)	13.55[b]
T3 (Reusable Fertilizer Porous Tube)	15.5[a]

Values in the same column followed by the same letter are not significantly different at p=0.05

Three treatment combinations as; recommended fertilizer with split fertilizer application included treatment No 1 and two types of Reusable Fertilizer Porous Tube (RFPT) as treatment No 2 and No 3 were established at Elston Estate to study the effectiveness of treatment combinations under the *Homagama* soil series. The leaf

nutrients and soil fertility data were given in Table 15 and Table 16 respectively and were not statistically analyzed. However, more or less similar values could be observed between treatments.

Table 15. *Effect of different fertilizer application techniques on leaf nutrients*

Treatments	N%	P%	K%	Mg%
T1 (Control)	2.60	0.255	0.848	0.240
T2 (RFPT type1)	2.495	0.263	0.810	0.243
T3 (RFPT type2)	2.62	0.237	0.890	0.245

Table 16. *Effect of different fertilizer application techniques on soil fertility parameters*

Treatments	pH	Organic carbon (%)	Total N (%)	Available P (ppm)	Exchangeable K (ppm)	Exchangeable Mg (ppm)
T1 (Control)	5.61	1.12	0.11	40.5	68	33
T2 (RFPT type1)	5.59	0.93	0.1	38	82	29
T3 (RFPT type2)	5.52	0.95	0.09	30.5	78	31

Plant girth was taken at 4 feet above the ground level of the plant at 40 months after the planting and showed no significant differences between treatments (Table 17).

Table 17. *Effect of different fertilizer application methods on plant girth at 40 months after planting*

Treatments	Girth (cm)
T1 (Control)	22.72[a]
T2 (RPT type 1, NPK mixture R/U 12:14:14 and Kieserite mixed with filling medium No.1)	21.22[a]
T3 (RPT type 2, NPK mixture R/U 12:14:14 and Kieserite mixed with filling medium No.2)	22.16[a]

Values in the same column followed by the same letter are not significantly different at p=0.05

Estimating of Soil Carbon Stock (SCS) and Identification of Spatial variability of SCS at the experimental site of Kuruwita Substation

As soil organic carbon is highly related to the nutrient use efficiency of plants, this study aimed to estimate the Soil Carbon Stock (SCS) in a selected 12-hectare study area containing a mature rubber plantation with the aim of identification management zones with different SCS levels. Eighteen soil samples were collected to assess the Soil Organic Carbon (SOC) content using the Walkley-Black method. Another set of 18 soil samples were collected in close proximity to the initial set to estimate the Bulk Density (BD) values. The sampling locations were accurately

demarcated using GPS coordinates. The collected data were utilized to employ specific equation (Eq.1) for estimating the soil carbon stock based on the obtained BD and SOC values (Table 18). These findings contribute to a better understanding of carbon storage dynamics in rubber plantations and have implications for carbon sequestration strategies while establishing site-specific management zones for the study area for Variable Rate Fertilizer (VRF) application.

To estimate the Soil Carbon Stock of the locations using the estimated Bulk Density (BD) and Soil Organic Carbon (SOC) values, the following equation was used:

Soil Carbon Stock = BD × SOC…… (Eq.1)

Where:
BD is the Bulk Density (in kg/m³)
SOC is the Soil Organic Carbon content (%)

Derived SCS values for each location were used to estimate the total carbon stock of the topsoil (15cm of topsoil layer) of the study area as follows:

Total Carbon Stock = Average SCS × Soil Depth × Land Area…… (Eq.2)

The average SCS for the study areas was founded as 26.08kg/m³ and the desired depth of the soil for the crop growth was 0.15m. Then the SCS for the 12ha of the study area was 469.48MT. The results revealed that the study area has low carbon stock values. This could be related to the "Boralu" soil series of the study area.

Further, the spatial variability of SCS was mapped using Geographic Information Systems (GIS) software for the identification of different zones with different SCS levels in the study area (Fig. 1).

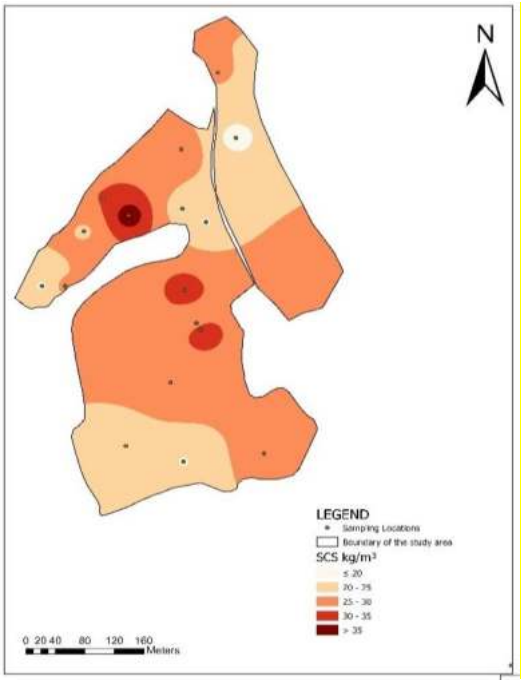


Fig. 1. Spatial variability of SCS

Table 18. *Soil bulk density, SOC concentration and SCS of each location of the study area*

Latitudes	Longitudes	Bulk density (kg/ m^3)	SOC (%)	SCS (kg C/m^3)
6.765566	80.354395	1575.06	1.70	26.78
6.764919	80.353442	1729.34	1.74	30.05
6.764683	80.353753	1797.13	2.12	38.19
6.764469	80.353203	1429.42	1.71	24.48
6.763737	80.352971	1467.06	1.75	25.67
6.763737	80.352687	1433.90	1.37	19.72
6.764772	80.354411	1829.06	1.26	23.09
6.761498	80.355417	1387.46	1.93	26.88
6.761388	80.354428	1421.24	1.40	19.90
6.761597	80.353720	1269.24	1.66	21.10
6.762446	80.354267	1501.03	1.97	29.65
6.76324	80.354583	1309.57	1.87	24.55
6.763155	80.354636	1906.55	1.80	34.32
6.763683	80.354439	1769.45	1.81	32.07
6.764594	80.3547	1084.13	1.82	19.79
80.3547	80.35493	1481.88	1.98	29.45
6.766593	80.354845	1608.40	1.56	25.13
6.765721	80.355068	1194.58	1.56	18.67

SOC = Soil Organic Carbon, SCS = Soil Carbon Stock

The findings are very useful to identification of site-specific management zones under mature rubber plantations with different soil quality statues beased on the soil carbon. The study will be conduted further to identify management zones with geo-spatial and geo-statistical techniques to reach the VRF application to ensure nutrient use efficiency under mature rubber (L A T S Liyanaarachchi, M W H Gayan and Kasun Rangana).

Modification of fertilizer recommendations of Hevea with reference to plant, soil and field parameters (a Special Capital Project - 0363K)

This project activity focused on five years period from 2017 to 2021 and completed all activities in 2021.

Collected plant growth as diameter and nutrient values; nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) in leaf tissues of immature rubber plants were utilized for the preparation of Diagnosis and Recommendation Integrated System (DRIS) indexes. DRIS method related to dual nutrient ratios in plant material is an efficient method to determine the nutritional status of the plant. Furthermore, the methodologies utilized under nutritional balancing are more precise in detecting nutritional deficiencies or/and excesses than the other traditional diagnosis methods. In Sri Lanka, the use of dual nutrient ratios of plant nutrients as a diagnostic tool is not practiced so far and leaf nutrient norms have not been yet established for rubber. Hence, the combination of the methods; DRIS, Nutrient Balance Index (NBI), Compositional Nutrient Diagnosis (CND) and sufficiency, deficiency and excessive nutrient levels of plant nutrients were utilized for efficient fertility management and maximizing the growth of plants.

This study utilized leaf nutrient ratios both directly (A/B) and inverse form (B/A) in the high growth rate populations for the determination of DRIS index. Further, leaf nutrient contents in Table 19 were utilized for the determination of DRIS indexes, which are in Table 20.

Table 19. *Plant girth and their leaf nutrient contents*

Plant No.	Girth (cm)	N%	P%	K%	Mg%
1	45	2.19	0.260	0.820	0.170
2	45.7	2.73	0.175	0.721	0.340
3	46	2.03	0.199	0.788	0.278
4	46.5	1.64	0.270	0.580	0.140
5	47	1.75	0.195	0.391	0.190
6	49	2.7	0.210	0.690	0.190
7	49	2.86	0.330	0.590	0.208
8	50	1.58	0.190	0.520	0.214

Plant No.	Girth (cm)	N%	P%	K%	Mg%
9	50	3.22	0.220	0.850	0.130
10	51	1.89	0.191	0.482	0.175
11	54	2.96	0.220	0.820	0.270
12	55	3.34	0.280	0.740	0.293
13	56	3.1	0.180	0.740	0.240
14	57	2.45	0.220	0.710	0.178
15	57	2.3	0.240	0.600	0.160
16	58	1.9	0.260	0.710	0.180
17	64	3.63	0.270	0.830	0.170

Further, regression equations were developed between two variables; nutrient contents verse indices and there was a possibility to observe the nutritionally balanced point of the plant when indices are close to zero (Figs. 2, 3, 4 and 5). Moreover, this information is very much helpful for the determination of the nutrient status of the plant and their revisions.

Table 20. *Calculated DRIS indexes for leaf nutrients; N, P, K and Mg*

Plant No.	N index	P index	K index	Mg index
1	-1.0345	0.7114	1.1182	-0.7951
2	0.0090	-1.9383	-0.2107	2.1399
3	-1.7937	-0.5055	0.9509	1.3483
4	-1.6106	2.2941	0.1448	-0.8282
5	-0.2493	0.9722	-1.8284	1.1054
6	0.4312	-0.2778	0.0420	-0.1954
7	0.3133	1.7489	-1.7913	-0.2709
8	-1.4541	0.3891	-0.2273	1.2923
9	1.3625	-0.2604	1.2277	-2.3299
10	-0.1888	0.4598	-0.6848	0.4137
11	0.0849	-0.8468	0.1990	0.5629
12	0.3960	0.0168	-1.0119	0.5990
13	0.9497	-1.5385	0.1132	0.4755
14	-0.0238	0.0467	0.3515	-0.3744
15	0.0189	0.8502	-0.3022	-0.5668
16	-1.4808	1.0977	0.6421	-0.2590
17	1.2574	0.1521	0.0893	-1.4988

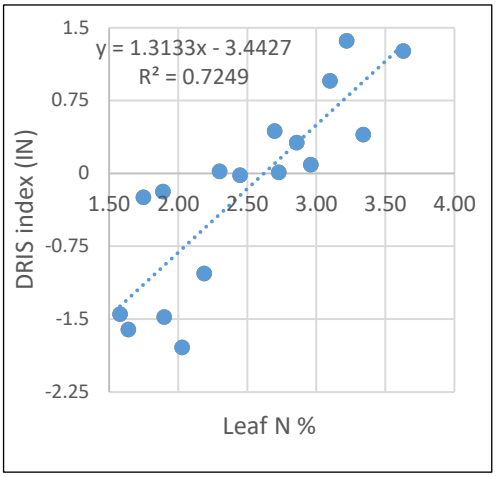


Fig. 2. Correlation between leaf nutrient content and their indices in

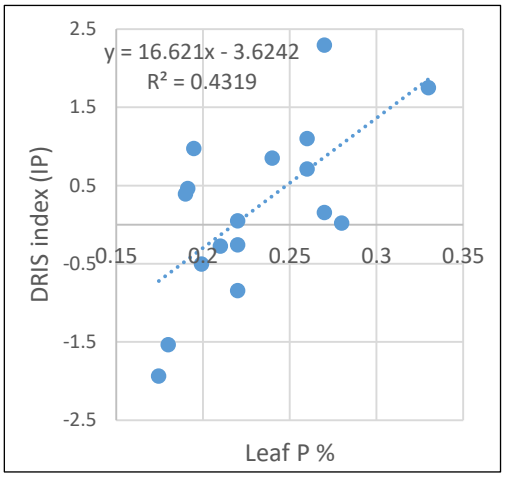


Fig. 3. Correlation between leaf nutrient content and their indices in relation

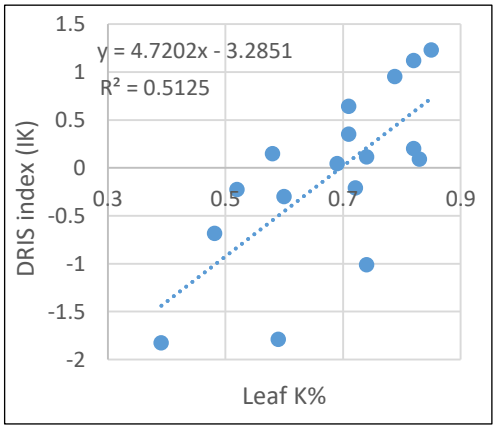


Fig.4. Correlation between leaf nutrient content and their indices in relation to K

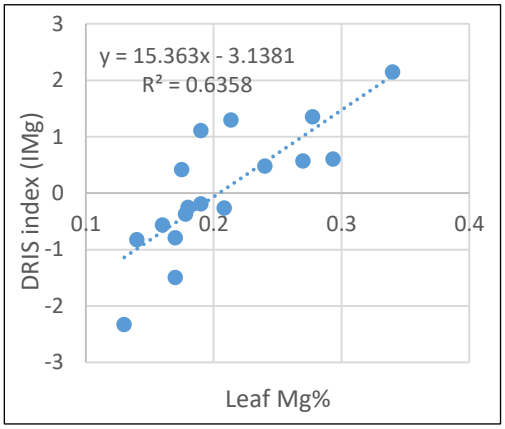


Fig. 5. Correlation between leaf nutrient content and their indices in relation to Mg

Figs. 2-5 shows the correlation between leaf nutrient content and their indices in relation to N, P, K and Mg respectively.

Services

Land selection and suitability for rubber cultivation

Under the routine land selection programme 57.2 hectares of land were surveyed for the suitability of rubber cultivation and 3 land suitability reports were issued. Details of the surveys are given in Table 21 (R P Hettiarachchi, L A T S Liyanaarachchi, G C Malawaraarachchi and all the department staff).

Table 21. *Details of the land selection program*

Place (GS Division)	Extent surveyed (ha)
Horaupathana, Anuradhapura	12
Lunugamwehera, Hambanthota	40
Keithigollaa, Anuradapura	5.2

Site-specific fertilizer recommendation by soil and foliar survey programme

Under this programme, 8,697 hectares of mature rubber fields were surveyed and 53 fertilizer recommendations were given for the next three years of 2023-2025. Details of the survey are shown in Table 22 (R P Hettiarachchi, H A R K Jayawardana, A Thewarapperuma, V Edirimanna and all the staff of the department).

Analytical service

Under this programme, various samples received from estates, smallholders, universities and other private organizations were analyzed according to the SLSI methods. Eighty-five samples (238 parameters) including 14 fertilizer samples from rubber growers were analyzed to ensure the application of good quality fertilizers to their rubber lands. Analytical service issued eight analytical reports and details of the service are given in Table 22 (R P Hettiarachchi, H A R K Jayawardana, K E de Silva, R M Baddevidana, V Edirimanna, A Thewarapperuma and all the staff of the department).

Table 22. *Details of the analytical services and site-specific fertilizer recommendation program*

	Name of the company/estate	Analytical services		Site specific fertilizer recommendation programme		Income	
		No of reports	No of samples	No of reports	Surveyed extent (ha)	Outside analytical service (Rs.)	Site specific fertilizer recommendation programme (Rs.)
1	Miriswatta	1	3			2025.00	
2	Mirishena	1	1			675.00	
3	Millakanda	1	35			3825.00	
4	Eladuwa	1	36			27900.00	
5	Konya Farms	1	1			675.00	

	Name of the company/estate	Analytical services		Site specific fertilizer recommendation programme		Income	
		No of reports	No of samples	No of reports	Surveyed extent (ha)	Outside analytical service (Rs.)	Site specific fertilizer recommendation programme (Rs.)
6	Haupe	1	1	1	39.86	1000.00	9965.0
7	Higgoda	1	5	1	118.9	3375.00	15459.0
8	Pelawatta	1	3			1875.00	
9	Atale			1	371.57		48304.1
10	yataderiya			1	118		15340
11	Pallegama			1	199.36		25916.8
12	Etana			1	249.92		32489.6
13	Doloswela			1	113.25		14722.5
14	Moralioya			1	192.38		25009.4
15	Vincit			1	84.04		10925.2
16	Sunny croft			1	139.84		18179.2
17	Ederapola			1	274.57		35694.1
18	Frocester			1	200		26000
19	Peenkande			1	251.36		32676.8
20	Puwakpitiya			1	6.53		848.9
21	Urumiwela			1	168.15		21859.5
22	Pambegama			1	328.13		82032.5
23	Ayr			1	207.5		51875
24	Halpe			1	351.51		87877.5
25	Keragala			1	105.58		26395
26	Hemingford			1	74.02		18505
27	Panawatta			1	197.69		49422.5
28	Opatha			1	175.74		43935
29	Salawa			1	216.54		54135
30	Galathura			1	103.47		25867.5
31	Mahawela			1	178.44		44610
32	Millawitiya			1	81.12		20280
33	Mutwagalla			1	150.52		37630
34	Palmgarden			1	147.67		36917.5
35	Rambukkanda			1	143.3		35825
36	Meddakanda			1	60.01		15002.5
37	Rye Wikiliya			1	84.79		21197.5
38	Ury			1	15.03		3757.5
39	Wewessa			1	25.14		6285

	Name of the company/estate	Analytical services		Site specific fertilizer recommendation programme		Income	
		No of reports	No of samples	No of reports	Surveyed extent (ha)	Outside analytical service (Rs.)	Site specific fertilizer recommendation programme (Rs.)
40	Madeniya			1	128.88		32220
41	Poronuwa			1	192.58		48145
42	Mahaoya			1	581.54		145385
43	Siriniwasa			1	164.87		41217.5
44	Hathbawa			1	92.68		23170
45	Palmadulla			1	164.48		41120
46	Kelani			1	136.69		34172.5
47	Reoberry			1	28.71		7177.5
48	Edella			1	79.22		19805
49	Elston			1	374		93500
50	Kiriporuwa			1	220.9		55225
51	Lavant			1	139		34750
52	Dewalakanda			1	280.29		70072.5
53	Kalupahana			1	113.5		28375
54	Ganepalla			1	203.34		50835
55	Pimbura			1	3.26		815
56	We oya			1	342.26		85565
57	Weniwella			1	178.2		44550
58	Udabage			1	42		10500
59	Frocester			1	57		14250
	Total	08	85	53	8697.3	41,350.00	1,875,790.00

BIOCHEMISTRY AND PHYSIOLOGY

Technology transfer programmes on low-intensity harvesting (LIH) systems with usage of yield stimulant were conducted to RPC owned estates and rubber smallholders. Adaptability to the S/2 d4 LIH system at Dartonfield estate, RPCs and smallholders was monitored throughout the year. Commercial scale investigations on locally produced ethephon formulation has been conducted as a PPP project at Elston estate, Awissawella.

Experimental fields established in non-traditional rubber growing areas have been monitored and investigations have been carried out to identify the best clones for the sub-optimal climatic conditions. Plant physiological data of different Hevea genotypes was collected from experimental fields established at Dry (Kandakadu), Intermediate (Padiyathalawa) and Wet (Meerigama) Zones.

Biochemical and physiological assessment of latex of twenty Hevea HP progenies developed in 2014 has been carried on request of Department of Genetics & Plant Breeding. Latex physiological parameters of established clones have been investigated in order to develop a physiological index to support the clonal screening.

Yield and physiological parameters have been monitored at the fields affected with circular leaf spot disease to identify any effect on yield determinant latex physiological factors in collaboration with the Plant Pathology and Microbiology Department, RRISL.

BIOCHEMISTRY AND PHYSIOLOGY

K V V S Kudaligama

DETAILED REVIEW

Staff

Dr (Ms) K V V S Kudaligama, continued duties as the Head of the Biochemistry & Physiology department. Mrs N P S N Karunarathne, Research Officer, Mr M K P Perera, Experimental Officer, Mr L T B K Fernando and Miss N N Abewardhana Technical Officers and Mrs H A M E Hettiarachchi, Management Assistant were on duty throughout the year. Mrs P D T L Madushani, Technical Officer was on maternity leave from 02nd of September 2022.

Research students

Student name	University	Research topic
KKDAT De Alwis	Uva Wellassa University of Sri Lanka	Industrial training programme of Bachelor's degree
SD Hansika Lakmini de Silva Kavindya Ishani Kottage	Aquinas College of Higher students, Colombo 8	Induction training programme of Higher National Diploma in Technology (Agriculture)
KPNM Jayawardhana	South Eastern University	Industrial training programme of Bachelor's degree
KDPD Jayathilaka MDP Malshan	National Youth NAITA	Induction training programme of Higher National Diploma in Technology
I Oshini Dilhara MPK Chandrakumari	Sri Lanka School of Agriculture - Agunakolapelessa	Induction training programme of Higher National Diploma in Technology (Agriculture)
AR Thameem AMS Ahamed SAM Fasarath	Wayamba University of Sri Lanka	Industrial training programme of Bachelor's degree
CAE Gayesha	Sabaragamuwa University of Sri Lanka	Development of latex based cocopeat media to grow *Trichoderma harzianum* as a bio- fungicide
KAL Vidushika	Eastern University	Industrial training programme of Bachelor's degree

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
NPSN Karunarathne NN Abewardhana LTBK Fernando	Workshop on Data Analysis	NRC
NPSN Karunarathne	Understanding fundamentals in GIS, remote sensing and geo-spatial applications	IRRDB and RRISL

Training programmes conducted

Officer/s	Subject/Theme	Remarks
KVVS Kudaligama	Effective introduction of new LIH systems to address current issues in the rubber plantation industry	Halpe Estate Salawa Estate 27 smallholdings

Field visits

Advisory - 29 visits
Experimental - 331 visits
Miscellaneous - 7 visits

Sample testing

Commercial ethephon mixtures - 03 samples

LABORATORY AND FIELD INVESTIGATIONS

Low-intensity harvesting to improve the sustainability of rubber farming (BCP/01)

Research, development and commercial introduction of low-intensity harvesting strategies

Commercial scale testing of S/2 d4, low-intensity harvesting system was continued in 04 tapping blocks replanted in 2010 (Field No: 2010/5.58) with RRIC 121/RRISL 203/RRISL 217 mixed genotypes in Gallewatte division, Dartonfield. Trees were stimulated with 2.5% water- based ethephon on monthly basis except during wintering and leaf fall due to circular leaf spot disease. Daily yields were monitored as dry rubber content and volume of latex together with scrap weight. The average actual tapping days under the S/2 d4 system was 77. In all four blocks, the average DRC% and g/t/t was 39.8% and 32.92 g. Trees maintained an average value of 2.53 kg YPT during the year. (Table 1) and it was 0.65 kg lower than that of the previous year. This lowering is mainly due to curtailing two ethephon applications due to the heavy leaf fall with circular leaf spot disease attack.

Table 1. *Yield parameters of four tapping blocks harvested with S/2 d4 system at Gallewatta division of Dartonfield Estate*

Tapping system	No. of trees	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
Block 1	172	75	39.8	32.30	9.69	2.39	955
Block 2	195	76	39.8	33.66	10.10	2.59	1036
Block 3	171	78	39.7	33.93	10.18	2.64	1056
Block 4	206	79	39.9	31.79	9.54	2.50	1000
Average	**186**	**77**	**39.8**	**32.92**	**9.88**	**2.53**	**1012**

Commercial level testing of S/2 d4 has been also continued in eight tapping blocks replanted with RRIC 121 and RRISL 203 clones in 2010 at Nivithigalakele Division of Dartonfield Estate (No:2010/5.17). The total number of tapping days under d4 frequency was 75. DRC% of the latex varied around 39.8%. The average productivity of a tree was around 2.84 kg whilst the field had an average of 1134 kg. Variation of the yield of blocks was mainly due to the degree of mixing clones (Table 2). Though this field was affected with circular leaf spot disease, average yield has not been reduced significantly than the previous year figures (Average YPT in 2021 is 2.91 kg).

Table 2. *Yield parameters of eight tapping blocks harvested with S/2 d4 system at Nivithigalakele division of Dartonfield Estate*

Tapping system	No. of trees	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
Block 1	192	78	40	41.96	12.59	3.53	1410
Block 2	217	78	39.4	38.12	11.44	2.97	1188
Block 3	252	80	39.8	37.66	11.30	3.01	1204
Block 4	254	78	39.8	33.33	10.00	2.68	1070
Block 5	223	75	39.6	35.16	10.55	2.66	1066
Block 6	168	77	39.9	33.58	10.07	2.67	1068
Block 7	132	72	39.88	41.24	12.37	3.03	1211
Block 8	199	60	39.96	34.33	8.58	2.13	852
Average	**205**	**75**	**39.79**	**36.92**	**10.86**	**2.84**	**1134**

(K V V S Kudaligama, V H L Rodrigo, N P S N Karunarathne, M K P Perera, P D T L Madushani, L T B K Fernando and N N Abewardhana)

Effective introduction of newly developed low-intensity harvesting (LIH) systems to address the current issues in the rubber plantation industry (Special Capital Project 36.1.17)

Allocation for the year 2022 has not been received from the Treasury of GoSL due to the financial crisis in the country to conduct the activities of a special capital project to popularize recommended low-intensity harvesting systems to rubber

growers in Sri Lanka. However, the activities to provide an evidence-based approach through demonstrations, to popularize new low-intensity harvesting systems in both smallholder and plantation sectors to address current issues and there by obtain associated benefits has been conducted with the R & D vote of the Department.

To improve the knowledge on S/2 d4 adaptation, 27 awareness programmes were conducted for rubber smallholders, and two programmes had been conducted to Managers, Field Officers, Supervisors and harvesters of Halpe Estate and Salawa Estate to improve their knowledge on stimulation based low intensity harvesting systems. In both estates 53 personals have been given both theoretical and practical knowledge on low intensity harvesting system and use of yield stimulants (K V V S Kudaligama, N P S N Karunarathne, M K P Perera, L T B K Fernando, P D T L Madushani and N N Abewardhana).

Research and development on biochemical and physiological aspects to improve the sustainability of rubber farming (BCP/02)

Growth and physiological performance of different clones planted under different agro-ecologies

Kandakaduwa (Dry zone)

Five clones developed by RRISL were established in the experimental field at Kandakaduwa in 2015. RRIC 100, RRIC 121, RRISL 203, RRISL 2001 and PB 260 clones were evaluated for their physiological performances in Dry Zone. Chlorophyll content, epicuticular wax content, relative water content (RWC), leaf area and stomatal conductance were assessed as physiological parameters. Wind speed, air temperature, relative humidity and soil moisture level were recorded as environmental parameters at the time of recording data. Soil moisture of the field varied between 7.3 - 14.5% at the time of data collection (Table 3).

Table 3. *Average environmental condition in Kandakaduwa field at the time of collection of plant physiological data*

Clone	wind speed (km/hr)	Air temperature (^oC)	Relative humidity (%)	Soil moisture content (%)
RRIC 100	8.5	29.4	83.8	7.30
RRIC 121	3.8	31.2	85.1	9.95
RRISL 203	4.1	33.7	76.7	14.48
RRISL 2001	4.7	33.2	75.7	8.78
PB 260	6.2	33.9	74.4	8.97

Chlorophyll content changed among clones as RRISL 203 (54.02 SPAD) having the highest content and followed by RRISL 100 (50.74 SPAD) > RRISL 2001 (50.01 SPAD) > PB 260 (48.60 SPAD) > RRIC 121 (48.50 SPAD) clones. Higher wax contents were observed in RRIC 121 (0.12 g/cm^2) and RRISL 203 (0.11 g/cm^2) while PB 260 (0.05 g/cm^2) and RRIC 100 (0.07 g/cm^2) had lower wax contents.

RRISL 203 (97.83 %) and RRIC 121 (91.66 %) clones had the maximum and minimum values for the RWC%, respectively. Relative water content of other clones studied changed as 93.78 % in RRIC 100, 93.65 % in RRISL 2001 and 92.58 % in PB 260. Leaf area of the clones varied between 64 cm^2 and 102 cm^2, RRISL 203 and PB 260 being the clones with largest and smallest leaves. The highest stomatal conductance was observed in RRISL 203 with a value of 1.67 $mmolm^{-2}s^{-1}$ and followed by RRISL 2001 (1.20 $mmolm^{-2}s^{-1}$), PB 260 (0.87 $mmolm^{-2}s^{-1}$), RRIC 121 (0.51 $mmolm^{-2}s^{-1}$) and RRIC 100 (0.34 $mmolm^{-2}s^{-1}$) (Fig. 1).

Padiyathalawa (Intermediate Zone)

Performances of nine clones developed by RRISL established in the experimental field at Padiyathalawa in 2017 were evaluated with plant physiological data during 2022. Chlorophyll content, epicuticular wax content, relative water content, leaf area, stomatal conductance and soil moisture level in the morning were assessed as physiological parameters of the clones planted at Padiyathalawa. Wind speed, air temperature and relative humidity were recorded as environmental parameters at the time of measuring. The level of the soil moisture varied between 10.26 - 16.22% in the studied field at the time of data collection (Table 4).

Table 4. *Average environmental condition in Padiyathalawa field at the time of collection of plant physiological data*

Clone	Wind speed (km/hr)	Air temperature (^oC)	Relative humidity (%)	Soil moisture content (%)
RRIC 100	1.4	32.3	83.4	10.26
RRIC102	1.1	29.9	83	14.70
RRISL 203	4.3	30	81.9	13.00
RRIC121	1.9	30.8	86.6	14.78
RRISL 201	1.5	29.5	85.3	17.58
RRISL 2001	1.8	35.1	72.5	12.24
RRISL 2100	1.8	35.1	72.5	16.22
Centennial 3	1.9	34.1	81.2	13.90
Centennial 4	1.2	30.3	81.5	12.03

As shown in Figure 2, RRISL 201 (64.23 SPAD) had the highest content of chlorophyll while it was between 52 -60 SPAD units in all other clones. Epicuticular wax content was high in RRISL 2001 (0.38 g/cm^2) and RRIC 100 (0.36 g/cm^2) clones. The lowest wax content was observed in RRISL 102 (0.15 g/cm^2) and RRISL 201 (0.16 g/cm^2) clones. Relative water content was maximum in RRIC 121 (96.4 %) and minimum in Centennial 3 (91.0%) clones. The highest and lowest leaf area were observed with RRISL 2100 (111.7 cm^2) and Centennial 4 (72.4 cm^2) respectively. Stomatal conductance varied between 0.53 $mmolm^{-2}s^{-1}$ and 2.07 $mmolm^{-2}s^{-1}$ among the clones where Centennial 3 had the highest value and Centennial 4 showed the lowest (Fig. 2).

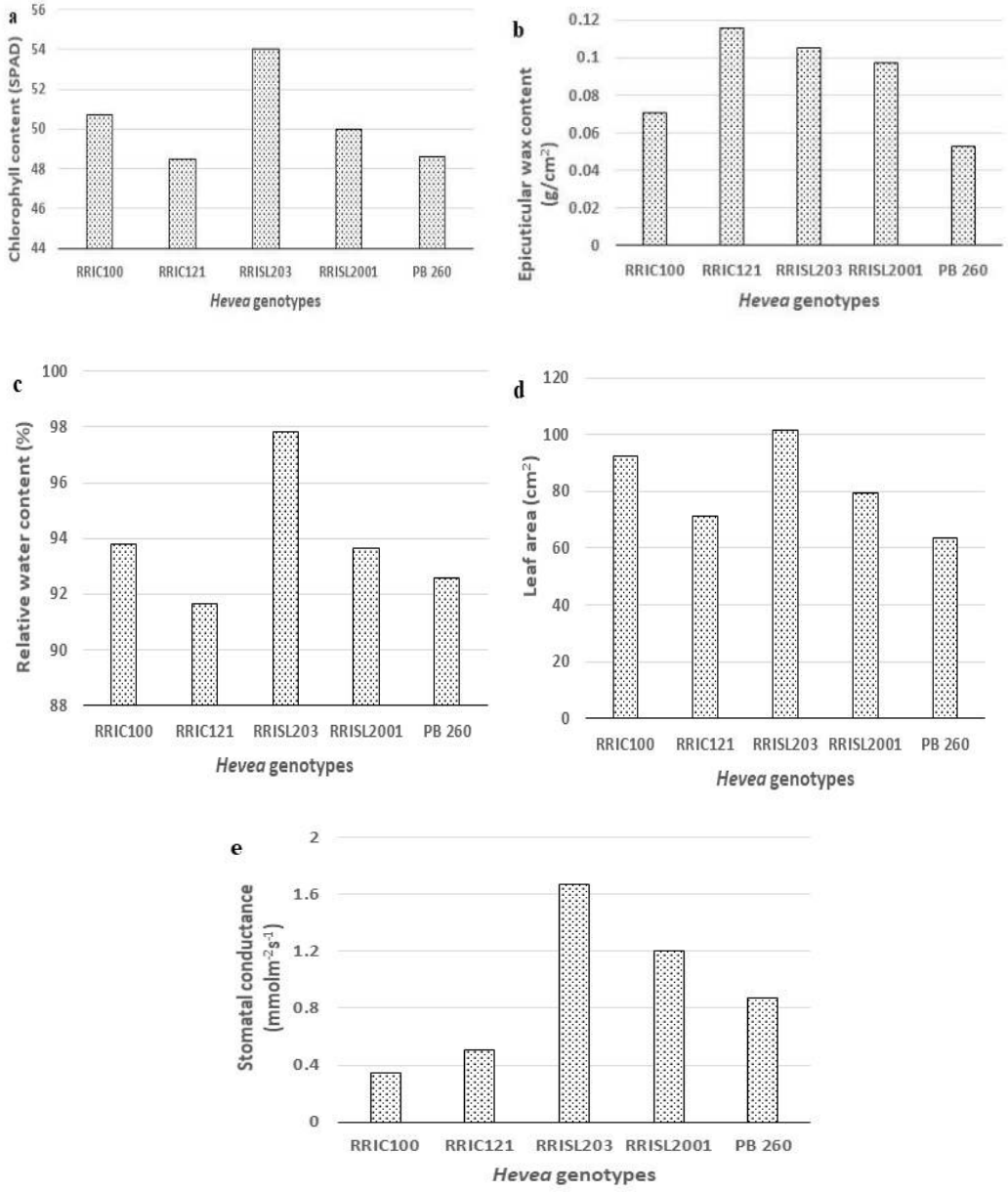


Fig. 1. a). Chlorophyll content, **b)**. epicuticular wax content, **c)**. relative water content, **d).** leaf area and **e).** stomatal conductance of sites planted different *Hevea* genotypes at the Kandakaduwa experimental site

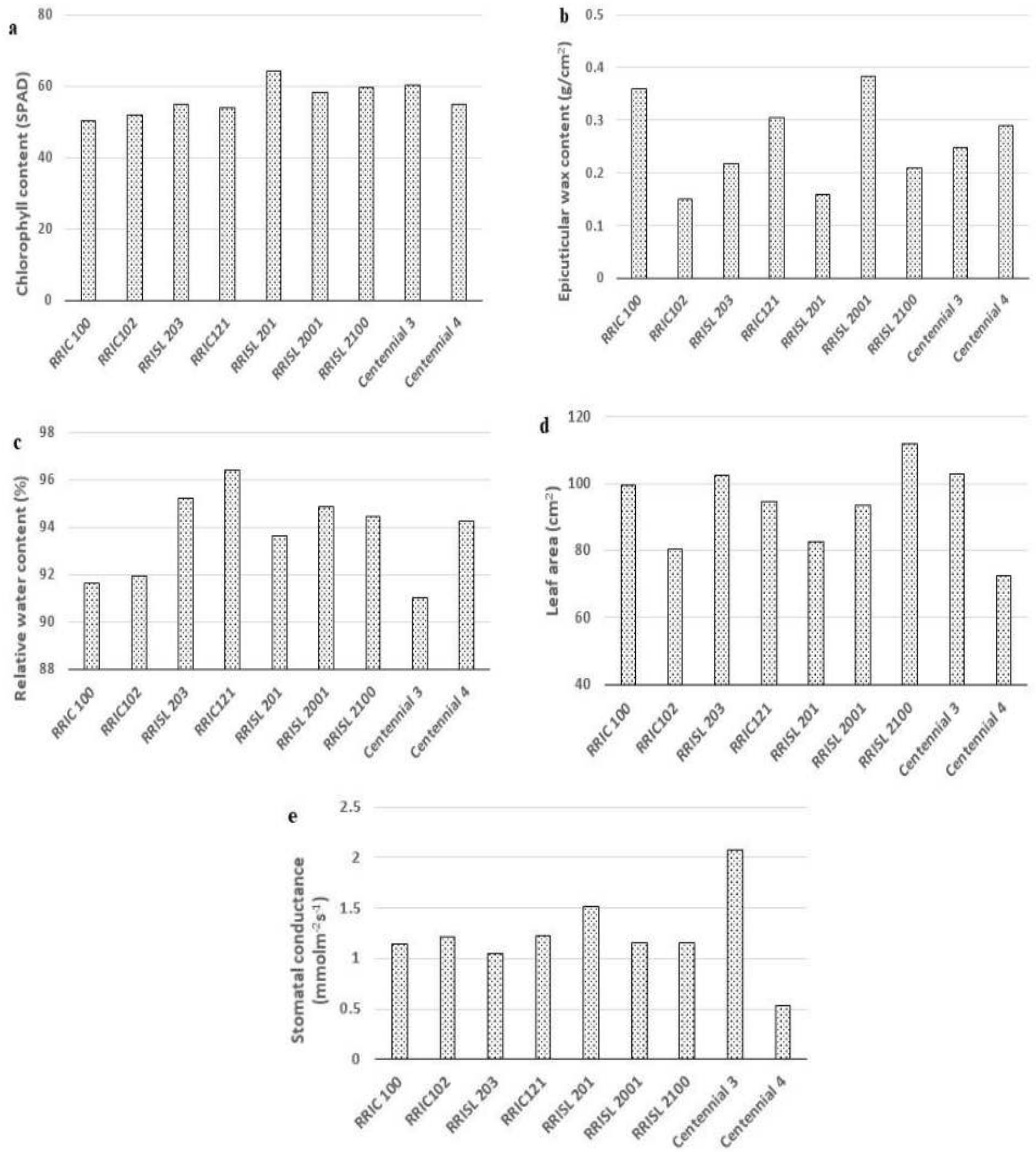


Fig. 2. a). Chlorophyll content, **b).** epicuticular wax content, **c).** relative water content**, d).** leaf area and **e).** stomatal conductance of different *Hevea* genotypes planted at the Padiyathalawa experimental site

Meerigama (Wet Zone)

Performances of four clones (RRISL 203, PB 260, RRIC 121 and RRISL 2001) developed by RRISL established in the experimental field at Meerigama in

2015 were evaluated with plant physiological data during 2022. Chlorophyll content, epicuticular wax content, relative water content, leaf area and stomatal conductance were assessed as physiological parameters of the clones planted at Pasyala. Wind speed, air temperature, relative humidity and soil moisture level during morning were recorded as environmental parameters at the time of taking measurements. Soil moisture level of the field during the time of data collection varied between 10.4 - 15.8% with an average value of 13.8% (Table 5).

