ISBN 1391-0043

RUBBER RESEARCH INSTITUTE OF SRI LANKA

Annual Review 2018

Cover Story

Plant breeding for next generation!

It is a known fact that the cultivation of rubber began with seedlings originated from the Wickham's narrowed genetic base. Through the hybridization, the potential yield has reached to the level of 3000-3500 kg/ha/yr with significant level of disease resistant/tolerant. However, expansion of genetic base is required for further increased in yields. For this purpose, breeding programmes are underway by incorporating genes from 1981 IRRDB (International Rubber Research and Development Board) germplasm collection from Amazon genetic base.

In addition, under the multi-lateral clone exchange programme among IRRDB member countries, 17 foreign clones were received and another 27 are to be added to our breeding pool.

Photographs show how scientists are promoting the shoot generation in tree stump (a,b), building up multiplication nurseries (c) and establishing breeding garden (d) with 1981 IRRDB germplasm collection. Budwood nurseries of a top ranking clones in India received under the multilateral clone exchange programme is also shown (e).

Rubber Research Institute of Sri Lanka

Annual Review - 2018

1st January 2018 to 31st December 2018

Editors
V H L Rodrigo, PhD (Wales)
G P W P P Seneviratne, PhD (Bath)
S Siriwardene, PhD (Malaysia)

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
Ratmalana

CONTENTS

RUBBER RESEARCH BOARD OF SRI LANKA

BOARD OF MANAGEMENT

Members appointed by the Hon Minister of Plantation Industries

Mr N V T A Weragoda, Chairman, Rubber Research Board (up to 29.10.2018)
Mr J R Godigamuwa, Chairman, Rubber Research Board (w.e.f. 11.09.2018)
Ms M K D N Madampe, Treasury Representative
Mr R A D S Ranatunga, Representative, Ministry of Plantation Industries
Mr Justin Seneviratne, Group Director, Lalan Rubber (Pvt) Ltd
Mr R C Peiris, Chief Executive Officer, Kotagala Plantation PLC
Mr Anusha Perera, Chief Executive Officer, Balangoda Plantation PLC
Dr J D H Wijewardana, Secretary/Director, Sri Lanka Council for Agricultural Research Policy
Mrs N M Thanthirige (w.e.f. 28.08.2018 up to 29.10.2018)
Mr K H M Ranbanda Herath (up to 29.10.2018)
Mr E G S Premachandra (up to 29.10.2018)
Mr V S Dickwella (w.e.f. 26.09.2018 up to 29.10.2018)

Ex-Officio Members

Mr R B Premadasa, Director General, Rubber Development Department
Mr S S Poholiyadda, Managing Director, RPC Plantation Management Services

STANDING COMMITTEES

Estates Committee

Mr N V T A Weragoda, Chairman, Rubber Research Board (up to 29.10.2018)
Mr J R Godigamuwa, Chairman, Rubber Research Board (w.e.f. 11.09.2018)
Dr W M G Seneviratne, Director, Rubber Research Institute (up to 18.11.2018)
Dr V H L Rodrigo, Additional Director, RRI
Dr (Mrs) P Seneviratne, Deputy Director - Research (Biology), RRI
Dr Susantha Siriwardena, Deputy Director - Research (Technology), RRI
Mr Nissanka Seneviratne, Director, Kotagala Plantations Ltd.
Mr Jagath Hettiarachchi, Senior Manager, Paiyagala Estate
Mr Prince Gunasekera, General Manager, Namunukula Plantations Ltd.
Mr P A Lukshaman, Senior Manager, Dartonfield Estate
Mr B S S Hewage, Senior Accountant, RRI
Mr Ajith Withanage, Deputy Director (Administration) (up to 02.05.2018)

Audit and Management Committee

Ms M K D N Madampe, Chairman of the Committee, Treasury Representative
Mr R B Premadasa, Director General, Rubber Development Department
Mr R A D S Ranatunga, Representative, Ministry of Plantation Industries

In attendance

Ms Nilani Jayasiri, Audit Superintendent, Ministry of Plantation Industries
Director, Rubber Research Institute (up to 16.11.2018)
Acting Director, Rubber Research Institute (w.e.f. 06.12.2018)
Mr S Hewage, Senior Accountant, RRI
Ms S Senadheera, Internal Auditor, RRB
Mr Ajith Vithanage, Deputy Director (Admin) (up to 02.05.2018)
Mr Susantha Dissanayake, Senior Administrative Officer (w.e.f. 03.05.2018)

Scientific Committee

Members of RRISL

Mr N V T A Weragoda, Chairman, Rubber Research Board (up to 29.10.2018)
Dr W M G Seneviratne, Director, Rubber Research Institute (up to 17.11.2018)
Dr V H L Rodrigo, Additional Director, RRI
Dr (Mrs) G P W P P Seneviratne, Deputy Director Research (Biology), RRI
Dr S Siriwardena, Deputy Director Research (Technology), RRI
Dr D M A P Dissanayake, Head, Advisory Services Dept., 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 N M C Nayanakantha, Head, Plant Science Dept., RRI
Dr (Mrs) T H P S Fernando, Principal Research Officer, Plant Pathology & Microbiology Dept., RRI
Dr (Mrs) E S Munasinghe, Principal Research Officer, Adaptive Research Unit, RRI
Dr (Mrs) K V V S Kudaligama, Senior Research Officer, Biochemistry & Physiology Dept., RRI
Dr (Mrs) R P Hettiarachchi, Senior Research Officer, Soils & Plant Nutrition Dept., RRI
Mrs A P Attanayake, Senior Research Officer, Raw Rubber & Chemical Analysis Dept., RRI
Mr K K Liyanage, Senior Research Officer, Genetics & Plant Breeding Dept., RRI
Mr T U K Silva, Senior Research Officer, Plant Science Dept., RRI
Mr P A Lukshaman, Senior Manager, Dartonfield Estate
Mrs B M D C Balasooriya, Research Officer, Adaptive Research Unit, RRI
Mrs D S A Nakandala, Research Officer, Plant Science Dept., RRI
Mrs M K R Silva, Research Officer, Plant Pathology & Microbiology Dept., RRI

Mrs P V A Anushka, Research Officer, Genetics & Plant Breeding Dept., RRI
Mr W D M Sampath, Research Officer, Rubber Technology & Dept., RRI
Mr P K K S Gunaratne, Advisory Officer, Advisory Services Dept., RRI
Mr R A D Ranawake, Advisory Officer, Advisory Services Dept., RRI
Mr J K S Sankalpa, 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
Mrs T T Tolshi Dahanayake, Research Officer, Genetics & Plant Breeding Dept., RRI
Miss B M Suboda Panditharatne, Research Officer, Plant Science Dept., RRI (up to 12.10.2018)
Mrs L H Samudra Gunaratne, Research Officer, Plant Pathology & Microbiology Dept., RRI
Mrs H A Ruwani Jayawardane, Research Officer, Soils & Plant Nutrition Dept., RRI
Miss N P Surani Karunaratne, Research Officer, Biochemistry & Physiology Dept., RRI
Miss P G N Ishani, Research Officer, Agricultural Economics Unit, RRI
Mr Yashoda Somaratne, Research Officer, Polymer Chemistry Dept., RRI
Mr Y C Yohan Sudusinghe, Research Officer, Raw Rubber Process Development & Chemical Engineering Dept., RRI

Members representing the Industry and other Institutions

Dr K de Silva, Director, Thurusaviya Fund, No 74, Kaduwela Road, Battaramulla
Dr P Dharmasena, Director, National Institute of Plantation Management, M D H Jayawardane Mawatha, Athurugiriya

Mr A I B Rajasinghe, Superintendent, Balangoda Plantations PLC, Palmgarden Estate, Ratnapura
Mr D K Wijerathne, Superintendent, Balangoda Plantations PLC, Rambukkande Estate, Ratnapura
Mr B L L Prematilake, Superintendent, Balangoda Plantations PLC, Mahawala Estate, Rathnapura

Mr A G Geeth Kumara, General Manager, Elpitiya Plantations PLC, Talgaswala Estate, Talgaswala

Mr S D G Hewagama, Kahawatte Plantations PLC, Hunuwella Estate, Openayake
Mr L Perera, Manager, Kahawatte Plantations PLC, Houpe Eatate, Kahawatte
Mr G Weerasekara, Manager, Kahawatte Plantations PLC, Opatha Estate, Kahawatte

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

Mr B Gunasekara, RGM, Kelani Valley Plantations PLC, Panawatte Estate, Yatiyantota
Mr S Fernando, RGM, Kelani Valley Plantations PLC, Dewalakande Estate, Dehiowita
Mr R L Obesekare, Manager, Kelani Valley Plantations PLC, Kiriporuwa Estate, Yatiyantota
Mr E M R B Ratnayake, Manager, Kelani Valley Plantations PLC, We oya Estate,
Mr P K A H Thilakarathne, Manager, Kelani Valley Plantations PLC, Yatiyantota

Mr J N Hettiarachchi, Senior Manager, Kotagala Plantations PLC, Paiyagala Estate, Dodangoda
Mr R Tennakoon, Senior Manager, Kotagala Plantations PLC, Padukka Estate, Padukka

Mr D U H Bulugahapitiya, Senior Manager, Malwatte Valley Plantations PLC, Talgaswala Estate,Talgaswala

Mr M H P Gunarathne, Superintendent, Maturata Plantations PLC, Andapana Estate, Kamburupitiya
Mr B Madagama, Superintendent, Maturata Plantations PLC, Wilpita Estate, Akuressa

Provident Fund Committee

Mr N V T A Weragoda, Chairman, Rubber Research Board (up to 29.10.2018)
Mr J R Godigamuwa, Chairman, Rubber Research Board (w.e.f. 11.09.2018)
Dr W M G Seneviratne, Director, Rubber Research Institute (up to 17.11.2018)
Mr Ajith Withanage, Deputy Director (Administration) (up to 02.05. 2018)
Mr D M S Dissanayake, Senior Administrative Officer
Mr B S S Hewage, Senior Accountant, RRI (Member)
Mr T B Dissanayake, Elected Committee Member
Mr R A D Ranawaka, Elected Committee Member
Mr P K K S Gunarathna, Advisory Officer, Elected Committee Member

Chairman's Office & Board Secretariat

Chairman	- Mr N V T A Weragoda (up to 29.10.2018)
	- Mr J R Godigamuwa (w.e.f. 11.09.2018)
Acting Secretary to the Board	- Dr (Mrs) Wasana Wijesuriya, PRO
Personal Assistant to the Chairman	- Mrs B H P Balasuriya
Management Assistants	- Mrs H N Kanchana
	- Mrs P S Ishara

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
No.306/72,
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 - 3349999
	034 - 2248459
Fax:	034 - 2247427
e-mail	dirrri@sltnet.lk
Website	www.rrisl.lk

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

Telephones:	
Chairman	011 - 2635019
Fax	011 - 2633353
Board Office	011 - 2635142
Fax	011 - 2605171
Director	011 - 2633351
Fax	011 - 2633351
Deputy Director Research (Technology)	011 - 2633352
General	011 - 2635851
	011 - 2635852

Fax: 011 - 2605171
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
e-mail: rrikuruwita@sltnet.lk

Polgahawela - Substation, Polgahawela
Telephone: 037 - 2244120

Monaragala - Substation, Monaragala
Telephone: 055 - 3600707

Website: www.rrisl.lk

RUBBER RESEARCH INSTITUTE OF SRI LANKA

STAFF

DIRECTORATE

Director	W M G Seneviratne, BSc (SL), PhD (Sussex) (up to 17.11.2018)
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)
Deputy Director (Administration)	Ajith Withanage, BLE, MHRM, EDBA (up to 02.05.2018)

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)
Senior Research Officer	K K Liyanage, BSc Agric (SL) MPhil (SL)
Research Officers	Mrs P V A Anushka, BSc Agric (SL)
	Mrs T T D Dahanayake, BSc Agric (SL)
Experimental Officers	I D M J Sarath Kumara (up to 04.10.2018)
	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)
	Miss W D A R Tharanga, BSc (SL) (up to 24.08.2018)
	Mrs Y S L Kumaranayake, BSc (SL) (up to 01.09.2018)
Management Assistants (Clerical)	Mrs S D P K L Peiris
Plant Science	*(at Dartonfield, Agalawatta)*
Head of Department	N M C Nayanakantha, BSc (SL), MSc (India), PhD (India)
Senior Research Officer	T U K Silva, BSc Agric (SL), MPhil (SL)

Research Officers	Mrs D S A Nakandala, BSc Agric (SL)
	Miss B M S S Panditharatne, BSc Agric. (SL) (up to 12.10.2018)
Experimental Officers	Mrs G A S Wijesekera
	Mrs R K Samarasekera
	W D M N de Alwis, BSc (SL)
	D L N de Zoysa
	P D Pathirana, BSc (SL)
	P K W Karunathilake, Dip. Agric (Ratnapura)
Technical Officers (Research & Development)	R Handapangoda, BSc Agric (SL)
	Mrs U Dissanayake, Dip. in Agric. (Naiwala) BSc (SL)
	Miss W K S W Watawala, BSc (SL)
	R P D Priyadharshana, BSc (SL)
	Miss H M Subsinghe, BSc (SL)
	Mrs U N Udaya Kumari, BSc (SL)
Management Assistants (Clerical)	Mrs H D D E Jayawardena
	Mrs Aruni de Almeida

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

Head of Department	Mrs T H P S Fernando, BSc (SL), MPhil (SL), PhD (SL) (from 19.06.2018)
Research Officers	Mrs M K R Silva, BSc Agric (SL), MSc (SL)
	Mrs L H S N Gunaratne, BSc Agric (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) (from 01.10.2018)
Technical Officers (Research & Development)	P W Balasooriya, BSc (SL)
	Miss R D N S Gunasekera, Dip. in Agric.
Management Assistant (Clerical)	Mrs K A D Y Madushani Lanka

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

Principal Research Officer	Mrs R P Hettiarachchi, BSc (SL), MPhil (SL), PhD (SL) (from 17.12.2018)
Research Officer	Mrs H A R K Jayawardana, BSc Agric. (SL)
Experimental Officers	Miss V U Edirimanne, BSc (SL)
	Miss A P Thewarapperuma
	P D T C Gunatilleke, NDT (Agric)
	J A Sarath Chandrasiri

Technical Officers	Mrs Eranga de Silva, NDT
(Research & Development)	C G Mallawaarachchi, Dip. in Agric. (Hardy)
	Mrs M Kulathunga, BSc (SL)
	Mrs R M Baddevidana, BSc (SL)
	Mrs P D S D O Rathnasooriya, BSc (SL)
	M H W Gayan, BSc (SL)
	S L N S L Madushanka, BSc (SL) (up to 14.05.2018)
	Mrs N S Siriwardena, BSc (SL)
Management Assistant (Stenography)	Mrs K A D L Rupasinghe Perera
Biochemistry and Physiology	*(at Dartonfield, Agalawatta)*
Principal Research Officer	Mrs K V V S Kudaligama, BSc (SL), MPhil (SL), PhD (SL) (from 17.12.2018)
Research Officer	Miss N P S N Karunaratne, BSc (SL)
Experimental Officers	M K P Perera, BSc (SL)
Technical Officers (Research & Development)	Mrs P A D T L Madushani, Diploma in Agric.
	Miss N N Abewardena, BSc (SL) (up to 05.11.2018)
Management Assistant (Clerical)	Mrs H A Manoji Erandika
Advisory Services	*(at Telewela Road, Ratmalana)*
Head of Department	D M A P Dissanayake, BSc Agric. (SL) PhD (Aberdeen)
Advisory Officers	P K K S Gunaratne, BSc Agric. (SL)
	R A D Ranawaka
Assistant Training Officer	Miss K G P Manahari, BSc (SL)
Rubber Extension Officers	R M S Ratnayake, NDT Agric. (Hardy)
	D E P M Nanayakkara, Dip. Agric. (Aquinas)
	M Dharmadasa, BSc (SL), MSc (SL)
	E G U Dhanawardena (up to 10.03.2018)
	Nihal Gamage, Dip. Agric. (Angunakolapelessa)
	G D N Seneviratne (up to 07.09.2018)
	S G G Wijesinghe
	I P L Kithsiri
	W M A S L Wanigasuriya, Dip. Agric. (Aquinas) (up to 27.04.2018)
	N L Dharmasena (up to 22.12.2018)
	W P G D C P K Senanayake, NDT Agric. (Hardy)
	T L Ramanayake, BSc (SL)
	A R Kulathunga, BSc (SL)
	H G M G Jayasinghe, BSc (SL)