Table 5. *Average environmental condition in Pasyala field at the time of collection plant physiological data*

Clone	Wind speed (km/hr)	Air temperature (^{o}C)	Relative humidity (%)	Soil moisture content (%)
RRISL 203	1.65	30.5	83.5	14.64
PB 260	3.5	29.45	85.8	15.79
RRIC 121	1.65	31.35	93.75	10.39
RRISL 2001	2.2	31.55	77.7	14.51

As shown in the Figure 3, out of four *Hevea* genotypes, RRISL 203 (64.85 SPAD) and RRISL 2001 (62.97 SPAD) had the highest chlorophyll contents while RRIC 121 (52.59 SPAD) had the lowest. Chlorophyll content of PB 260 clone was around 59.08 SPAD units. Higher contents of epicuticular wax was recorded in RRISL 203 (0.0038 g/cm^2) and RRIC 121 (0.0038 g/cm^2) clones and the lowest was in RRISL 2001 (0.0020 g/cm^2) and PB 260 (0.0029 g/cm^2). The maximum and minimum relative water contents were found in RRISL 2001 (93.18%) and RRIC 121 (90.84%) respectively. In between RRISL 203 and PB 260 clones had relative water contents around 92.73% and 91.73% respectively. RRISL 2001 (118.72 cm^2) clone had larger leaves than other clones RRIC 121 (109.23 cm^2), PB 260 (74.39 cm^2) and RRISL 203 (71.32 cm^2) which had the smallest leaves. The highest stomatal conductance was observed in RRISL 2001 (2.76 mmolm^{-2}s^{-1}) followed by RRISL 203 (1.97 mmolm^{-2}s^{-1}), RRIC 121 (1.67 mmolm^{-2}s^{-1}) and PB 260 (1.31 mmolm^{-2}s^{-1}) (Fig. 3) (K V V S Kudaligama, N P S N Karunarathne and M K P Perera).

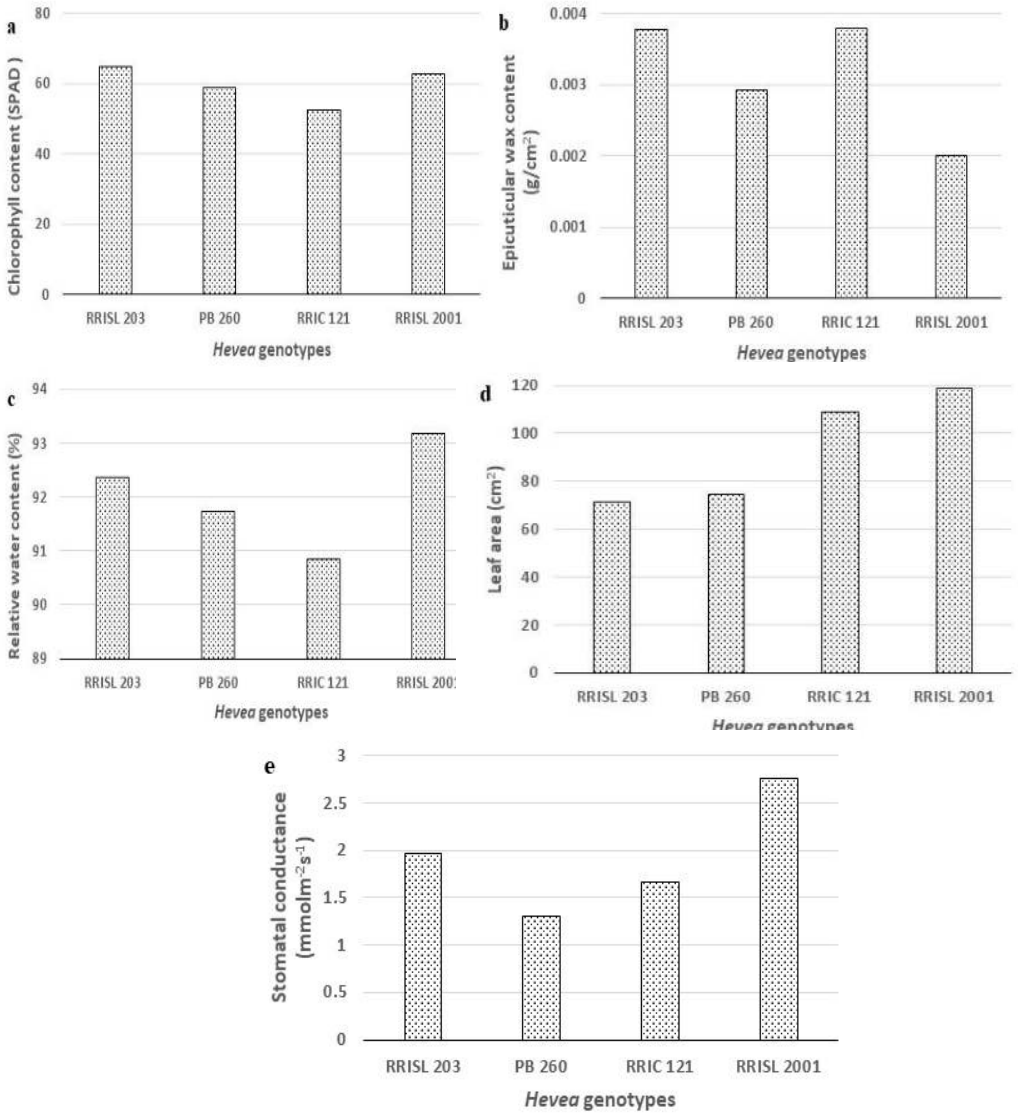


Fig. 3 a). Chlorophyll content, **b).** epicuticular wax content, **c).** relative water content, **d).** leaf area and **e).** stomatal conductance of different *Hevea* genotypes planted at Pasyala experimental site

Research and development on rubber latex to identify best genotypes that produce quality raw rubber during screening process

Biochemical and physiological screening of HP progenies

Biochemical and physiological assessment of latex of twenty *Hevea* HP genotypes of the progeny developed in 2014 was carried out at the field established in Nivithigalakele Sub-station on request of Department of Genetics & Plant Breeding. The contents of sucrose, inorganic phosphorus, thiol polyphenols, dry rubber content, total solids content and g/t/t were determined during the year 2022 (Table 6).

According to the results, *Hevea* genotype No. 42 had the highest g/t/t whilst No: 106, 164 and 167 showed a comparatively medium g/t/t values. All other genotypes showed lower g/t/t level revealing deficient latex regeneration capacities. Though the latex sucrose content of genotype 42 is lower, considerably higher g/t/t and DRC levels indicated that this genotype has a higher metabolic activity with an ability to perform well in converting sucrose to *Cis*-polyisoprene. Genotypes No: 106, 164 and 167 had higher level of sucrose with lower inorganic phosphorous which reveals a better performance as high yielders with a medium metabolic activity. Even though genotypes No: 15, 35, 78 and 83 resulted in very high sucrose contents in latex compared to other genotypes, their g/t/t values were very low. Therefore, these could be categorized as the genotypes that are suitable for stimulation based harvesting systems. Thiols and polyphenols were more or less similar among the genotypes (Table 6).

Table 6. *Latex physiological parameters of Hevea HP progeny developed by 2014 hand pollination programme (under micro tapping condition)*

Genotype No.	Sucrose (mM)	Inorganic phosphorus (mM)	Thiol (mM)	Poly-phenols (mM)	Dry Rubber Content (%)	Total Solid Content (%)	Non rubber content (%)	Total volume (ml)	g/t/t (g)
2	4.58	0.68	0.20	1.13	52.72	56.09	3.37	5.5	2.90
11	13.90	1.94	0.37	2.04	51.96	55.23	3.27	10.0	5.20
13	16.63	0.38	0.31	1.93	51.06	54.07	3.01	13.5	6.89
15	23.45	1.63	0.32	1.60	53.19	57.44	4.25	5.5	2.93
21	8.84	1.76	0.26	1.84	53.52	57.92	4.40	12.0	6.42
33	19.10	1.18	0.40	2.98	50.25	53.04	2.79	19.0	9.55
35	24.20	1.24	0.29	1.60	53.20	56.78	3.58	11.0	5.85
39	15.89	1.33	0.36	1.83	50.63	51.12	0.49	12.5	6.33
42	5.31	0.75	0.25	1.28	49.63	52.18	2.55	86.0	42.68

Genotype No.	Sucrose (mM)	Inorganic phosphorus (mM)	Thiol (mM)	Poly-phenols (mM)	Dry Rubber Content (%)	Total Solid Content (%)	Non rubber content (%)	Total volume (ml)	g/t/t (g)
58	8.61	0.94	0.32	1.98	47.04	49.44	2.40	26.0	12.23
62	14.77	1.08	0.41	1.51	52.13	54.62	2.48	10.0	5.21
65	22.03	2.41	0.30	2.53	52.34	56.65	4.31	3.5	1.83
78	25.49	1.32	0.24	1.98	51.10	55.24	4.14	12.0	6.13
79	13.08	0.56	0.38	1.80	44.98	48.48	3.50	7.5	3.37
83	26.23	1.97	0.32	1.39	47.22	50.91	3.69	13.5	6.37
102	11.57	0.67	0.24	1.73	44.37	47.38	3.01	18.5	8.21
106	11.58	0.71	0.30	1.67	44.03	46.65	2.62	43.5	19.15
114	19.46	1.98	0.28	1.32	47.58	49.73	2.15	9.5	4.52
164	21.74	1.30	0.33	1.48	36.46	39.49	3.03	63.5	23.15
167	22.68	0.78	0.31	1.21	43.50	47.17	3.67	36.5	15.88

(N P S N Karunarathne, K V V S Kudaligama N N Abewardhana and P D T L Madushani in collaboration with Genetics and Plant Breeding Department, RRISL)

Supporting the clonal screening activities through physiological and biochemical aspects

An experiment was started to evaluate the physiological performance of established clones and develop a physiological index to support the clonal screening. Seven *Hevea* clones (RRISL 208, RRISL 203, RRISL 2006, RRISL 201, Centennial 3, Centennial 4 and Centennial 5) planted in 2009 at Eladuwa estate were assessed during 2022 for their latex physiology, latex flow and yield parameters (Table 7).

Of the clones tested, RRISL 208 showed the highest sucrose content in latex (19.22 mM) followed by RRISL 2006 (15.81 mM). Centennial 3 and Centennial 4 had considerably lower sucrose contents than the other tested clones. RRISL 2006 resulted the highest inorganic phosphorus (31.02 mM) in latex while Centennial 5 showed the lowest (5.23 mM). The highest g/t/t values were observed in RRISL 2006 (50.90 g) and RRISL 208 (34.13 g) clones. All other clones had g/t/t values varying between 20-30g (Table 7).

Table 7. *Yield and latex physiological parameters of different Hevea clones planted in Eladuwa Estate experimental field*

Hevea clone	Sucrose (mM)	Inorganic phosphorus (mM)	Thiol (mM)	Polyphenols (mM)	Dry Rubber Content (%)	Total Solid Content (%)	g/t/t (g)	pH	Plugging index
RRISL 201	10.49	10.25	0.25	1.07	46.04	47.33	24.84	6.53	5.43
RRISL 203	12.43	7.08	0.21	2.28	43.30	46.85	23.10	6.53	8.75
RRISL 208	19.22	6.56	0.33	4.82	40.83	44.16	34.13	6.68	8.10
RRISL 2006	15.81	31.02	0.24	4.95	47.09	49.38	50.90	6.59	2.91
Centennial 3	7.35	7.64	0.52	1.85	34.35	37.59	25.63	6.62	3.96
Centennial 4	7.88	15.40	1.47	1.16	39.32	42.62	27.34	6.82	3.79
Centennial 5	12.48	5.23	0.26	1.46	32.58	35.89	22.26	6.69	5.89

The highest and lowest latex thiol contents was observed in Centennial 4 (1.47 mM) and RRISL 203(0.21 mM) respectively. Latex polyphenol content was higher in RRISL 208 (4.82 mM) and RRISL 2006 (4.95 mM) clones and lower in RRISL 201 (1.07 mM) and Centennial clones (Table 7). Comparatively lower dry rubber contents and total solids contents were observed in Centennial clones. All other clones had their DRC% values between 40 – 48% and TSC% between 44 – 50%. No significant difference was observed among pH values of all the clones tested which had average value of 6.64. Having high plugging index values RRISL 203 (8.75) and RRISL 208 (8.10) showed early plugging whereas RRISL 2006 (2.91) showed late plugging affinity after tapping (Table 7) (N P S N Karunarathne, K V V S Kudaligama, N N Abewardhana, L T B K Fernando and P D T L Madushani).

Effect of circular leaf spot disease on yield and biochemical components of latex

An experiment has been conducted in collaboration with the Plant Pathology and Microbiology Department of RRISL in order to investigate effects of new leaf fall disease on latex yield and physiological parameters. Tapping blocks have been selected from 2010 replanted field in the Gallewatte division of Dartonfield Estate. The majority of the trees are of RRIC 121 genotype and tapped with S/2 d4 latex harvesting system. This field was severely attacked by the new leaf disease in 2020. The yield data was monitored throughout the year 2022. October - December yield data could not be collected due to unavailability of a permanent harvester in the field.

For the period of January to September, ethephon stimulation was suspended during January and February due to de- foliation and stimulation was done in other months according to the recommendations. A drop in DRC % was observed during the wintering – refoliation period in February-March. However, dry rubber content increased to 40% in April and remained constant for the rest of the period. Daily dry

rubber yield per tree (g/t/t) fluctuated throughout the study period. During January - February average g/t/t was 25 g and thereafter an increase has been observes. During the May-September period g/t/t observed was between 30 - 42 g with an average value of 35 g. About 19.5% reduction in average daily dry rubber yield per tree was observed compared to the year 2021 (K V V S Kudaligama, N P S N Karunarathne, L T B K Fernando, N N Abewardhana, P D T L Madushani and M K P Perera, in collaboration with Plant Pathology and Microbiology department, RRISL).

Commercial scale testing of in-country ethephon formulation developed by RRISL

Experiment established at Elston Estate, Puwakpitiya has been continued to investigate the effectiveness of new water based (NWB) formulation together with two commercial ethephon mixtures available in the local market, *i.e.* existing water based (EWB) and existing oil based (EOB). Tapping system used was S/2 d4 system with application of 0.6 g of 2.5% ethephon per tree at a rate on monthly basis avoiding the wintering period. This field has been replanted in 2010/2011 season with RRIC 121 clone and opened for tapping in 2018. Tapping task size is 300-317 trees/tapper and for each formulation three tapping blocks were allocated.

During the year 2022 trees treated with new water- based ethephon showed a higher dry rubber and total solids contents when compared to the both existing ethephon formulations. No significant difference was observed among pH values under three stimulant types. Sucrose and inorganic phosphorus levels were comparatively higher in latex of trees treated with NWB ethephon (Table 8). The highest thiol contents were observed in trees applied the EWB ethephon. The highest polyphenol content was observed in locally produced water-based stimulation and lowest was in trees applied existing water based ethephon (Table 8).

Both water based formulations showed a comparatively higher plasticity retention index than with the oil based ethephon. New water- based ethephon had the highest Mooney viscosity value and the lowest was given by EOB ethephon. Ash content and lovibond color index in rubber under different types stimulants were more or less similar (Table 9).

Table 8. *Latex physiological parameters of trees treated with new water based (NWB) ethephon, existing water based (EWB) ethephon and existing oil based (EOB) in 2022*

Parameter	NWB ethephon	EWB ethephon	EOB ethephon
Dry rubber content (%)	45.53	39.52	38.10
Total solids content (%)	48.47	41.15	40.74
pH value	6.8	6.7	6.7
Sucrose content (mM)	6.49	5.71	6.33
Thiol content (mM)	0.31	0.38	0.28
Inorganic phosphorus content (mM)	10.93	9.51	9.09
Polyphenol content (mM)	1.69	1.20	1.34

Table 9. *Properties of unfractioned unbleached crepe rubber harvested from trees treated with new water based (NWB) ethephon, existing water based (EWB) ethephon and existing oil based (EOB) in 2022*

Raw rubber property	NWB ethephon	EWB ethephon	EOB ethephon
Plasticity Retention Index	87	89.54	84.58
Mooney viscosity ML (1+4)@100^{0}C	86.61	85.21	84.1
Nitrogen Content %	0.41	-	0.48
Ash content %	0.19	0.19	0.20
Colour (Lovibond)	2.5	2.5	2.5

Over the year, average dry rubber content of latex in tapping blocks applied three formulations varied from 32-39% and the average value was about 36% in all three treatments. Due to the higher rainfall received during the year 2021, the number of tapping days was lower than the expected level (*i.e.* 73 days/yr) under S/2 d4 condition. In addition to the recommendation, ethephon applications have been suspended for another four months due to the heavy leaf fall occurred with new leaf fall disease. This has been lowered the average daily intakes of the field by about 5 kg. The observed yield per hectare (assuming 400 trees/ha) was 1101, 988 and 1046 kg, respectively in blocks applied new water based, existing water based and existing oil based formulations. On average yield obtained from a tree has been reduce from 3.6 kg to 2.6 kg during year 2022 when compared to 2021. However, the new water based formulation showed comparatively higher productivity than that of the existing formulations (Table 10).

Table 10. *Average yield of tapping blocks (300 trees) harvested with S/2 d4 system using different types of ethephon formulations in Elston Estate*

Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
New water based	74	35.95	37.20	11.16	2.75	1101
Existing water based	72	35.93	34.30	10.29	2.47	988
Existing oil based	74	35.74	35.35	10.65	2.62	1046

(K V V S Kudaligama, T H P S Fernando, V H L Rodrigo, P Seneviratne, A P Attanayaka, K M E P Ferando, N P S N Karunarathne, L T B K Fernando, N N Abeywardhena, P D T L Madushani and M K P Perera)

ADVISORY SERVICES

The extension strategy focusing on the farmer participatory development of selected rubber smallholdings was continued in each REO division in traditional rubber growing areas, and 104 rubber smallholdings were developed as model rubber smallholdings. Twenty-three rubber processing centers were developed as models, and the construction of 12 new RSS processing centers and rehabilitation of 14 substandard centers were attended. Twenty smallholdings were fixed with rain guards as demonstrations. Six smallholdings were established with different intercrops as models. Advisory visits (1163) were carried out to solve technology adoption problems based on rubber smallholders' requests. Training workshops were conducted, educating 471 rubber smallholders and 154 estate staff on general cultivation practices, rain guard fixation and processing aspects of rubber. To solve the tapper shortage in rubber growing areas, 05 Mobile Tapper Training programmes were conducted in Galle and Ratnapura Districts covering both practical and theoretical aspects, and 29 and 19 new tappers from each District participated, respectively. To upgrade the knowledge and skill levels of semi-skilled rubber tappers, 22 skill development training programmes were conducted for selected 752 semi-skilled in the estate sector. Eight skill development training programmes were conducted for 92 semi-skilled tappers in the smallholder rubber sector. To improve the product quality of RSS produced by rubber smallholders, 02 training programmes were conducted for the benefit of 29 selected RSS producers in Kalutara and Galle Districts. Under the "Livelihood Development for Sustainable Rural Economy" project, the Saubhagya paper production workshop was organized and conducted for 13 participants in Kegalle District. Under the collaborative research project "Usage of rubber effluent as a source of fertilizer for short term crops", research was established among the 14 rubber smallholders. The "Alpha Generation for Natural Rubber (ඇG 4 NR)" awareness programme was initiated, aiming for the younger generation, including school students in Kegalle District, to transfer new technologies and knowledge on rubber to the younger generation. Surveys were conducted to identify the Tapping Panel Dryness in selected RRISL 203 lands in rubber growing districts and to identify the Petalotiopsis disease-affected lands in Kalutara, Ratnapura, Colombo, Kegalle, Galle and Matara Districts.

ADVISORY SERVICES

P K K S Gunarathne

DETAILED REVIEW

Staff

Mr P K K S Gunarathne, Advisory Officer (Head – cover-up duties) was on duty throughout the year. Mr Susith Rathnayake (Rubber Extension Officer) retired from the service effective from the 31st of December 2022. Mr T L Ramanayake (Rubber Extension Officer) resigned from the service with effect from the 12th of December 2022. Mr K D K L Siriwardhana (Rubber Extension Officer) departed from the country for a foreign job on leave with effect from the 29th of August 2022.

Conferences/Meetings/Seminars/Workshops attended

Officer/s	Subject/s	Organization/s
PKKS Gunaratna All REOs	Technology Update Programmes	RRISL
PKKS Gunaratna	Meetings of staff, review, research, Scientific Committee and budget	RRISL
PKKS Gunaratna Sarath Chandrasiri	Provident Fund Meeting	RRISL
PKKS Gunaratna	Workshop on issues of rubber farming in Kegalle District	GA Office, Kegalle District
	Workshop on issues of the smallholder rubber sector	RDD and RRISL
	Project on "Road map for organic agriculture.	Ministry of Plantation of Sri Lanka
	Committee on Development of Walahanduwa Estate as a model Estate using new rubber technologies	Ministry of Plantation of Sri Lanka
	Workshop on "Understanding fundamentals in GIS, remote sensing and Geo-spatial applications."	IRRDB and RRISL
	The PGIA Annual Congress presented a paper titled "A case study on the impact of newly introduced rubber farming system on the livelihood of smallholders in Moneragala District."	Postgraduate Institute of Agriculture, University of Peradeniya

Officer/s	Subject/s	Organization/s
PKKS Gunaratna	The international forestry and environment symposium presented a paper titled "Eco-system Services of Smallholder Rubber Cultivation - A Case Study in Moneragala District in Sri Lanka."	University of Sri Jayewardenepura
	Tenth YSF Research Symposium - 2022 and presented a paper titled "Factors influencing rubber smallholders' behaviour in adopting rubber processing technologies in Monaragala District."	YSF, Sri Lanka
	Online Workshop on "Basic Introduction to Scientrometrics"	Indian Institute of Science

PROGRESS OF PROJECTS AND SERVICES

Extension and advisory programmes were carried out under four thrust areas to improve the productivity of the rubber smallholder and estate sectors by enhancing the adoption rate of recommended technologies developed by RRISL.

Thrust area 01: Transfer of technologies to improve the productivity of the smallholder rubber sector and estate sector

Project 1 (ASD/01/A) Participatory development of selected rubber smallholdings as models

To demonstrate the value of adopting RRISL recommendations to increase the land-use-efficiency of rubber smallholdings, the extension strategy focused on farmer participatory development of selected rubber holdings as "Model rubber holdings" was continued successfully (Table 1). As models, 46 immature and 58 mature holdings were fully developed (Figs. 1, 2).

Fig. 1. Mature model rubber holding - Mr Nihal Susilasiri (Colombo REO range)

Fig. 2. Immature model rubber holding - Mr Kodithuwakku, DJ Estate (Matugama REO range)

Table 1. *Details of participatory development done for selected smallholder rubber holdings*

Region	No. of developed holdings	
	Mature	**Immature**
Colombo/Gampaha	6	13
Kegalle	12	17
Kalutara	6	4
Ratnapura	11	11
Galle/Matara	11	13
Total	46	58
	104	

Project 2 (ASD/01/B) Participatory development of rubber processing centers as models

Advisory and extension support services were provided to maintain 23 "Model Rubber Processing centers" to demonstrate the importance of the adoption of recommended practices to improve the quality of RSS to obtain maximum economic returns (Table 2).

Fig. 3. Inside of a model Rubber Processing Center - Mr. Pathirage (Bulathsinhala REO range)

Table 2. *Participatory development of rubber processing centers for selected smallholders*

Region	No. of model centers developed
Colombo/Gampaha	4
Kegalle	8
Kalutara	2
Ratnapura	7
Galle/Matara	2
Total	23

Project 3 (ASD/01/C) Promotion of usage of rainguards

To popularize the rain guard technology as a short-term strategy to increase the productivity of rubber smallholdings, 20 demonstration plots were established under the supervision of REOs (Table 3).

Fig. 4. Rainguard model rubber holding – Mr. Sanath Kithsiri (Kegalle REO range)

Table 3. *Details of rainguard demonstration holdings*

Region	No. of demonstration holdings established
Colombo/Gampaha	2
Kegalle	9
Kalutara	1
Ratnapura	7
Galle/Matara	1
Total	20

Project 4 (ASD/01/D) Promotion of area specific intercropping and mixed cropping systems

To popularize area specific intercropping systems to increase the income during the immature period of rubber smallholdings, 06 intercropping demonstration plots were established (Table 4).

Fig. 5. Intercrop model with pineapple - Mr. Wickramathunga (Matugama REO range)

Table 4. *Area-specific intercropping and mixed cropping demonstration holdings*

Region	No. of demonstration
Colombo/Gampaha	2
Kegalle	2
Kalutara	1
Galle/Matara	1
Total	6

Project 5 (ASD/01/E) Construction, rehabilitation and modification of new and substandard rubber processing centers

Advisory and extension services were provided for constructing 12 new RSS production centers and rehabilitating 14 substandard processing centers to maintain them as cost-effective units per the owners' requests (Table 5) (Fig. 6).

Fig. 6. New rubber processing center - Mr. Nalin Sriyadasa (Matugama REO range)

Table 5. *Construction, rehabilitation and modification of new and sub-standard rubber processing centers*

Region	**No. of RSS production centers**	
	New centers	**Rehabilitated centers**
Colombo/Gampaha	1	1
Kegalle	5	3
Kalutara	2	0
Ratnapura	0	5
Galle/Matara	4	5
Total	12	14

Project 6 (ASD/01/F) Projects related to advisory visits in traditional rubber growing areas

Rubber Extension Officers conducted nine hundred seventy pre-planned advisory visits to solve technology adoption problems in the participatory development models (Table 6).

Table 6. *Details of projects-related advisory visits*

Region	Nature of advisory visit						
	Establishment of model rubber holdings	Introduction of Intercropping systems	Introduction of rain guard technology	Maintenance of model RSS centers	Construction of new RSS centers	Rehabilitation of substandard RSS centers	Total
Colombo/Gampaha	19	2	2	4	2	3	**32**
Kalutara	61	9	3	19	16	0	**108**
Kegalle	171	6	43	26	7	7	**260**
Rathnapura	22	0	7	11	0	0	**40**
Galle/Matara	242	9	21	17	22	23	**334**
Total	**515**	**26**	**76**	**77**	**47**	**33**	**774**

Thrust area 02: Advisory programmes to solve technology adoption problems of all stakeholders of the rubber sector

Project 7 (ASD/02/A) Individual advisory visits and demonstrations on requests of rubber smallholders

Three hundred and eighty nine advisory visits and three hundred seventy five demonstrations were made by REOo to solve technology adoption problems of rubber smallholders about all agronomic and processing aspects. A separate report was prepared by REOs on each visit, and foll,ow-up actions were attended where necessary (Tables 7 and 8).

Table 7. *Demonstrations conducted on requests of rubber smallholders*

Type of demonstration	No. of demonstrations
Immature	
Planting holes	13
Planting	3
Soil conservation	18
Branch induction	7
Removal of branches	13
Fertilizer application	20
Weed control	8
Intercropping	10

Type of demonstration	No. of demonstrations
Diseases	8
Cover crops	3
Animal damages	7
Other	6
Mature	
New panel marking	17
Tapping correction	57
Fertilizer application	13
Rain guard	29
New tapping knife	13
Disease	41
TPD	27
Other	15
Processing	
Ceiling	6
Oven	5
Sheet making	13
One day Smoke House	6
New Smoke Houses	8
Chimneys	7
Other	2
Total	**375**

Table 8. *Details of Individual advisory visits conducted on requests of smallholders*

Region	No. of advisory visits made by REOo			
	Immature	**Mature**	**Processing**	**Total**
Colombo/Gampaha	4	17	4	25
Kegalle	28	101	34	163
Kalutara	26	25	5	56
Ratnapura	18	34	11	63
Galle/Matara	15	62	5	82
Total	**91**	**239**	**59**	**389**

The above advisory visits were categorized as follows (Figs. 7, 8 and 9).

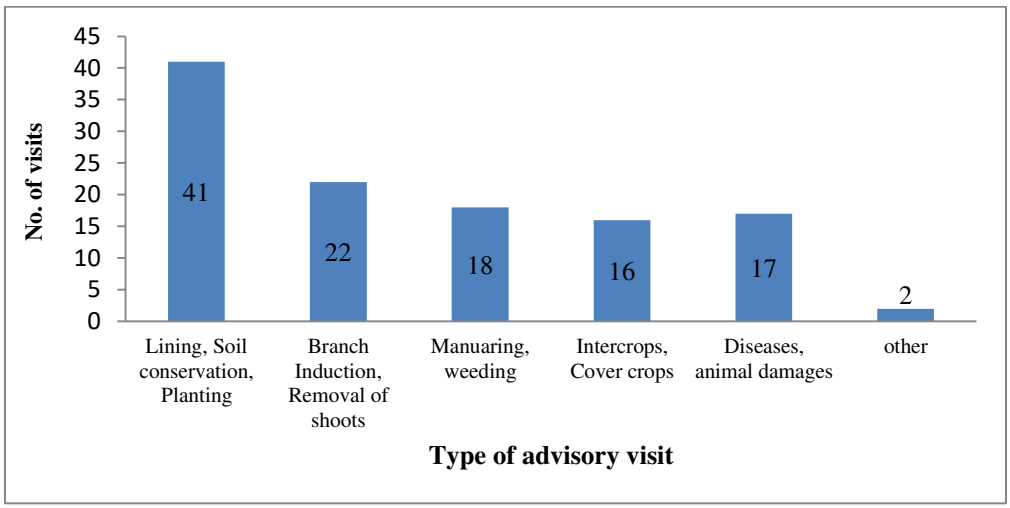


Fig. 7. Types of advisory visits conducted in immature holdings

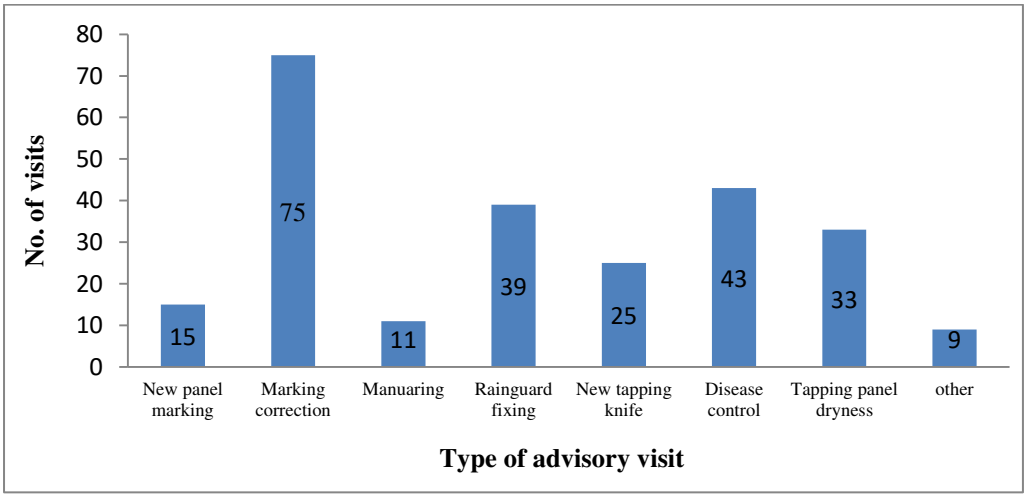


Fig. 8. Types of advisory visits conducted in mature holdings

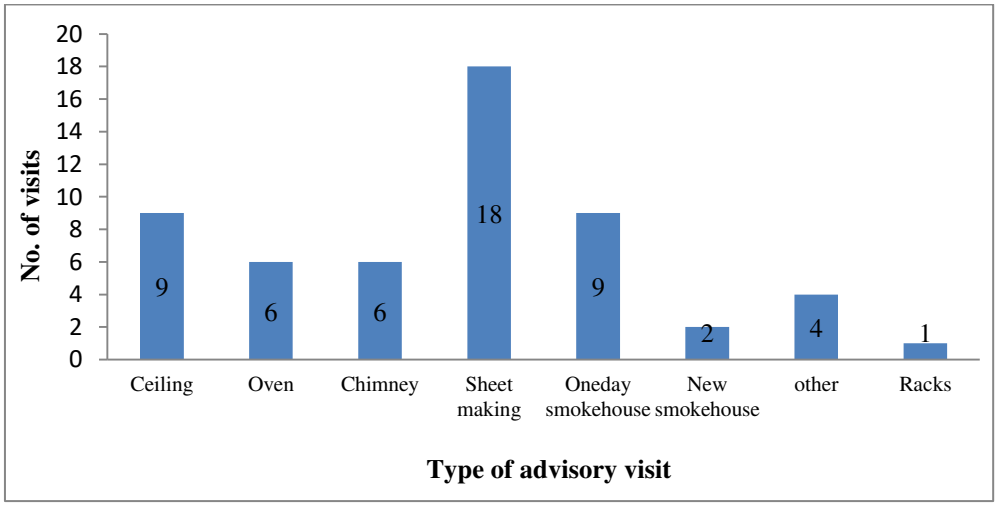


Fig. 9. Types of advisory visits conducted in RSS production centers

Project 8 (ASD/02/B) "Vihidum Sathkara": centrally planned special group advisory and extension programmes for smallholders in rubber growing areas

To meet the growing demand for advisory services, a group extension programme called "*Vihidum Sathkara"* was effectively conducted for 32 smallholdings in traditional rubber growing areas for necessary improvement (Table 9). A schematic representation of this activity is given in Figure 10.