Rubber Extension Officers	K D K L Siriwardena, BSc (SL)
	S G Hewanambikanda, BSc (SL) (up to 28.06.2018)
	Miss K K I Jayasundera, BSc (SL)
	D S Dissanayake, BSc (SL)
	Mrs G R Tennakoon, BSc (SL)
Experimental Officer	S M A Samarakoon, Dip. Agric. (Kundasale)
Management Assistants (Clerical)	Mrs C Gunatilleke
	Mrs J N R Jayasinghe
	R G A S Dharmaratne
	Mrs S M Kaluarachchi
	T R C Silva
	Mrs K Y G M P Kumari, BA (SL)

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)
Research Officer	W D M Sampath, BSc (SL)
Experimental Officers	Mrs S I Yapa, Dip. Rubber Tech. (PRI) (up to 10.12.2018)
	S L G Ranjith, Dip. Rubber Tech. (PRI), BSc (SL)
	P L Perera (up to 24.01.2018)
	Mrs G M Priyanthi Perera, BSc (SL), MSc (SL)
Technical Officers (Research & Development)	V G M J Abeywardena, NDT
	Miss S G P Bhagayawedha, NDT
	K I D P Perera, BSc (SL)
	Miss P K I L Jayaratne, BSc (SL)
	P D A Gunasekera, BSc (SL) (up to 18.08.2018)
Management Assistant (Clerical)	Miss S M D S R de A Wijeratne

Polymer Chemistry *(at Telewela Road, Ratmalana)*

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

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 Officers	Mrs H V K Gamage
	Mrs C S Lokuge
	Miss D M S Wijesekera, Dip. Rubber Tech. (PRI)
	L P P Vitharana
Technical Officers (Research & Development)	Miss S P Wijewardena, BSc (SL)
	Miss N C Y Kithmini, BSc (SL)
	Miss M U D S Weerasinghe, BSc (SL)
	H D M S Wijewardena, BSc (SL)
	K A S T Koswatta, BSc (SL)
Management Assistant (Clerical)	Miss W D D Samanmali

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

Research Officer	Y C Y Sudusinghe, BSc (SL)
Experimental Officers	Mrs W K C Nalinie, Dip. Rubber Tech. (PRI)
	Mrs U M S Priyanka, BSc (SL), MSc (SL)
	Mrs V C Rohanadeepa
	A K D W Prasad
Technical Officers (Research & Development)	R D Illeperuma, BSc (SL)
	Miss P K N N Sandamali, BSc (SL)
	W R U de Silva, Dip. in Chem.
Management Assistants (Clerical)	Miss H A Janani Lakshika, BA (SL)
	Miss 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)
Experimental Officers	Mrs H K D C S Munasinghe, NCT Polymer (Moratuwa), Dip. Rubber Tech. (PRI), Dip. Computer Science (IDM)
	O V Abeyawardene, Dip. 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)
Research Officer	Mrs B M D C Balasooriya, BSc Agric (SL)

Technical Officer (Research & Development)	P M M Jayatilleke, NDT (Agric.) Mrs N M Piyasena, Dip. in Agric.
Management Assistant (Clerical)	Mrs M A Randima Srimalee
Agricultural Economics Unit	*(at Dartonfield, Agalawatta)*
Research Officers	J K S Sankalpa, BSc (SL), MSc (SL) Miss P G N Ishani, BSc Agric. (SL)
Library and Publications Unit	*(at Dartonfield, Agalawatta)*
Librarian & Publication Officer	Mrs N C D Wijesekara, BA (SL)
Library Assistant & Assistant Publication Officer	Mrs R M Amaratunga, Intermediate; Lib. Sci. Doc. & Info. (SLLA)
Library Assistant & Publication Assistant	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 C P Peiris, BSc (SL)
Administration Department (Agalawatta)	*(at Dartonfield, Agalawatta)*
Senior Administrative Officer	D M S Dissanayake, BSc (Mgt.) (SL), MHRM (SL)
Management Divisions	
Registered Medical Practitioner	M Subasinghe
Administrative Officer	Mrs P Mandalawatta (Dip. in HRM)
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
Management Assistant (Stenography)	Mrs J A H S Kumari
Telephone Operator	Mrs J A D C Preethika

Administration Unit (Ratmalana)	*(at Telewela Road, Ratmalana)*
Administrative Officer	Mrs U K Akila Tharinduni, BSc (SL)
Management Assistants (Clerical)	A T Senaratne
	Mrs A R M de Alwis
	Mrs K A Geetha, BA (SL)
Telephone Operator	Miss G D D Kalamini
Internal Audit Unit	*(at Dartonfield, Agalawatta)*
Internal Auditor	Mrs M S I Senadeera, IFA, IPFA, IRCA, LICA, FPFA, PGDM
Management Assistants (Clerical)	M A D W K Tilakeratne
	Mrs W L Sunali Shashikala, BA (SL)
Works Section	*(at Dartonfield, Agalawatta)*
Resident Engineer	K A D K Chathuranga, BSc (Eng.) (from 23.06.2018)
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 K C S Jayaweera
	Mrs J A S Dharshanie (Dip. in Management)
	Mrs K K D K P Ranaweera
	Mrs M S W H Kumari, BSc (SL)
	Udaya Samantha Munindradasa, BA (SL)
Accounts Section	*(at Dartonfield, Agalawatta)*
Senior Accountant	S S Hewage, CPFA (UK), CBA, FPFA
Accountant	Mrs A M Lasanthi, BSc (SL)
Management Assistants (Accounting)	Mrs R Handungoda
	Mrs G P Kukulewithana
Management Assistants (Clerical)	Mrs K J M C R Fernando
	Mrs C Dissanayake
	A K D A Wickremasinghe
	Mrs S I K Pathirage
	Mrs S A Niluka Harshani
	Mrs K K D Y L Ranaweera
	Miss K K T L Jayasekera
	Miss R P Thilini
	J A J R Lakmal, BA (Mgt.)
	K A Dilan Sampath
	Mrs Erandi Kanchana Jayasinghe, BA (SL)

Management Assistants (Clerical)	Mrs S R Sinhabahu
	Harith Kalutharawithana, BSc (SL)
	G N K Gunasena
	Mrs K G P Hasara
Cashier	Mrs G A D D Jayawardena
Kuruwita Sub-Station	*(at Kuruwita)*
Manager	S A R Samarasekera (up to 13.01.2018)
Management Assistants (Clerical)	D S Jayasinghe
	K D P Senaratne
Polgahawela Sub-Station	*(at Narampola Estate, Nungamuwa, Yatigaloluwa)*
Management Assistant (Accounting)	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	H D D Achinda
	M A N Sachith Pawinda
	T D Harsha
Field Officers (Nivitigalakele)	B M Siriwardena
	A G L Sadaruwan (w.e.f. 25.01 2018 up to 28.09.2018)

Awards

Presidential merit award in the "Chemistry" category was received for the patented mechano-chemical reclaiming process (Oreclaim) for ground rubber tyre developed using a natural product.

Dr. N.M.C. Nayanakantha, Head of Plant Science Department of RRISL, received an Award for the "Best Overall Oral Presenter" and "Session's Best Oral Presenter" for the paper entitled "Exogenous nitric oxide donor sodium nitroprussside improves growth and physiological attributes of rubber (*Hevea brasiliensis*) under abiotic stress conditions" presented in the Technical Session on "Agriculture and Sustainable Development" at the 5th International Conference on Agriculture (AGRICO), The International Institute of Knowledge Management, Colombo, 16-17th August, 2018.

Also, he received an Award for the "Session's Best Oral Presenter" and "Best Oral Presenter in the Plenary III" for the paper entitled "Priming with nitric oxide donor sodium nitroprusside enhances germination and storage life of recalcitrant rubber (*Hevea brasiliensis*) seeds" presented in the Technical Session on "Animal and Crop Production Technology" at the 2nd International Research Symposium, Uva Wellassa University, 1-3rd February, 2018.

List of Abbreviations

ANRPC	- Association for Natural Rubber Producing Countries
COP	- Cost of Production
CSD	- Civil Security Department
EU 28	- European Union Countries
GRT	- Ground Rubber Tyre
HP	- Hand Pollination
IPT	- Intake per Tapping
IRRDB	- International Rubber Research & Development Board
IRSG	- International Rubber Study Group
NR	- Natural Rubber
NIPM	- National Institute of Plantation Management
NSA	- Net Sale Average
PMI	- Purchasing Managers' Index
PRI	- Plastic Retention Index
REO	- Rubber Extension Officer
RSS	- Ribbed Smoked Sheets
SMR	- Synthetic Mixed Rubber
SR	- Synthetic Rubber
TOCOM	- Tokyo Commodity Exchange
TPD	- Tapping Panel Dryness
TSR	- Technically Specified Rubber
YPH	- Yield per Hectare

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

V H L Rodrigo

This review provides an overview of the local and international scenario of the rubber industry together with how research of the Rubber Research Institute of Sri Lanka (RRISL) has been geared to address the in-country issues. Since the details of research and development (R&D) activities conducted under each research division are provided in separate sections, this comprises only the major directions of research together with some highlights. Key obstacles for R&D are also mentioned very briefly. In addition to R&D, improvements made in administrative and financial functions of the Institute are stated.

Rubber industry of Sri Lanka

Rubber production

According to the statistics available at the Rubber Development Department (RDD) the natural rubber (NR) production of the country in 2018 was 82,560 tons showing about 1% decrease from the value recorded in 2017. Average yield per hectare was recorded as 774 kg/ha/year while it was 809 kg/ha/year in 2017. This could have attributed to the ignorance of rubber growers on on-farm activities associated with the decline in natural rubber price in the local market. Despite slight recovery of rubber prices in the year 2016, local and international rubber prices have shown a downward trend in the year 2017 and 2018. However, total NR consumption in the country has increased further reaching to a level of 135,237 tons showing about 5% improvement against the previous year. The rubber industry faces serious drawbacks in the supply side which may finally result in drastic effect on the flourishing rubber products manufacturing sector in the country.

Rubber extent

Total rubber extent in the country at the end of 2018 has been recorded as 136.9 thousand hectares with about 75-80% of the extent under tapping. Accordingly, there has been 0.6% increase of land under cultivation over the values recorded in the previous year. This could mainly be attributed to 1,800 ha of new planting.

NR exports and imports

According to Sri Lanka Customs, the country has exported only 13,982 tons of natural raw rubber in the year 2018 showing a decline from the value of 17,230 tons recorded in 2017. Imports of NR have increased by 6.9% to 76,100 tons from the value of 71,200 tons in 2017. However, synthetic rubber imports have decreased by

4.7% to a 62,691 tons. Accordingly, there was an increase in total rubber imports indicating the development of the rubber product industry in the country.

Rubber manufacturing sector

Earnings through raw rubber exports was Rs.5.1 billion in year 2018 against the Rs.5.9 billion in year 2017. Export earnings from finished products recorded a value of Rs.141 billion in 2018, showing an increase of about 11% against the previous year. Exports earnings from semi processed rubber remained at Rs.0.63 billion in 2018, while it was Rs.0.64 billion in the year 2017. Accordingly, total export earnings from the rubber industry remained at Rs.147.4 billion in 2018 showing 4.8% increase from the previous year.

Global rubber industry review

Natural rubber supply

Total world NR production has appreciated by 5% from 13,287 thousand tons in 2017 to 13,960 thousand tons in 2018, according to statistics of the Association of NR Producing Countries (ANRPC). This would have had some association with the price improvements shown during the mid of the year in the major markets in Asia Pacific region.

NR average yield

Despite a decline in yield per hectare recorded in Thailand, China, India, Cambodia, Vietnam and Sri Lanka, it has increased in Malaysia, Indonesia, and Philippine during 2018. The expansion in mature area in Thailand reflects the large scale planting undertaken during the period from year 2005 to 2012.

Global NR demand

Total NR demand was estimated as 14,017 thousand tons in 2018 showing 5.2% increase over the value recorded in previous year. This increase could be accounted to economic growth in China, and USA as recorded as 6.5% and 2.8%, respectively during the year in concern. Accordingly, a deficit of about 57,000 tons of NR was recorded; however, it has had no clear impact on the rubber price.

World NR price movement

Despite an increase in the year 2017, rubber price was generally in a declining trend in most of the international markets from 2011 to 2016. In 2018, this situation continued showing slight decrease in rubber price compared to the values recorded in 2017. In Sri Lanka, annual average RSS 3 price was US$ 2.20/kg in year 2017 and it decreased to US$ 1.84/kg in 2018. In Bangkok, average price of RSS 3 was recorded as US$ 2.03 and 1.56 in respective years. Average price of Indian RSS 4 has decreased to US$ 1.84 from US$ 2.09 per kg in the previous year. However in short term, global natural rubber prices are likely to appreciate due to stronger crude

oil prices, growth in rubber product industry, increase Chinese demand and change in the position of US dollar, according to the ANRPC predictions.

Research focus

Effect of the present crisis in the rubber price is more on rubber plantation industry in Sri Lanka. With low farm gate price for raw rubber and escalating cost of production particularly with high worker wages, farmers are reluctant to replant their senile rubber or going for new planting. There is a tendency to utilize rubber lands for other economic ventures in traditional growing areas and also a slow progress in expanding rubber cultivation in non-traditional areas. Therefore, research was focused more on resolving these issues than on research in academic interest. Research and development activities have targeted to increase not only the productivity of rubber but also the overall land productivity and farm income. Avenues for reducing the cost of production and efficient use of workers were at high level of consideration. Further, whilst supporting to expand rubber cultivation to new areas, projects were launched to remunerate the environmental benefits of rubber cultivation for the benefit of both rubber growers and product manufacturers. For instance, developing and adopting good agricultural practices, low frequency harvesting systems, farming systems and voluntary carbon market were in focus. Technology transfer was geared more on strategic manner demonstrating easily adopted technologies for productivity improvements and reducing cost of production. Developing new rubber based products, encouraging SMEs in product manufacture and facilitating local rubber product industries to be competitive in international market with adequate testing facilities, have been streamlined. Among the research highlights, scientists of RRISL were able to secure a presidential merit award in the chemistry category for the patented mechano-chemical reclaiming process (Oreclaim) for ground rubber tyre.

Further, reusable porous fertilizer tube was developed for immature rubber plants to achieve high level of fertilizer use efficiency.

Obstacles for research

Despite an appreciable level of research and development activities conducted with the support of all stakeholders, RRISL suffers from dearth of qualified senior scientists due to the fact that present remuneration packages are not attractive enough for such high caliber positions. Therefore, active involvement of all well-wishers of the rubber industry is expected to establish performance based remuneration packages to attract high caliber scientists to the institute.

Administrative and financial functions

Change in the Chairmanship and Board of Directors towards the end of year, affected the overall management system of the institute showing some delays in procurement procedures. However, expected performance levels were achieved to a greater extent by the end of the year. In view of improving the human resource available, both local and international trainings were provided to the employees,

particularly in research and technical categories in the institute. In total, 22 were sent abroad for the participation in Training programmes, Conferences and Workshops in the countries; *viz*. Cambodia, China, India, Indonesia, Ivory Coast, Malaysia and Thailand, whilst 17 attended in local programmes. Further, few recruitments (06) were also made.

In view of minimizing the errors and improving the efficiency in financial management, the accounting system in the institute was fully computerized. Also, payroll system was computerized with paying salaries through banks. The problems associated with unaccounted profits in the Provident fund were cleared and monthly based interest calculating procedure was introduced with the computerized accounting system.

Appreciations

In effective conduct in R&D, the guidance and directions together with financial support and patronages given by the Rubber Research Board and the Ministry of Plantation Industries are appreciated. Other stakeholder support received in conducting R&D activities is well respected. The contributions made by Deputy Directors, all Heads of scientific and non-scientific divisions and other staff towards the Annual Review are acknowledged. In particular, special appreciations are given to the Economic Unit for providing required data for this review and to the staff in the Library and Publication Unit for compiling the materials and finally building up the Annual Report 2018.

GENETICS AND PLANT BREEDING

S P Withanage

DETAILED REVIEW

Staff

Dr (Mrs) S P Withanage, Head of the Department, Mr K K Liyanage, Senior Research Officer, Mrs P V A Anushka, Mrs T T D Dahanayake, Research Officers, 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, Technical Officers and Mrs S D P K L Peiris, Management Assistant were on duty throughout the year. Mr K K Liyanage successfully completed the defense exam for his PhD on 30th November and graduated.

Technical Officers Miss W A D R Tharanga and Mrs Y S L Kumaranayake resigned from the service with effect from 23rd August and 31st August respectively.

Experimental Officer Mr I D M J Sarath Kumara retired from the service with effect from 4th October. His invaluable contribution to the RRISL and the rubber industry during past 36 years is greatly appreciated. He has always been a very dedicated and diligent officer of the department. His leadership and guidance to junior officers and experience always supported the department to perform the way to success. I wish him for his new chapter of life filled with good health, relaxation and fun on behalf of the Department.