Table 9. *Number of smallholdings that conducted Vihidum Sathkara programmes for rubber smallholders*

Region	**No. of lands (Vihidum Sathkara)**	
	Immature	**Mature**
Kegalle	5	13
Ratnapura	1	4
Galle/Matara	9	0
Total	15	17

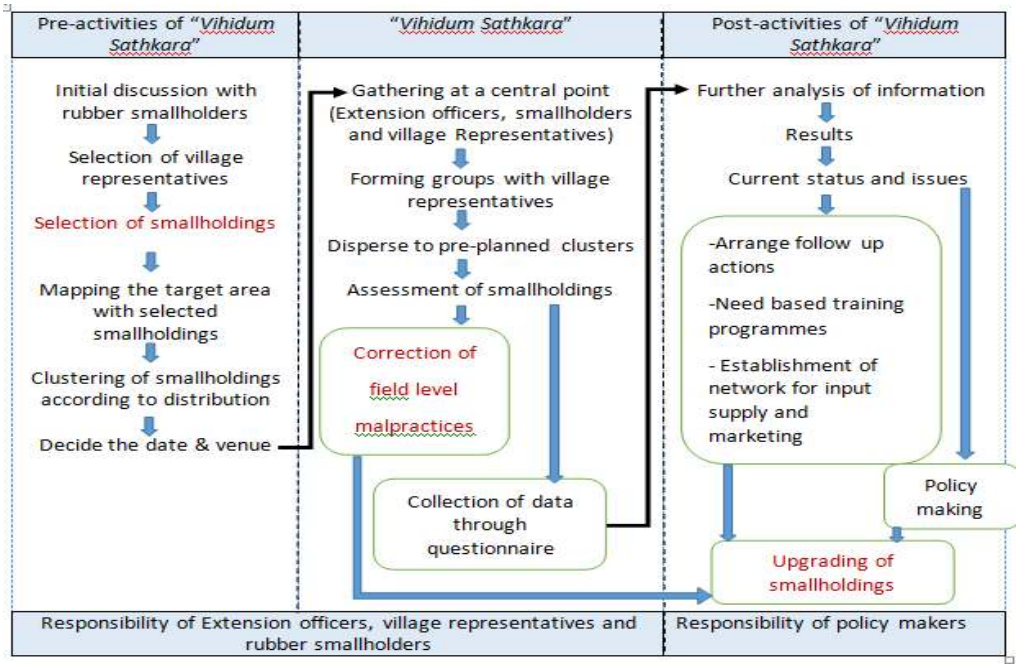


Fig. 10. Schematic representation of "Vihidum Sathkara" group advisory programme

Thrust area 03: Human resource development of all stakeholders in the rubber smallholder sector and estate sector

Project 9 (ASD/03/A) Awareness-raising programmes

Nine awareness-raising programmes on general cultivation aspects of rubber were conducted to educate 154 field staff of estates. Thirty-six awareness-raising programmes on general cultivation aspects of rubber were conducted to educate 471 smallholder farmers. (Figs. 11 and 12). Participation from each estate and the district in awareness programmes on general cultivation aspects of rubber are summarized in Tables 10 and 11.

Table 10. *Details of Estate staff participation in Awareness programmes on general cultivation and processing aspects of rubber in the estate sector*

Name	No. of participants
Keeragala estate	26
Palm garden estate	40
Pailgardn estate	07
Kiribathgla Estate	20
Watapotha Estate	04
Salawa Estate	26
Siriniwasa Estate	07
Wilpita Estate	12
Payagala Estate	12
Total	**154**

Table 11. *Details of Estate staff participation in Awareness programmes on general cultivation and processing aspects of rubber in the smallholder sector*

Estate	No. of programmes	No. of farmers trained
Kalutara	7	106
Galle	3	33
Kegalle	10	97
Ratnapura	16	235
Total	**36**	**471**

Fig. 11. Awareness and Training programme conducted for field officers at Keeragala Estate Pussellawa Plantation

Fig. 12. Organic fertilizer awareness programme at Bondupitiya (Matugama REO range)

Project 10 (ASD/03/B) Mobile tapper training schools

To solve the tapper shortage in rubber growing areas, 05 Mobile Tapper Training programmes were conducted in Galle and Ratnapura Districts covering both practical and theoretical aspects and 29 and 19 new tappers from each district participated, respectively (Table 12).

Table 12. *Details of Tapper Training Programmes conducted for rubber tappers (smallholder sector)*

Region	No. of programmes	No. of new tappers trained
Galle	2	29
Ratnapura	3	19
Total	**5**	**48**

Project 11 (ASD/3/C) Skills development of rubber tappers

To upgrade the knowledge and skill levels of semi-skilled rubber tappers, twenty-two skill development training programmes were conducted for 752 semi-skilled tappers to improve the quality of tapping in the estate sector. Eight skill development training programmes were conducted for ninety-two semi-skilled tappers to enhance the quality of tapping in the smallholder rubber sector (Table 13) (Figs. 13 and 14).

Table 13. *Details of skill development programmes conducted for semi-skilled rubber tappers (Estate sector)*

Estate	No. of programmes	No. of semi-skilled tappers trained
Karadupana Estate	1	18
Raddagoda Estate	1	34
Gonadiwatta Estate	1	23
Mabopitiya Estate	1	24
Moragahakanda Estate	1	07
Parambe Estate	1	22
Heminford Estate	1	36
Keeragala Estate	1	44
Palmgarden Estate	1	52
Divurumpiitiya Estate	1	27
Watapotha Estate	1	25
Halpe Estate	1	46
Penrith Estate	1	51
Salawa Estate	1	41
Elston Estate	1	28
Siriniwasa Estate	1	49
Ayre Estate	1	52
Wlpita Estate	1	06
Halwathura Estate	1	28
Mirishena Estate	1	40
Payagala Estate	1	52
Payagala Estate	1	47
Total	22	752

Table 14. *Details of skill development programmes conducted for semi-skilled rubber tappers (Smallholder sector)*

Region	No. of programmes	No. of new tappers trained
Kegalle	4	40
Colombo	1	10
Galle	1	06
Kalutara	2	36
Total	**8**	**92**

Fig. 13. Tapping skill development programme conducted at Watapotha Estate – Agalawatta Plantation

Fig. 14. Tapping skill development programme conducted at Ayre Estate - Pussellawa Plantation

Project 12 (ASD/3/D) Quality improvements of RSS

To improve the product quality of RSS produced by rubber smallholders, 02 training programmes were conducted for the benefit of 29 selected RSS producers in Kalutara and Galle Districts (Table 15).

Table 15. *Details of quality improvements of RSS programmes conducted for rubber smallholders*

Region	No. of programmes	No. of rubber smallholders trained
Kalutara	1	18
Galle	1	11
Total	**2**	**29**

Project 13 (ASD/03/E) Involvement of REOs as resource personnel for other organizations

The following programmes were attended by REOs as resource personnel on requests made by different organizations (Table 16).

Table 16. *Details of the services provided by REOs*

Name of the programme	Organization	Number of programmes
Quality improvement of RSS (One day)	Thurusaviya Fund	02
Tapper Tanning School (Five Days)	Thurusaviya Fund	08
Awareness programme (One day)	Thurusaviya Fund	08
Disease control programme (One day)	Rubber Development Department	05
		02

Project 14 (ASD/03/F) Training Centre

The training center of the ASD is located in Nivitigalakale premises with accommodation facilities for 50 individuals. Nine awareness and training programmes were conducted for 350 participants, and accommodation was provided for 78 participants in 2022.

Thrust area 04: Development of an effective extension network in the smallholder rubber sector

Project 15 (ASD/04/A) Organization of Saubhagya paper production Workshop in Technology Transfer Centre, Regional Office in Kegalle

Under the "Livelihood Development for Sustainable Rural Economy" project, the Saubhagya paper production workshop was organized and conducted with the collaboration with Rubber Technology and Development Department for 13 participants in Kegalle District.

Fig. 15. Saubhagya paper production workshop in Technology Transfer Center, Kegalle - Regional Office

Project 16 (ASD/04/B) Distribution of mini-scale effluent treatment plants and equipment among rubber smallholders

Under the collaborative research project "Usage of rubber effluent as a source of fertilizer for short term crops" with Raw rubber processing and soil and plant nutrition departments, mini scale effluent treatment plants used to collect effluent were distributed among the 14 rubber smallholders. The project was initiated based on the Kegalle, Kalutara, Kurunegala and Galle Districts.

Fig. 16. Mini scale effluent treatment plants distributed among rubber smallholders and ongoing trials

Project 17 (ASD/04/C) Initiation of Alpha Generation for Natural Rubber (à G 4 NR)" Awareness programme was initiated aiming younger generation, including school students in Kegalle district.

Alpha Generation for Natural Rubber (à G 4 NR) awareness programme was initiated aiming younger generation, including school students in Kegalle District. The programme's objective is to transfer new technologies and knowledge of rubber to the younger generation, thereby increasing the sustainability of the rubber sector shortly.

Fig. 17. Initiation of Alpha Generation for Natural Rubber (à G 4 NR) awareness programme at Kegalle District

Project 18 (ASD/04/D) Introduction and establishment of new fuelwood growing models in selected lands of smallholder rubber farmers

Under the "Livelihood Development for Sustainable Rural Economy" project, Rubber based value added product development training programme was conducted to educate 13 participants with the collaboration with Rubber Technology and Development Department. The training programme was conducted at RRISL Ratmalana Auditorium and the laboratory of the Rubber Technology and Development Department.

Fig. 18. Rubber-based value-added product development training programme at Auditorium, Ratmalana RRISL and Rubber Technology and Development Department Laboratory

Project 19 (ASD/04/E) Identification of Tapping Panel Dryness condition in selected RRISL 203 clonal lands

The survey was conducted to identify the Tapping Panel Dryness in selected RRISL 203 lands covering Kalutara, Ratnapura, Colombo, Kegalle, Galle and Matara districts. Fifty-three lands were observed under the project, and the report was submitted.

Fig. 19. Mr. Shakila Wijewardana, Pannipitiya - RRISL 203 land

Project 20 (ASD/04/F) Identification of Petalotiopsis disease affected lands

The survey was conducted to identify the Petalotiopsis disease affected lands covering Kalutara, Ratnapura, Colombo, Kegalle, Galle and Matara districts. One hundred forty lands were observed under the project, and the report was submitted.

RUBBER TECHNOLOGY AND DEVELOPMENT

Paper was produced using the fibres of the "Mana" weed and modified field latex, a low cost alternative for the currently used high cost imported synthetic polymer based binder. Environmental and user-friendly sesame oil was used as an alternative to petroleum based aromatic processing oil in the development of tyre tread compounds. Crepe rubber based fishing bait, eraser, yoga mat and dental device were developed in collaboration with industrialists for local and foreign markets. Natural rubber composites with enhanced properties were developed using reduced graphene oxide synthesized in the laboratory. Novel rubberized-coir based slipper and novel shoe sole with tyre crumbs and compounded NR latex were also produced. Fifty nine entrepreneurs/rubber small holders were trained on rubber based product manufacture. 147 crepe rubber, 517 rubber compound, 29 rubber product and 40 polythene sample tests were conducted and reports were issued at the request of the rubber industry and state Universities.

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

DETAILED REVIEW

Staff

Dr (Mrs) Dilhara G Edirisinghe, Head of the Department and Mrs U Aloka Weerasinghe, Research Officer were on duty throughout the year. Mr W D M Sampath, Senior Research Officer reading for PhD. degree (Wayamba University of Sri Lanka) was on full-time study leave throughout the year.

Mrs Priyanthi Perera, Experimental Officer and Mr Mahesh Abhayawardena, Miss Ishani Jayaratne, Mr Nadun Tillekeratne and Mrs Nushara Nanayakkara Technical Officers were on duty throughout the year. Miss Gayathri Bhagyawedha, Technical Officer was on maternity leave until 20th April. Miss Madushani Gunawardena, Technical Officer was on maternity leave from 20th August.

Research students

Postgraduate students

- Mr W D M Sampath (Research Officer, Rubber Technology & Development Dept.), PhD student, Wayamba University of Sri Lanka continued his research project on "Synthesis of nanographene and characterization of its composites based on natural rubber" under the supervision of Dr (Mrs) D G Edirisinghe.
- Mr Indika Perera, MPhil student, University of Sri Jayewardenepura continued his research project on "Modification of rigid polyurethane foam waste to develop blends with nitrile rubber for special applications" under the supervision of Dr (Mrs) D G Edirisinghe.
- Mr Danushka Wijewardena, MPhil student, Uva Wellassa University of Sri Lanka continued his research project on "Rheological and mechanical properties of ternary composites of thermoplastics and skim natural rubber" under the supervision of Dr Susantha Siriwardena and Dr (Mrs) D G Edirisinghe.
- Mr A J M Vithanachchi, MPhil student, University of Sri Jayewardenepura, Sri Lanka continued his research project on "Improvement of electrical insulation of rubber mats produced with NR/SBR blends using inorganic fillers" under the supervision of Dr (Mrs) D G Edirisinghe.

Undergraduate students

- Miss A D Wickramapala, BSc (Palm & Latex Technology and Value Addition) undergraduate student, Uva Wellassa University of Sri Lanka conducted her research on "Evaluation of suitability of sesame oil as an alternative processing

aid for aromatic oil in carbon black filled natural rubber composites" under the supervision of Dr (Mrs) D G Edirisinghe.

- Mr W V C O Jayashankha, BSc (Engineering Technology) undergraduate student, Department of Nano Science Technology, Faculty of Technology, Wayamba University of Sri Lanka conducted his research on "Evaluation of suitability of nut grass tuber powder as an alternative antioxidant in natural rubber compounding" under the supervision of Mrs Aloka Weerasinghe.

Webinars/Training/Conferences/Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Meeting – Development of fishing bait	Ministry of Fisheries
	Technical Meeting on "Finalizing Promotional Leaflet for the use of NR in Road Construction"	Association of Natural Rubber Producing Countries (ANRPC)
	Technical Committee Meeting to review the SLS standard on "Polyurethane Foam Mattresses & Cushions"	Sri Lanka Standards Institution (SLSI)
	Meeting of the SLSI working group set up to formulate a SLS Standard for Passenger Car Tyres with the officials of Ferentino Tyre Co., Horana	SLSI – Engineering Division
	Two working group meetings on formulating a SLS Standard for Passenger Car Tyres	SLSI – Engineering Division
	Meetings - Editorial, Seminars, Workshops and Image Building Committee	Plastics & Rubber Institute of Sri Lanka (PRISL)
	Advisory Committee Meeting on Rubber, Rubber Products and Plastics	Export Development Board (EDB)
DG Edirisinghe, UA Weerasinghe & Nadun Tillekeratne	Meeting - Development of fishing bait	Samson International Plc., Galle
DG Edirisinghe & UA Weerasinghe	Meeting – Trouble shooting	DSL Toy Co.
	Scientific Committee Meeting	RRISL
	Procurement Training Program	Ministry of Plantation Industries (MPI) and RRISL
Staff of the department	Human resource training program	RRISL

Lectures/Webinars/Conferences/Training/Workshops conducted

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe, UA Weerasinghe & Nushara Nanayakkara	Two Workshops in Kegalle in collaboration with Advisory Services Department (ASD) of RRISL - Manufacture of paper based on fibers of "Mana" weed using the novel binder developed with modified field latex	13 female entrepreneurs/ Divisional Secretariat, Galigamuwa
Staff of the department	Training - Rubber Product Manufacture	32 Entrepreneurs/rubber smallholders
	Workshop - Manufacture of rubber products at cottage level in collaboration with the ASD of RRISL in connection with the program, "Livelihood Development for Sustainable Rural Economy".	A group of 14 rubber smallholders
WDM Sampath	Lecture - Compounding ingredients used in dry rubber industry	Students of the Certificate Course in Rubber Technology - PRISL
	Lecture - Rubber coated textiles	Students of the Certificate Course in Rubber Technology - PRISL
	Lecture - Overview of the rubber industry and future challenges with emphasis on quality improvement & productivity enhancement. Collection, preservation and transportation of latex	Professional Programme in Rubber Manufacture & Factory Practices - NIPM
	Lecture - Natural rubber latex composition and its variability	National Diploma in Plantation Management - Rubber Processing I - NIPM
UA Weerasinghe	Lecture - Introduction to value added rubber products	National Diploma in Plantation Management - NIPM
	Lecture - Natural rubber latex, manufacturing processes and their properties	Students of the Certificate Course in Rubber Technology - PRISL
	Lecture - Latex compounding ingredients	Students of the Certificate Course in Rubber Technology - PRISL

Officer/s	Subject/Theme	Beneficiary/Client
Staff of the department	Practical demonstration on "Latex based and dry rubber based products manufacture" at RRISL, Ratmalana	BSc (Agri. Sp.) undergraduates of the Department of Plantation Management, Wayamba University of Sri Lanka
	Field training on "Rubber Technology"	Undergraduate students of Palm & Latex Technology and Value Addition – Uva Wellassa University
	Field training on "Rubber Technology"	Undergraduate students of Dept. of Agricultural Technology, Faculty of Technology, University of Colombo

LABORATORY INVESTIGATIONS

Dry rubber technology

Evaluation of suitability of natural plant based materials as alternative antioxidants in natural rubber compounding

Ageing of natural rubber (NR) based products leads to deterioration in various properties and hence reduction in quality of the final products. The use of antioxidants (AOs) in rubber based compounding has been introduced to mitigate this issue up to a certain level. The commercially available AOs tend to generate hazardous substances which can affect the eco systems adversely. As a result, the viability of using natural antioxidants was evaluated with the use of natural plant based materials mainly lemongrass leaf powder and nut grass tuber powder.

(a) *Lemongrass leaf powder*

Several studies have been conducted based on the AO activity of lemongrass. In this study, a series of NR based compounds were produced considering the compound without any AO as the control and adding commercially available AOs such as IPPD, TMQ and WSP amounting to 1phr for each of the other compounds. An equivalent amount of Lemon Grass Powder (LGP) was added to another compound to compare the effect of antioxidant activity. Cure characteristics and physico-mechanical properties of rubber compounds were evaluated according to international standards. The samples were aged at 70±2 ^{o}C for 72 hrs to analyze for ageing resistance.

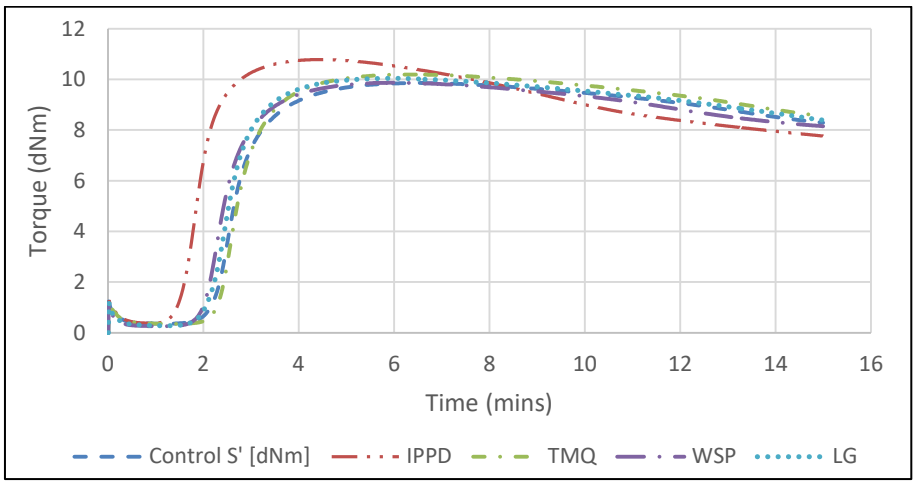


Fig. 1. Rheographs of NR compounds

The rheographs of all the composites (Fig. 1) indicated that the composite with LGP had similar characteristics to that of the composites containing TMQ and WSP AOs and the control, whereas IPPD containing compound showed a slight difference owing to its high activity.

Tensile strength of compounds indicated similar values ranging from 21.2-21.4 MPa for all the compounds including the control (Fig. 2). However, with the applied ageing conditions, tensile strength has deteriorated providing the lowest value to the control (14.7 MPa) and the highest value in the TMQ incorporated compound (20.1 MPa). The LGP incorporated compound reveals better results compared to the compound prepared with WSP.

Variation of elongation at break is illustrated in Figure 3. The highest elongation at break is observed for the TMQ incorporated compound and the lowest for the IPPD incorporated compound. Nevertheless, after ageing results reveal that almost similar values have been obtained for the compounds prepared with TMQ, WSP and LGP, whereas the IPPD incorporated compound and the control compound gained the lowest values with ageing.

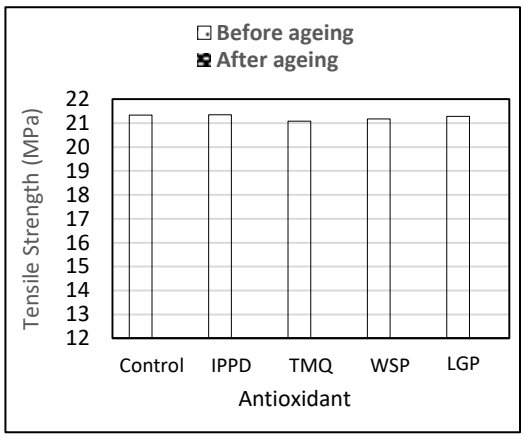


Fig. 2. Tensile strength of the NR compounds

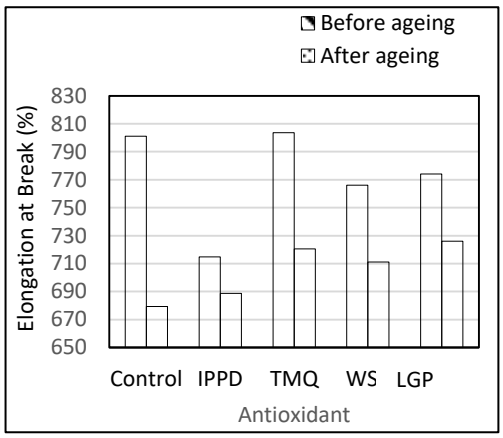


Fig. 3. Elongation at break of the NR compounds

LGP comprises of phenolic substances which give rise to its antioxidant properties. When considering the cure characteristics and physico-mechanical properties, it was observed that LGP could generate antioxidant properties better than the commercially available phenolic AO (WSP) for the selected composite formulation, whereas the commercially available paraphenylene diamine type AO (IPPD) and trimethyl-dihydroquinoline type AO (TMQ) provided the next best option in regard to cure characteristics and tensile properties (U A Weerasinghe, D G Edirisinghe, W D M Sampath and Nushara Nanayakkara)

(b) *Nut grass tuber powder*

Nutgrass (*Cyperous rotundus*) (NG) tubers are considered as a species known for its numerous ayurvedic medicinal uses. Apart from this aspect, NG is noticeable for its antioxidant properties owing to its high polyphenolic content.

A series of NR based compounds were prepared to assess the activity of NG powder as a natural AO in rubber compounding. The control was generated with the commercially available phenolic AO, WSP to compare the activity with NG powder. The loading of WSP in the control was 1phr, whereas the NG powder loading was changed from 0.5-1.5 phr at 0.25 phr intervals. Cure characteristics and physico-mechanical properties of rubber compounds were evaluated according to international standards. The samples were aged at 70±2 ^{o}C for 72 hrs to analyze for ageing resistance.

The cure characteristics of the compounds (Table 1) indicate higher maximum torque and hence higher stiffness for the compounds with NG. A similar level of scorch time, cure time and minimum torque are observed for the control and the other compounds S1-S5 indicating similar processability.

Table 1. *Cure characteristics*

	AO	Loading (phr)	Maximum torque (dNm)	Minimum torque (dNm)	Scorch time (min)	90% Cure time (min)
Control	WSP	1.00	10.41	0.32	4.89	9.09
S1	NG	0.50	11.38	0.29	4.70	8.75
S2	NG	0.75	11.78	0.37	4.37	8.20
S3	NG	1.00	12.69	0.37	4.73	8.63
S4	NG	1.25	12.30	0.23	4.66	8.38
S5	NG	1.50	12.16	0.39	4.91	8.99

Table 2. *Ageing properties of the control compound*

	Tensile strength (MPa)	Elongation at break (%)	Hardness (IRHD)
Before ageing	20.02	667.35	47.02
After ageing	16.05	566.15	50.31

The ageing properties of the compounds indicate an enhancement in relation to elongation at break and hardness (Figs. 6 and 7). One possible reason can be the presence of excess sulphur in the compounds which could form crosslinks during ageing. Then comparison of the results with the control compound (Table 2), similar or much enhanced results are observed with the compound with 1phr NG loading.

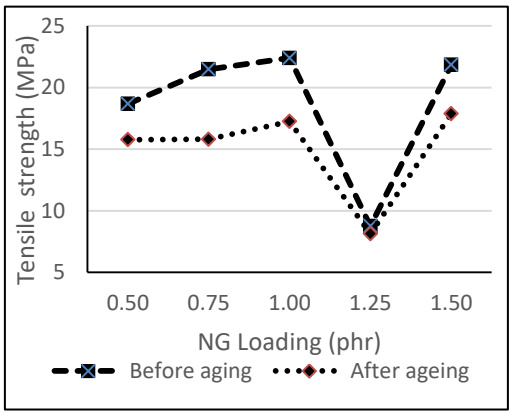


Fig. 4. Tensile strength of NG incorporated compounds

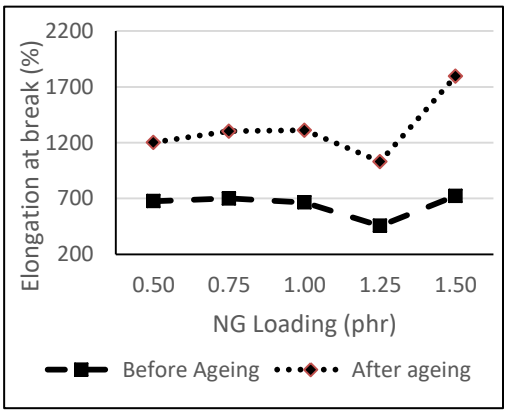


Fig. 5. Elongation at break of NG incorporated compounds

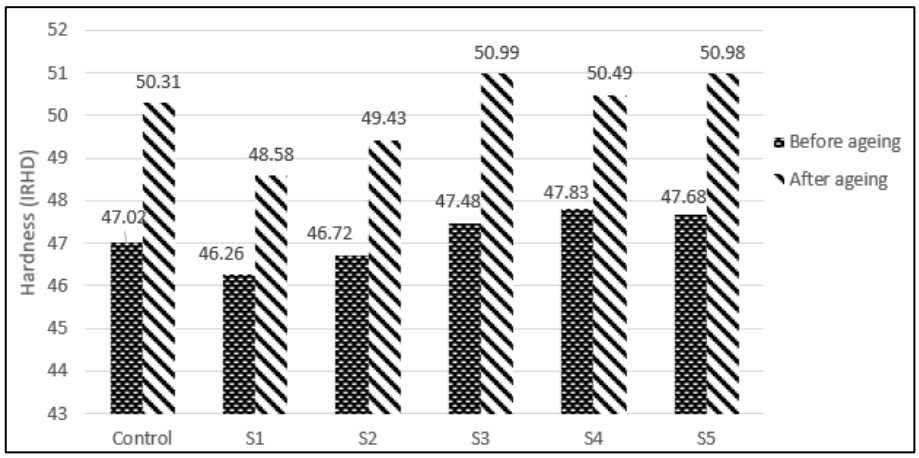


Fig. 6. Hardness of NG incorporated compounds

Overall, this study reveals that NG tuber powder can be used as an alternative natural AO for WSP at a loading of 1phr. However, further studies need to be conducted with respect to other ageing properties (U A Weerasinghe and W V C O Jayashankha, undergraduate student - Bachelor of Engineering Technology, Department of Nano Science Technology, Faculty of Technology, Wayamba University of Sri Lanka).

Synthesis of copper-grafted graphite and effect of its loading on properties of natural rubber composites

(a) *Synthesis of Cu-g-graphite*

Graphite particles were heated in air at 400 ^{o}C for 2 hrs to activate their surfaces. Thereafter, a slurry was prepared by mixing 5 g of activated graphite particles, 1.5 ml of N, N-dimethyl formamide (DMF), 35 g of $CuSO_4.5H_2O$, 10 g of Zn granulates and 5 ml of distilled water. Then the slurry was stirred at 50 rpm for about 1 hr at room temperature (27 ^{o}C) for proper mixing. The coated particles were soaked in a mixture of 75% of water, 10% H_2SO_4, 10% H_3PO_4 and 5% tartaric acid for 20 minutes. Then the particles were sucked using a Buchner funnel and washed with ethanol. Finally, Cu coated graphite particles were dried by using a vacuum oven at 60 °C for 20 min.

(b) *Preparation of Cu-g-graphite/NR composites*

A series of NR composites was formulated by varying the Cu-g-graphite loading from 2-10 phr at 2 phr intervals. The NR composite prepared without Cu-g-graphite was considered as the control. The formulation of the composites is given in Table 3.

Table 3. *Formulation of the Cu-g-graphite/NR composites*

Ingredient	Function	Phr
Natural rubber (RSS-2)	Rubber	100
ZnO	Inorganic activator	5.0
Stearic acid	Organic co-activator	2.0
TMQ	Antioxidant	1.0
Cu-g-graphite	Conductive filler	0 2 4 6 8 10
ZDC	Accelerator	1.5
Sulphur	Vulcanizing agent	2.0

The composites were prepared by melt mixing using a Brabender Plasticorder operated at room temperature, at a rotor speed of 60 rpm. Total mixing time was kept constant at 10 min. Composites were compressed in an electrically heated hydraulic press machine at 150 ^{o}C under a pressure of 0.35 MPa to produce 2 mm thick sheets. Test specimens were cut from these sheets according to the standards.

(c) *Characterization of graphite and Cu-g-graphite*

TGA was used to analyze the thermal stability of Cu-g-graphite by observing the weight change which occurs when the sample is heated at a constant rate. The TGA curves of graphite and Cu-g-graphite are shown in Figure 7. Graphite does not show any significant weight loss up to 500 ^{o}C. This plot shows that the weight loss of Cu-g-graphite particles takes place in two systematic steps. The primary weight loss of the Cu-g-graphite sample occurs in the temperature range 80–100^{o}C. This weight loss up to 100 °C may be due to the elimination of water adsorbed on the surface. The secondary weight loss of the Cu-g-graphite sample occurs in the temperature range between 100 - 235 ^{o}C. The slight weight loss up to 100 °C may be due to the decomposition of Cu.

The FTIR spectra of graphite and Cu-g- graphite are shown in Figure 8. As seen in the Figure 8, natural graphite powder indicates a weak peak at 1766 cm^{-1}, which shows the stretching vibration of aromatic C=C bond. However, Cu-g-graphite shows better functionality compared to the graphite powder. The C–H stretching for Cu-g-graphite shows two peaks between 2900 - 3000 cm^{-1}. Further, the Cu element indicates a peak at 1610 cm^{-1} and, it confirms that Cu has been grafted onto the graphite surface. Compared to the graphite powder, the surface of graphite coated with Cu powder is characterized by new weak peaks between 800 - 1500 cm^{-1}.

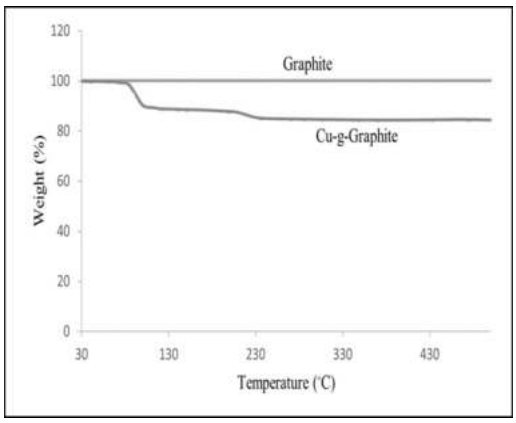


Fig. 7. TGA curves of graphite and Cu-g-graphite

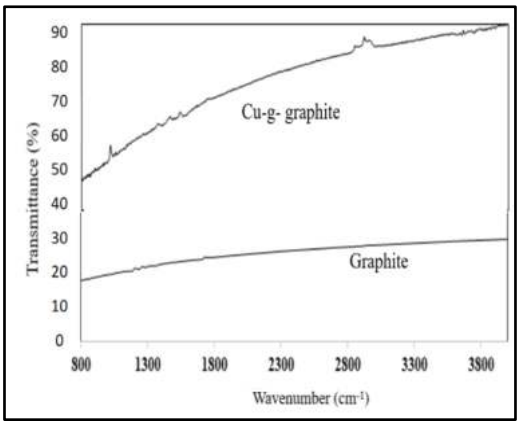


Fig. 8. FTIR spectra of graphite and Cu-g-graphite

The surface morphologies of graphite and Cu-g-graphite were studied using SEM. According to Figure 9 (a), the surfaces between graphite particles do not show adhesion since the free volume among the graphite particles is very high. However, Cu-g-graphite shows some adhesion between graphite particles and illustrates a crystal form (Figure 9 (b)). Cu particles accumulate on the graphite surface due to the high free volume between particles. Cu-coated particles are almost irregular in shape and bigger than natural graphite particles.

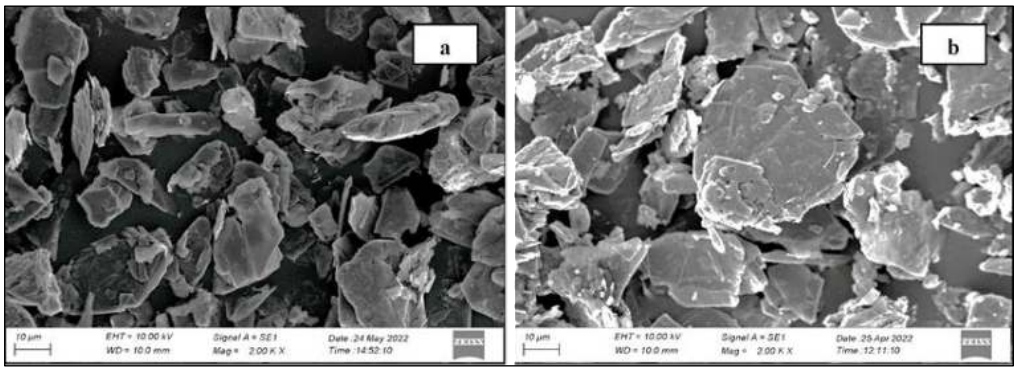


Fig. 9. SEM image of surface of (a) graphite (b) Cu-g-graphite

XRD patterns of graphite and Cu-g-graphite are shown in Figure 10. Graphite powder shows a characteristic peak at $2\theta = 26.5^{o}$. When Cu is grafted to graphite, the graphitic peak shifts to $2\theta = 26.7^{o}$. In addition, few extra narrow peaks have appeared at $2\theta = 20^{o}$, 40º, 36.5º and 55º due to grafting of Cu. A similar observation has been reported for copper films. In addition, graphite shows two other very low peaks at

$2\theta = 44.65^{o}$ and $2\theta = 54.67^{o}$. However, these peaks are shifted to $2\theta = 44^{o}$ and $2\theta = 55^{o}$, respectively due to incorporation of Cu.

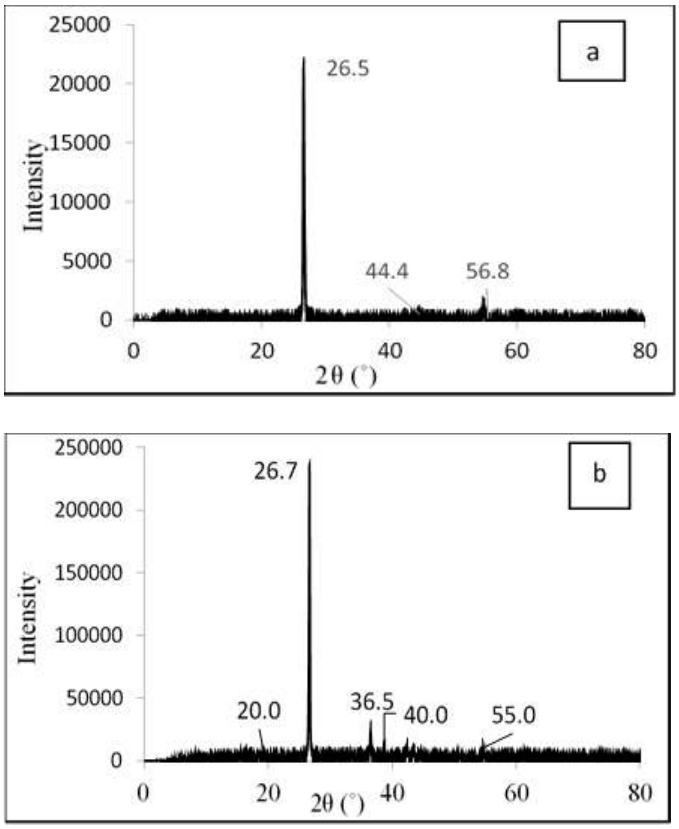


Fig. 10. XRD diffractogram of (a) graphite (b) Cu-g-graphite

(d) *Physico-mechanical properties of Cu-g-graphite/NR composites*

Figure 11 shows the stress-strain behaviour of NR composites with and without Cu-g-graphite. Composites prepared with Cu-g-graphite show higher stress-strain properties compared to the control. Generally, stiffness of rubber composites increases with filler loading. In this study also the stiffness or toughness of the composites, which is indicated by the area under the stress-strain curve has increased with the increase of Cu-g-graphite loading. In addition, area under the stress-strain curve represents the elastic potential energy of a polymeric material. Hence, the composites prepared with Cu-g-graphite show a higher elastic potential energy than the control.