Research students

Seven research students conducted their final year research projects under the supervision of Dr (Mrs) S P Withanage.

Name of the student	Title of the project	University
WADR Tharanga	Screening of microsatellite markers for early detection of *Corynespora* leaf fall disease resistance in rubber (*Hevea brasiliensis*) clones	University of Ruhuna
NS Gamage	Identification of high yielding genotypes of rubber (*Hevea brasiliensis*) at the early stage of their breeding cycle using rubber elongation factor (*Ref*) gene and promoter	University of Ruhuna
HANR Samindi	Analysis of the promoter region of the rubber elongation factor (Ref) gene of *Hevea brasiliensis* Muell. Arg. cv RRIC 121	University of Wayamba

Name of the student	Title of the project	University
DDSDZ Abeysiriwardana	Screening of drought tolerance in selected clones of *Hevea brasiliensis*	University of Wayamba
LHN Perera	Comparison of some key antioxidant gene expression between tapping panel dryness (TPD) affected and healthy rubber trees (*Hevea brasiliensis*)	University of Sabaragamuwa
KKT Mihiran	Detection of suitable yield parameters for early selection of high yielding *Hevea brasiliensis* (rubber) clones	University of Ruhuna
DDT Chamika	Assessment of soil moisture stress on three rubber (*Hevea brasiliensis*) clones of RRIM 600, RRISL 203 and RRIC 121	University of Jaffna

Seminars/Training Programmes/Workshops/Exhibitions conducted

The department staff provided the necessary training for the NIPM trainees, School teachers, undergraduate students and stakeholders of various categories and conducted following workshops during the year.

Officer/s	Subject/Theme	Date	Department
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	Bio red-Real-time PCR Workshop	19 February	Genetics and Plant Breeding Nivitigalakele
SP Withanage	Workshop on Gel Documentation System	24 February	Genetics and Plant Breeding Nivitigalakele
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	Workshop on Basic Molecular Techniques	27- 29 March	Genetics and Plant Breeding Nivitigalakele

Meetings/Seminars and Workshops attended

Officer/s	Subject/Theme	Date	Organization
SP Withanage KK Liyanage	Workshop on the Procurement Procedure	2nd February	RRB, Ratmalana
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	Technology Update	6th February	RRISL, Dartonfield

Officer/s	Subject/Theme	Date	Organization
SP Withanage	Seminar Frontiers Agrochical	12th February	Institute of Chemistry
	CARP/NCCIA* Meeting	23rd February	CARP/Colombo
	CARP/NCCIA* Meeting	20th April	CARP/Colombo
	Workshop on Quality Management	29th June	NIPM/Colombo
TTD Dahanayake	Board Meeting, Presentation made on 'Progress of Research 2018'	24th August	RRB, Ratmalana
KK Liyanage	Plant Breeders Meeting	29-30th August	Rubber Research Institute of Indonesia
	International Plant Protection Workshop on Integrated Disease Management in Rubber Plantation	31st July - 1st August	Palembang, Indonesia
SP Withanage	CARP/NCCIA* Meeting	31st August	CARP/Colombo
	CARP/NCCIA* Meeting	27th September	CARP/Colombo
PVA Anushka TTD Dahanayake	CATAS Project Meeting	28th September	MPI
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	Workshop on Statistical Applications in Socio-Economic Research	1st - 2nd October	RRISL, Agalawatta
SP Withanage KK Liyanage PVA Anushka TTD Dahanayake	Forum on Socio-Economic concerns in the Rubber Sector for Better Productivity	3th - 5th October	RRISL, Agalawatta
SP Withange	CARP/NCCIA* Meeting	7th December	CARP/Colombo
	CARP/NCCIA* Meeting	17th December	CARP/Colombo

Screening of selected *Hevea brasiliensis* (L.) genotypes from 2005 HP progeny for Corynespora leaf fall disease (CLF) resistance using Microsatellite Molecular markers

Six clones and 35 genotypes from 2005 HP progeny were screened with four polymorphic SSR molecular markers. The pairwise genetic distance matrix was developed using Power marker program V 3.25 and dendrogram was constructed by MEGA 6.06 programme. Two main clusters were produced. The clones RRIC 103, RRISL 201, PB 86 and RRIC 52 were grouped while grouping other groups into three subgroups. The CLF resistant clone RRIC 100 was clustered with eleven genotypes which showed field level CLF resistance. All these genotypes were selected for further CLF resistance screening in molecular and field level (S P Withanage, W A D R Tharanga and Y S L Kumaranayake).

Screening of new genotypes developed using the germplasm of Hevea obtained from 1981 IRRDB expedition to the Amazon (RRI/ECT collaborative trial 2011-Yatadola estate)

Ten genotypes selected from 1995 hybridization programme where non-Wickham clone GPS 1 was used as the male parent, were characterized. Fifteen Microsatellite molecular markers were screened, and three distinct groups were developed. Other parameters such as girth bark thickness, bole height, branching pattern and canopy density were also used in genotype screening. Tapping was started at the end of the year (S P Withanage, A K Gamage W A D R Tharanga and Y S L Kumaranayake).

Analysis of antioxidant gene expression in tapping panel dryness (TPD) affected rubber tree (Hevea brasiliensis Muell. Arg.) and the effect of exogenous application of Ascorbic acid on alleviating TPD

This was started with the objectives of studying the role of antioxidant genes on TPD and the effect of exogenous application of antioxidants on TPD affected rubber trees.

The latex protein profiles of some TPD affected and healthy rubber clones were analyzed using SDS-PAGE to identify potential protein markers for early detection of TPD susceptible trees. In the beginning, RRISL 2001 and RRIC 121 TPD affected and healthy trees were used for latex protein profile analysis. A protein band with around 35 kDa of size (Indicated in arrowheads in Fig. 1) was present in all the healthy tees but absent in all the TPD affected trees (Fig. 1). However, later analysis of latex protein profiles of different other clones (RRISL 217, RRISL 2100 and RRISL 2003) indicated that this protein band is not a reliable marker as it was present in both latex protein profiles of TPD affected and healthy trees of above clones.

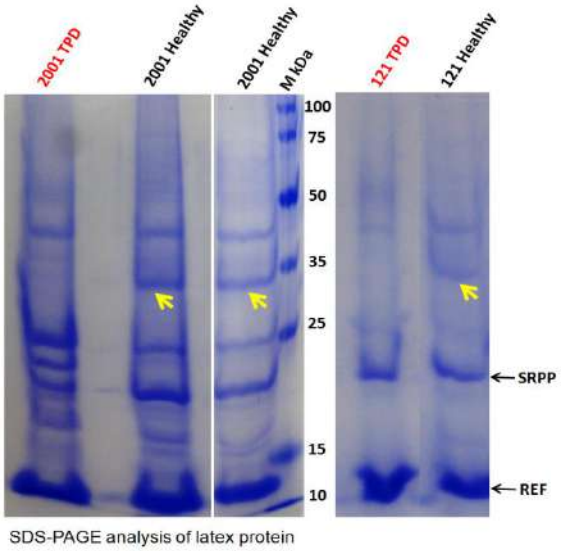


Fig. 1. The SDS-PAGE analysis of latex protein profiles from TPD affected and healthy clones. SRPP: small rubber particle protein, REF: rubber elongation factor, M: protein size marker

[S P Withanage (NST granted collaborative project – NSF/RG/2015/BT/01 with University of Sabaragamuwa)]

Ascorbic acid application of TPD affected trees

This experiment was repeated in different time periods. As rubber trees used for this study have already been established in the field, a pre-determined experimental design was impossible. Therefore, 15 trees each from eight clones (same age: 9 years of tapping, same girth, same tapping panel and same TPD severity) were randomly selected. Three concentration levels of ascorbic acid (5 mM, 10 mM, and 15 mM) were exogenously applied on tapping panels of TPD affected trees. All trees were tapped at S2d2 tapping system. TPD recovery observations were taken in the first experiment at Payagala and Eladuwa estates in 4^{th}, 5^{th} and 8^{th} week after starting the application of ascorbic acid and data were analyzed using analysis of variance and mean separation was done using Duncan's Multiple Range Test (DMRT) ($P < 0.05$). A positive response (TPD incidences) of exogenous application of ascorbic acid was observed in all clones at both sites. Compared to the control plants, all clones in both sites showed significantly different TPD recovery ($p < 0.05$) after ascorbic acid application. In the second experiment also, all the clones showed significantly different in mean TPD recovery with compared to their controls after

13^{th}, 15^{th} and 17^{th} weeks of exogenous application of ascorbic acid. But not clear differences among different concentrations and time durations of application indicating the antioxidant activity of exogenous application of ascorbic acid helps rubber trees to mitigate TPD severity (Table 1).

Table 1. *Duncan's Multiple Range Test values for the mean of TPD recovery with different concentrations of Ascorbic Acid application in registered and nonregistered clones at Payagala, Clyde and Nivitigalakele estates. Mean values without a letter in common are significantly different (P < 0.05)*

Site	Clone	Concentration	Mean TPD recovery		
			After 13^{th} week	After 15^{th} week	After 17^{th} week
Payagala	RRISL 2000	5mM	0.04^{a}	0.12^{a}	0.26^{a}
		10mM	0.04^{a}	0.07^{b}	0.25^{a}
		15mM	0.02^{b}	0.07^{b}	0.2^{a}
		Control	0.01^{b}	0.03^{c}	0.09^{b}
	RRIC 121	5mM	0.15^{a}	0.04^{a}	0.24^{a}
		10mM	0.12^{a}	0.19^{b}	0.3^{a}
		15mM	0.35^{x}	0.05^{b}	0.29^{a}
		Control	0.1^{a}	0.01^{c}	0.2^{b}
Clyde	RRISL 2003	5mM	0.06^{b}	0.15^{ab}	
		10mM	0.11^{b}	0.05^{b}	
		15mM	0.23^{a}	0.21^{a}	
		Control	0.04^{b}	0.05^{b}	
	RRISL 2000	5mM	0.16^{b}	0.16^{b}	
		10mM	0.23^{a}	0.15^{b}	
		15mM	0.23^{a}	0.23^{a}	
		Control	0.04^{b}	0.14^{b}	
Nivitigalakele	78HP-150	5mM	0.04^{a}	0.12^{a}	
		10mM	0.04^{a}	0.07^{b}	
		15mM	0.02^{ab}	0.07^{b}	
		Control	0.01^{b}	0.03^{c}	

(S P Withanage, B W A N Baddewithana, T M S K Gunasekara and Y S L Kumaranayake [(NST granted collaborative project - NSF/RG/2015/BT/01 with University of Sabaragamuwa)].

Functional analysis of the promoter sequence regions of the rubber elongation factor gene from *Hevea brasiliensis*

Rubber elongation factor (ref) gene is the key gene which is involved in rubber biosynthesis. REF protein is the major protein which is tightly bound to the

surface of large rubber particles in latex. It represents around 10-60% of the total protein in the whole latex but is absent in C-serum. However, it shows differential expression among clones of *H. brasiliensis.* The specific research objectives of this study are cloning and characterization of the distal promoter sequence of the rubber elongation factor gene from high yielding and low yielding *H. brasiliensis* clones and functional analysis of the promoter region of the ref gene. It has been observed that REF gene expressed differentially among rubber clones and the 377bp of REF promoter gene has isolated and transferred to the pCAMBIA 1391Z (11, 227 bp) vector to study the expression using GUS gene. The construct is ready to transfer to the rice callus through *Agrobacterium* mediator (S P Withanage and T T D Dahanayake [(CARP granted collaborative project -NARP/16/WUSL/APM/01 with Faculty of Plantation Management, Wayamba University and Department of Chemistry, University of Colombo)].

Hand pollination programme

The annual hand pollination programme was done at Neuchatle Estate. Three promising clones were used as female parents whereas, four clones, including one germplasm selection, were used as male parents with an aim to develop genetically diverse high yielding vigorous genotypes. Eight different crosses were carried out, and the pollination success was 2.3 per cent. The progeny size was eleven. Details of new genotypes and crosses made are given in Table 2.

Table 2. *Details of parentage and the number of genotypes obtained in 2018 hand pollination programme*

Cross	No. of genotypes obtained
RRISL 211 x RRISL 203	04
RRISL 2006 x RRISL 203	02
RRISL 2006 x Germplasm MT 11-76 (ii)	00
RRISL 211 x Germplasm MT 11-76 (ii)	04
RRISL 203 x RRISL 2005	00
RRISL 203 x RRISL 2006	00
RRISL 211 x RRISL 2006	01
RRISL 211 x RRISL 2005	00
Total	**11**

(S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, B W A N Baddewithana, I D M J Sarath Kumara and T M S K Gunasekara)

Developing the Hevea Breeding garden

An area of 2.88 ha was selected for establishing a *Hevea* breeding garden at Neuchatel estate. Rubber trees were trained by bending branches towards the ground for easy and safe access to flower inflorescences for future breeding programmes. Annual hand pollination programme was conducted with these trees in the year under review. Pruning and training of branches in selected trees were done (S P Withanage, K K Liyanage, P V A Anushka, I D M J Sarath Kumara, T M S K Gunasekara and B W A N Baddewithana).

Multilateral clone exchange programme

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 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 performance of all the exchanged clones in different agro-climatic conditions in the member countries.

In this year we have received five clones from Cote d'Ivoiry and budgrafted (Table 3). Overall twenty two foreign clones were established at bud wood nursery at Neuchatle Estate and the bed size was 20-25 plants in each clone. The twelve clones received from India, Myanmar and Thailand in last year, were prepared to test their adaptability and performances at large scale clonal trials. Fifty tree plots in each clone were designed to plant at Neuchatle estate and bud grafting is continued for further adaptability trials.

Table 3. *Details of clones received from Cote d'Iviory, number of grafts done and their bud grafting success*

Clones received	Number of bud grafts done	Number of success plants
IRCA 41	26	09
IRCA 230	33	11
IRCA 317	25	09
IRCA 331	24	11
IRCA 825	30	11

(S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, I D M J Sarath Kumara, T M S K Gunasekara and B W A N Baddewithana).

Evaluation of mother plant nursery

With an aim of early selection of best performing genotypes, five years old 2012 hand pollinated progeny was subjected to repeated evaluation. It was

characterized for yield parameters; girth, latex yield and bark thickness. Girth was measured in individual genotype at the height of 45 cm from the ground level and tapping was done at the same height. Morris- Mann tapping was processed during the cropping months (October – December). Latex from five consecutive tappings done at S2d3 was collected into a single tube and the dry weights were measured. Five such measurements were taken. Overall disease incidences, especially for Corynespora leaf fall disease were recorded with the help of Plant Pathology Department.

Twenty genotypes were selected from four categories by statistically analyzing the average yield and girth measurements (Table 4) for further bark anatomy analysis to develop a yield index based on characteristics of latex vessels.

Table 4. *Twenty genotypes selected from four categories of 2012 HP progeny for bark anatomy analysis*

	Category			
	High yield/high girth	**High yield/low girth**	**Low yield/high girth**	**Low yield/low girth**
2012 HP Genotype number	115,95,82,108,109	83,116,92,96,99	171,80,133,173,39	150,20,157,84

(S P Withanage, P V A Anushka, A K Gamage, B W A N Baddewithana and T M S K Gunasekara)

Evaluation of the previous hand pollinated (HP) progenies

Small Scale Clone Trials

The details of the small scale clone trials which were maintained and monitored during the year under review are given in Table 5. However, due to heavy rainfall received throughout the year, the yield data collection in most of the trials was not possible. However, Duncan's Multiple Range Test values for the mean girth, yield and bark thickness were taken where ever possible. Mean values without a letter in common are significantly different ($P < 0.05$).

Table 5. *Details of Small Scale Clone Trials*

HP year	**Site**	**Planting season**	**Current status**
2000	Delkeith IV & V	June 2003	8th year of tapping
	Elston VIII & IX	July 2003	8th year of tapping
2002	Pallegoda I	July 2007	5th Year of tapping
2002	Eladuwa II	May 2009	4th Year of tapping

HP year	Site	Planting season	Current status
2004	Eladuwa Trial I	July 2009	4th Year of tapping
2004	Neuchatel Trial II	Nov 2009	4th Year of tapping
2007	Kuruwita Substation (seedlings)	July 2009	3rd Year of tapping
1995	Yatadola	July 2011	3rd Year of tapping
2006	Payagala	July 2012	2nd Year of tapping
2005	Monaragala	Nov 2014	2nd Year of tapping
	Galewatta	May 2016	Immature
2008	Eladuwa	Nov 2016	Immature
2010	Eladuwa	Nov 2016	Immature
2011	Eladuwa	Oct 2018	Immature

(S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, I D M J Sarath Kumara, T B Dissanayake, H P Peiris, T M S K Gunasekara, A K Gamage, B W A N Baddewithana, W A D R Tharanga and Y S L Kumaranayake)

Evaluations at Dalkeith estate (GPB/BST/HPS/2000/04 and 05), Nivithigalakele substation (GPB/BST/HPS/2000/06 and 07) and Elston estate (GPB/BST/HPS/ 2000/08 and 09)

Dalkeith estate Trial IV (GPB/BS/HPS/2000/04)

In this trial, 112 genotypes derived from two families (RRIC 121 × PB 235 & PB 235 × RRIC 121) (56 from each family) had been planted in a completely randomized block design with three single tree plots per clone. Eighth-year yield data collection was done only for two months, and it was not analyzed. Fifteenth-year girth and bark thickness of individual genotype were given. Four genotypes with promising Latex- Timber properties were selected for bud wood nursery (Table 6).