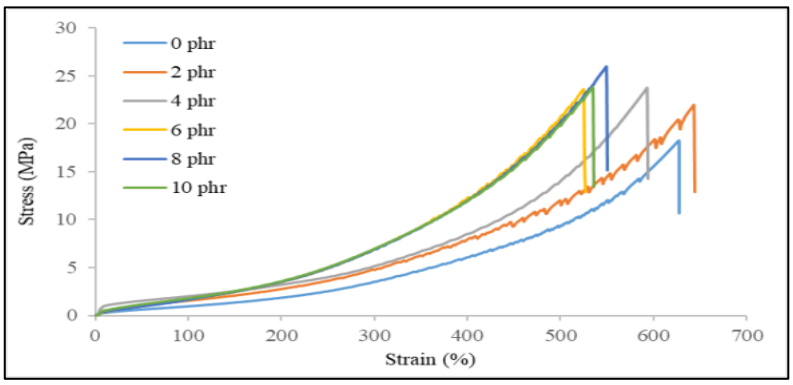


Fig. 11. Stress-strain properties of Cu-g-graphite/NR composites

Variation of hardness of NR composites with Cu-g-graphite loading is shown in Figure 12. Hardness of all the six composites is observed in the range 41–48 IRHD. Hardness of all the composites prepared with Cu-g-graphite is higher than that of the control. Hardness of a polymeric material is a measure of its stiffness. The composite prepared with 8 phr loading of Cu-g-graphite shows the highest hardness and it can be attributed to the highest toughness. Tensile strength of the NR composites varies according to a cyclic pattern with the increase of Cu-g-graphite loading as shown in Figures 13. Tensile strength of Cu-g-graphite based composites is higher than that of the control due to better adhesion between NR and Cu-g-graphite phases. Further, the highest value for tensile strength is observed when 8 phr of Cu-g-graphite is incorporated into the NR matrix. The composite prepared with 10 phr loading of Cu-g-graphite shows a slight reduction in tensile strength compared to that prepared with 8 phr loading of Cu-g-graphite. In addition, the former composite shows poor homogeneity compared to the latter composite (Fig. 13). Elongation at break of the composites has also varied in a cyclic pattern with the increase of Cu-g-graphite loading (Fig. 14), however a decreasing trend is observed. Further, the composite prepared with 6 phr loading of Cu-g-graphite shows the lowest elongation at break and it can be attributed to the lack of adherence between the NR matrix and the reinforcement or to the poor distribution of the Cu-g-graphite in the NR matrix by the tendency to form aggregates. In contrast, all composites illustrate good elastic nature as indicated by high elongation at break values and all are greater than 500%. In addition, the composite prepared with 2 phr loading of Cu-g-graphite shows the highest elongation at break since its fracture surface is smooth and plane (Fig. 14).

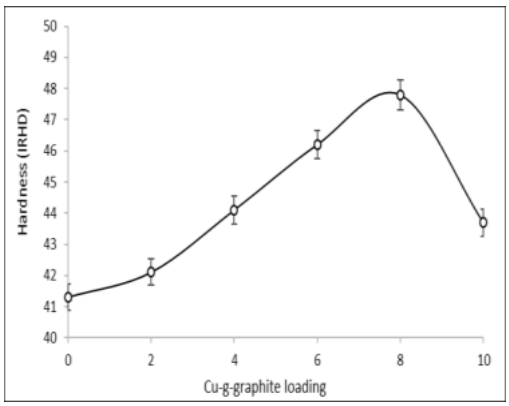


Fig. 12. Hardness of Cu-g-graphite/NR composites

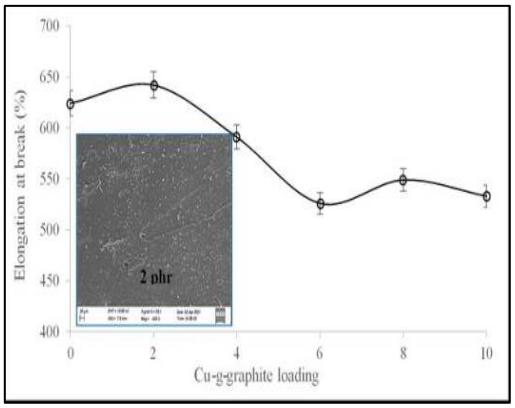


Fig. 13. Tensile strength of Cu-g-graphite/NR composites

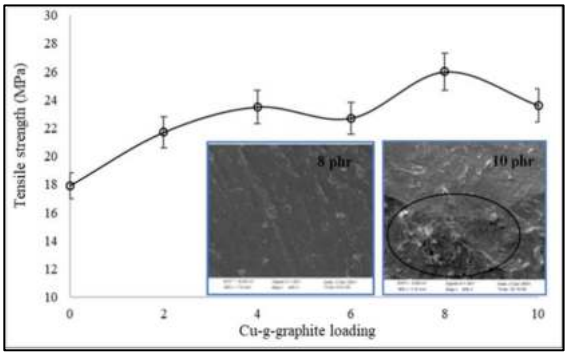


Fig. 14. Elongation at break of Cu-g-graphite/NR composites

Tear strength of the composites has also varied in a cyclic pattern with the increase of Cu-g-graphite loading (Fig. 15), however an increasing trend is observed. Tear strength of all NR composites prepared with Cu-g-graphite is higher than that of the control and may be due to existence of a strong interface between the NR matrix and Cu-g-graphite due to improved adhesion between the two materials. In addition, tear strength of Cu-g-graphite composites is observed in the range 39–44 N/mm hence, they do not show a significant variation.

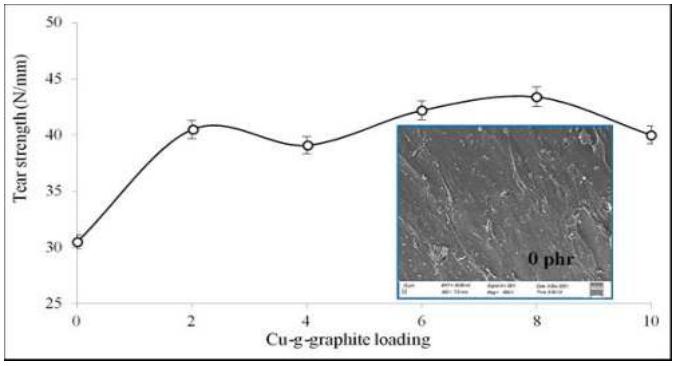


Fig. 15. Tear strength of Cu-g-graphite/NR composites

(e) *Tear and tensile properties of Cu-g-graphite / NR composites after ageing*

Table 4 shows the tear and tensile properties, after ageing of the control, and the other NR composites prepared with different Cu-g-graphite loadings. The composite prepared with Cu-g-graphite loading of 10 phr has shown higher retention of elongation at break. Further, the composite prepared with 2 phr loading of Cu-g-graphite illustrates the highest retention of tensile strength since it exhibits better homogeneity according to the SEM image. Further, retention of tear strength of all NR composites is higher than 94% and indicates good thermal stability for high heat transfer applications. However, the composite prepared with 10 phr loading of Cu-g-graphite indicates the lowest retention of tear strength since copper accelerates the oxidation of NR. Hence, NR composites prepared with higher loadings of Cu-g-graphite would form a weak interface between the NR and graphite. In addition, the rubber composites prepared with low loadings of graphite have reported better thermal diffusivity for solid tyre applications.

Table 4. *Retention of tear and tensile properties of Cu-g-graphite /NR composites*

Property	Cu-g-graphite loading (phr)					
	0	2	4	6	8	10
Retention of tensile strength (%)	77.5	118.8	72.8	70.6	73.6	75.9
Retention of elongation at break (%)	75.1	76.4	86.3	89.7	96.3	107.1
Retention of tear strength (%)	118.4	105.2	108.2	97.0	104.4	94.7

(f) *Electrical conductivity of Cu-g-graphite/NR composites*

Electrical conductivity of Cu-g-graphite filled NR composites varies from 0.258 to 99.2 µs/m as shown in Figure 16. The Figure 16 clearly illustrates that the electrical conductivity increases with the increase of Cu-g-graphite content. Moreover, Cu-g-graphite becomes considerably effective in enhancing the electrical

conductivity of NR. However, there is no significant variation between the electrical conductivity of Cu-g-graphite filled NR composites prepared with 4-10 phr loading. Hence, 4 phr loading of Cu-g-graphite would be sufficient to generate better electrical conductivity for NR composites.

Variation of electrical resistivity of NR composites show an opposite trend to that of electrical conductivity as shown in Figure 16. Furthermore, the electrical conductivity of the 10 phr Cu-g-graphite loaded composite and the control are 9.92 x 10^{-5} and 2.58 x 10^{-7} Sm^{-1}, respectively. Cu-g-graphite has improved the electrical conductivity of the composites by two orders of magnitude (W D M Sampath, Prof. C A N Fernando- Head/Department of Nano Science Technology and D G Edirisinghe).

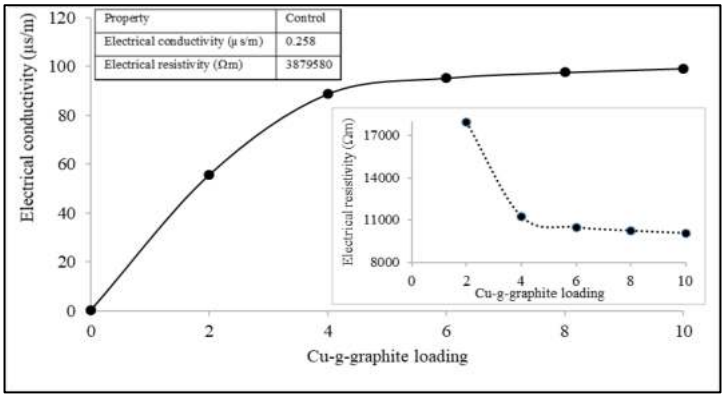


Fig. 16. Electrical conductivity of Cu-g-graphite/NR composites

Evaluation of suitability of sesame oil as a replacement for aromatic processing oil in natural rubber composites

Polycyclic aromatic compounds (PCAs) widely used in the tyre industry have been recognized as potential carcinogens. Hence, there is a growing interest for the search of processing aids low in aromatic content namely natural oils as replacements for polycyclic aromatic oils.

In this study, viability of using organic virgin sesame oil as a replacement for petroleum-based processing oil was assessed. Sesame oil was characterized using FTIR analysis. Natural rubber-based tyre tread composites were prepared by varying the sesame oil loading from 3-9 phr at 2 phr intervals. Cure characteristics, physico-mechanical and swelling properties of these composites were evaluated and compared with those of the composite prepared with aromatic processing oil, Dutrex-R (control). Dispersibility of carbon black with sesame oil and Dutrex-R was compared.

The composites produced with sesame oil showed higher stock viscosity, better processing safety, faster cure and lower cross-link density in comparison to the

composite produced with Dutrex-R. Therefore, sesame oil could behave as a co-activator in rubber compounding.

Further, hardness, modulus at 100% elongation and abrasion volume loss of the vulcanizates prepared with more than 5 phr sesame oil were lower, whereas tensile strength, elongation at break and resilience were higher than those of the control. Tear strength and compression set of the vulcanizates prepared with 5 phr sesame oil were comparable to those of the control. Furthermore, the former vulcanizate showed a higher swelling index in toluene and a lower swelling index in water in comparison to the control. Additionally, the vulcanizates prepared with sesame oil showed better ageing resistance compared to the control. Overall, the composite produced with 5 phr sesame oil could be a suitable replacement for the composite produced with Dutrex-R in tyre tread compounds (D G Edirisinghe, P K I L Jayarathna, A D Wickramapala – undergraduate student, A M W K Senevirathna and C G Bandara - Faculty of Animal Science and Export Agriculture, Uva Wellassa University of Sri Lanka, Badulla).

Industrial extension

The following properties of polymer materials/compounds/products were tested and test reports were issued to the respective Companies/Universities on their request.

Sole Crepe Hardness	**Rubber compound** Physico-mechanical properties	**Rubber product** Physico-mechanical properties	**Polythene** Tensile and ageing properties
• Atale Estate, Kegalle Plantations.	• Lanka Tyre Retreaders (Pvt.) Ltd.	• Quality Latex Products (Pvt.) Ltd.	• Lalan Rubbers (Pvt.) Ltd.
• Elston Estate, Pussellawa Plantations Ltd.	• D. Samson Industries (Pvt.) Ltd.	• Lalan Rubbers (Pvt.) Ltd.	
• Panawatte Estate, Kelani Valley Plantations Plc.	• Ceytra (Pvt.) Ltd.	• Richard Pieris Rubber Products Ltd.	
• Dewalakanda Estate, Kelani Valley Plantations Plc.	• Lakjeewa Industries (Pvt.) Ltd.	• Ceyflex Rubber Ltd.	
• Elpitiya Plantations Plc.	• Shamini Rubber Industries	• Kohu Creations (Pvt.) Ltd.	
	• Inova Environmental Services (Pvt.) Ltd.	• Yasara Enterprises	

Sole Crepe Hardness	**Rubber compound** Physico-mechanical properties	**Rubber product** Physico-mechanical properties	**Polythene** Tensile and ageing properties
	• Lak Rubbers • University of Colombo • University of Peradeniya • University of Ruhuna • PV Siripala (Entrepreneur) • UGDP Ranathunga (Entrepreneur)		

Development of rubber compounds/products

The following rubber compound/product developments were conducted on requests made by the respective clients.

Development	**Client**
Crepe rubber based cellular compound for yoga mat	Ceyflex Rubber Ltd.
Crepe rubber based dental device	Entrepreneur
Crepe rubber based eraser	Entrepreneur
Novel rubberized-coir based slipper sole	Entrepreneur
Low cost, novel shoe soles with different designs were produced using tyre crumbs (GRT) and compounded natural rubber latex	Champion Recycle Ltd.
Natural rubber latex based fishing bait in collaboration with Samson International Plc.	Ministry of Fisheries
Natural rubber latex based binder for wool carpets	Bremworth Carpets & Rugs Ltd., New Zealand

POLYMER CHEMISTRY

Correlations between crosslink density and properties of nitrosamine safe DIXP accelerated vulcanizates were evaluated and established for three binary accelerator systems which are suitable for use in dry rubber-based formulations.

The effect of exfoliated waste mica as a filler in natural rubber composites was studied. In this study, a method was developed to exfoliate waste mica. Then latex stage mixing was conducted to produce exfoliated mica incorporated natural rubber composites. The final results showed better processability and heat build-up properties of natural rubber composites with low filler loadings of exfoliated waste mica.

Novel gravimetric test method was developed for the determination of concentration of bleaching agent use in the crepe rubber industry.

More than a thousand samples of polymeric materials and compounding ingredients received from industry and academia were analyzed using advanced instrumentation including, Fourier transform infrared spectrophotometer (FTIR), Differential Scanning Calorimeter (DSC), Dynamical Mechanical Analyzer (DMA) and Thermo-gravimetric Analyzer (TGA).

POLYMER CHEMISTRY

I H K Samarasinghe

DETAILED REVIEW

Staff

Mr Y R Somarathna, Research Officer covered up the duties of the Head of Department–throughout the year. Mrs I H K Samarasinghe, Research Officer, Dr Ravindra Alles, Senior Research Officer, Mrs Nirmala Jayawardena, Experimental Officer were on duty throughout the year. Mrs H M H Dhanukamalee, Mrs P S V Rupasinghe, Mr D V D Mallikaarachchi, and Mrs H L T Tharaka; Technical Officers were on duty throughout the year. Mr N W E Chanu Maduranga, Management Assistant was also on duty throughout the year.

Research students

- Mr H M S S Weerarathna, an undergraduate student from Faculty of Technology-Department of Nano Science, Wayamba University of Sri Lanka conducted his industrial project titled "Preparation and characterization of epoxidized natural rubber from natural rubber latex" under the supervision of Mrs I H K Samarasinghe.
- Ms G L H Rathnayaka, an undergraduate student from Uva Wellassa University of Sri Lanka conducted her final year industrial project titled "Preparation of exfoliated mica/natural rubber composites by latex mixing method" under the supervision of Mr Y R Somarathna.
- Mr W S P Fernando, undergraduate student from the Wayamba University of Sri Lanka conducted his final year industrial project titled "Study of structure and properties of geothermal water derived silica filled nitrile rubber nano composites" under the supervision of Dr W R N Alles.
- Ms K M Darshika Kulathunga, undergraduate student from the Uva Wellassa University of Sri Lanka conducted her final year industrial project titled "A new test method for the sodium salt of thiol mercaptan bleaching agent used in the crepe rubber industry" under the supervision of Dr W R N Alles.
- Mr M H Nayanajith, undergraduate student from the Sri Jayewardenepura University of Sri Lanka conducted his final year industrial project titled "Development of a slow-release transdermal drug loaded natural rubber band" under the supervision of Dr W R N Alles.

Lectures/Seminars/Webinars/Training/Workshops/Conferences conducted

Officer/s	Subject/Theme	Beneficiary/Client
IHK Samarasinghe	Chemistry of Natural Rubber	Students of Advance Certificate Course in Plantation Management, National Institute of Plantation Management
YR Somarathna	Value added natural rubber grades	Students of Advance Certificate Course in Plantation Management, National Institute of Plantation Management
	Manufacturing of concentrated latex	Students of Advance Certificate Course in Plantation Management, National Institute of Plantation Management
	Introduction to rubber compounding ingredients and their applications	Students of Diploma Course in Dry Rubber Technology, Plastics & Rubber Institute, Sri Lanka
WRN Alles	Value added natural rubber grades	Students of Advance Certificate Course in Plantation Management, National Institute of Plantation Management
	Compound Formulations & Processing techniques (Latex)	Students of Diploma Course in Dry Rubber Technology, Plastics & Rubber Institute, Sri Lanka
	Project report evaluating and viva-voce examiner for the project "Review of factors affecting web holes in synthetic gloves"	A student of Diploma in Polymer Technology Course, Plastics & Rubber Institute, Sri Lanka
Staff of the department	Field training program on "Familiarization to advanced polymer material characterization"	Undergraduate students of Sabaragamuwa University of Sri Lanka
	Field training program on "Familiarization to advanced polymer material Characterization"	Undergraduate students of Palm & Latex Technology and Value Addition, Uva Wellassa University

Lectures/Seminars/Webinars/Training/Workshops/Conferences/Meetings attended

Officer/s	Subject/Theme	Organization
IHK Samarasinghe YR Somarathna &WRN Alles	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka

Officer/s	Subject/Theme	Organization
IHK Samarasinghe WRN Alles	The First Awareness Workshop on Patenting for Scientists, Researchers, and Innovators	National Science Foundation and National Intellectual Property Office
	Workshop on "Estimating Measurement Uncertainty in Routine Analysis" conducted by Dr H P P S Somasiri	Rubber Research Institute of Sri Lanka
	"Measurement of Uncertainty of Test Methods"- Part 2	Rubber Research Institute of Sri Lanka
	Workshop on "Quality Control on Routine Analysis" conducted by Mrs. Subadra Jayashinha	Rubber Research Institute of Sri Lanka
YR Somarathna	Steering Committee Meetings	Finite Element Analysis and Simulation Centre, and Plastics & Rubber Institute
	Workshop on "How to Target your Research Publications in High Impact Journals"	Rubber Research Institute of Sri Lanka
	Workshop Series on "Effective Research Proposal Writing"	National Science Foundation of Sri Lanka
WRN Alles	Webinar on "The Art of Writing a Research Policy Brief"	NSF
	Webinar on "Research Idea Generation"	SLCARP

LABORATORY INVESTIGATIONS

Development of property correlations for nitrosamine safe binary accelerator systems in sulfur vulcanized natural rubber

Three nitrosamine safe accelerator systems which consist of nitrosamine free diisopropyl xanthogen polysulfide (DIXP) accelerator were identified for efficient sulfur vulcanization of natural rubber (NR). Crosslink density of the vulcanizates prepared with the above binary accelerator systems was quantified in relation to the variation of accelerator loading and the loadings were varied in the range covering efficient sulfur vulcanizing and conventional sulfur vulcanizing systems. The impact of crosslink density on the mechanical and physical properties of vulcanizates produced with the three nitrosamine safe systems was investigated and correlations between crosslink density and the vulcanizate properties were established (I H K

Samarasinghe, D G Edirisinghe, S Walpalage and S M Egodage - Senior Lecturers, Dept. of Chemical and Process Engineering, University of Moratuwa).

Preparation of exfoliated mica (eM)/NR composites by latex stage mixing

When considering the drawbacks associated with commonly used reinforcing fillers in rubber industry such as carbon black and precipitated silica, mica waste could be a potential and commercially viable alternative for certain applications in the rubber industry. The objectives of this study were to exfoliate mica waste obtained from the mica mining industry in Sri Lanka and use eM as a filler in NR compounds. Therein, waste mica was first treated by microwave-assisted hydrothermal reactions using Na_2CO_3 as the mineralizer as an attempt to exfoliate waste mica flakes. Then the exfoliated waste mica (eWM) was mixed with centrifuged NR latex to increase the dispersibility of filler followed by the preparation of eWM/NR composites using a standard dry rubber formulation. Therein, eWM loading was varied from 2.5 to 10.0phr at 2.5 phr intervals (the samples are denoted as C0, C2.5, C5.0, C7.5, and C10.0).

Partial exfoliation of waste mica powder was observed by the scanning electron microscopic (SEM) images (Fig. 1) and further confirmed by the X-Ray diffraction patterns.

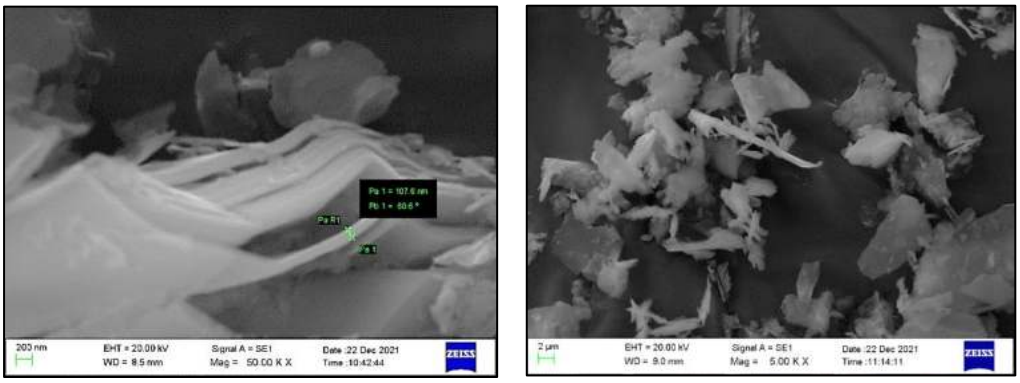


Fig. 1. SEM images of eWM

The cure characteristics, Mooney viscosity and physico-mechanical properties of NR/eWM composites were studied. The cure characteristics of NR/eWM composites did not show a significant different to those of the control composite prepared without mica.

The Mooney viscosity of NR/eWM composites shows a decreasing trend with increasing filler loading (Fig. 2). The highest Mooney viscosity is observed in the control composite.

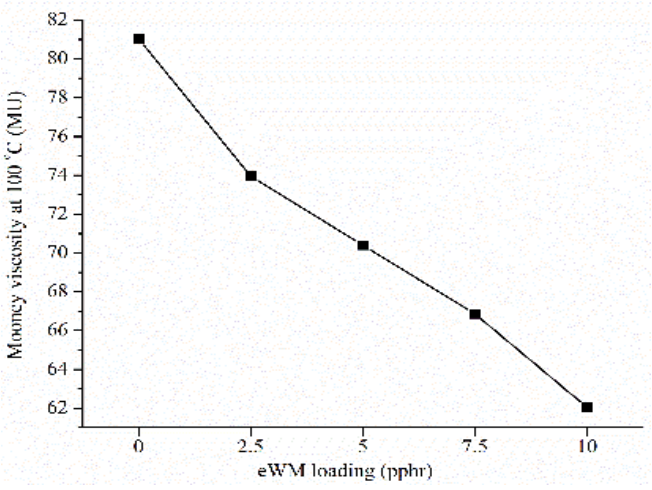


Fig. 2. Variation of Mooney viscosity of the composites with eWM loading

Table 1 summarizes some of the physico-mechanical properties of NR/eWM composites. The improvement of hardness is significant, and may be due to the occurrence of an even filler dispersion during latex stage mixing. The highest tensile strength is observed in the sample loaded with 2.5 phr eWM, which might be the optimum filler loading with highest rubber filler interactions. All the mica filled NR composites show improved rebound resilience, which reflects good heat build-up properties of mica. Abrasion resistance of NR/eWM composites have improved with increasing filler loading (Y R Somarathna, Nirmala Jayawardena, H M H Dhanukamalee, D V D Mallikarachchi, P S V Rupasinghe, H L T Tharaka and G L H Rathnayake (Undergraduate student of Uva Wellassa University of Sri Lanka).

Table 1. *Physico mechanical properties of NR/eWM composites*

Composite	**Hardness (Shore A)**	**Tensile strength (MPa)**	**Rebound resilience (%)**	**Abrasion Volume Loss (mm^3)**
C0	36	15.67±2.02	70.95±1.44	337.94±21.18
C2.5	41	29.47±0.19	74.11±0.11	238.79±12.27
C5.0	44	25.40±0.31	75.00±0.00	219.26±26.88
C7.5	47	26.83±0.17	73.33±0.33	185.86±04.53
C10.0	50	22.46±0.50	75.11±0.11	157.42±09.05

A new test method for the sodium salt of thiol mercaptan - Bleaching agent used in the crepe rubber industry

High level of purity in the crepe rubber, is mandatory to target the export market as well as the local market. Purity of crepe rubber is estimated by visual inspection. Discoloration can lower the crepe rubber quality. Discoloration occurs as a result of the carotenoid pigments present in the latex. Chemical structure of the carotenoid can be change by adding a bleaching agent, to the fraction removed latex. Sodium para toluene thiophenate, an aromatic mercaptan, is the bleaching agent typically used in Sri Lanka. It is a must to know the exact amount of the bleaching agent that should be added during manufacture of crepe rubber to get the best possible colour.

The bleaching chemical that is the readily accessible in the market has concentration of 35-40% w/w. The exact strength of the bleaching agent is determined by (back) titration, but obtaining the correct end-point is difficult due to the presence of the precipitate of the silver salt of the bleaching agent in the back titration solution. Only an experienced analyst can correctly determine the end point. To overcome errors happening in the detection, a new gravimetric analysis method was introduced.

The validity of the gravimetric analysis method was tested using the FTIR. The FTIR test showed that absorption peaks given for the pure bleaching agent (sodium salt of the bleaching agent, Na-BA) and for the gravimetric precipitate (silver salt of the bleaching agent, Ag-BA) are basically the same (Fig. 3).

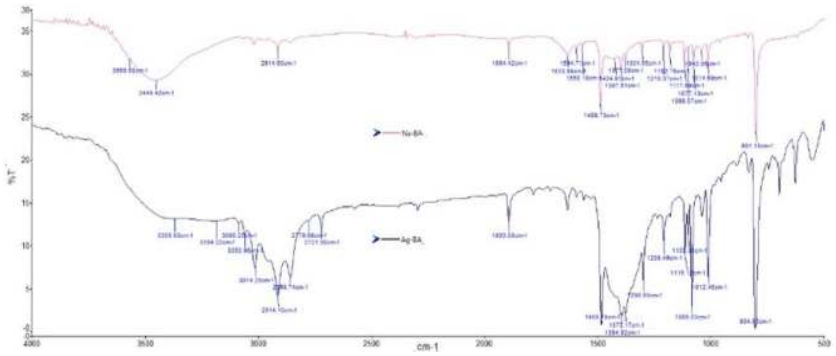


Fig. 3. FTIR spectra of Na-BA and Ag-BA

One reason for the minor variations in the two spectra may be the fine dry nature of the Ag-BA precipitate and the wet nature of the Na-BA precipitate. Dry Ag-BA precipitate would result a fine spectrum with more details, while wet Na-BA

would result a spectrum with limited vibrational frequencies as hydrogen bonding with water which results a broad high absorption background.

Hence, it can be concluded that during the gravimetric titration, the active ingredient in the bleaching agent precipitates out as silver salt and no other compound or other bond is formed.

Therefore, using the weight of the gravimetric precipitate, concentration of the commercial bleaching agent can be calculated. Further, prepared silver salt of the bleaching agent was stable in the dark lab environment for more than six months ensuring the validity of the weight measurements.

The active ingredient concentration of the bleaching agent with the gravimetric method was calculated to be 46% w/w. In contrast, verified active ingredient concentration with the back titration is known to be 36% w/w.

In order to compare and establish the correct concentration, eight crepe rubber samples were prepared using these two different w/w ratios at four different weight ranges. Raw rubber properties such as Plasticity Retention Index (PRI), Lovibond colour index and volatile matter content were analyzed.

It was observed that the properties of the crepe rubber prepared using the 0.06 weight level under the 46% w/w concentration were the same as those of the crepe rubber prepared using the 0.04 weight level under the 36% w/w concentration. Obtained PRI values for the eight crepe rubber samples are illustrated in the Table 2.

Table 2. *Average PRI values of the 8 crepe rubber samples at four concentration levels (a-d) of bleaching agent*

Level of bleaching agent added	**Sample set A: Prepared with gravimetric concentration (46 w/w %)**		**Sample set B: Prepared with titrimetric concentration (36 w/w %)**	
	Added weight of Na-BA /g	**PRI**	**Added weight of Na-BA /g**	**PRI**
0.03 (a)	0.068	57.16 ± 2.90	0.873	55.18 ± 0.58
0.04 (b)	0.801	55.95 ± 0.52	**1.035**	**55.18 ± 0.78**
0.05 (c)	0.972	55.91 ± 1.07	1.242	50.70 ± 1.07
0.06 (d)	**1.172**	**55.61 ± 1.12**	1.494	50.83 ± 1.90

Obtained Lovibond colour index values of the eight crepe rubber samples are illustrated in the Table 3.

Table 3. *Average Lovibond colour indices for the 8 crepe rubber samples at four concentration levels (a-d) of bleaching agent*

Level of bleaching agent added	Sample set A: Prepared with gravimetric concentration (46 w/w %)		Sample set B: Prepared with titrimetric concentration (36 w/w %)	
	Added weight of Na-BA/g	Lovibond colour index	Added weight of Na-BA/g	Lovibond colour index
0.03 (a)	0.068	2 ± 0	0.873	1.875 ± 0.25
0.04 (b)	0.801	1.875 ± 0.25	**1.035**	**1.5 ± 0**
0.05 (c)	0.972	1.625 ± 0.25	1.242	1.5 ± 0
0.06 (d)	**1.172**	**1.5 ± 0**	1.494	1.5 ± 0

Hence, it seems that the titration method underestimates the concentration of the bleaching agent. However, to establish this assumption, further research is needed.

In conclusion, we can use the newly introduced gravimetric method to obtain the concentration of the commercial sodium para toluene mercaptan bleaching agent. Gravimetric method is easy to follow, no previous experience is required and the results obtained were more consistent. Even though the prevailing bad odor, was claimed by the analyst during the titrimetric procedure, no such odor was experienced during the entire gravimetric analysis process, which is another advantage (K M Kulathunga - Undergraduate student of Uva Wellassa University of Sri Lanka, D V D Mallikarachchi, P S V Rupasinghe and W R N Alles).

Industrial extension

The following clients obtained both technical and consultancy services from the department throughout the year.

- National Water Supply & Drainage Board
- Sri Lanka Railway Department
- Export Development Board
- Associated Motorways (Pvt.) Ltd.
- Elastomeric Technologies (Pvt.) Ltd.
- Dipped Products PLC
- Samson Rubber Industries (Pvt.) Ltd.
- Textrip (Pvt.) Ltd.
- Polymer Products Impex (Private) Ltd.
- Samson International PLC
- Samson Rubber Products (Pvt.) Ltd.
- Associated Speciality Rubbers (Pvt.) Ltd.
- Samson Compounds (Pvt.) Ltd.

- Jafferjee Brothers Exports (Pvt.) Ltd.
- University of Ruhuna
- University of Sri Jayewardenepura
- University of Colombo
- University of Peradeniya

RAW RUBBER AND CHEMICAL ANALYSIS

This department provides analytical testing services as per industry demands and needs. Our scope is to empower the raw rubber producers, rubber exporters and, small and medium scale industrialists by providing internationally accepted testing facilities. The department offered testing, analytical and certification services on raw natural rubber and rubber chemicals to all sectors of the rubber industry. These services were also extended to rubber traders, researchers from fellow departments of the institute, and various local institutions such as Universities, other research institutes as well as individuals including postgraduate students, consultants, and inventors, etc.

A total number of 823 samples of natural rubber latex, dry rubber, and processing chemicals were tested for their quality during the year. This included 1214 dry rubber test, 590 latex test, and 254 rubber processing chemicals. 344 no test certificates were issued on requests received from the respective parties for their quality assessment and marketing purposes. In addition, the department carried out miscellaneous analytical tests, troubleshooting activities, and two major research projects during the year. This department participated for international proficiency testing programme conducted by the Malaysian Rubber Board and showed outstanding performances among 15 international laboratories. Successfully completed the MPI funded special project for laboratory accreditation and laboratory procedures were established as per ISO 17025 Laboratory accreditation requirement.

The department staff provided two training programs on raw rubber and natural rubber latex testing for university undergraduates. Three factories visited were made for troubleshooting activities during the year.

RAW RUBBER AND CHEMICAL ANALYSIS

Anusha Attanayake

DETAILED REVIEW

Staff

Dr (Mrs) A P Attanayake, Senior Research Officer was the officer in-charge of the overall activities of the department throughout the year. Mr A M K S P Adhikari, Research Officer returned to the Institute after his postgraduate studies at University Putra Malaysia, Malaysia.

Mrs C Lokuge, Experimental Officer-was on duty throughout the year, Ms M U D S Weerasinghe, Mr H D M S Wijewardana and Mr K A S T Koswatta, Technical Officers were on duty throughout the year. Miss W D D Samanmali, Management Assistant was on duty throughout the year.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Officer/s	Subject	Beneficiary/Client
Department Staff	Latex & raw rubber testing	Group of students from Uva Wellassa University
	Latex Testing	Officers from Prime Polymer Industries Pvt. Ltd.
	Latex & raw rubber testing	Students from Sabaragamuwa University
AP Attanayake	Latex & raw rubber testing	Students from National Institute of Plantation Management

Lectures/Seminars/Workshops/Meetings attended

Officer/s	Subject	Organization
AP Attanayake	Workshop on "Manuscript writing"	RRISL
	Progress Review Meeting - Special Project	
	Executive Officers Meeting	
	Scientific Committee Meeting	
	Technology Update Meeting	
	Procurement Training Meeting	
	Capacity Building Programme	

LABORATORY INVESTIGATIONS

Effect of ammonia preservative systems in centrifuged latex on phosphate levels and latex film properties

The amount of diammonium hydrogen phosphate (DAHP) added prior to centrifugation will be decided by an estimation of Mg^{2+} concentration in latex. However, in practice, most of the centrifuged latex (CL) manufacturers add constant amount of DAHP during the year without estimating the Mg^{2+} in the latex and some manufacturers add excess amount of DAHP to reduce Mg^{2+} content to a minimum level. In most cases, it will leave excess PO_4^{3-} in latex which leads to quality issues in CL latex and products. The objectives of the present study were to determine how natural phosphate ion content of CL vary with storage time and compare the variation of phosphate ion content, viscosity and stability of CL treated with different amounts of DAHP with storage time. Concentrated latex processing facilities are confronted with issues related to latex characteristics due to high phosphate levels in latex. Two grades of CL namely, 0.7% ammoniated CL (HACL) and 0.2% ammoniated CL (LACL) were used. Both HACL and LACL samples were characterized for initial total phosphate and other basic latex properties (Table 1).

At initial stage, the LACL had the highest mean total phosphate level of 434.20 ± 2.20 ppm, while the HACL had the lowest of 412.02 ± 1.42 ppm (Table 1). Changes in latex properties such as total phosphate and soluble magnesium content were monitored once a week for a month adhering to ISO standard procedures.