Table 6. *Mean girth, yield and bark thicknesses of the best performing genotypes in trial IV at Dalkeith estate, planted in 2003*

Genotype	Mean girth of the fifteenth year (cm)	Mean bark thickness (mm)
2000HP-935	102^{a}	6.87
2000HP-585	101^{ab}	7.02
2000HP-875	96^{abc}	6.7
2000HP-568	93^{abcd}	9.85

(S P Withanage and A K Gamage)

Dalkeith estate Trial V, GPB/BST/HPS/2000/05

In this trial, 98 genotypes from two families [BPM 24 × PB 260 (53) and

RRIC 121 × PB 260 (45)] were planted in a completely randomized design with three single tree plots per clone. Eighth year yield data collection was done only for two months and it was not analyzed. Family means, of the fifteenth year girth and bark thickness of individual genotypes was analyzed. Two genotypes which would be promising for Latex- Timber purpose were selected for bud wood nursery (Table 7).

Table 7. *Mean girth, yield and bark thicknesses of the best performing genotypes in trial V at Dalkeith estate, planted in 2003*

Genotype	Mean girth of fifteenth year (cm)	Mean bark thickness (mm)
2000HP-1198	103[a]	9.22
2000HP-1141	93[b]	7.9

(S P Withanage and A K Gamage)

Evaluation of 2001 HP clones - Payagala estate (GPB/BST/HPS/2001/01) and Kuruwita Substation (GPB/BST/HPS/2001/02)

Due to poor support given by the estate, a decision was made to discontinue the 2001 HP trial at Payagala estate (GPB/BST/HPS/2001/01).

The mean girth of clones in 12th year were grouped using Duncan's multiple range test and topmost promising HP entries of Kuruwita substation are given in Table 8. Top-ranked HP entries in Kuruwita Substation had yielded from 37 g/t/t to 67 g/t/t.

Table 8. *Mean yield and girth of the best performing HP entries of the 2001 HP progeny planted in 2006 in Kuruwita Substation*

Kuruwita Sub-station		Kuruwita Sub-station	
Clone	**Yield (g/t/t)**	**Clone**	**Mean girth (cm)**
2001 HP-179	67[a]	2001HP-220	71.2[a]
RRIC121	56.5[ab]	RRIC 121	68.4[ab]
2001 HP-170	54.4[abc]	2001HP-185	66.4[abc]
2001 HP-220	53.8[abc]	2001HP-179	63.4[abcd]
2001 HP -185	52.9[abc]	HP 205	61.9[bcde]
2001 HP -227	45.1[abcd]	RRISL 203	61.6[bcde]
2001HP- 89	39.6[bcd]	2001HP-183	61.3[bcde]
RRISL203	38.9[bcd]	2001HP-207	60.7[bcde]
2001-164	38.4[bcd]	2001HP-227	60.2[bcdef]
2001-205	37.2[bcd]	2001HP-89	59.2[bcdef]

(P V A Anushka, S P Withanage, T M S K Gunasekara and H P Peiris)

Evaluation of 2002 HP clones

Pallegoda estate (GPB/BST/HPS/2002/01)

Eleventh-year girth measurements were taken and the mean girth of clones were grouped using Duncan's multiple range test, and the results are given in Table 9. Genotype 2002-18 has performed better in comparison to control clone RRISL 203.

Table 9. *Mean girth of best performing HP entries selected from the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002-18	72^{a}
RRISL 203	71.1^{ab}
2002-96	70.9^{ab}
2002-14	68.5^{abc}
2002-17	68.2^{abc}
2002-11	67.6^{abc}
2002-24	65.2^{bcd}
2002-86	63.8^{cde}
RRIC121	63.7^{cde}
2002-69	63.0^{cdef}

(P V A Anushka, S P Withanage, K K Liyanage and B W A N Baddewitana)

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. Randomized Block Design was used with four replicates per genotype. Replicate size was six. Ninth year girth was taken at the height of 150 cm from the bud union and mean girth values are shown in Table 10. Although third year yield data collection was started, only two test tapings (January & February) were possible. However, according to the available data, genotype 2002 HP-138 recorded the highest yield around 72.6 g/t/t and the second highest was around 56.4 g/t/t in genotype 2002 HP-30. However, the yield of reference clones RRIC 121 and RRISL 203 were recorded 48.7 g/t/t and 22.4 g/t/t respectively (Table 10).

Table 10. *Mean girth of best performing HP entries control clones selected from the 2000 HP progeny planted in 2009 at Eladuwa*

Clone	Mean girth (cm)	Mean yield (g/t/t)*
2002HP-138	78.6	72.6
2002HP-66	69.7	54.1
2002HP-30	66	56.4
2002HP-93	64.2	40
RRIC121	62.4	48.7
2002HP-139	62.2	24
2002HP-9	59.7	46.1
2002HP-19	58.2	46.2
2002HP-62	54.3	48.6
2002-78	53.9	30.2
RRISL 203	53.3	22.4

*Average of two test tappings

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

Evaluation of 2004 HP clones

Twenty-two genotypes from 2004 hand pollination progeny had been planted in two trials at Eladuwa estate and Nuechatle estate in the year 2009. RRIC 121 was used as the control clone in Eladuwa estate and RRISL 203 and PB 260 were used as control clones in Nuechattle estate. A randomized block design was used with four replicates per genotype.

Neuchatle estate trial I (GPB/BST/HPS/2004/01)

This trail has shown a poor growth performance during the past few years even under good agronomic practices. Possibly it might be owing to substandard ground conditions. Thus, the decision was taken to terminate the trial (P V A Anushka, S P Withanage and I D M J Sarath Kumara).

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

The eighth-year girth was taken. The HP entry 2004-347 showed significantly higher girth and five entries were ranked above the clone RRIC 121 (Table 11).

Table 11. *Mean girth for 8th year of the best performing HP-entries selected from the 2004 HP- progeny planted at Eladuwa estate*

Clone	Mean girth (cm)
2004-347	55.9[a]
2004-107	55.9[a]
2004-48	55.1[ab]
2004-190	54.2[abc]
2004-228	54.1[abc]
RRIC 121	53.8[abcd]
2004-320	53.3[abcde]
2004-50	51.8[abcde]
2004-164	50.9[bcde]
2004-456	49.5[cdef]

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

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

Tenth-year girth data were collected for the seedling progeny and family means are given in Table 12. Family RRIC 130 x GP 1-2 recorded the highest girth. The third-year tapping data were also collected from the above progeny, and family means are given in Table 13. Family IAN 45/710 x PB 260 recorded the highest yield (g/t/t).

Table 12. *Family mean girth of 2007 HP - progeny at the Kuruwita Substation planted in 2008*

Clone	Mean girth (cm)
RRIC 130 x GP 1-2	65.0[a]
RRIC 130 x GP 22- 137	63.6[a]
RRIC 130 x GP 21 - 163	63.4[a]
PB260 x IAN 45/710	59.2[a]
RRIC 130 x GP 10 -154	59.0[a]
IAN 45/710 x PB 260	59.0[a]
RRIC 130 x GP 44 - 24	51.5[a]

Table 13. *Family mean yield of 2007 seedling HP progeny planted in 2008*

Clone	Yield (g/t/t)
RRIC 130 x GP 44 - 24	30.70[a]
IAN 45/710 x PB 260	38.59[a]
PB260 x IAN 45/710	34.53[a]
RRIC 130 x GP 22- 137	34.51[a]
RRIC 130 x GP 10 -154	30.48[a]
RRIC 130 x GP 21 - 163	27.24[a]
RRIC 130 x GP 1-2	15.30[a]

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

Evaluation of 2005 HP progeny planted in 2014 at Monaragala GPB/BST/HPS/2005/01 and 2016 at Galewatta GPB/BST/HPS/2005/02

Thirty-five genotypes from 2005 hand pollination progeny which was raised by double selfing of *Corynespora* susceptible clone RRIC 103, were established at Monaragala Substation with control clones RRIC 100, RRIC 103, RRIC 52, PB 86 and RRISL 201. A complete randomized block design was used with 10 replicates per genotype. Screening of genotypes against *Corynespora* leaf fall disease was conducted with the help of Plant Pathology and Microbiology Department. Fourth-year girth and *Corynespora* screening were not done due to unavoidable reasons. However, plants were prepared to fill the vacancies and routine maintenance was done (S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake and W A D R Tharanga).