Table 1. *Initial latex properties of LACL and HACL samples (Data represent the mean ± SEM of three replicates)*

Latex property	Latex samples (Treatment)	
	LACL	**HACL**
Alkalinity (%)	0.22±0.00	0.74±0.03
DRC (%)	61.25±0.01	60.46±0.05
TSC (%)	62.46±0.03	62.19±0.01
Viscosity (cP)	97.66±0.01	76.33±0.01
VFA No.	0.04±0.02	0.03±0.01
KOH No.	0.61±0.02	0.71±0.01
MST (s)	495.00±0.50	690.00±0.50
Soluble Magnesium content (ppm)	144.92±0.10	85.47±0.07
Total Phosphate content (ppm)	434.19±0.55	412.02±0.19
N-RC (%)	1.21±0.00	1.73±0.00

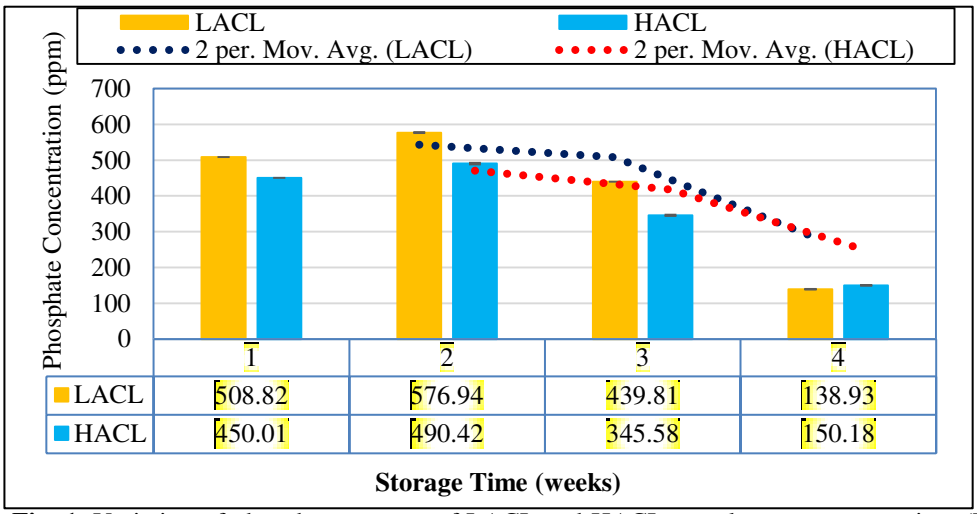


Fig. 1. Variation of phosphate content of LACL and HACL samples over storage time (Data represent the mean ± SEM of three replicates)

A statistically significant interaction between the storage time and the ammonia concentration ($p < 0.05$) on phosphate content was observed (Fig. 1). To understand the fluctuation of phosphate level, soluble magnesium content was recorded over a month of storage for LACL and HACL samples and is illustrated in Fig. 2.

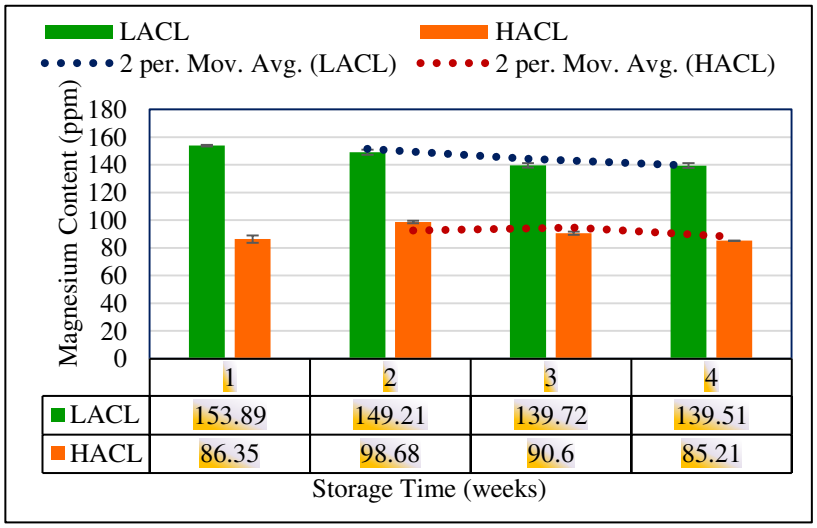


Fig. 2. Variation of Magnesium content of LACL and HACL samples over storage time (Data represent the mean ± SEM of three replicates)

To understand the impact of ammonia concentration and phosphate levels on vulcanized latex film properties of CL, tensile strength, tear strength, and EB were recorded for both samples and presented in Table 2.

Table 2. *LACL and HACL latex film properties after storage (Data represent the mean ± SEM of three replicates)*

Treatment	Tensile strength ± SD (MPa)	Tear strength ± SD (MPa)	EB ± SD (%)
LACL	2.49 ± 0.03^{b}	8.41 ± 0.01^{b}	769.73 ± 10.20^{b}
HACL	2.73 ± 0.08^{a}	8.78 ± 0.05^{a}	886.00 ± 9.31^{a}

The LACL had the lowest tensile strength (2.49±0.03 MPa), while the HACL had the highest (2.73±0.08 MPa). HACL recorded the highest elongation at break (886±9.31%). In addition, the LACL had the lowest tear strength (8.41±0.01 MPa), while the HACL had the highest (8.78±0.05 MPa) (Table 2). The highest phosphate concentration throughout the storage period was recorded in the LACL sample. Further, the highest mechanical properties were observed in HACL sample over LACL sample. Hence, this study concludes that high phosphate levels impair the quality of CL (A P Attanayake, M U D S Weerasinghe and R A A P Ranawaka).

Effect of ammonium laurate concentration on properties of natural rubber latex films

Centrifuged latex (CL) manufacturers mainly use preservative systems, which contains alkalis to avoid latex coagulation before it is used for the desired productions. As a secondary preservative system, tetramethyl thiuram disulphide/ zinc oxide (TMTD/ZnO) is used for latex stabilization with 0.2% ammonia and 0.05% lauric acid. This system tends to ammonium laurate (AL) which has the ability to act as a surfactant. Although addition of surfactant has the ability to enhance latex properties, it interferes desired qualities while forming unwanted clots when added beyond its recommended concentrations. Hence, the requirement of investigating the initially added AL level quantitatively or qualitatively is necessary. Further, the addition of AL surfactant to latex results in changes in chemical composition and extensive effects on the production of latex based products, while altering its film properties. Hence, this study was carried out to understand the effect of AL soap concentrations on natural rubber latex (NRL) film properties.

Concentrated NRL preserved with ammonia without adding TMTD/ZnO was collected as four liters per each from Lak Latex, Agalawatta. Among the four gallons, three gallons were treated with 10% AL solution as 6,16.8 and 20ml to get the concentration levels as 1.5×10^{-4}, 4.2×10^{-4} and 5.0×10^{-4} moles per 100 g of latex, respectively while one sample was kept as it is without adding AL (control). Then the samples were stirred for 2 minutes and kept at the temperature of 25 ^{o}C without disturbing for 24 hours for maturation. After maturation of latex, the initial latex

properties such as alkalinity, TSC, DRC, MST, VFA and KOH were tested according to the relevant ISO standard. Further, MST, KOH and VFA were measured during a four-week time period (Table 3). The change in VFA number of different soap concentrations with time shows a rapid decline within the 3rd week of maturation and it can be a result of the potential of AL in controlling antimicrobial action, while performing surface activation (Fig. 3).

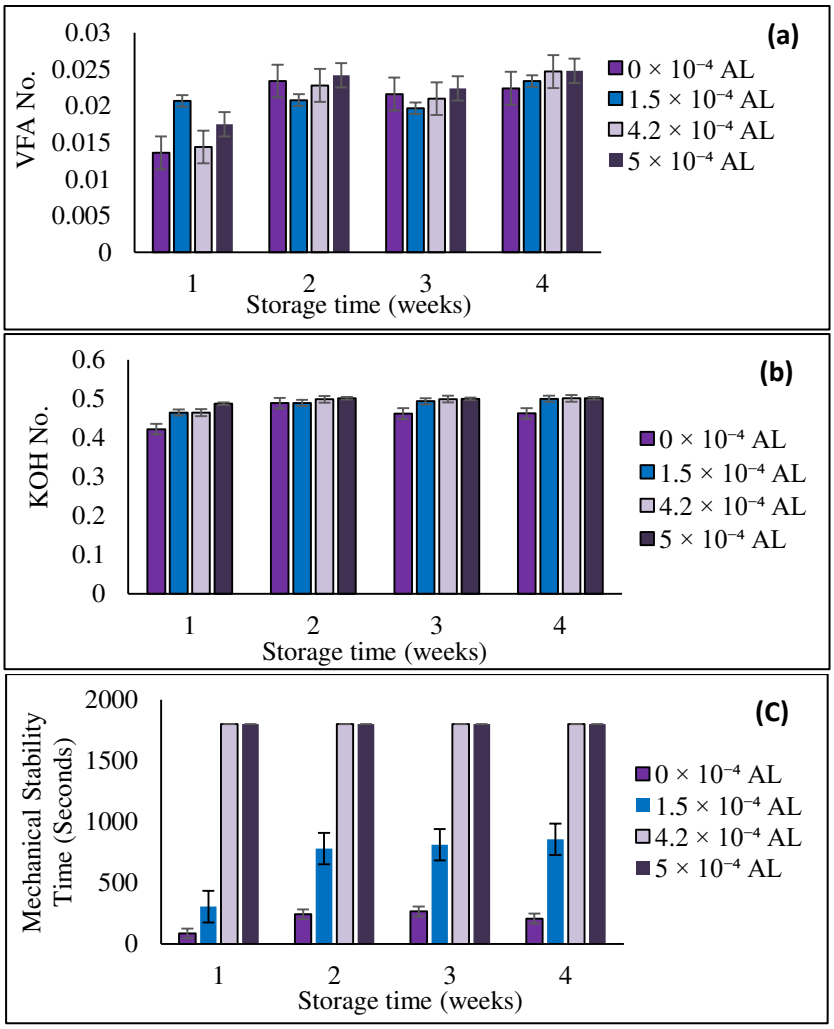


Fig. 3. Variation of **(a)** VFA number **(b)** KOH number and **(c)** MST of latex over different soap concentrations with storage time

Table 3. *Initial latex properties of prepared NRL samples*

Latex property	Latex sample (Ammonium laurate concentration × 10^{-4})			
	0 AL	**1.5 AL**	**4.2 AL**	**5.0 AL**
Alkalinity (%)	0.241	0.250	0.243	0.246
TSC (%)	62.30±0.02	61.42±0.05	61.765±0.07	62.09±0.02
DRC (%)	60.81±0.02	60.17±0.04	60.80±0.02	60.55±0.02
N-RC (%)	1.49	1.255	0.965	1.545
Viscosity cp	100±0	83.33±0.33	82.167±0.16	80.00±0.57
MST (s)	87.6±0.17	306±0.55	1800±0.64	1800±0.64
VFA No.	0.0136±0.0001	0.0207±0.0001	0.0144±0.0001	0.0175±0.0001
KOH No.	0.4221±0.004	0.4645±0.004	0.4756±0.004	0.4877±0.004

The values in each column represents the means of three replicates ± SE (standard error)

According to the analysis, the KOH No. of the samples increases during storage, resulting in the formation of many acid radicals. AL may have adsorbed to the particle surface, displacing some proteins or short chain fatty acids while producing acidity through protein hydrolysis, releasing some amino acids into the medium. This increase in acid radicals in the serum could have contributed to the rapid rise in KOH No. The adsorption of surfactants such as AL onto the surface of the rubber particles helps to increase electrostatic repulsion between rubber particles and therefore prevents further flocculation of the rubber particles while stabilizing the latex. The magnitude of the effects on MST depends upon the amount of soap added.

Latex film preparation and characterization

After 21 days of maturation time, latex films were prepared using a surgical glove formulation containing 20% potassium laurate solution, 10% KOH solution, and a 50% dispersion of sulphur, ZnO, WSP and ZDEC in accordance with the mixing cycle. The latex compound was poured into three glass molds, each weighing 20.0 ± 1.0g for film casting. Then the glass molds were air dried overnight and placed in a 60 °C oven for 30 minutes. Tensile strength, elongation at break and tear strength were evaluated according to the ISO standards (Fig. 4).

In this study, tensile strength reduction with the increment of AL concentration of the latex was expected due to the reduction in crosslink density, which results ~~of~~ in increased mobilization of latex particles. Furthermore, surfactant has potential of denaturing proteins from latex particles while transferring them to the serum phase. This phenomenon leads to a reduction in nitrogen content of the latex, which in turn improves tensile strength of latex films. However, the sample which has an AL concentration of 1.5×10^{-4} moles per 100g of latex showed unexpected property enhancement, which can be due to the possible chemical reactions within latex colloids and the critical level of addition of AL soap.

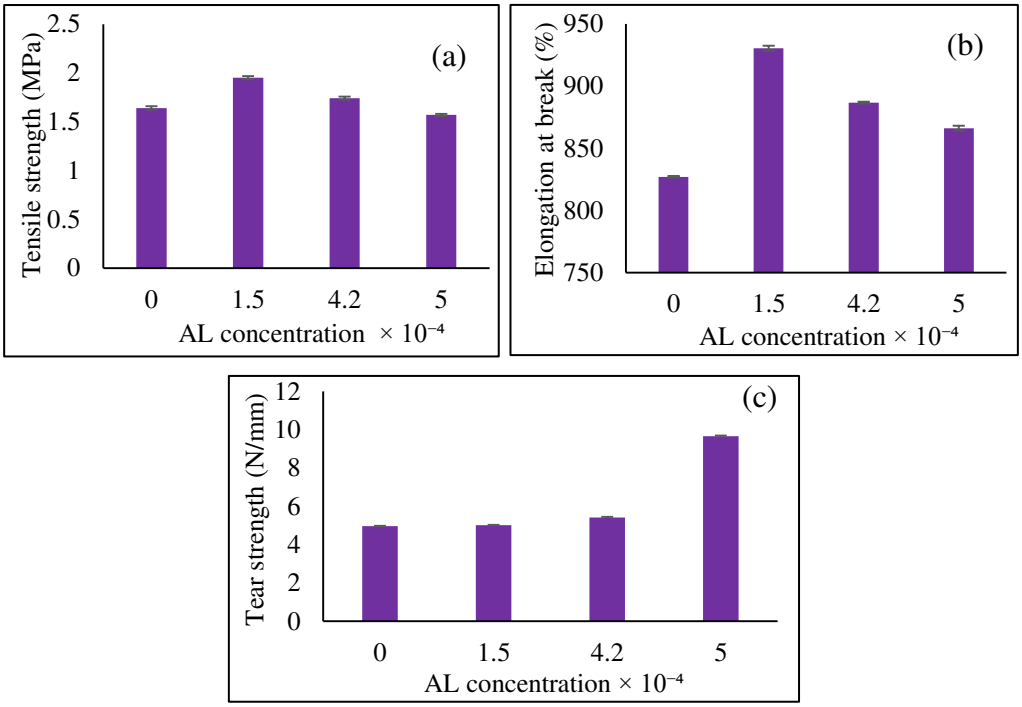


Fig. 4. Variation in **(a)** tensile strength, **(b)** elongation at break, **(c)** tear strength with AL concentration

Although non-rubbers especially the proteins might be the responsible factor for the variation of tear strength of the latex casting films , the changes in KOH No. with the addition of AL for the latex system positively affect the physico-mechanical properties.

The work and results reported in this study suggests that the ammonium laurate soap has a significant effect on natural rubber latex film properties such as tensile strength, tear strength and elongation at break and the magnitude of these effects depends upon the amount of added soap concentration. Furthermore, this confirms that the addition of TMTD/ZnO has a potential of enhancing crosslink density while increasing tensile strength of centrifuged latex films. This study suggests a method using KOH No. to identify the soap concentration added to latex, which can interfere with the quality of latex in compounding and processing. It is also apparent that foreign soap has an effect on the variation of MST and VFA No. with storage time (A P Attanayake, C Lokuge, Supun Tharaka and Dilmi Ayesha).

Quality analysis of latex, raw rubber and rubber processing chemicals

Testing and certification services were provided to all the sectors in the rubber industry as given below:

Service	No. of samples
Miscellaneous analysis	
Dry rubber tests	1214
Latex sample tests	590
Chemical tests	254
Test certificates issued	344

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Three major research projects were conducted during the year 2022 while providing the services of sample testing, troubleshooting and required advisory services for the rubber industry. In addition, undergraduate and postgraduate students from different universities were guided and facilitated for their research projects.

Formic acid is the most widely used coagulant at present in RSS manufacturing. The higher price and scarcity of formic acid in the market encouraged us to find alternative sources especially acid sources extracted from natural substances. Several naturally occurring acid sources were tested in order to use them as a coagulant replacing formic acid. Narang (Citrus microcarpa) and Ambul dodam (Citrus crenatifolia) juice extracts as well as their peel wastes were used successfully. This project is continued in the coming year too to investigate user friendly and cost effective coagulants for RSS manufacturing.

The potential of applying treated crepe rubber effluent water as a liquid fertilizer was studied with different vegetable crops. Treated effluent water showed a better growth rate and better harvest proving that the effluent water has nutrients that could be used as a supplementary liquid fertilizer for vegetable farming. The effects of applying crepe rubber effluent to the soil and its nature should be investigated for a recommendation which is currently being conducted.

A new test method was developed to estimate the ammonia level in the field latex by using Nessler's reagent. This is a very useful approach to estimate ammonia in the field because it can be used to identify ammonia contaminated latex and excess ammonia added latex in the field easily and quickly.

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

K Adhikari

DETAILED REVIEW

Staff

The duties of the head of the department were covered by the Deputy Director Research (Technology), Dr S Siriwardena during the first six months of the year. Mr K Adhikari was appointed as the Officer in Charge of the department and he was on duty throughout the year from 1st June, 2022.

Experimental Officers Mrs U M S Priyanka, Mrs V C Rohanadeepa and Mr A K D Warnajith, Technical Officers Mrs P K N N Sandamali, Mr R D Illeperuma, Mr A S Bandara, Management Assistant Mrs H A J Lakshika and Development Officer Mrs W H C Nuwanthika were on duty throughout the year.

Research assistants

- Miss N L A Prabodani, Research Assistant, conducted a research "Application of wood ash for neutralization of crepe rubber effluent and utilization of it as a source of fertilizer" under the supervision of Dr S Siriwardena.

Postgraduate students

- Mr Danushka Wijewardena, MPhil student, Uva Wellassa University of Sri Lanka continued his research project "Rheological and mechanical properties of ternary composites of thermoplastics and skim natural rubber" under the supervision of Dr S Siriwardena and Dr (Mrs) D G Edirisinghe.

Undergraduate students

- Ms P G U Chathuranga, BSc (Special) undergraduate student from University of Kelaniya, Sri Lanka, completed her research project titled "Alternative acids from citrus species for the coagulation of field latex in RSS manufacturing" under the supervision of Dr S Siriwardena and Mr K Adhikari.

- Ms G M Panditharathna, BSc (Special) undergraduate student from University of Kelaniya, Sri Lanka, completed her research project titled "Development of a test method for the estimation of ammonia level in field latex" under the supervision of Dr S Siriwardena and K Adhikari.

- Ms D M S Iresha, BSc (Special) undergraduate student from Sabaragamuwa University of Sri Lanka, completed her research project titled "Comparative study of raw rubber properties of RSS manufacture by using pineapple peel extract in contrast to formic acid" under the supervision of Dr S Siriwardena.

Seminars/Training programs/Workshops/Conferences/Meetings attended

Officer	Subject	Organization
K Adhikari	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
	ISO 17025 training	
K Adhikari UMS Priyanka	Procurement Handling and Productivity Development Workshop	Rubber Research Institute of Sri Lanka
UMS Priyanka PKNN Sandamali	Training on Measurement of Uncertainty of Test Methods	Rubber Research Institute of Sri Lanka
UMS Priyanka	Training on Quality Control System	Rubber Research Institute of Sri Lanka
	Productivity Development Workshop	
VC Rohanadeepa	Procurement Training	Rubber Research Institute of Sri Lanka
VC Rohanadeepa PKNN Sandamali RD Illeperuma	Employ Productivity Development Workshop	Rubber Research Institute of Sri Lanka
PKNN Sandamali	Training on Advanced Instruments	Industrial Technology Institute

Seminars/Training programs/Workshops/Exhibitions conducted

Officer	Subject	Organization
K Adhikari	Conduct practical sessions for Undergraduate students	Rajarata University of Sri Lanka
K Adhikari AKD Warnajith PKNN Sandamali RD Illeperuma	Training Program on raw rubber processing for undergraduates	Faculty of Technology, University of Sri Jayawardenapura
AKD Warnajith	Certificate Course in Rubber and Plastics Technology	Plastic and Rubber Institute
	Training program on "RSS sorting and grading" for staff	Rigid Tyres
	Training program on "RSS manufacturing" for smallholders (Four programs)	Smallholder Tea and Rubber Revitalization (STARR) Project
	Training program on "Latex preservation and safe chemical handling" for smallholders (Two programs)	Dipped Products Ltd.

Officer	Subject	Organization
AKD Warnajith UMS Priyanka	Field training program on Raw rubber processing	National Institute of Plantation Management
UMS Priyanka VC Rohanadeepa PKNN Sandamali RD Illeperuma	Training Programme conducted for Uva Wellassa undergraduates on Waste water testing	Uva Wellassa University of Sri Lanka

Advisory visits

Service	No. of factories/visits
Process and quality improvements	06
Waste water treatment	07
Waste water sample collection for testing	16
Plans issued for construction of new SS drying systems with capacity less than 100kg	09
Miscellaneous advisory and troubleshooting	12

Waste water analysis

Collection of waste water samples from raw rubber processing and allied industries and analysis of waste water for water quality parameters were carried out throughout the year.

Industrial sample testing service

Type of sample	Number of samples/ certificates
Waste water: rubber related	45/40
Waste water: non-rubber related	23/14
Processing water	13/07
Miscellaneous samples (metal ions, ZnO *etc*.)	42/06
Analysis of extractable proteins	10/04
Number of certificates of epidemic prevention	83

LABORATORY INVESTIGATIONS

Crepe rubber effluent water as a liquid fertilizer in green capsicum **cultivation**

Total number of 48 green capsicum plants were planted in four beds so that one bed contains 12 plants (Fig. 1). Three plants from each bed were marked as control and treated with 500 ml water in the morning and in the evening. The rest of the plants were daily treated with crepe rubber effluent water collected from a crepe rubber factory (pH adjusted to 6.4) in the morning (500ml) and in the evening (500ml).

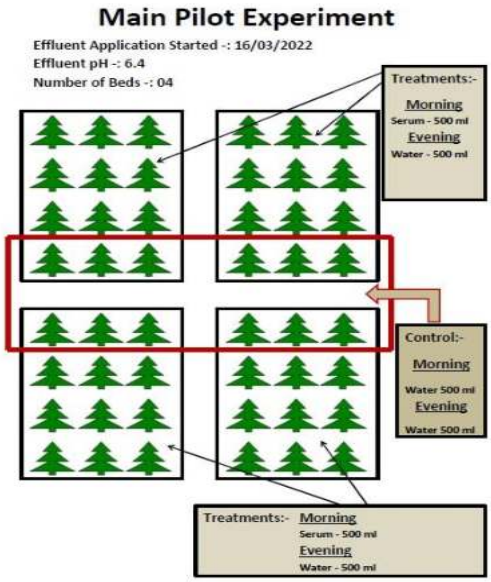


Fig. 1. The capsicum plants planted in four experimental beds

Growth measurements: The number of leaves, flowers and pods were counted (Fig. 2) once in two weeks and height of the plants were measured and recorded. According to collected data (Table 1), growth level of the plants after 90 days of planting can be categorized into three groups; well grown, moderately grown and poorly grown plants.

Well grown plant **Moderate size plant** **Poorly grown plant**

Fig. 2. Growth level of the plants after 90 days of planting

Table 1. *Growth condition of treated plants and control plants*

Growth type	Number of treated plants	Number of control plant
Well grown	11	1
Moderately grown	15	7
Poorly grown	10	4
Total	36	12

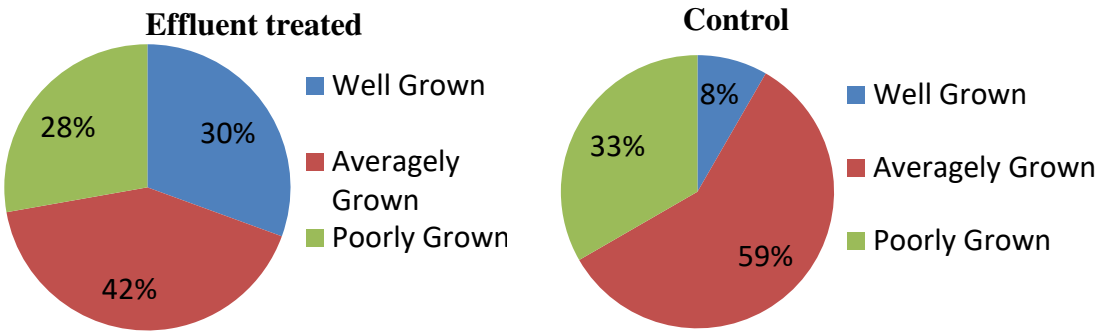


Fig. 3. Growth rate of eluent treated plants and control plants

From the above results we can conclude that crepe rubber effluent water contain a considerable amount of nutrients to grow plants. It can be used as a partial replacement for fertilizer (Fig. 3) (S Siriwardena, U M S Priyanka, V C Rohanadeepa, A K D Warnajith and P K N N Sandamali).

Crepe rubber effluent water as a hydroponic culture media

A small scale trial was conducted to study the crepe rubber effluent water as a hydroponic culture media using 12 capsicum plants which were divided in to two sets as control and treated and planted in a hydroponic system (Table 2). The pH of the effluent was adjusted to 6.5 using Eppawala rock phosphate and dried natural rubber latex sludge.

Table 2. *Treatment with effluent water and Albert solution*

No. of plants	Medium used	Application frequency	Amount added
6 (Treated)	Crepe rubber effluent water	14 days	2500ml (pH-6.5)
6 (Control)	Albert solution (2g/l)	14 days	2500ml

At the beginning, all 12 plants were in good condition. Growth of the effluent treated plants retarded with time and almost all trial plants died after 30 days (Fig. 4). Crepe rubber effluent water cannot be used as the sole fertilizer in hydroponic culture and further experiments have been planned to continue the project (U M S Priyanka, V C Rohanadeepa).

Fig. 4. The hydroponic system after 30 days

Neutralization of crepe rubber effluent by using wood ash in order to apply as a liquid fertilizer

The project was initiated to investigate the possibility of applying crepe rubber effluent water as a fertilizer after treating with wood ash to adjust the pH in the range 6.0-6.5. A series of the effluent water samples with different ash amounts added in order to adjust the pH to 6.0-6.5 (Table 3).

Table 3. *Sample preparation - crepe rubber serum*

Treatment	Liquid amount (mL)	Ash amount (g)
$\mathbf{A_1}$	Effluent (500)	0.5
$\mathbf{A_2}$	Effluent (500)	1.0
$\mathbf{A_3}$	Effluent (500)	1.5
$\mathbf{D_1}$	Effluent (250) Water (250)	0.5
$\mathbf{D_2}$	Effluent (250) Water (250)	1.0
$\mathbf{D_3}$	Effluent (250) Water (250)	1.5

Among the above samples, 1.0g of wood ash in 500mL sample has shown optimum pH in the range 6.0–6.5 (Fig. 5 and Table 4) which is suitable for the cultivation of vegetable plants. Also, crepe effluent characterization was carried out to examine the changes in characters (total nitrogen, total ammoniacal nitrogen and metal ions) of crepe effluent after the pH adjustments with ash treatments. Results (Table 5) have shown high total nitrogen amount (196mg/l) and high calcium ion amount (151.05mg/kg) in ash treated effluent sample when compared to the initial effluent samples. For plant growth, nitrogen is an essential primary macro nutrient and calcium is an important secondary macro nutrient. Hence, it can be suggested that the pot/field experiments have to be conducted to investigate the effect of crepe effluent on the growth and yield of vegetable plants (S Siriwardena, U M S Priyanka, A K D Warnajith and N L A Prabodani).

Table 4. *pH change with time*

Treatment	Day 1	Day 2	Day 3	Day 4	Day 5
$A_{1\,[0.5]}$	5.10	5.94	6.22	6.49	6.61
$A_{2\,[1.0]}$	6.18	6.54	6.78	6.81	6.88
$A_{3\,[1.5]}$	6.56	7.21	7.98	8.21	8.78
$D_{1\,[0.5]}$	6.07	6.51	6.68	6.79	6.83
$D_{2\,[1.0]}$	6.60	7.24	7.86	8.32	8.54
$D_{3\,[1.5]}$	7.01	7.85	8.23	8.86	8.97

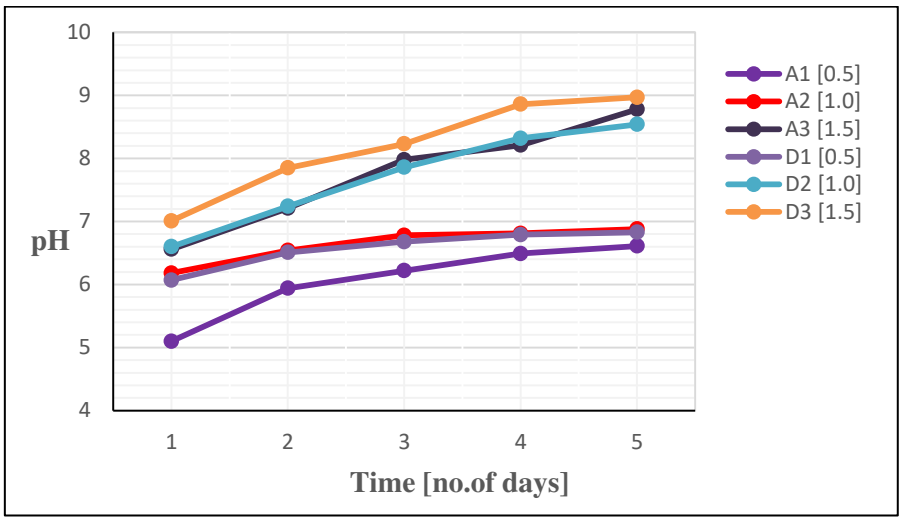


Fig. 5. pH of the wood ash treated effluent water with time

Table 5. *Characterization of ash treated crepe rubber serum samples*

Treatment	Total Ammoniacal Nitrogen (mg/L)	Total Nitrogen (mg/L)	Calcium ion (mg/kg)
Serum	22.40	182.0	20.43
A_2	43.40	196.0	151.05
D_1	20.10	100.8	80.68

Development of a test method for the determination of ammonia in latex using Nessler's reagent

When Nessler's reagent is added to a diluted ammonium salt solution, the liberated ammonia (NH_3) reacts with the reagent fairly rapidly to form an orange-brown product, which remains in the colloidal solution, but flocculates on long standing.

The reaction with Nessler's reagent can be represented as:

$$2K_2[Hg1_4] + 2NH_3 \longrightarrow NH_2Hg_2I_3 + 4KI + NH_4I$$

The reagent is employed for the determination of ammonia in very dilute ammonia solutions and in water. In the presence of interfering substances, it is better to separate the ammonia first by distillation under suitable conditions.

First, the Nessler's reagent was prepared as follows. Potassium iodide (35g) was dissolved in 100 mL water. Mercury (II) chloride (4%) solution was added while stirring until a slight red precipitate is formed (about 325mL is required). Then a sodium hydroxide solution (3.0M) was introduced while stirring. Mercury (II) chloride solution was added again until there's a permanent turbidity. The mixture was kept one day to settle and the sediment was decanted off. Finally, the solution was kept in a stoppered dark-coloured bottle. Next, a latex series which contains 0.01% to 0.05% ammonia was prepared using a 1% ammonia solution and separately taken into petri dishes as thin layers. At the same time, a latex sample with zero ammonia content was taken into another petri dish. Three drops of Nessler's reagent were added into each latex sample and the colour was recorded.

Following observations were recorded. The control sample with zero NH_3 did not give any color with Nessler's reagent. However, a slight increase of brown color was seen with increasing ammonia levels from 0.01% to 0.05%. There was no identical difference of the pattern that the color is spreading through latex when the NH_3 level increases.

According to the results, ammonia-free latex, low-ammoniated latex and high-ammoniated latex can be distinguished. A pale yellow colour was shown by ammonia free latex (fresh latex) without any precipitate formation, while low-ammoniated latex showed precipitate formation appearing in a dirty yellow colour as shown in the Fig. 6. A dark brown precipitate formation can be seen with the high ammoniated latex with the addition of Nessler's reagent. This method is further studied to develop a test method to identify ammonia contaminated latex in the field (S Siriwardena, K Adhikari, P K N N Sandamali and G M Panditharathna).

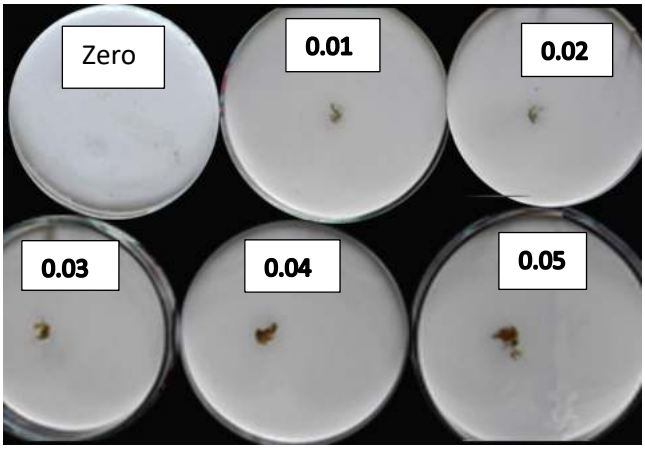


Fig. 6. The colour changes with the addition of Nessler's reagent into different levels of ammonia treated latex

Raw rubber properties of RSS coagulated with pineapple peel extracts

This research was planned to test the variation of raw rubber properties of RSS when it is produced by coagulation with pineapple peel extract which is a waste of a natural substance. Five samples of RSS were prepared by varying the pineapple peel extract level and a control RSS sample was produced by coagulating with conventional formic acid. After drying, the samples were tested for their raw rubber properties in which the results are listed in the Table 6.

Table 6. *The test results of raw rubber properties of RSS*

Sample No.	Volatile matter (%)	Wallace plasticity		Nitrogen content (%)	Mooneyviscosity ML (1+4) 100 °C	Ash (%)	Dirt (%)
		P0	PRI				
S_1	0.35	54.50	83.96	0.13	90.18	0.25	0.03
S_2	0.45	55.75	85.16	0.17	87.63	0.21	0.03
S_3	0.53	54.00	87.50	0.14	88.43	0.20	0.05
S_4	0.70	51.00	90.21	0.13	87.87	0.19	0.02
S_5	0.44	57.25	91.27	0.39	-	0.23	0.03
S_6 (Control)	0.72	56.75	89.48	0.37	88.20	0.20	0.02

According to the test results it is clear that there is no much difference in the raw rubber properties, except the total nitrogen content. Interestingly, a significant reduction in the nitrogen level of the pineapple peel treated samples was observed with respect to the conventional formic acid coagulated sample (Fig. 7).

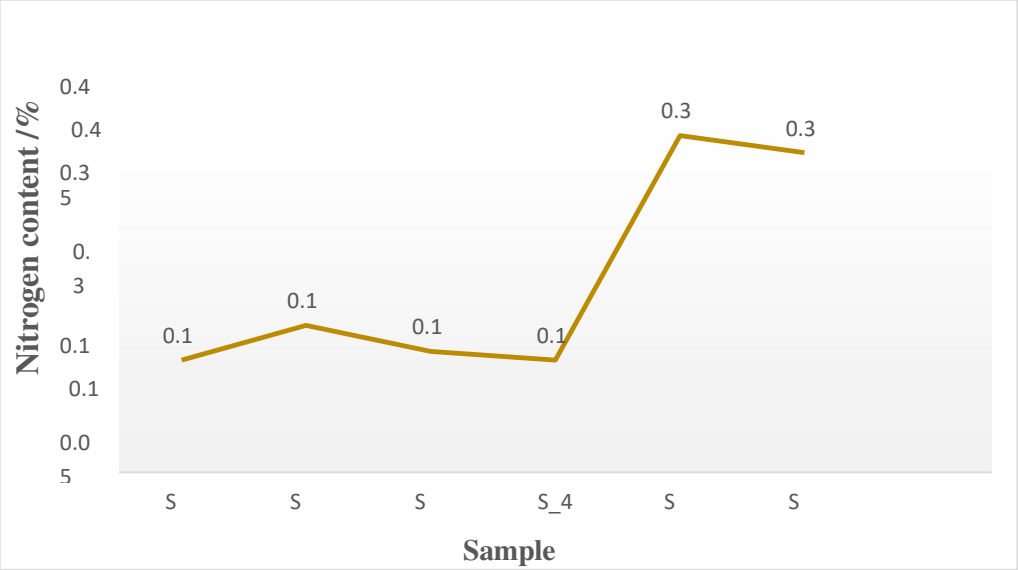


Fig. 7. The variatiom of Nitrogen content of the RSS samples

Since this project shows some interesting results it will be continued in 2023 also to further investigations of the suitability of using pineapple peel extract to produce deproteinized raw rubbers while introducing as an alternative coagulant in the RSS manufacturing process (S Siriwardena, U M S Priyanka and D M S Iresha).

Extracted acid sources from citrus species for coagulation of field latex in RSS manufacturing

Narang (Fig. 8) and ambul-dodam (Fig. 9) are two citrus species available in Sri Lanka and both juice and the peel extract are acidic.

Narang fruits (50g) were crushed and the juice was taken and filtered through Whatman filter paper. Then the peels of the fruits were taken and water (250mL) was added and crushed in a grinder. The extract was filtered and the filtrate was collected.

Fig. 8. Narang (*Citrus microcarpa)*

Fig. 9. Ambul dodam (*Citrus crenatifolia)*

Similarly, ambul-dodam juice and peel extracts were prepared. All four types of acid extracts were used to prepare RSS as follows:

A1 1mL raw narang waste + 10mL field latex
A2 1mL raw narang juice + 10mL field latex
A3 1mL soar narang waste + 10mL field latex
A4 1mL soar narang juice + 10mL field latex
A5 1mL ambul dodam waste + 10mL field latex
A6 1mL ambul dodam juice + 10mL field latex

The pH values of the extracted acid samples were given in Table 7. It was observed that all juice extracts start coagulation within an hour while the waste extracts take more than three hours to start coagulation. Also, it was observed that the juice treated latex were fully coagulated within 6 hours while the waste treated samples take 24 hours.

All the sheets were then dried in a smoke house for 5 days for completion of the drying process and sent for testing of raw rubber properties in the following day. This project is continued in the year 2023 for further testing and evaluations (S Siriwardena, K Adhikari, U M S Priyanka, R D Illeperuma, W H C Nuwanthika and P G U Chathuranga).

Table 7. *pH of the extracted acid samples*

Sample	**pH**	
	Waste	**Juice**
Narang (raw)	3.16	2.67
Narang (ripe)	3.13	2.62
Ambul dodam	3.87	2.97

ADAPTIVE RESEARCH

Latex harvesting was inaugurated in the firstly planted rubber field in Mullaithivu District. Feasibility assessments on rubber cultivation and awareness programmes were conducted to educate farmers on dry zone rubber cultivation in the North Central province. Farmer participatory adaptive research trials were established in Horowupathana, Nochchiyagama and Nuwaragam Palatha-Central of Anuradhapura district. Findings of the study conducted to identify growth and canopy performance of immature rubber trees under different climatic conditions revealed that the growth performance of rubber trees in wet climate was better; however, canopies have been adapted to some specific morphological features to outfit the dry climatic conditions which could effectively be utilized in breeding programs on developing clones for drier climates. The average Technical Efficiency; an indicator developed in compared to the best farmer provided with same inputs, estimated for four districts i.e. Kegalle, Gampaha, Kurunegala and Kandy was reported as 71%. The psychosocioeconomoc survey conducted in the rubber plantation sector reveled that the female contribution in household decision making was 86%. Development of GPS map for 3,000 ha of new rubber smallholdings in Moneragala and Ampara districts was completed in collaboration with Smallholder Tea and Rubber Revitalization (STaRR) Project. The validation of the carbon trading project was completed by a third-party accredited auditor and Final Validation Report was submitted to the Verra Registry.

ADAPTIVE RESEARCH

E S Munasinghe

DETAILED REVIEW

Staff

Dr (Mrs) E S Munasinghe, Principal Research Officer, Mrs B M D C Balasooriya, Research Officer (Polgahawela Substation), Mr P M M Jayathilake and Mrs N M Piyasena Technical Officers and Mrs M A R Srimali, Management Assistant were on duty throughout the year.

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
ES Munasinghe	Rubber cultivation in non traditional area	Students of University of Jaffna

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
ES Munasinghe	Workshop on 'Developing carbon net zero 2050 road map'	Ministry of Environment
BMDC Balasooriya	Wayamba University Research Congress	Wayamba University of Sri Lanka
ES Munasinghe & BMDC Balasooriya	Workshop on 'Understanding Fundamentals in GIS, Remote Sensing and Geo-spatial Applications'	RRISL & IRRDB
ES Munasinghe & BMDC Balasooriya	Scientific Committe Meetings	RRISL
ES Munasinghe & BMDC Balasooriya	Research Meetings	RRISL

Field visits

Experimental - 144
Advisory - 02
Other - 02

FIELD INVESTIGATIONS

Expansion of rubber cultivation to non-traditional areas (ARU/01)

Improving the protocols available to cultivate rubber in the Dry Zone

With the aim of improving suitable protocols to cultivate rubber in the Dry Zone, farmer participatory adaptive research trials were maintained in the Northern and North Central Provinces of the country.

Growth performance (in terms of girth and height) of immature rubber plants of sites in Kilinochchi, Mullaithivu and Anuradhapura was assessed (Table 1).

Table 1. *Details of rubber planting sites in the Dry zone*

Sites	Year of planting	Site code	Land extent (Ac)	Clone	% Tree density	Mean girth at 120 cm (cm)	Mean height (cm)
Kilinochchi	2017	2017/K2	½	RRISL 203	67	28.6±0.48	Not taken
Mullativu	2017	2017/M2	½	RRIC 121	75	32.3±0.74	Not taken
Anuradhapura	2017	2017/A1	2	RRISL 203	93	40.2±0.32	Not taken
			2	RRIC 121	98	39.6±0.25	Not taken
	2019	2019/A2	½	RRIC 121	99	19.8±0.31	Not taken
			½	RRISL 203	96	14.6±0.24	Not taken
			½	RRISL 2001	98	17.8±0.27	Not taken
	2019	2019/A3	¾	RRIC 121	92	21.0±0.31	Not taken
	2019	2019/A4	1	RRIC 121	93	19.4±0.24	Not taken
	2019	2019/A5	1	RRIC 121	92	21.5±0.27	Not taken
			½	RRISL203	86	19.4±0.40	Not taken
			½	RRISL 2001	88	19.6±0.38	Not taken
	2021	2021/A6	1	RRIC 121	99	6.1± 0.12	261.1±5.92
	2021	2021/A7	1	RRIC 121	99	6.2± 0.14	278.8±6.72

Awareness programmes were conducted to educate rubber growers on dry zone rubber cultivation in Horowupathana of Anuradhapura district in collaboration with the Rubber Development Department.

Feasibility studies were conducted for suitability assessments and farmer participatory adaptive research trials were established in Horowupathana, Nochchiyagama and Nuwaragam Palatha Central of Anuradhapura district

A training programme was conducted on latex harvesting and sheet rubber processing for rubber farmers in the Northern Province in collaboration with the Advisory Services Department.

Latex harvesting was inaugurated in the firstly planted rubber field in Mullaithivu District (Fig. 1). An average yield of 21.5 g of dry rubber per tree per tapping was reported in the field (E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena).

.

Fig. 1. Latex harvesting at firstly planted rubber field in Mullative district

Effect of climate on growth and canopy performance of immature rubber

The study was conducted with the aim of identifying growth and canopy performance of immature rubber trees under different climatic conditions. Two rubber clones, RRISL 203 and RRIC 121 established in 2017 were considered for assessments. The experiment was carried out in smallholdings of Anuradhapura and Kalutara districts representing two Agroclimatic Zones, *viz*. Dry Zone (DZ) and Wet Zone (WZ), respectively. Growth in terms of girth and the total height of trees were measured whilst canopy performances such as canopy height, canopy width, canopy density, leaf area index, branching habit and leaf characteristics were assessed.

Girth and total height of rubber trees in both RRIC 121 and RRISL 203 clones in the WZ showed significantly (at ≤ 0.05 level) higher values than those in the DZ (Table 2).

Table 2. *Growth of rubber clones RRIC 121 and RRISL 203 in Dry and Wet zones of Sri Lanka*

Clone	Climate Zone	Mean girth at 120 cm (cm)	Mean total heght (m)
RRIC 121	Dry Zone	30.54[b]	11.57[b]
	Wet Zone	37.88[a]	12.62[a]
RRISL 203	Dry Zone	35.00[b]	8.89[b]
	Wet Zone	38.73[a]	9.97[a]

Canopy height of RRIC 121 and RRISL 203 clones in the WZ showed significantly higher (at ≤ 0.05 level) values than those of the DZ. Nevertheless, canopy width of both RRIC 121 and RRISL 203 clones of the DZ showed significantly (at ≤ 0.05 level) higher values over the WZ. Further, canopy density and leaf area index of RRISL 203 clone of DZ was significantly (at ≤ 0.05 level) higher than those of the WZ. Though RRIC 121 and RRISL 203 clones showed a typical clonal branching pattern demarcating the heredity, a drooping effect of branching habit was prominent in the DZ (Table 3).

Table 3. *Canopy performance of rubber clones RRIC 121 and RRISL 203 in Dry and Wet Zones of Sri Lanka*

Clone	Climate Zone	Mean Canopy height (m)	Mean Canopy width (m)	Mean Canopy density (%)	Mean Leaf Area Index	Branching habit
RRIC 121	Dry Zone	8.57[b]	6.04[a]	86.09[a]	1.992[a]	Droopy
	Wet Zone	9.68[a]	4.67[b]	84.52[a]	1.915[a]	Upright
RRISL 203	Dry Zone	6.25[b]	5.71[a]	86.34[a]	2.043[a]	Droopy
	Wet Zone	6.96[a]	5.17[b]	79.19[b]	1.607[b]	Upright

All leaf characteristics assessed such as leaf length, leaf width, leaf and leaflet angle of both RRIC 121 and RRISL 203 in DZ are significantly higher (at ≤ 0.05 level) than those of the WZ (Table 4).

Table 4. *Leaf characteristics of rubber clones RRIC 121 and RRISL 203 in Dry and Wet Zones of Sri Lanka*

Clone	Climate Zone	Mean leaf length (cm)	Mean leaf width (cm)	Mean leaf angle (degree)	Mean Leaflet angle (degree)
RRIC 121	Dry Zone	26.73[a]	27.51[a]	74.48[a]	63.68[a]
	Wet Zone	20.45[b]	17.87[b]	49.72[b]	50.68[b]
RRISL 203	Dry Zone	22.92[a]	21.97[a]	88.36[a]	50.44[a]

Wet Zone	16.32[b]	15.27[b]	45.00[b]	36.96[b]

Those results revealed that growth performance of rubber trees in wet climates was better; however, canopies have been adapted to some specific morphological features to outfit the dry climatic conditions. Such characteristics could effectively be utilized in breeding programs in developing clones for drier climates which affect productivity ultimately (K K P M Kulathilake, E S Munasinghe, P M M Jayathilake and N M Piyasena).

Water requirement of young rubber plants in the Dry zone

This was a continuation of the experiment conducted to assess the water requirement of young rubber plants in the Dry Zone of the country at Thalawa, Anuradhapura. The results of the previous trial indicated that the application of 4 litres of water weekly was sufficient for young rubber in this region. Accordingly, this experiment was laid out in a farmer participatory adaptive research trial established in 2021 at Nachchaduwa, Anuradhapura under reduced amounts of water. The new experiment was arranged with 2, 4 and 6 litres of water per plant at watering intervals of 5, 6 and 7 days. Randomized Complete Block Design was applied with four blocks (replicates) with each block having all nine combinations of watering intervals and amounts. Each treatment plot contained 6 trees of RRIC 121 clone. The watering schedule as follows;

T1 - 2 l in 5 day interval
T2 - 2 l in 6 day interval
T3 - 2 l in 7 day interval
T4 - 4 l in 5 day interval
T5 - 4 l in 6 day interval
T6 - 4 l in 7 day interval
T7 - 6 l in 5 day interval
T8 - 6 l in 6 day interval
T9 - 6 l in 7 day interval

(E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena)

Increase land productivity through technology adoption (ARU/02)

Farmer perceptions and economics of technology adoption in the smallholder rubber sector in Sri Lanka

The study was started to assess the farmer perception and economics of technology adoption in the smallholder sector, and it was carried out in four traditional rubber growing districts: Kegalle, Kurunegala, Gampaha and Kandy. A pre-tested semi-structured questionnaire survey was used as the data collection tool for the cross-sectional data collection. A stratified random sampling technique was adopted for sampling. Part of the results was presented in the Annual Review of 2019,

2020 and 2021. During this year, adoption levels for each recommendation and the Technical Efficiency (TE) were estimated.

The results revealed that level of adoption to the recommendations on correct planting space, planting time and planting hole, removal of unnecessary branches and fertilizer application was over 90%. However, rainguard application, mulching, mixing and removal of froth in RSS production reported low level of adoption with the values of 9%, 19% and 22%, respectively (Table 5).

Table 5. *Adoption levels of different recommendations in rubber smallholder sector*

	Recommendation	**Level of adoption (%)**
Agronomic practices:		
1	Correct planting space	94
2	Correct planting time	90
3	Correct planting depth	59
4	Correct planting hole size	90
5	Vacant filling	63
6	Removal of unnecessary branches up to 8 feet	92
7	Branch induction	50
8	Establishment of stone terraces	29
9	Establishment of main drains	33
10	Establishment of lateral drains	39
11	Establishment of cover crops	42
12	Mulching	19
13	Weed management	96
14	Fertilizer application	76
15	Use of new tapping knife	34
16	Application of rain guards	09
17	Panel marking with a stencil	73
18	Tapping with a recommended tapping system	73
RSS Production:		
19	Mixing acid with water 1:84 ratio	35
20	Straining of latex	68
21	Mixing and removal of froth	22
22	Washing of sheets	58
23	Dripping and sun drying	81

The Technical Efficiency (TE); an indicator showing the efficiency of a particular farmer with compared to the best farmer in the sample provided with the same inputs, was estimated using Stochastic Frontier Analysis (SFA). The Translog

model with half-normal inefficiency distribution was chosen as the best fit model to estimate TE. The technical efficiency estimations obtained from the Translog – half normal model was between 25% and 90% whilst, the average technical efficiency value observed was 71% for the rubber smallholder sector in the given four districts (B M D C Balasooriya, P Seneviratne and N M Piyasena).

Harvesting techniques adoption in the rubber smallholder sector

The study was started to assess the harvesting techniques used in the rubber smallholder sector. Sixty smallholdings in the Kurunegala district were assessed for the adoption of tapping techniques. The adoption of recommendations on harvesting techniques was assessed through field evaluations and smallholder interviews. Annual panel marking has been practised in none of the fields, however, panel marking at the opening of the panel has been done in 83% of the fields. The tapping height was correct in 90% of the sample, however, 3% commenced tapping at a lower position where as other 7% at a higher position over the recommended. Though some farmers started tapping at the correct height in virgin bark, shifted to 150 cm height in the renewed bark. The tapping direction was correct in almost all the rubber smallholders. Issues with tapping angle were observed in 40% of the smallholdings (B M D C Balasooriya and N M Piyasena).

Socioeconomic improvement in plantation workers (ARU/03)

Psychosocioeconomic status of the rubber plantation workforce

This study was commenced to identify the psychosocioeconomic status of the rubber plantation workforce. A semi-structured pre-tested questionnaire survey was conducted to collect data on gender issues, child protection and education systems among plantation workers. The data collection was completed in Geekiyanakanda, Eladuwa, Culloden estates. The age distribution of the sample was depicted in Figure 2.The demographic features of the sample were given in the Table 6.

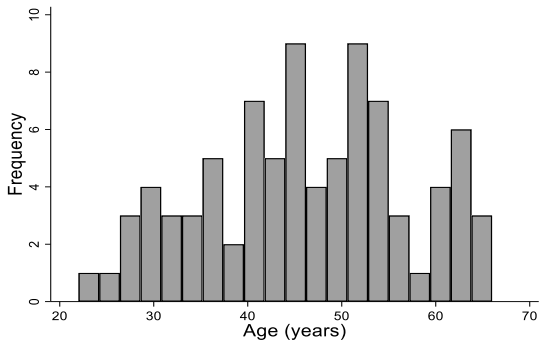


Fig. 2. *Age distribution of the plantation workers*

Table 6. *Demographic features of the plantation workers*

	Variable	Percentage
Gender	Male	48
	Female	52
Civil Status	Married	86
	Unmarried	06
	Divorced	02
	Widowed	06
Nationality	Sinhala	13
	Tamil	87
Religion	Buddhist	16
	Hindu	74
	Catholic	10
Years in schooling	No schooling	07
	1-5 years	38
	6-10 years	40
	Above 11years	15

Household Decision Making Index was calculated using the guidelines provided by the Indikit (a smart indicator for gender equality). Accordingly, female participation in decision-making was found as 86% whilst female participation in community groups as 78% for the considered communities. (B M D C Balasooriya, E S Munasinghe, V H L Rodrigo and N M Piyasena).

Developing a project to approach the voluntary carbon market with the rubber cultivation in Eastern and Uva Provinces for the sustainable rubber industry (Treasury Funded Development Project)

The project was initiated with the objective of developing a carbon trading project to obtain Verified Carbon Standards (VCS) for 3,000 ha of new rubber cultivations in the Uva and Eastern Provinces. The validation of the project was completed and Final Validation Report (FVR) was submitted to international accredited VCS registry; Verra. Demarcation of 43 sampling plots covering both provinces was completed and growth measurements were taken.

Identification of GPS locations of *ca*. 3,000 ha of new rubber smallholdings in Moneragala and Ampara districts was completed in collaboration with Smallholder Tea and Rubber Revitalization (STaRR) Project (V H L Rodrigo and E S Munasinghe).

BIOMETRY

The Biometry section has been involved in research, focusing on Biometrical aspects, especially on the development, modification and application of statistical methodologies related to the needs of the rubber sector. Statistical methods, research support and studies on climatology are the three major research and development focuses of the Biometry section. During the year review, the research studies focused applying forecasting techniques for latex crepe prices in the Sri Lankan market and applying statistical process control in quality assurance of latex crepe production.

Research support extended to other departments included assisting the design of experiments, data analysis, design and analysis of surveys, interpretation of results and database management. Databases on meteorological data collected in the stations at Dartonfield, Moneragala and Kuruwita and rainfall data collected in stations at Nivitigalakele, Galewatta and Polgahawela were updated and provided the data for scientific purposes on request. The database on rainfall in rubber growing areas was updated for the reporting year. Moreover, the officers of the Biometry section have been involved with multi-disciplinary studies with different departments of RRISL, Universities and other crop research institutions.

Furthermore, the Rubber Research Institute of Sri Lanka (RRISL) and the International Rubber Research and Development Board (IRRDB) jointly organized a workshop with the objectives of enhancing knowledge on remote sensing and GIS applications, developing skills in GIS for land suitability identification, and sharing knowledge on GIS applications in rubber-growing countries.

BIOMETRY

Wasana Wijesuriya and Dilhan Ratnayaka

DETAILED REVIEW

Staff

Dr (Mrs) Wasana Wijesuriya, Principal Research Officer and Mr Dilhan Rathnayaka, Research Officer, and the Experimental Officer, Mr Vidura Abeywardene, were on duty throughout the reporting year. Mrs S N Munasinghe, Management Assistant attached to the Biometry section, was also on duty throughout.

Research students

- L A T S Liyanaarachchi - Continued work for his MPhil on "Indicator-based identification, forecasting and mapping of droughts in Sri Lanka" at Wayamba University.
- Ms P W Jeewanthi - Commenced work for her MPhil on "Forecasting rainfall anomalies and modeling rainfall extremes to minimize the risk in Agriculture Sector" at the Postgraduate Institute of Agriculture, University of Peradeniya.

Seminars/Training/Workshops addressed/conducted

Dr (Mrs) Wasana Wijesuriya and Mr Dilhan Rathnayaka conducted the following training programmes organized by RRISL. Mr Vidura Abeywardene assisted in practical sessions on meteorological data recording.

Subject/Theme	Beneficiary/Client
Climatic conditions and rainfall distribution in rubber growing areas	Participants of the Advanced Certificate Course in Plantation Management
Climatic conditions and rainfall distribution in rubber growing areas	Officers of Rubber Development Department
Understanding fundamentals in GIS and Geo spatial applications (Jointly organized with IRRDB)	Scientists from IRRDB member countries, Officers of RRISL, and Managers of Regional Plantation Companies

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject/Theme	Organization
Wasana Wijesuriya & Dilhan Rathnayaka	Experiences during the 2021/22 North East monsoon season	Department of Meteorology
	Experiences during the 2022 South West monsoon season	Department of Meteorology

Officer	Subject/Theme	Organization
Dilhan Rathanayaka	ArcGIS Pro Training program	GIS Solution (Pvt.) Ltd
	Impact Forecasting and Risk Analysis for select countries in South and Southeast Asia	United Nations (UN)/ Regional Intergrated Multi-Hazard Early Warning System (RIMES)
	Workshop on Introduction to Scientometrics	National Science and Technology Commission (NASTEC)/ Indian Institute of Science (IISc)

Seminars/Conferences/Workshops/Meetings/Training sessions addressed

Officer	Subject/Theme	Organization
Wasana Wijesuriya & Dilhan Rathnayaka	Experiences during the 2021/22 North East monsoon season	Department of Meteorology
	Experiences during the 2022 South West monsoon season	Department of Meteorology

RESEARCH AND DEVELOPMENT

The Biometry section focuses its activities on two different programmes, *viz.* improving the reliability of interpretations through appropriate statistical methods (BM 01) and Improving the knowledge base on climate, climate change and variability for better decision making in rubber growing areas (BM 02).

Improving the reliability of interpretations through appropriate statistical methods (BM 01)

Statistical consultancy (BM/01/a)

Statistical consultancy is provided on designing experiments and questionnaires, statistical analyses, designing and developing databases and interpretation of experimental results to fellow scientists at RRISL and industry stakeholders on request. A full-day hands-on training programme was conducted for handling statistical software for research and technical staff of the Department of Genetics and Plant Breeding (W Wijesuriya and D Rathnayaka).

Development, modification and application of appropriate statistical methods for agronomic, socio-economic and industrial experiments in the rubber sector (BM 01/b)

This activity aims to familiarize the statistical techniques among the researchers and encourage the proper use of these methods.

Forecasting latex crepe prices in the Sri Lankan market using Artificial Neural Networks (ANN)

This study attempted to forecast Latex Crepe Grade 1 (LC-1) prices in the Sri Lankan market through Seasonal Auto-Regressive Integrated Moving Average (SARIMA), Holt Winter's exponential smoothing (HW_ETS) and Artificial Neural Network (ANN) models.

Monthly time series data of LC-1 from January 1986 to December 2020 were used to estimate LC-1 prices with SARIMA and HW_ETS. For Artificial Neural Network (ANN) models, 70% of the data set was used for training, and the rest was used for testing. To forecast LC-1 prices, three time periods *viz.* three, six and 12 months were used for all models beyond January 2021. The variables, international rubber prices, exchange rates; Sri Lankan rupee per US$ and Japanese Yen per US$ and crude oil prices were used with their first two lags as independent variables in ANN, together with 12 lags of monthly LC-1. The forecast performance of the models was evaluated using Root Mean Square Error (RMSE) and Mean Absolute Percentage Error (MAPE). The selected ANN models (ANN_M1: 12 lags of LC-1 and ANN_M2: 12 lags of LC-1 with Cr_OP and its first 2 lags) yielded relatively better forecast performances than the conventional time series models and the other ANN models tested. For 12 - and six-month forecasts, model M_1 performed better; for three-month forecasts, model M_2 was the best model with acceptable ranges of MAPE (8-9%) and RMSE.

Fig. 1. Variation Latex Crepe Grade 1 (LC-1) prices of the Sri Lankan market

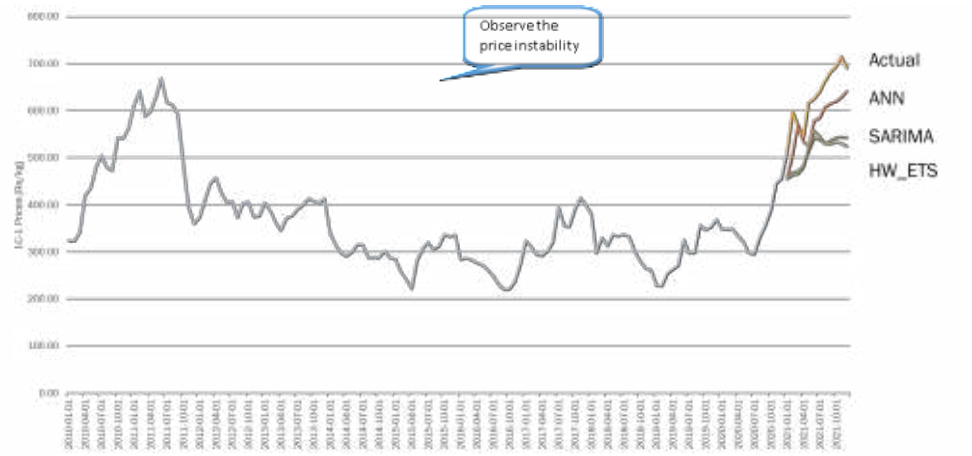


Fig. 2. Variation of monthly LC-1 forecast prices in different models

Statistical quality control

Statistical Quality Control (SQC) is the term used to describe the set of statistical tools used by quality professionals. These statistical principles and techniques are used to analyze and solve the quality problems. Also, it is helpful to monitor and maintaining the quality of products and services in all stages of the process.

There are many statistical techniques histograms, scatter diagram, Pareto chart, control charts, sampling inspection plans, analysis of variance and analysis of correlations. These statistical method is an effective tool for data processing when quality control is carried out. The usefulness of statistical quality control depends upon the integrated way of procedures from planning down to final action according to any problem presented.

Statistical process control in quality assurance of latex crepe production in the Dartonfield Factory, Agalawatta

Statistical process control is a mechanism of examining the variability of the considered quality parameters. Out of control instances are identified by shifts from the standard mean value and high variability. The quality of latex crepe manufacturing process in the Dartonfield Factory was evaluated considering applied dosages of sodium bisulfite, bleaching agent and formic acid. Moving range charts (MR chart), individual value charts (I chart) and cumulative sum (CUSUM) charts were used as tools for quality assurance of the latex crepe manufacturing process in this study. MR chart was used to study the stability of the process, and I charts were used to identify out of control chemical applications. Change point analysis was done

for CUSUM charts to detect trends in chemical applications. CUSUM charts can detect fluctuations in properties of quality parameters within a narrow range. Ranked CUSUM charts can be plotted if the variability of the data is high or the error structure of the data is non independent. According to the results, the application of sodium bisulfite, bleaching agent and formic acid were done according to the RRI recommendations. The chemical application in the crepe rubber manufacturing process was stable and under control except on the 13th of May 2022. Although the addition of sodium bisulfite has fluctuated during 2021-2022, it has been within standard control limits (computed using the 2004 standard data set) according to both individual and moving range charts. According to moving range charts for added bleaching agents and formic acid dosages, they have been within standard limits.

Improving the knowledge base on climate, climate change and variability for better decision making in rubber growing areas (BM 02)

Maintenance and establishment of meteorological and agro-meteorological stations (BM/02/a)

Maintenance and data recording are being done in the meteorological stations owned by RRISL by visiting and inspecting these sites and providing instruments when necessary. These include the AGROMET station at Dartonfield and rainfall stations in Moneragala, Kuruwita, Nivitigalakele, Polgahawela, Galewatta and Nivitigalakele. The data and information pertaining to these stations are explained in the Meteorological Summary of this report (W Wijesuriya, D Rathnayaka and O V Abeywardene).

Maintenance of databases on meteorological data in rubber growing areas (BM/02/b)

The database with daily meteorological data collected at Dartonfield meteorological station was adequately maintained. Reports were prepared from this daily database and sent to the Department of Meteorology. Rainfall records received at the Dartonfield Station are sent to National Building and Research Organization (NBRO) for issuing warnings on landslides. Rainfall records of substations, *viz.* Moneragala, Kuruwita, Nivitigalakele and Polgahawela were also maintained in a database. These data were made available to researchers and organizations on request. Data pertaining to the current year appear in the Meteorological Review. A database is maintained on rainfall experienced in rubber growing areas of Sri Lanka. Monthly rainfall values experienced in rubber growing areas are given in Table 1 (W Wijesuriya, D Rathnayaka and V Abeywardene).

Table 1.*Monthly rainfall in rubber growing areas in 2022*

Month	Location										
	Hanwella	**Rathnapura**	**Agalawatta**	**Galle**	**Kekanadura**	**Nittabuwa**	**Kurunegala**	**Monaragala**	**Uhana**	**Matale**	**Badulla**
	WL 1a	**WL 1a**	**WL 1a**	**WL 2a**	**IL 1a**	**WL3**	**IL 1a**	**IL 1c**	**DL 2a**	**WM 3b**	**IM 1a**
January	123.6	204.2	181.6	72.9	7.0	46.7	9.0	76.1	229.3	0.3	99.0
February	84.7	150.9	189.1	118.1	21.0	52.8	15.0	72.7	110.8	29.4	66.9
March	58.3	299.5	163.7	144.2	169.0	107.2	104.0	74.2	150.6	76.4	104.5
April	391.4	432.0	284.6	257.0	188.0	280.0	332.3	418.5	248.9	368.9	436.1
May	695.0	794.1	970.9	505.8	371.7	436.1	222.9	46.6	53.6	133.4	66.9
June	128.3	232.5	254.0	192.7	183.5	122.8	75.5	40.6	38.8	18.4	53.4
July	38.2	259.9	153.2	61.5	336.8	46.8	124.7	213.0	16.9	147.4	145.3
August	269.8	529.8	455.6	184.4	104.6	193.7	266.8	79.1	64.1	264.4	126.2
September	294.0	212.1	278.4	74.6	50.5	NA	208.3	42.5	69.1	151.3	76.9
October	754.5	685.5	864.3	749.9	282.5	551.0	351.2	397.1	260.9	232.8	183.0
November	291.2	342.0	272.5	162.3	315.0	170.8	260.0	417.2	255.2	183.9	291.5
December	311.2	234.9	219.0	190.4	NA	NA	273.2	283.7	265.8	172.3	173.1
Total Rainfall (mm)	3440.2	4377.4	4286.9	2713.8			2242.9	2161.3	1764.0	1778.9	1822.8
No. of Rainy days	150	226	230	184			159	138	90	126	157

Collaborative Research

Involvements in IRRDB activities

Mrs Wasana Wijesuriya continued to assist IRRDB in attending to the duties of the Liaison Officer of the Socioeconomic Specialist Group during 2022 and organized the event mentioned below.

International Workshop on understanding fundamentals in GIS and Geo spatial applications, 20th – 22nd December 2022

The Rubber Research Institute of Sri Lanka (RRISL) and the International Rubber Research and Development Board (IRRDB) jointly organized the above workshop with three main objectives, *viz.* building up knowledge on remote sensing and GIS applications, developing basic skills in GIS applications on land suitability identification and sharing the knowledge on GIS application in different rubber growing countries. This workshop included a guest lecture titled "Towards the Digital Agriculture" by Dr Senani Karunaratne, Senior Research Fellow (Honorary) at the National Institute of Fundamental Studies, Kandy and a series of lectures and practical sessions with hands-on support. Mr J K S Sankalpa, Mr Sangeeth Liyanaarachchi, Mr Dilhan Ratnayaka, and Ms Nadeesha Ishani have assisted the participants as resource persons from RRISL. The GIS Solutions (Pvt) Ltd. assisted the programme by providing licenses for the ArcGIS Pro software and also delivered a lecture on "New Trends in GIS" by Mr Supun Siriwardene, General Manager - Technical & Presales, GIS Solutions Pvt Ltd.

Applications on GIS and remote sensing in rubber growing countries were also shared. Scientists from Malaysian Rubber Board and Rubber Research Institute of India presented four papers on this aspect. This workshop was attended by six foreign participants representing four member countries: Malaysia, Cambodia and Thailand and six participants representing three regional Plantation Companies. Participants from Rubber Development Department and the Rubber Research Institute of Sri Lanka have also participated in the workshop. This workshop provided an excellent platform for networking with the key personnel working on this subject.





AGRICULTURAL ECONOMICS

The Agricultural Economics Unit (AEU) has meticulously undertaken a systematic review of the worldwide rubber industry and analyzed rubber prices by leveraging extensive world trade statistics. It highlighted some significant movements in the industry irrespective of the Economic crisis prevailing in the country. The Agricultural Economics Unit (AEU) has taken proactive measures to establish a fair price for rubber at the smallholder farmers' level. They have introduced a guidance price formula to provide a transparent and equitable pricing mechanism. Additionally, the AEU is currently engaged in an ongoing review to assess the applicability and effectiveness of this formula, ensuring that it aligns with the specific needs and circumstances of smallholder rubber farmers. Furthermore, the Agricultural Economics Unit (AEU) has recently updated the cost of new planting and replanting in the rubber sector.

AEU also has contributed to an externally funded collaborative project on continuation to test and exemplify the use of Geographic Information System (GIS) and Remote Sensing (RS) techniques in rubber plantation management. Furthermore, the AEU has compiled and conducted a comprehensive analysis of key features related to revenue generation from rubber CESS. By examining the various aspects of the rubber cess, such as collection methods, rates, and utilization, the AEU will be provided valuable insights and recommendations for optimizing revenue generation from this source.

AGRICULTURAL ECONOMICS

J K S Sankalpa

DETAILED REVIEW

Staff

Mr J K S Sankalpa, Senior Research Officer and Mrs P G N Ishani, Research Officer, were in duties throughout the year.

Seminars/Conferences/Meetings/Workshops attended

Mr Sankalpa and Mrs P G N Ishani attended the following during the year under review.

Activity	Organisation
Scientific Committee Meeting	Organized by the Rubber Research Institute of Sri Lanka
Workshop on GIS application	International Rubber Research and Development Board & RRISL

Services

Research support

Various cost-benefit and economic analyses were carried out at the request of other researchers.

Database management

A database on auction prices in Sri Lanka and International rubber prices was updated throughout the year. The Agricultural Economics Unit analysed the rubber price and rubber products export performance quarterly and presented the information to both the industry and the plantation sector.

Rubber marketing in Sri Lanka

The Colombo auction is the main mode of disposal of rubber manufactured in factories. The number of auctions conducted by the Ceylon Chamber of Commerce under the Colombo Rubber Traders' Association (CRTA) was 50 during this year. All these were updated and recorded in a database. The monthly average prices of major raw rubber categories are given in Table 1.

Prices of Ribbed Smoked Sheets (RSS)

The monthly average of RSS1 and RSS3 are given in Figures 1(a) and 1(b), respectively. The highest average price of RSS1 was Rs.800, recorded in June 2022. Yearly average prices of all grades of RSS were higher than that of the previous year (2021). Higher prices than the last year were recorded starting from the beginning of

2022. The average RSS1 price difference against the previous year was around Rs.133. The yearly average RSS1 price has increased by 29% compared to 2021. This was mainly due to currency depreciation and demand improvement in 2022.

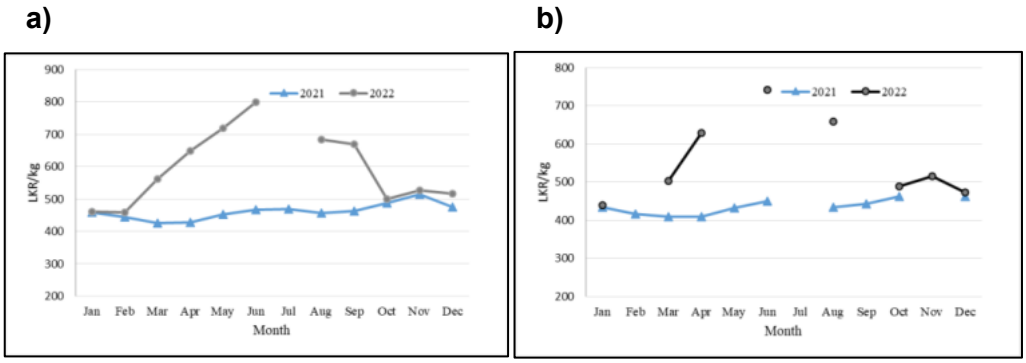


Fig. 1. The monthly average prices of RSS 1 **(a)** and RSS 3 **(b)** in 2021 & 2022

Prices of Latex Crepe (LC)

Prices of Latex Crepe1X for 2021 and 2022 are shown in Figure 2. LC1X prices have remarkably increased during the middle of the year 2022. The gap between the LC prices was high at the mid of the year, and prices gradually increased up to July, then decreased dramatically at the end of the year. The average LC1X price ranged from Rs.1450 (July) to Rs.613 (November) during 2022. The average price of LC1X was Rs.903, a 41% improvement compared to the previous year.

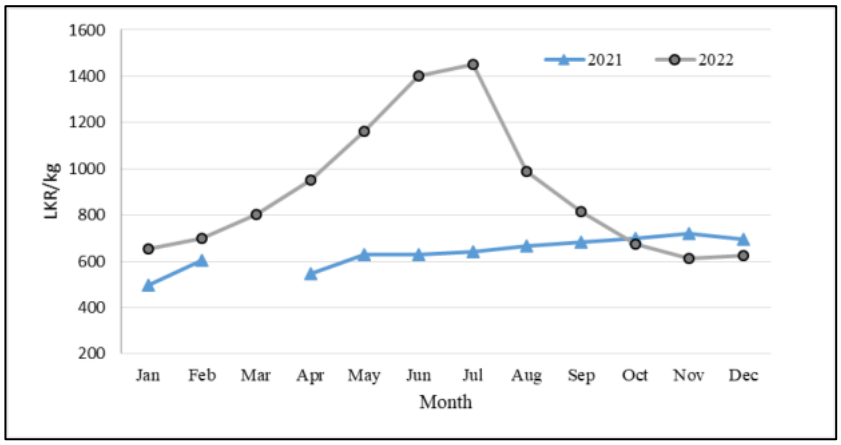


Fig. 2. The monthly average nominal LC1X price in the years 2021 & 2022

Table 1. *The monthly Auction Prices of Rubber (Latex Crepe, Sheet and Scrap) in the year 2022*

Month	RSS Prices (Rs./kg)					Latex Crepe Prices (Rs./kg)					Scrap Crepe Prices (Rs./kg)				
	RSS1	RSS2	RSS3	RSS4	RSS5	LC-1X	LC-1	LC-2	LC-3	LC-4	1Xbr	2Xbr	3Xbr	4Xbr	Flat Bark
Jan	461	.	440	430	.	652	650	585	513	411	399	393	395	386	380
Feb	459	.	.	.	.	701	698	668	620	456	399	389	385	380	.
Mar	563	594	503	.	.	804	797	765	722	545	460	450	400	430	410
Apr	649	639	629	610	.	953	938	883	790	599	538	515	534	505	.
May	718	.	.	.	.	1163	1154	1066	916	661	552	548	554	535	524
Jun	800	.	743	710	.	1400	1392	1309	1144	733	675	663	608	588	568
Jul	.	.	.	.	.	1450	1248	1095	930	681	643	645	619	604	.
Aug	685	.	660	.	.	988	988	874	694	559	529	515	560	540	.
Sep	670	.	.	.	.	813	805	733	656	481	451	405	443	433	.
Oct	500	495	490	473	457	675	675	585	514	455	413	408	402	389	400
Nov	527	520	515	480	.	613	609	544	510	499	446	432	428	424	.
Dec	518	505	473	473	458	625	622	525	471	460	444	441	438	434	430
2022 Average	595	551	557	529	457	903	881	803	707	545	496	484	480	471	452

RESEARCH

The following studies were conducted in 2022.

Analysis of rubber sector policy changes (AE/03)

A study was initiated to investigate the rubber CESS collection and its impact on the industry. Data collection was completed, and a few analysis was in progress. Accordingly, the calculation and collection of cess in the rubber industry depend on different factors based on the type of transaction. When it comes to imports, the cess is calculated either on the value of the product or on the percentage of rubber content, and it is payable at the point of importation. For exports, the cess is calculated based on the percentage of rubber content, and it is payable either at the point of purchase of raw rubber by the manufacturer or at the point of export. Similarly, for local consumption, the cess is calculated based on the percentage of rubber content and payable at the point of purchase within the country.

The data presented in the chart reflects the CESS revenue collected from rubber exports, imports, and local consumption from 2007 to 2022. In 2022, the total cess revenue amounted to LKR 3497 million. Notably, more than 80% of the total CESS revenue is derived from imports. While the cess collected from local consumption has remained relatively stable, the revenue collected from exports and imports has experienced a significant decline over the past four to five years. The declining trend in cess revenue from exports and imports suggests potential shifts in trade patterns, changes in market dynamics, or other factors impacting the overall revenue generated. This information can be crucial for policymakers and industry stakeholders to evaluate and potentially revise the existing cess structure to address these declining trends and ensure sustainable revenue generation in the rubber sector.

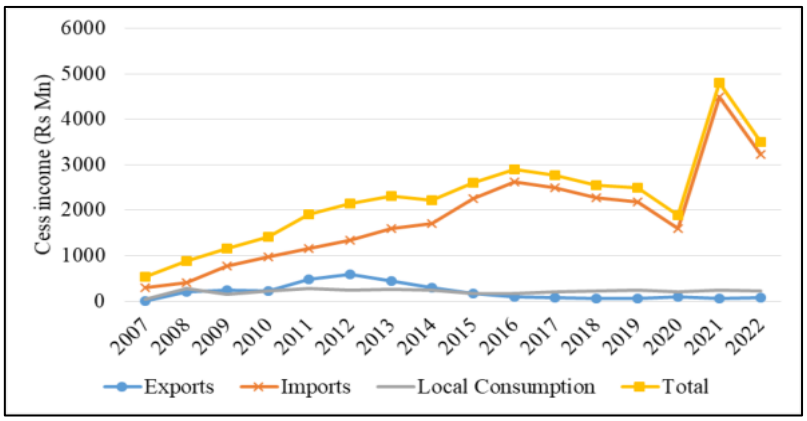


Fig. 3. Rubber CESS revenue change from 2007 to 2022 by different categories

Use of GIS in rubber plantation management (AE/06)

AEU has been involved in the externally funded research project (collaborative research between RRI and Genesis Pvt. Ltd.), which is titled "Use of GIS in rubber plantation management". Further information relevant to activities under this project is reported under the review of the Soils and Plant Nutrition Department.

Updating databases on the rubber industry, analysis of rubber end products manufacturing sector and other economic evaluations (AE/05)

The Agricultural Economics unit has conducted several studies to analyse the cost of rubber new planting and replanting in Sri Lanka and rubber prices that prevailed in the international and local markets. The aim was to present the current status in the local and international markets and thereby assist the stakeholders in taking suitable measures to improve the gains from the rubber industry. Fig. 4 shows the cost of rubber new planting and replanting change in the country during the last five years. In 2021, the cost of new planting in the rubber industry was LKR 1.2 million. However, by 2022, this cost had significantly increased to well above LKR 2 million. The notable increase can be attributed to the rising cost of materials throughout the year. Factors such as inflation, fluctuations in commodity prices, and changes in market conditions likely contributed to the higher expenses associated with this. This upward trend in costs highlights the importance of closely monitoring and managing input expenses in the rubber sector to ensure sustainable and profitable cultivation practices. Indeed, it is reasonable to anticipate a reduction in the cost of new planting in the rubber industry once the economic situation returns to a more normal position.

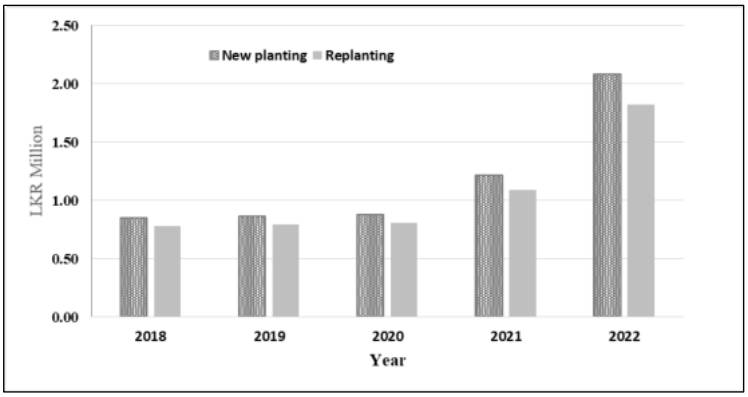


Fig. 4. Cost of new planting of rubber during the last five years

Throughout the year, the Agricultural Economics Unit (AEU) has analyzed both international and local rubber price movements. The farmgate price received by smallholder farmers has been a subject of debate, prompting authorities to formulate potential solutions to ensure fair pricing for these farmers. The AEU has specifically investigated price fluctuations in the international rubber market. Based on their findings, they have experimented with a formula incorporating various costs associated with rubber transportation. This formula aims to prevent local rubber prices from exceeding the average price observed in the international market. By considering transportation costs, the AEU aims to establish a pricing mechanism that aligns more closely with global market trends, providing smallholder farmers a fair and reasonable price for their produce.

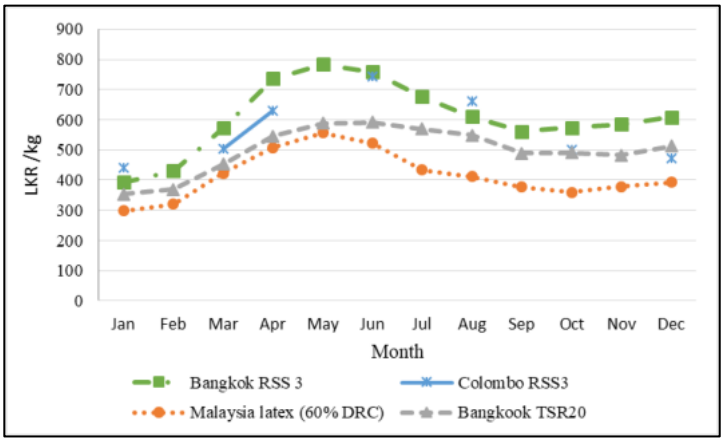


Fig. 5. International and Colombo auction rubber prices change (monthly average exchange rates were used in the conversion)

The rubber prices at the major International and Colombo auction are depicted in Figure 5. The monthly average price movement was considered in determining the guidance price for rubber in the country.

To prepare an RSS3 rubber guidance price, the Physical market price of RSS3 traded in Bangkok, Thailand, was selected. Singapore Commodity Exchange was selected to observe the suitable rubber futures prices for RSS. Similarly, those markets were selected to obtain the physical and futures prices of TSR20. For Latex prices, it was decided to get only the physical market prices of latex rubber from Malaysia. This study also observed the average freight cost paid to import rubber to Sri Lanka. The estimated average freight cost for imported kilogrammes of rubber was LKR 30 as of the end of the year 2022. The difference between the average CIF value and the estimated import value, calculated by adding FOB prices and the freight cost, was substantial. This is primarily a result of the categorization of rubber grades

and annual changes in freight costs. The estimated transportation cost from the farmer to the warehouse was LKR 15 per kg. Therefore, this difference is about LKR 15 per kg for international and local transport. At the experimental stage, it was decided not to take freight cost in the formula.

$$Guidance\ Price\ RSS\ 3 = \left(Average\ ((FOB_{Bangkok-RSS)})Ex_{USD} + (Futures_{SICOM-RSS})Ex_{SGD})\right)$$

Where;

$FOB_{Bangkok\text{-}RSS}$ = Rubber RSS 3 price in USD at Bangkok market
$Futures_{SICOM\text{-}RSS}$ = Rubber RSS 3 price in USD at Singapore market
Ex_{USD} = USD Dollar to LKR Exchange rate;
EX_{SGD} = Singapore Dollar to LKR

The guidance price formula for Latex is as follows,

$$Guidance\ Price\ Latex = \left(Average\ ((FOB_{Malaysia-Latex)})Ex_{USD}\right)$$

$FOB_{Malaysia\text{-}Latex}$ = Rubber Latex price in USD at the Malaysia market

The guidance price formula for TSR 20 is as follows,

$$Guidance\ Price\ TSR\ 20 = \left(Average\ ((FOB_{Bangkok-TSR)})Ex_{USD} + (Futures_{SICOM-TSR})Ex_{SGD})\right)$$

$FOB_{Bangkok\text{-}TSR}$ = Rubber RSS 3 price in USD at Bangkok market
$Futures_{SICOM\text{-}TSR}$ = Rubber RSS 3 price in USD at Singapore market

(P G N Ishani, J K S Sankalpa, W Wijesuriya and O V Abewardena)

LIBRARY AND PUBLICATION

The Library and Publication Unit continued with its regular services in collecting and disseminating information on natural rubber and related subject areas and also processing and publishing its periodicals. The Library and Publication Unit supported the staff of the Institute by providing primary as well as secondary sources, maintaining permanent collections, and providing access to all necessary materials. The services provided by the Library include lending facilities for books and other printed materials, tracing references, facilitating inter-library loans, photocopying, indexing service for publications, circulating content pages of latest periodicals among researchers, current awareness service on updating the users on new arrivals of book and selective dissemination of information (SDI) service on demand.

Nineteen books were added to the reference section of the library, bringing the total collection up to 6233. Twenty journals were received on an exchange basis.

LIBRARY AND PUBLICATION

N C D Wijesekara

DETAILED REVIEW

Mrs N C D Wijesekara, Librarian & Publication Officer, Mrs R M Amaratunga, Library Assistant & Assistant Publication Officer, Mrs D N C Amaratunga, Library Assistant & Publication Assistant (Rathmalana Library), Mr P M Prema Jayantha, Management Assistant and two Library Attendant were on duty throughout the year.

Publications

Institutional publications, namely Rubber Puwath, Vol. 34 (2022), RRISL Bulletin, Vol. 57 (2020), RRISL Journal, Vol. 101 (2021), Annual Review 2021 and Annual Report 2021 were prepared during the year. All publications were uploaded to the institute's Website (www.rrisl.gov.lk).

List of books purchased during the year

No	Title	Publisher	Year of Publications
1	International standard ISO- 4650 Rubber Identification - Infrared Spectrometric Methods	ISO 4650 Switzerland	2012
2	Standard Test Method for Rubber Compositional Analysis by Thermo gravimetry (TGA) Designation - D 6370-99 (Reapproved 2019)	ASTM International United State	2019
3	Hybrid Nanographite based Polymeric Nanocomposites	LAP Lambert Academic Publishing Gmble & Co. Germany	2012
4	Reverse Engineering of Rubber Products Concepts, Tools and Techniques	CRC Press Taylor & Francis Group, New York	2017
5	The Soil of Sri Lanka	Springer Netherland	2020
6	Principles of Instrumental Analysis Seventh Edition	Cengage Learning India	2018
7	Practical Biotechnology Plant Tissue Culture	S. Chand Publishing, New Delhi, India	2016
8	Graphitic Nanofibers - A Review of Practical and Potential Applications	Elsevier –Netherland	2017

No	Title	Publisher	Year of Publications
9	Chemistry Manufacture and Application of Natural Rubber	Woodhead Publishing Series is Imprint of Elsevier	
10	A Study of Brown Root Disease of Rubber and Its Causative Fungus *Phellinus noxius*	Faculty of Science University of Colombo	2020
11	Handbook of Rubber Vol.1: Agronomy	Rubber Research Institute of Sri Lanka	2021
12	Handbook of Rubber Vol.1: Agronomy	Rubber Research Institute of Sri Lanka	2021
13	Essentials in Elastomer Science Vol.1: Physical and Chemical Testing of Elastomers components	Colombo 05	2022
14	Essentials in Elastomer Science Vol.2: Understanding Elastomer Science	Colombo 5	2022
15	Essentials in Elastomer Science Vol.3: Science and Mixing Process Control and Filler	Colombo 5	2022
16	Statistical Information on Plantation Crops 2020	Ministry of Plantation	2022
17	Around the Topics of Biotechnology an Agricultural Perspective	Vidyalankara Printers & Publishers	
18	Around the Topics of Biotechnology an Agricultural Perspective	Vidyalankara Printers & Publishers	
19	Around the Topics of Biotechnology an Agricultural Perspective	Vidyalankara Printers & Publishers	

DARTONFIELD GROUP

A total crop of 99,988kg has been harvested during the year under review 58.25% of the estimated crop. When compared with the previous year, crop records a decrease of 11.76%. The crop harvested on wet days due to the rain guards was 24,304kg which amounts to 24.30% of the total harvested crop.

The average Yield per Hectare (YPH) for the year was 591kg showing a decrease of 75kg from the previous year.

The average intake per tapper recorded during the year was 5.6kg from a tapping task of 195trees. The highest intake per tapper of 8.3kg was recorded from the 4.69ha (RRIC 121/102 PB260, PB 217 clones) planted in the year 2007 and tapped at S/2 d4 low frequency systems with etharal stimulation (tapping task of 259 trees).

The total number of normal, late, rain guard & no tapping days recorded during the year were 200,15, 77 & 73 days, respectively.

Total rainfall recorded for the year was 4287.5mm with 159 wet days showing 1,222.7mm lowest rainfall and 20 wet days than the values recorded in the previous year.

The Cost of Production (COP) and Net Sale Average (NSA) recorded for the year were Rs.617.70 and Rs.718.02 respectively, giving a profit of Rs.100.32per kg and a total profit of Rs.10 Million. Profit per hectare recorded for the year was Rs.59,261.75.

The average percentage of Pale Crepe grade No. 01 was 77% during the year.

DARTONFIELD GROUP

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman Senior Estate Manager, Mr Dinesh Achinda, Mr M N S Pavinda Management Assistants, Mr T D Harsha, Acting Factory Officer Mr B M Siriwardena Field Officer and Mr K A Sarath Kumara, Mr Jagath Nakandala and Mr Lasantha Sampath, Acting Junior Assistant Field Officers were on duty throughout the year.

Summary of land use - Dartonfield group

The summary of the land use at Dartonfield Group is given in Table 1.

Table 1. *Land use (ha) at Dartonfield group*

	Dartonfield division	Gallewatte division	Nivitigalakele division	Total
Mature area	15.49	120.01	33.76	169.26
Immature area	18.28	36.96	9.56	64.80
Cinnamon under power line	1.00	2.08	0.28	3.36
Cemetery	0.60	-	-	0.60
Compost Unit	0.25	-	-	0.25
State land take in	0.27	-	-	0.27
Nurseries	7.01	2.61	2.00	11.62
Paddy/Deniya land	0.75	1.22	1.22	3.19
Waste land	0.19	0.18	-	0.37
Earth slipped area	4.88	1.26	-	6.14
Jungle	0.80	0.50	1.03	2.33
Rocky areas	2.14	7.07	2.76	11.97
Roads	2.92	6.57	0.36	9.85
Building	18.06	4.44	7.79	30.29
Play Ground	1.00	-	-	1.00
Abandoned Area	-	-	12.31	12.31
Proposed Cinnamon Ns.	0.20	1.1	-	1.30
Streams	0.45	0.35	2.17	2.97
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 4,287.5mm with 159 wet days. Details of past five years are given in Table 2.

Table 2. *Annual rainfall and wet days of the group for the past five years*

	2018	2019	2020	2021	2022
Rainfall (mm)	3,773.3	4389.7	3376.8	5,049.1	4,287.5
Wet days	195	204	177	176	159

From 2020, a day having more than 5mm rainfall was considered as a rainy day which was only 1mm before 2020

Crop

A total crop of 99,988 kg has recorded against the estimated crop of 171,649kg the difference was 71,661kg (58.25%). The crop and YPH (kg) of the Dartonfield group from 2018 to 2022 are given in Table 3.

Table 3. *The crop and YPH (kg) of the Dartonfield group from 2018 to 2022*

Hect.	2018		2019		2020		2021		2022	
	178.02		178.02		181.97		166.71		169.26	
Division	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH
Dartonfield	19,477	841	15,683	677	17,774	767	10,387	681	8,898	574
Gallewatta	119,458	986	104,699	865	116,501	932	79,771	672	70,470	587
N'kele	39,600	1,173	300,34	890	31,696	939	21,595	640	20,620	611
Group total	178,535	1,003	150,416	845	165,971	912	111,752	666	99,988	591
Group estimate	193,037	1,084	197,295	1,108	197,393	1,085	184,571	1,107	171,649	1,014

Low crop was experienced due to unexpected rainfall pattern that caused the severe leaf fall Disease occurrence.

Tappers productivity

The average IPT during the last five years is given in Table 4.

Table 4. *The average IPT (kg) of the Dartonfield group from 2018 to 2022*

	2018	2019	2020	2021	2022
Dartonfield	7.1	6.7	6.8	5.1	5.1
Gallewatte	7.9	7.1	8.0	6.4	5.4
Nivitigalakele	8.7	7.8	9.2	7.0	6.6
Group average	**8.0**	**7.2**	**8.0**	**6.4**	**5.6**

Continues unexpected rainfall also result of more No tapping days and also month of May to December had only 30-50% of remain leaf due to pestolopsis.

Tapping days

Annual break down of Normal tapping (NT), Late tapping (LT), Double tapping (DT), and No tapping of Dartonfield estate is given in Table 5.

Table 5. *Actual number of tapping days of Dartonfield group during last five years*

	2018	2019	2020	2021	2022
Normal tapping	222	201	217	171	200
Late tapping	6	19	11	35	14
Cash/Double tapping	(25)	(21)	(18)	(03)	-
No tapping	52	80	52	76	73
Rain guard tapping	85	65	85	82	77
Slight rain	-	-	-	01	01
Total no of tapping days	313	285	313	289	292

Rainguards

Total areas of 129.67 hectares were rain guarded during the year and an additional crop of 24,304kg was harvested which amounts to 24.3% of total crop harvested. Additional tapping days done with rain guards during the year were 27, 86 and 117 for Dartonfield, Galewaththa and Nivithigalakele respectively. Profit generated due to rain guarding was Rs.9,958,385.58 and profit per hectare was Rs.76,797.91.

Table 6. *Additional income generated by fixing of rainguards (Rs/kg)*

	Dartonfield Division	Gallewatta Division	Nivithigalakale Division	Total
Hectare	9.66	89.21	30.80	129.67
No. of rainguards fitted	2,509	22,059	7,893	32,461
Additional crop (kg)	1,043	16,211	7,050	24,304
Rainguard cost per kg.	99.30	100.71	85.23	107.06
Tapping cost per kg.	239.79	239.79	239.79	239.79
C.O.M. Rs/kg.	64.39	64.39	64.39	64.39
Total cost Rs/kg.	403.48	404.89	389.41	411.24
N.S.A. Rs./kg.	718.02	718.02	718.02	718.02
Additional profit Rs./kg.	314.54	313.13	328.61	306.78
Additional profit from rainguard (Rs.)	328,065.22	6,907,334.67	2,593,718.73	9,958,385.58
Additional profit per hectare (Rs.)	33,961.20	77,427.81	84,211.65	76,797.91

Total profit and profitability per hectare

The total profit and profit per hectare were Rs.10,030,643.59 and Rs.59,261.75 for the year under review.

Table 7. *Comparative statement of the revenue profit per kg and profit per hectare for the past five years*

	Years				
	2017	**2018**	**2019**	**2020**	**2021**
Mature area (ha)	178.02	178.02	181.97	166.71	169.26
Total profit/(loss) (Rs.)	(2,319,169.65)	(8,226,251.04)	5,448,827.93	6,966,796.71	10,030,643.59
Profit/(loss) per ha. (Rs.)	(13,027.58)	(46,209.70)	29,943.55	41,789.91	59,261.75

Cost of production and productivity

2018 and 2019 Estate was loss due to very low NSA as explain below Table 8.

Table 8. *Labour rates and break down of cost of production from 2018 to 2022 (Rs./kg)*

	2018	**2019**	**2020**	**2021**	**2022**
1. Labour wages	805	805.00 up to Jan. & 855.00 from Feb.	855.00	855.00 up to Mar. & 1150.00 from Mar.	1150.00
2. Cost of production	268.43	330.91	300.90	502.49	617.70
2.1 Tapping	115.63	139.94	138.17	204.01	239.79
2.2 Manufacture	33.08	35.35	38.94	49.56	64.39
2.3 General charges	98.10	124.18	94.87	113.03	125.23
2.4 Mature/area upkeep	21.62	31.44	28.92	38.65	71.90
2.5. Administrative	-	-	-	97.23	116.40
3. N.S.A.	255.44	276.22	333.73	564.83	718.02
4. Profit/(loss) per kg	(12.99)	(54.69)	32.83	62.34	100.32

Manufacture

Out of the latex crop of 88,984 kg harvested, 68,324kg has been graded as Pale Crepe No. 01 which is 77%. Details are given in Table 9.

Table 9. *Summary of grades manufactured during the year*

Grade	Quantity (kg.)	Percentage %
Latex crepe No.1	68,324	77
Latex crepe No.2	2,700	03
Latex crepe No.3	5,825	07
Latex crepe No 4	11,675	13
Total	**88,524**	**100**
RSS No.01	410	90
RSS No.02	-	-
RSS No.03	50	10
RSS No.04/05	-	-
Total	**460**	**100**
Scrap crepe No. 1	10,454	95
Scrap crepe No.2	330	03
Scrap crepe No.3/4	220	02
Total	**11,004**	**100**
Grand Total	**99,988**	**-**

Different types of rubber manufactured, percentage of grades received for pale crepe, RSS and Scrap Crepe are shown in Figures 1(a) and (b).

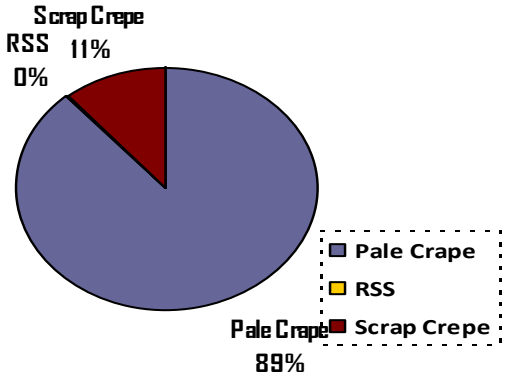


Fig. 1(a). Grade Percentages of different types of rubber manufactured Pale Crepe

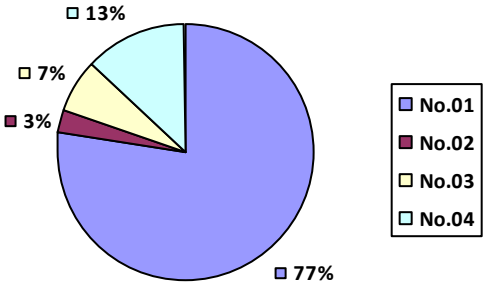


Fig. 1(b). Percentage of grade of Pale Crepe manufacture

Dartonfield Estate Group has received the best Auction prices of sheet rubber category one (Pale Crepe) for 08 times during out of 20 dispatches of the year 2022 (Table 10). The highest value for the best price received for the Pale Crepe was LKR. 1450.00 In June 2022 and higher prices have been enhanced by the favorable market condition prevailed during the latter part of the year.

Table 10. *Best Auction prices received in the year 2022 by the Dartonfield Estate Group*

Date	Category	Quantity sold (kg)	Price at auction (LKR/kg)
2022.02.15	LCR No.1x	3,225	715
2022.03.15	LCR No.1x	5,000	800
2022.03.22	LCR No.1x	2,650	850
2022.04.05	LCR No.1x	1,375	900
	LCR No.1x	4,375	900
2022.04.26	LCR No.1x	1,975	1000
2022.05.17	LCR No.1	1925	1100
	LCR No.1x	650	1100
2022.06.21	LCR No.1x	3,025	1450
2022.06.22	RSS No.1	175	500
	LCR No.1	1,125	625

KURUWITA SUB - STATION

This year the mature extent of rubber in the Kuruwita Sub Station was 77.66ha and harvested 45,820kg of rubber. However, it is a reduction of 16,624kg from previous year. The actual yield per hectare per year (YPH) was 590kg. The average intake tapper (IPT) of the estate is recorded as 4.8 kg, and this is a reduction of 2.6kg compared to the previous year. The number of Normal, Rainguard and No tapping days recorded during the year was 221, 95 and 49 respectively. The annual rain fall recorded the year was 4,762.1mm with 134 wet days as against 5,396.8mm with 177 wet days during the previous year. The cost of production (COP) and the net sale Average (NSA) for the year were Rs.577.99 and Rs.653.25 per kg, respectively. The profit made for the year was Rs.3.4 million rupees and the profit per hectare recorded for the year was Rs.44,403.98. The average percentage of Pale Crepe grade No. 01 was 72% during the year.

KURUWITA - SUB STATION

P A Lukshaman

DETAILED REVIEW

Staff

Mr P A Lukshaman Senior Manager (Estate), Mr D S Jayasinghe, Management Assistants (with effect from 10.04.2022) Mr D D A Jayathunga Field Officer, K K S Dinesh and E P S L Erewwala General workers were on duty throughout the year.

The estate cadre stood as follows at the end of the year.

Intermediate staff	- 01
Assistant staff	- 02
Minor staff	- 02

Land use

A summary of the land use is given in Table 1.

Table 1. *Land use in Kuruwita Sub station*

Land type	Extent (ha.)
Mature area	77.66
Nurseries	2.25
Immature - rubber	4.30
Tea area	3.49
Paddy	1.00
Buildings, Gardens and Road	10.23
Water tank	0.01
Unsuitable for planting	1.06
Total	**100.00**

Crop

Although the total crop was 45,820kg in this year, it was decrease of 16,624kg from the last year. The actual yield per hectare (YPH) was 590.01kg which is a decrease of 196.8kg compared to the previous year crop. The yield per hectare (YPH) for the past five years are given in the Table 2.

Table 2. *Yield per hectare (YPH) for the past five years*

YPH (kg)	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Estimated	1,320.61	1,271.0	1,238.6	1219.6	1119.7
Actual	1,025.11	911.1	1,001.2	786.8	590.01

The yield per hectare recorded (kg) for each month during the year is given in Table 3.

Table 3. *Actual yield per hectare (kg) recorded for each month during the year*

Month	YPH (kg)
January	67.8
February	48.6
March	62.5
April	46.0
May	39.6
June	47.1
July	54.7
August	33.9
September	43.2
October	21.3
November	51.5
December	73.8

Tapper productivity

The average intake per tapper at the end of the year was 4.8kg. The average IPT during the last five years are given in Table 4.

Table 4. *The average intake per tapper (IPT) (kg) for the last five years*

IPT (kg.)	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Intake per tapper	8.6	7.3	7.4	6.1	4.8

Rainfall

The annual rainfall recorded during the year was 4,762.1mm with 134 wet days (Table 5).

Table 5. *Annual rainfall figures and the number of wet days of the estate for the past 5 years*

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Rainfall (mm)	4,560.8	3,976.8	3428.3	5396.8	4762.10
Wet days	244	226	138	177	134

Tapping days

There were 316 tapping days recorded during the year (Table 6). This was possible merely due to the use of rainguards.

Table 6. *The Average number of tapping days of the Kuruwita Sub Station for the past five years*

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
01.Total tapping days	**324**	**323**	**337**	**316**	**316**
1.1 Normal	232	250	241	189	221
1.2 Late	-	11	-	17	-
1.3 Rain interference	-	-	-	-	-
1.4 Tapping under rainguard	92	62	96	110	95
02. Recovery tapping	-	-	-	-	-
03. No tapping	41	42	29	48	49

When compared with the last year there was an increase in normal tapping days from 189 to 221 days during the year.

Rainguard

The use of rainguards has given opportunity to get an additional 95 tapping days and it is contributed to 26% of the total crop yield and added to the profit Rs.4,485,292.57 The analysis of the use of rainguards for last five years are given in Table 7.

Table 7. *An analysis of the use of rainguards (Rs./kg)*

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Area (ha.)	64.96	70.25	79.36	67.15	53.70
No. of rainguards fitted	22758	23212	23150	18480	14802
Additional tapping days	92	62	96	110	95
The harvest of rubber (kg)	18419	12113	19558	25667	11761
Rainguard cost per kg of rubber	49.76	82.55	26.75	21.37	62.78
Tapping cost (Rs./kg.)	105.14	127.94	127.79	192.91	255.76

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Total cost (Rs./kg.)	154.90	210.49	154.54	214.28	318.54
N.S.A (Rs./kg.)	244.89	263.54	311.69	523.82	653.25
Additional Profit (Rs./kg.)	89.99	53.05	157.15	309.54	334.71
Additional profit from rainguards (Rs.)	1657525	642,594	3073539	7944963	3936524.31
Additional profit per hectare (Rs.)	25516.08	9147.25	38729.07	118316.65	73305.85

Total profit and profitability per hectare

The total Profit and Profit per hectare were Rs.3,448,413.20 and Rs.44,403.98 respectively for the year 2022.

Table 8 gives a comparative statement of the mature extent, total profit and profit per hectare for the past five years.

Table 8. *Comparative statement of the mature extent, total profit and profit per hectare for the past five years*

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Mature extent (ha.)	79.16	79.36	79.36	79.36	77.66
Total profit (Rs.)	(2,908,957.77)	(5,363,084.36)	1,535,903.81	5076072.76	3,448,413.20
Profit per hectare (Rs.)	(36,747.82)	(67,579.19)	19,353.63	63962.61	44403.98

Cost of production and profitability

The cost of production has increased by Rs.57.36 per kg compared to the last year (Table 9). The Labour rate and the breakdown of the cost of production (Rs./kg) for the past five years are given in Table 9.

Table 9. *Labour rate (Rs.) and the breakdown of the cost of production from 2018 to 2022 (Rs./kg.)*

	Year				
	2018	**2019**	**2020**	**2021**	**2022**
Labour rate (Rs)	805	805 up to Jan. & 855.00 from Feb.	855.00	855.00 up to Mar. & 1150.00 from Mar.	1150.00
Cost of production (Rs)	279.36	337.71	292.36	442.53	577.99
Tapping cost	108.8	134.74	137.41	205.40	272.89
Manufacturing	36.33	33.11	37.12	45.41	71.91
General chargers	97.16	135.40	89.49	157.64	159.72
Field & cultivation cost	37.07	34.47	28.35	34.08	73.47
N.S.A	244.89	263.54	311.69	523.82	653.25
Profit /kg.	(44.17)	(74.17)	19.33	81.29	75.26

POLGAHAWELA SUB - STATION

A total crop of 12,507kg harvested during the year and it was 72.04% of the estimated crop. However, there was a 34.54% decrease from previous year.

The YPH was 705kg. This showed a decrease of 43kg (6.09%) over the last year.

The average intake per tapper during the year was 7.0kg. The highest intake per tapper of 7.7kg was recorded from the 2008 field with a tapping task of 269 trees of clone RRIC 121 tapped on S/2 d3 systems.

The total numbers of Normal, Late, and No Tapping Days during the year were 261, 02, and 38 respectively.

Total rainfall recorded for the year was 2350.6mm with 94wet days.

Out of the total manufactured RSS, the share of No.01 grade was 82%.

POLGAHAWELA SUBSTATION

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman, Senior Estate Manager overlooked the activities of the Substation and Mr D P Nuwan Dissanayaka, Management Assistant was on duty throughout the year.

Summary of the land use

	Extent (ha)
Mature	17.75
Immature	1.50
Cashew	0.25
Rocks	23.60
Total	**43.10**

Crop

A total crop of 12,507kg has been harvested against the estimated crop of 17,361kg and the decrease is 4,854kg. The total crop, YPH and IPT for last five years are given in (Table 1).

Table 1. *Total crop (kg), YPH (kg) and IPT (kg) for the years of 2018, 2019, 2020, 2021and 2022*

Year	Hectare	Crop (kg)	YPH (kg)	IPT (kg)
2018	13.75	14710	1070	9.9
2019	17.75	15678	883	9.4
2020	17.75	17080	962	8.8
2021	17.75	16828	948	8.0
2022	17.75	12507	704	7.0

Rainfall

The annual rainfall recorded for the year was 2,350.6mm with 94 wet days (Table 2).

Table 2. *Annual rainfall and wet days of the estate for last five years*

	2018	**2019**	**2020**	**2021**	**2022**
Rainfall	2,683.7	2,170.5	2,385.5	3,485.4	2,350.6
Wet days	153	139	118	128	94

From 2020, a day having more than 5mm rainfall was considered as a rainy day which was only 1mm before 2020.

Tapping days

The annual breakdown of Tapping days and No tapping days are given in Table 3.

Table 3. *Annual Tapping days and No tapping days of the estate for last five years*

	2018	**2019**	**2020**	**2021**	**2022**
Tapping days	293	310	301	313	327
No tapping days	72	55	65	52	38

METEOROLOGICAL REPORT

The total annual rainfall at Dartonfield during this year was 4288mm, which accounted for a 24% decrease compared to the previous year. Remarkably high above-average monthly rainfall values were observed in May (971mm-66%) and October (864mm-68%). Above average rainfall values were also observed in January, February and August, while below average rainfall value were observed in the rest of the months. The minimum monthly rainfall of 153mm was recorded in July, whilst the maximum monthly rainfall of 970 mm was recorded in May.

Rains during the South West season carried most of the rains (2,112mm compared to the long-term average of 1,564mm) during 2022. This rainfall amount contributed 49% to the total rainfall. During the North East season (December 2021 to February 2022), 609mm of rain was recorded, which is slightly lower (14%) than the long-term average contribution (15%) of this season.

Five rainfall events exceeded the hazardous limits for landslides (100mm of rainfall during a day) reported during the year under review. A dry spell lasting over a month or more can adversely impact rubber plantations. There were only 4 dry spells greater than or equal to 7 days.

The minimum temperature did not drop below 20 ^{0}C except once in January, August and December. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.4 ^{0}C. The lowest mean monthly minimum temperature of 17.9 ^{0}C was observed in January while the highest monthly mean maximum temperature of 38.7 ^{0}C was observed in February. A total of 1696 bright sunshine hours was received at an average rate of 4.8 hours/day which was comparatively higher than the respective figures observed during the last year. Daily morning RH at Dartonfield in 2022 was observed in the range, 69% to 99%. The mean RH values recorded at 08:30 and 15:30 were 86% and 73%, respectively.

The annual rainfall totals of 4,799mm, 2,353mm, 2,082mm, 3,663mm and 3,642mm were recorded, respectively, in Kuruwita, Narampola, Moneragala, Galewatta and NivithigalaKele stations maintained by RRISL during 2022. The respective rainy days for these stations were 228, 115, 100, 170 and 178.

Meteorological Summary

Dartonfield Station

Wasana Wijesuriya and Dilhan Rathnayaka

The total annual rainfall at Dartonfield during this year was 4288 mm, which accounted for a 24% decrease compared to the previous year. Remarkably high above-average monthly rainfall values were observed in May (971 mm-66%) and October (864 mm-68%). Above average rainfall values were also observed in January, February and August, while below average rainfall value were observed in the rest of the months. The minimum monthly rainfall of 153 mm was recorded in July, whilst the maximum monthly rainfall of 970 mm was recorded in May.

Rains during the South West season carried most of the rains (2112 mm compared to the long-term average of 1564 mm) during 2022. This rainfall amount contributed 49% to the total rainfall. During the North East season (December 2021 to February 2022), 609 mm of rain was recorded, which is slightly lower (14%) than the long-term average contribution (15%) of this season.

Five rainfall events exceeded the hazardous limits for landslides (100 mm of rainfall during a day) reported during the year under review. A dry spell lasting over a month or more can adversely impact rubber plantations. There were only 4 dry spells greater than or equal to 7 days.

The minimum temperature did not drop below 20 ^{0}C except once in January, August and December. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.4 ^{0}C. The lowest mean monthly minimum temperature of 17.9 ^{0}C was observed in January while the highest monthly mean maximum temperature of 38.7 ^{0}C was observed in February. A total of 1696 bright sunshine hours was received at an average rate of 4.8 hours/day which was comparatively higher than the respective figures observed during the last year. Daily morning RH at Dartonfield in 2022 was observed in the range, 69% to 99%. The mean RH values recorded at 08:30 and 15:30 were 86% and 73%, respectively.

The annual rainfall totals of 4799 mm, 2353 mm, 2082 mm, 3663 mm and 3642 mm were recorded, respectively, in Kuruwita, Narampola, Moneragala, Galewatta and Nivithigala Kele stations maintained by RRISL during 2022. The respective rainy days for these stations were 228, 115, 100, 170 and 178.

Meteorological Report – 2022

The AGROMET station at Dartonfield, Agalawatta is maintained by the Biometry Section of the Rubber Research Institute of Sri Lanka. This station located in the Agro-Ecological Region $WL_{1a,}$ recorded an average annual rainfall of 4259 mm during the last 20 years. Out of the 23 years since 2000, a total rainfall of less than

3000 mm has been recorded only once during 2016 which was 2966 mm (Fig. 1). The rainfall recorded in 2022 was 4288 mm, which accounted for a decrease of 24%, compared to the previous year. The annual rainfall in 2022 slightly above the average for the last 20 years (4126 mm). The long term average rainfall is marked as a horizontal line in Fig. 1.

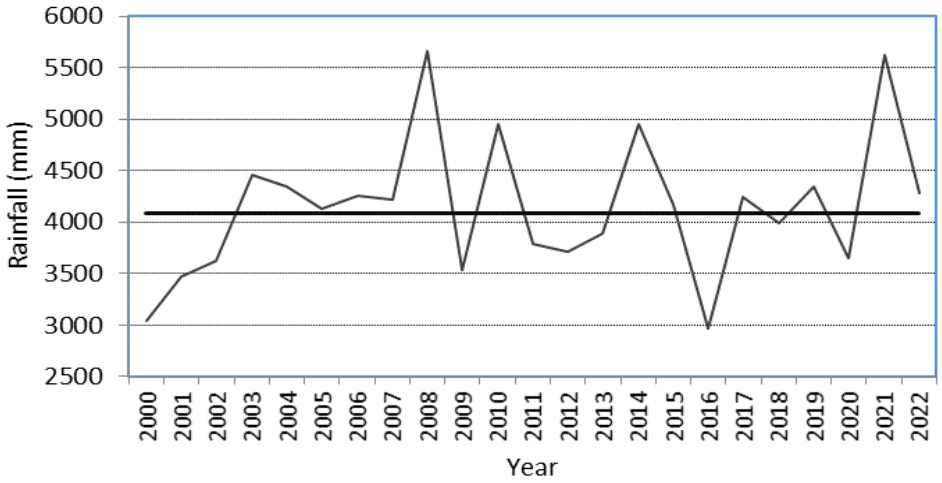


Fig. 1. Variation in annual rainfall at Dartonfield from 2000 to 2022

As indicated in Fig. 2, the rainfall distribution at Dartonfield during this year departed from the usual bimodal rainfall pattern. Remarkably high above-average monthly rainfall values were observed in May (971 mm-66%) and October (864 mm-68%). Above average rainfall values were also observed in January (182 mm-16%), February (189 mm-66%) and August (455 mm-70%) while below average rainfall value were observed in the rest of the months. The minimum monthly rainfall of 153 mm was recorded in July whilst the maximum monthly rainfall of 970 mm was recorded in May.

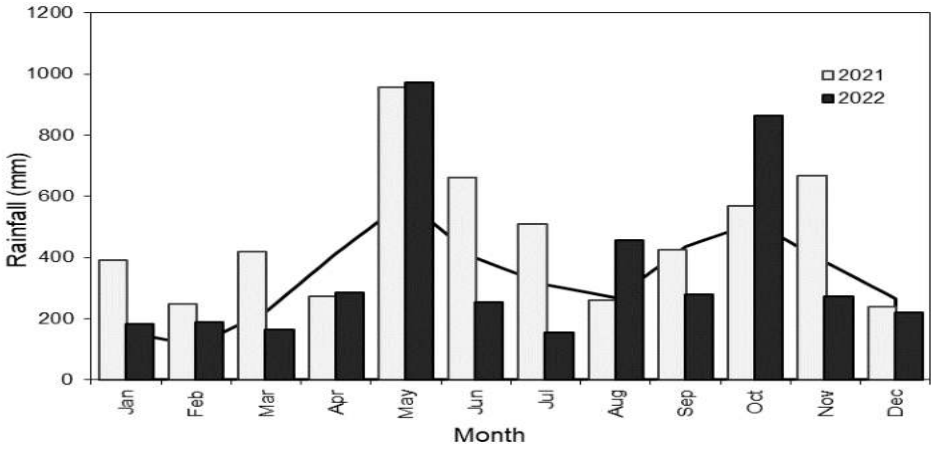


Fig. 2. Distribution of monthly rainfall in 2021 and 2022 at Dartonfield (The line graph indicates the long-term average)

The distribution of rainfall in different seasons at Dartonfield is given in Fig. 3. Rains during the South West season (May-September) carried most of the rains (2112 mm compared to the long-term average 1564 mm) during 2022. This rainfall amount contributed 49% to the total rainfall, which is slightly higher than the long-term average contribution (48%). Rainfall during IM2 (October & November) in 2022 brought 1136 mm whilst IM1 (March & April) recorded a low rainfall of 448 mm. During the North East season (December 2021 to February 2022), 609 mm of rain was recorded, which is slightly lower (14%) than the long-term average contribution (15%) of this season.

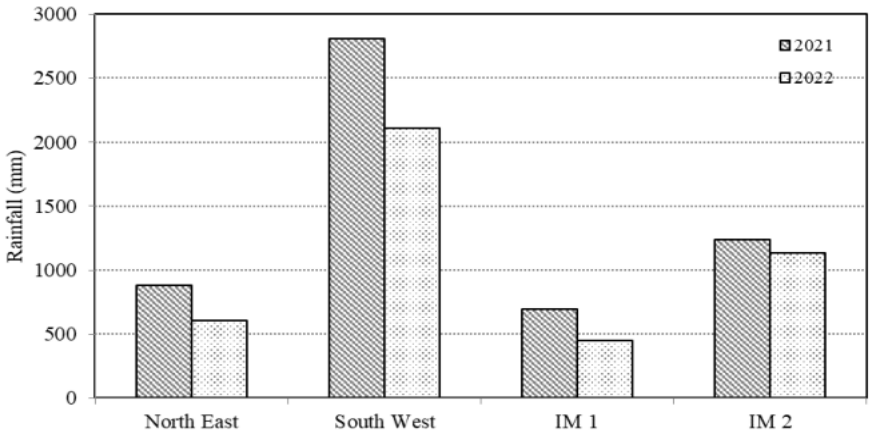


Fig. 3. Seasonal distribution of rainfall at Dartonfield in 2021 and 2022

The distribution of weekly rainfall is depicted in Fig. 4. six dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year. The highest weekly rainfall of 345 mm was observed in the 41st standard week (8th - 14th October).

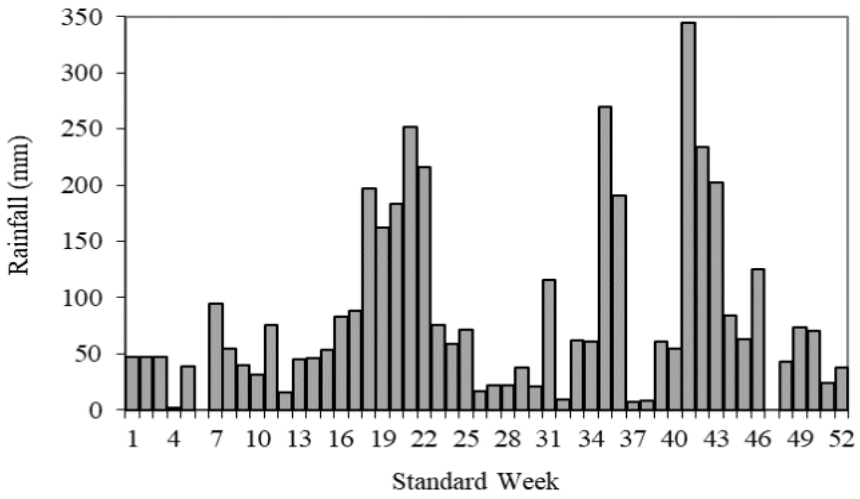


Fig. 4. Weekly variation in rainfall in 2022

Five rainfall events exceeded the hazardous limits for landslides (100 mm of rainfall during a day) reported during the year under review. A dry spell lasting over a month or more can adversely impact rubber plantations. There were only 4 dry spells greater than or equal to 7 days (Table 1).

Table 1. *Details of dry spells at Dartonfield in 2022*

Dry spell No.	Period	No. of days
1	1st - 11th February	11
2	27th - 6th February	8
3	9th - 17th August	9
4	16th - 26th November	11

The amount of rainfall and the number of rainy days under low, moderate and high rainfall categories are listed in Table 2. The observed total number of rainy days of the year was 231, which is higher than the long-term average of 220 days.

Table 2. *Monthly variation of rainfall and rainy days in 2022 at Dartonfield, Agalawatta*

Month	Total 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	181.6	(156)	12	(11)	4	8	0	3.43
February	189.1	(114)	7	(09)	1	5	1	3.77
March	163.7	(222)	17	(13)	6	11	0	3.62
April	284.6	(415)	23	(18)	2	21	0	3.50
May	970.9	(584)	30	(24)	4	19	7	3.37
June	254.0	(398)	25	(23)	2	23	0	3.16
July	153.2	(313)	17	(22)	7	10	0	2.84
August	455.6	(268)	20	(20)	3	15	2	3.09
September	279.0	(436)	19	(22)	8	9	2	3.37
October	864.3	(513)	25	(23)	3	16	6	3.03
November	272.5	(387)	18	(20)	2	15	1	2.70
December	219.0	(266)	18	(15)	3	15	0	2.64
Total	4287.5	(4072.0)	231	(220)	45	167	19	38.52

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm
** Average values for 1980-2005 are shown in parentheses

Rainfall at RRISL substations:

RRISL maintains substations in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}), Moneragala (IL_{1c}), Galewatta (WL_{1a}) and Nivithigalakele (WL_{1a}). The annual rainfall totals of 4799 mm, 2353 mm, 2082 mm, 3663 mm and 3642 mm were recorded, respectively, in Kuruwita, Narampola, Moneragala, Galewatta and Nivithigala Kele stations during 2022. The details of rainfall in these stations are given in Tables 3 to 7.

Table 3. *Monthly variation of rainfall and rainy days in 2022 – Kuruwita*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	86.9	13	5	8	0
February	112.4	8	2	5	1
March	318.1	14	2	10	2
April	369.6	25	8	16	1
May	887.3	28	2	21	5
June	337.1	25	4	20	1
July	315.2	22	9	10	3
August	568.9	20	5	11	4
September	328.3	17	6	9	2
October	918.4	28	5	14	9
November	328.8	13	0	12	1
December	228.4	15	6	7	2
Total	**4799.4**	**228**	**54**	**143**	**31**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 4. *Monthly variation of rainfall and rainy days in 2022- Gallewatta*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	141.5	10	1	9	0
February	175.5	6	1	4	1
March	141.5	10	1	9	0
April	311.5	18	2	15	1
May	784.0	19	2	11	5
June	256.5	25	2	23	0
July	130.0	8	0	8	0
August	432.0	17	1	15	1
September	230.5	8	1	5	2
October	756.1	23	1	15	7
November	158.8	15	2	13	0
December	144.9	11	2	9	0
Total	**3662.8**	**170**	**16**	**136**	**17**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 5. *Monthly variation of rainfall and rainy days in 2022 –Nivithigalakele*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	66.1	7	1	6	0
February	89.5	5	1	4	0
March	136.9	8	1	7	0
April	176.8	17	3	14	0
May	724.0	26	2	20	4
June	281.8	25	2	22	0
July	128.4	13	1	12	0
August	366.8	17	2	13	2
September	258.0	10	2	6	2
October	923.3	23	0	17	6
November	211.9	15	1	14	0
December	278.9	12	0	10	2
Total	**3642.4**	**178**	**16**	**145**	**16**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 6. *Monthly variation of rainfall and rainy days in 2022 –Moneragala*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	69.0	8	2	6	0
February	51.2	5	1	4	0
March	67.6	7	0	7	0
April	367.5	18	2	15	1
May	43.4	2	0	2	0
June	32.4	2	0	2	0
July	260.3	8	1	6	1
August	77.5	4	0	3	1
September	46.1	4	1	3	0
October	399.5	17	4	11	2
November	495.1	13	0	10	3
December	172.1	12	3	8	1
Total	**2081.7**	**100**	**14**	**77**	**9**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 7. *Monthly variation of rainfall and rainy days in 2022 – Narampola (Polgahawela)*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	0.0	0	0	0	0
February	35.4	2	0	2	0
March	28.1	3	1	2	0
April	344.2	12	0	10	2
May	465.0	18	1	15	2
June	100.0	11	0	8	0
July	115.7	8	2	5	1
August	203.0	11	1	9	1
September	180.9	7	1	5	1
October	423.5	20	4	11	3
November	266.2	12	1	9	2
December	190.9	11	0	11	0
Total	**2352.9**	**115**	**11**	**87**	**12**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Other meteorological parameters:

Table 8 depicts the monthly values of important meteorological observations and averages from 1980 to 2005 at Dartonfield. Daily fluctuations of the minimum and maximum temperatures at Dartonfield are illustrated in Fig.5. During the year under review, the minimum temperature dropped below 20 ^{0}C in once in January, August and December. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.4 ^{0}C, which could be a favorable condition for rubber plantations. The lowest mean monthly minimum temperature of 17.9 ^{0}C was observed in January while the highest monthly mean maximum temperature of 38.7 ^{0}C was observed in February. However, any signs of adverse conditions concerning the temperature regime at Dartonfield were not reported during the year.

A total of 1696 bright sunshine hours was received at an average rate of 4.8 hours/day which was comparatively higher than the respective figures observed during the last year. The distribution of bright sunshine hours during the year is depicted in Fig. 6. Bright sunshine hours exceeded 6 in 41% of the days, while in 41% of the days, it was below 4 hours.

High morning Relative Humidity (RH) is favourable for high latex yields. Daily morning RH at Dartonfield in 2022 was observed in the range, 69 % to 99 %. The mean RH values recorded at 08:30 and 15:30 were 86% and 73%, respectively.

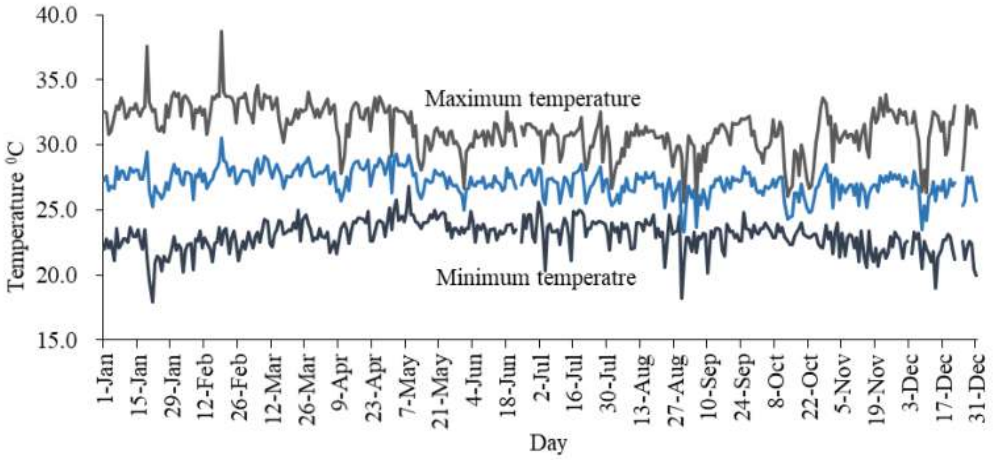


Fig. 5. Daily minimum, maximum and average temperature distributions in 2022

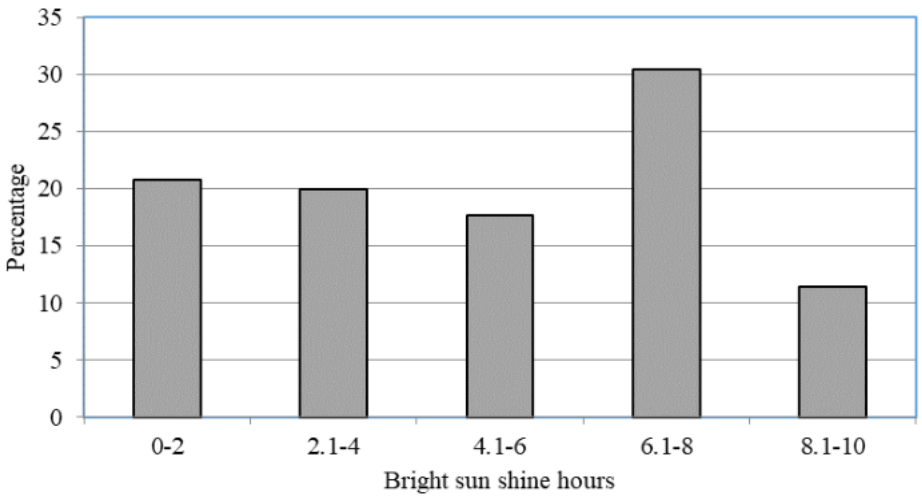


Fig. 6. Distribution of bright sunshine hours in 2022

Table 8. *Variation of observed meteorological factors at Dartonfield – 2022*

Month	***(Latitude 60^{0}32'; Longitude 80.09 E; Altitude 65.50mm)***								
	Temperature (^{0}C)					**Relative Humidity (%)**			**Mean Wind Speed (km/hour)**
	Mean Max	**Mean Min**	**Mean**	**No of Days Min Temp<20**	**Sun shine hours**	**8.30 am**	**No of Days 8.30am >90%**	**3.30 pm**	
January	32.7	22	27.4 (26.7)	2	6.7	84 (88)	4	65 (68)	0.27
February	33.3	22.3	27.8 (27.1)	0	5.9	84 (86)	2	65 (65)	0.23
March	32.7	23.3	28 (27.6)	0	5.9	85 (85)	5	68 (68)	0.83
April	32.2	23.4	27.8 (27.8)	0	5.3	85 (85)	7	74 (75)	0.71
May	30.6	24.3	27.5 (27.6)	0	3	89 (88)	13	81 (77)	0.95
June	30.7	23.5	27.1 (26.9)	0	3.3	89 (89)	13	75 (77)	0.85
July	30.5	23.7	27.1 (26.7)	0	3.8	87 (89)	8	77 (75)	1.37
August	29.9	23.2	26.6 (26.6)	1	4.9	87 (88)	9	73 (74)	1.54
September	30.5	29.9	30.2 (26.7)	1	6	87 (88)	5	69 (75)	1
October	29.7	23.1	26.4 (26.6)	0	3.8	88 (86)	13	78 (77)	0.67
November	31.3	22.2	26.8 (26.6)	0	4.9	85 (85)	6	72 (77)	0.28
December	31	21.9	26.5 (26.7)	1	4.5	85 (85)	6	75 (73)	0.22

** Average values for 1980-2005 are shown in parentheses

List of Publications

Scientific Journals
(Bold type - Employees of Rubber Research Institute of Sri Lanka)

Attanayake, A.P. and **Weerasinghe, M.U.D.S.** (2021). Study of raw rubber and dynamic properties of RRISL 203 genotype using rubber process analyzer. *Journal of the Rubber Research Institute of Sri Lanka* **101**, Pp.26-35.

Balasooriya, B.M.D.C., Edirisinghe, J.C. and **Seneviratne, P.** (2021). Nexus between awareness, perception and adoption of recommended technologies: Evidences from smallholder rubber cultivation. *Sri Lankan Journal of Agricultural Economics* **22**(1), Pp.1-17.

Dananjaya, S.A.V., **Priyanka, U.M.S., Somarathna, Y.R.,** Karunanayake, L. and **Siriwardena, S**. (2022). A comparative study on mica waste-filled natural rubber foam composites made out of creamed and centrifuged latex. *Journal of Vinyl and Additive Technology* **28** (4), Pp.907-919.

Dananjaya, S.A.V., **Somarathna, Y.R.,** Karunanayake, L. and **Siriwardena, S.** (2022). Physical properties of natural rubber latex foams produced with processed mica waste powder and creamed natural rubber latex. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.1-10.

De Alwis, W.D.M.N., Nakandala, S.A. and **De Zoysa, L**. (2022). Effect of seed quantity on growth performance of rubber seedling plants and quality of planting material. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.11-18.

Gunarathne, P.K.K.S., Thennakoon, T.M.S.P.K. and Edirisinghe, J.C. (2022). Identification and prioritization of the constraints of rubber farming in Moneragala District. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.55-68.

Gunarathne, P.K.K.S., Wikramasuriya, H.V.A., Jayathilaka, M.W.A.P. and **Wijesuriya, Wasana** (2021). Behavioural factors affecting the adoption of manuring of smallholder mature rubber cultivations in Moneragala district. *Journal of the Rubber Research Institute of Sri Lanka* **101**, Pp.36-48.

Liyanaarachchi, L.A.T.S., Sankalpa, J.K.S., **Ishani, P.G.N., Rathnayaka, A.M.R.W.S.D., Gayan, M.W.H., Wijesuriya, B.W**. and **Hetiarachchi, R.P**. (2022). Annual soil loss assessment of smallholder rubber growing lands in the Kalutara District, Sri Lanka using the RUSLE model in GIS. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.43-54.

Samararathna, S.D.R.P. and **Siriwardena, Susantha.** (2021). Preparation of Liquid NR *via* microwave irradiation as performance improving agent in tyre carcass compounds. *Journal of the Rubber Research Institute of Sri Lanka* **101**, Pp.49-64.

Samarasinghe, **H.K**., Walpalage, S., **Edirisinghe, D.G.** and Egodage, S.M. (2022). The use of Diisopropyl Xanthogen Polysulfide as a Potential Accelerator in Efficient Sulfur Vulcanization of Natural Rubber Compounds. *Journal of Applied Polymer Science* **139**(18), 52063.

Sampath, W.D.M., Fernando, C.A.N. and **Edirisinghe, D.G.** (2022). Synthesis of polyethylene glycol-grafted graphite and effect of its loading on properties of natural rubber composites. *Journal of the National Science Foundation of Sri Lanka* **50**(4), Pp.785-798.

Sampath, **W.D.M., Weerasinghe, U.A.** and Wickramaachchi, W.P.P.T. (2022). Effect of blowing agent type and blowing agent loading levels on mechanical and cell morphological properties of dry natural rubber cellular compounds. *Journal of the Rubber Research Institute of Sri Lanka* **101**, Pp.11-25.

Seneviratne, P., **Nakandala, S.A., Samarasekera, R.K**. and **Karunathilake, P.K.W.** (2021). A study of different tapping times on latex production in smallholder rubber fields in Moneragala District in Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka* **101**, Pp.65-75.

Silva, M.K.R., Fernando, T.H.P.S., Wijesundara, R.L.C. and Nanayakkara, C.M. (2022). A comparison of symptom-development by different isolates of *Phellinus noxius*: the causal agent of brown root disease of rubber. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.19-29.

Weerasinghe, **U.A., Sampath, W.D.M., Edirisinghe, D.G.** and Madushika, T.G.K.H. (2022). Evaluation of the cure characteristics and physico mechanical properties of treated oil palm fiber based natural rubber composites**.** *Journal of Plastics and Rubber Sri Lanka* **20**, Pp.89-94.

Wickramapala, A.D., **Edirisinghe, D.G.,** Jayarathna, P.K.I.L., Senevirathna, A.M.W.K. and Bandara, C.G. (2022). Evaluation of suitability of sesame oil as an alternative for aromatic processing oil in natural rubber composites. *Journal of the Rubber Research Institute of Sri Lanka* **102**, Pp.30-42.

Wijesinghe, H.G.I.M., Etampawala, T.N.B., **Edirisinghe**, **D.G.,** Gamlath, G.R.V.S. Wadugodapitiya, R.R.W.M.U.G.K. and Bandara, T.A.R.W.M.M.C.G. (2022). Properties of rice husk ash silica filled natural rubber and acrylonitrile-butadiene rubber blends. *Journal of Agricultural Sciences Sri Lanka* **17**(1), Pp.1-18.

Wijewardane, D.S., Senevirathna, M.A.S.R., **Siriwardena, S., Edirisinghe, D.G. and Sudusingha, Y.C.Y.** (2022). Preparation of skim natural rubber and polypropylene blends *via*. melt blending: A study on processability. *Progress in Rubber Plastics and Recycling Technology* **38**(3), 1-20. https://doi.org/ 10.1177/14777606221105293.

Bulletin/Rubber Puwath/Reports

අබේරත්න, ඒ.එච්.එම්.එන්.ආර්., ප්‍රනාන්දු, ටී.එච්.පී.එස්. සහ සිරිවර්ධන, ඩිල්ෂාරි. (2022). රබර් වගාවේ රෝග පාලනයට ජෛව පළිබෝධනාශක භාවිතය. *රබර් පුවත්* **34**, 17-21.

අබේරත්න, ඒ.එච්.එම්.එන්.ආර්. සහ ප්‍රනාන්දු, ටී.එච්.පී.එස්. (2022). තිරසාර රබර් වගාවක් උදෙසා පාංශු බැක්ටීරියා භාවිතයෙන් නිපදවන ලද ජෛව පොහොර භාවිතය. *රබර් පුවත්* **34**, 57-62.

බද්දෙවිතාන, අමිල, විතානගේ, එස්.පී., ලියනගේ, කේ.කේ. සහ **ජයසිංහ, එන්.එස්.** (2022). ශ්‍රී ලංකාව තුළ රබර් ශාකයේ අභිජනන ක්‍රියාවලිය වැඩි දියුණු කර ගැනීම සහ වේගවත් කර ගැනීමට නම්. *රබර් පුවත්* **34**, 9-13.

බාලසූරිය, බී.එම්.ඩී.සී., මුණසිංහ, ඊ.එස්. සහ රොද්‍රිගෝ, වී.එච්.එල්. (2022). රබර් සමග අන්නාසි වගාවේ ආරම්භය, විකාශය සහ නව ප්‍රවනතා. *රබර් පුවත්* **34**, 50-56.

Balasooriya, B.M.D.C., Silva, M.K.R., Fernando, T.H.P.S., Munasinghe, E.S. and **Piyasena, N.M.** (2022). Mammalian pest damages and prospects of application of repellent formulation in smallholder rubber fields in the intermediate zone: A case study in Kurunegala District. *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.51-56.

Dahanayake, T.T.D., Liyanage, K.K., Baddewithana, B.W.A.N. and **Jayasinghe, N.S.** (2022). Details on the development of the clone RRISL 2000 (1976 HP-8). *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.1-14.

Dahanayake, T.T.D., Liyanage, K.K., Baddewithana, B.W.A.N. and **Jayasinghe, N.S.** (2022). The hybridization procedure for the development of Hevea clones. *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.15-29.

ද සිල්වා, නිශාන්ත, ගුණරත්න, පී.කේ.කේ.එස්. සහ ගමගේ, නිහාල්. (2022). පළිබෝධ නාශක ලේබලයෙන් ඔබට. *රබර් පුවත්* **34**, 63-69.

Gunarathna, P.K.K.S. (2022). Policy directions for improving the extension service in the smallholder rubber sector through overlooking the institutional and structural transformation in the history. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.32-37.

ගුණරත්න, පී.කේ.කේ.එස්., දිසානායක, ඩී.එම්.ඒ.පී. සහ **රත්නායක, සුසිත්.** (2022). නිපුණතා සවිය තුලින් කිරි පිහිය හඳුන්වාදීමට දැක්වූ පිටිවහල. *රබර් ප්‍රවත්* **34**, 29-33.

Gunarathna, P.K.K.S. (2022). Level of adoption of recommended rubber harvesting practices by self-latex harvesters in Ratnapura district. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.38-44.

Hettiarachchi, R.P., Edirimanna, V.T., Gunathilake, E. de Silva and **Chandrasiri, J.A.S.** (2022). Role of slow-release fertilizer for immature rubber (*Hevea brasiliensis*). *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.43-50.

Kudaligama, K.V.V.S. (2022). Ethephon (2-chloroethylphosphonic acid) as a yield stimulant in *Hevea. Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.57-62.

කුලතුංග, ඒ. රෝහණ (2022). උපාය මාර්ගික කළමනාකරණය තුළින් රබර් වගාවේ වැඩි ආදායමක් ලබාගැනීම. *රබර් ප්‍රවත්* **34**, 45-49.

Lianage, K.K., Dahanayake, T.T. and **Baddewithana, B.W.A.N**. (2022). A comprehensive overview of the clone RRIC 102. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** 16-31.

Munasinghe, E.S. and **Rodrigo, V.H.L**. (2022). Waiting for 30 years to replant rubber; is it justifiable under Sri Lankan situation? *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.63-69.

නානායක්කාර, මනෝජ්. (2022). කිරි කැපුම් ශිල්පීන් සජීවීකරණයේ අත්දැකීම්. *රබර් ප්‍රවත්* **34**, 1-8.

පියසේන, එන්.එම්., මුණසිංහ, ඊ.එස්. සහ රොද්‍රිගෝ, වී.එච්.එල්. (2022). රබර් වගාව සමග පිබිදෙන නැගෙනහිර ජන ජීවිතය. *රබර් ප්‍රවත්* **34**, 22-28.

Rodrigo, Lakshman. and **Hettiarachchi, Rasika.** (2022). Do we need to think of the nutrient value of firewood? *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.30-34.

සිල්වා, එම්.කේ.ආර්., ප්‍රනාන්දු, ටී.එච්.පී.එස්., විජේසුන්දර, ආර්.එල්.සී. සහ නානායක්කාර, සී.එන්. (2022). රබර් වගාවේ දුඹුරු මුල් රෝගය පාලනයෙහිලා බිම් සැකසීමේ වැදගත්කම. *රබර් ප්‍රවත්* **34**, 14-16.

සේනානායක, ඩබ්ලිව්.පී.පී.ඩී.සී.පී.කේ. සහ ගුණරත්න, පී.කේ.කේ.එස්. (2022). නව තාක්ෂණික කිරි පිහිය භාවිතය හා කුඩා රබර් ඉඩම් හිමියා. *රබර් ප්‍රවත්* **34**, 34-38.

Seneviratne, P., Perera, M.K.P., **Nakandala, S.A.** and **Handapangoda, R**. (2022). Growth and yield performances of PB 86 and RRIC 100 clones harvested with different tapping systems under wet climatic conditions in Sri Lanka. *Bulletin of the Rubber Research Institute of Sri Lanka* **59,** Pp.35-42.

සෙනෙවිරත්න, පී. හදපාන්ගොඩ, රවීන්ද්‍ර. සහ පෙරේරා, එම්.කේ.පී. (2022). PB 86 ක්ලෝනය නැවත රබර් වගාවට හඳුන්වා දුන්නේ ඇයි?. *රබර් පුවත්* **34**, 39-44.

Seneviratne, Priyani and **Samarasekara, R.K**. (2022). Underutilized clone RRIC 102 can be used to balance the clone composition of Sri Lanka. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.1-8.

Seneviratne, P., Ishani, P.G.N., Handapangoda, R., Perera, M.K.P. and **Watawala, W.K.S.W.** (2022). Low planting densities have many advantages in rubber plantations. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.45-55.

Seneviratne, P., **Perera, M.K.P**. and **Handapangoda, R.** (2022). Comparison of performance of two types of rubber planting materials: bare root budded stumps and young buddings. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp**.**56-64.

Seneviratne, Priyani. (2022). The historical rubber-rice pact. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.65-78.

Wijesuriya, Wasana. and **Rathnayake, Dilhan**. (2022). Rainfall forecasts for the benefit of rubber growers. *Bulletin of the Rubber Research Institute of Sri Lanka* **58,** Pp.9-15.

Conferences/Seminars/Workshops/Reports

Balasooriya, B.M.D.C., Edirisinghe, J.C. and **Seneviratne, P.** (2022). Modeling awareness, perception and adoption of recommendations in smallholder rubber sector in Sri Lanka. *Proceedings of the Wayamba University of Research Congress,* Wayamba University of Sri Lanka. Pp.17-18.

Sampath, W.D.M., Fernando, C.A.N. and **Edirisinghe, D.G**. (2022). Synthesis and characterization of poly (ethylene glycol) grafted graphite and graphite oxide and comparison with natural graphite. *Proceedings of the 10th YSF Symposium.* March 2022, p.194.

Wickramapala, A.D., **Edirisinghe**, **D.G., Jayarathna**, **P.K.I.L.,** Bandara, T.A.R.W.M.M.C.G. and Senevirathna, A.M.W.K. (2022). Suitability of sesame oil

as an alternative processing aid for aromatic oil in carbon black filled natural rubber composites. *Proceedings of the IRCUWU2022, 6th International Research Conference of Uva Wellassa University*. 28-29th July 2022, p.250.

Sampath, W.D.M., Fernando, C.A.N. and **Edirisinghe, D.G.** (2022). Effect of copper grafted graphite loading on cure characteristics of natural rubber composites. *Proceedings of the 2nd International Conference on Science and Technology.* South Eastern University of Sri Lanka, 24th of August 2022, Pp.152-156. W.D.M. Sampath received the Best Presenter Award.

Sampath, **W.D.M.,** Fernando, C.A.N. and **Edirisinghe, D.G.** (2022). Effect of graphite oxide loading on tensile properties of natural rubber composites. *Proceedings of the International Research Conference (IRC), Technological Campus*, 29-30th of September 2022, Pp.102-103.

Sampath, W.D.M., Fernando, C.A.N. and **Edirisinghe, D.G.** (2022). Effect of graphite oxide loading on physical properties and electrical conductivity of natural rubber composites. *Proceedings of the Wayamba University Research Congress (WURC)*. 2022, Pp.151-152.

Dilmi, L.A.A., **Attanayake**, **A.,** Perera, G.A.A.R. and Lochana, E.A.L. (2022). Effects of added ammonium laureate soap on physico-mechanical properties of natural rubber latex, *6th International Research Conference of Uva Wellassa University*, 28th-29th July. P.252.

Ranawaka, R.A.A.P., **Attanayake, A.P**. Bandara, T.A.R.W.M.M.C.G. and Senevirathna, A.M.W.K. (2022). Effect of ammonia preservative systems in centrifuged latex on phosphate levels and latex film properties. *6th International Research Conference of Uva Wellassa University*. July 28th-29th. P.251.