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 Eladuwa estate in complete randomized block design with control clones, RRIC 121 and RRISL 2001. All agronomical practices such as weeding, manuaring, off shoots removing *etc*. were done according to RRISL recommendations. First year girth was taken and mean girth values of best performing six genotypes are given in Table 14 with the control clones.

Table 14. *Mean girth for 1st year for HP-entries of best performing six genotypes with their control clones of the 2004 HP- progeny planted at Eladuwa estate*

Clone	Girth (cm)
2010HP38	8.6 [a]
2010HP9	8.6[a]
2010HP44	8[ab]
2010HP25	7.8[ab]
2010HP42	7. 6[ab]
2010HP22	7.3[abc]
RRIC 121	7.3[abc]
RRISL 2001	5.1[de]

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

Evaluation of 2008 HP progeny planted in 2016 at Eladuwa GPB/BST/HPS/2008/02

Eighteen genotypes selected from 2008 progeny were planted in Eladuwa estate in a complete randomized block design with control clones PB 28/59, RRIC 121 and RRIC 100. The trial was terminated due to poor establishment rate and the vacancies were filled with RRISL 203 clone (S P Withanage, P V A Anushka, T T D Dahanayake, K K Liyanage and W A D R Tharanga).

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

Annual girth measurements were taken from all the trials. Table 15a (registered clones) and 15b (unregistered clones) show the girth measurements at five feet height for the year under review and for the previous two years and the planting sites.

Table 15a. *Mean annual girth measurements for registered clones of ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Mean girth (cm)		
			2016	2017	2018
RRISL 201	Dammeria B	2010	33.2	43.4	46.1
RRISL 203	Monaragala	2009	44.6	47.0	50.0
	Wewassa	2011	32.6	46.4	49.8
	Lagos	2011	47.1	53.2	56.4
	Muwankanda	2010	43.4	48.5	49.0
	Dammeria B	2010	34.2	39.4	40.2
	Kamburupitiya (University)	2011	52.2	58.5	61.6

Clone	Site	Year of planting	Mean girth (cm)		
			2016	2017	2018
RRISL 208	Dartonfield	1994	77.2	76.9	78.6
	Lagos	2013	31.8	40.2	48.7
	Moralioya	2010	49.1	NT	56.7
	Dammeria B	2010	30.0	37.1	NT
	Eladuwa	2009			64.2
RRISL 210	Payagala	2006	63.5	64.6	67.1
RRISL 211	Dartonfield	1994	75.4	79.0	78.9
RRISL 212	Kuruwita	2006	56.7	57.8	-
RRISL 214	Kuruwita	2006	51.7	53.1	-
RRISL 216	Dartonfield	1994	79.6	79.6	82.7
RRISL 219	Dartonfield	1994	85.9	89.3	-
	Kuruwita	2008	49.1	50.6	52.5
RRISL 2000	Kuruwita	2005	66.9	69.1	71.3
RRISL 2001	Dammeria B	2010	46.6	52.7	55.7
	Muwankanda	2010	45.5	52.2	55.0
	Dammeria B (Hanipe Dev.)	2011	34.6	53.7	-
	Lagos	2013	30.1	40.3	49.5
RRISL 2003	Lagos	2013	35.2	43.7	51.1
RRISL 2006	Lagos	2013	25.3	33.3	42.1
	Monaragala	2009	50.3	53.1	57.4
	Eladuwa	2009	-	55.3	57.5
	Moralioya*	2010	Not Taken		59.3
RRISL 2100	Monaragala	2009	52.1	53.6	57.0
	Edalla	2010	51.5	52.8	54.0
	Kuruwita	2011	41.8	47.9	50.8
RRISL Centennial 3	Kuruwita	2009	57.9	57.4	58.0
	Monaragala*	2009	47.2	49.61	53.2
	Eladuwa	2010	59.9	60.3	64.2
	We-oya	2010	52.7	55.7	57.4
	Edalla	2010	55.6	57.4	59.8
	Kuruwita	2010	46.4	53.2	56.5
	Siriniwasa	2011	-	56.9	58,8
	Lagos	2013	33.3	45.0	55.8
RRISL Centennial 4					
	Kuruwita	2007	55.1	56.5	57.6
	Eladuwa	2009	52.0	53.4	54.8
	Monaragala	2009	51.0	52.7	56.0
	Lagos	2011	46.1	53.8	58.6
RRISL Centennial 5	Eladuwa	2009	52.8	56.1	59.7
	Kuruwita	2007	57.7	59.9	62.5

Table 15b. *Mean annual girth measurements of un-registered 2004- entries selected to ECTs (Estate/RRISL Collaborative Trials)*

Clone	Site	Year of planting	Girth in cm		
			2016	2017	2018
86-10	Kuruwita	2009	46.7	48.0	50.4
86-87	Kuruwita	2009	49.9	-	53.5
87-235	Kuruwita	2008	47.0	50.0	53.8
	Kuruwita	2007	55.9	57.5	59.5
95-33	Kuruwita	2004	-	-	-
95-55	Kuruwita	2004	-	-	-
95-55	Lagos	2013	30.6	43.4	56.1
GP 12-93	Kuruwita	2006	55.1	56.2	-
RRIC 100 seedlings	Kuruwita	2005	66.5	68.9	71.0

(S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, I D M J Sarath Kumara, T B Dissanayake, H P Peiris, T M S K Gunasekara, A K Gamage, B W A N Baddewithana, W A D R Tharanga and Y S L Kumaranayake)

Yield of ECTs (Estate/RRISL Collaborative Trial) - GPB/BST/ECT/95/01

The average estate yields obtained from ECT trials are given in Table 16.

Table 16. *Average yield (g/t/t) and the percentage of BB of the clones in 14th year of tapping, of ECT trials at Galewatta*

Clone/Selected HP- entry	Average (g/t/t)	Current BB %
RRISL 208	60.85	52
RRISL 211 (S2/d2) *	77.26	20
RRISL 211 (S2/d3) *	77.45	16
RRISL 216	45.9	12
RRISL 219	38.88	11

(S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, I D M J Sarath Kumara, T B Dissanayake, T M S K Gunasekara, H P Peiris, A K Gamage, B W A N Baddewithana, W A D R Tharanga and Y S L Kumaranayake)

Screening of new genotypes developed using the germplasm of Hevea obtained from 1981 IRRDB expedition to the Amazon (RRI/ECT collaborative trial 2011- Yatadola estate)

Ten genotypes selected from 1995 hybridization programme where non-Wickham clone GPS 1 was used as the male parent, were characterized. Fifteen

Microsatellite molecular markers were screened and three distingue groups were developed.

All six clones and 35 genotypes from 2005 HP progeny were screened with four polymorphic SSR molecular markers. A pairwise genetic distance matrix was developed using Power marker program V 3.25 and dendrogram was constructed by MEGA 6.06 programme. Two main clusters were produced. The clones RRIC 103, RRISL 201, PB 86 and RRIC 52 were grouped together while grouping other groups into three subgroups. The CLF resistant clone RRIC 100 was grouped with eleven genotypes which showed field level CLF resistance. All these genotypes were selected for further CLF resistance screening in molecular and field level. Tapping was started and yield data collection was done twice a month, plot-wise (S P Withanage, A K Gamage W A D R Tharanga and Y S L Kumaranayake).

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

Multiplication and evaluation of the genotypes collection of Hevea obtained from 1981 IRRDB expedition to the Amazon (under new development proposal for Annual budget 2014 - GPB/GP-NC)

Multiplication/Establishment and scientific evaluation of the *Hevea* germplasm collection was started with the aim of enhancing productivity through genetic improvement and management of genetic resources of *Hevea.* Around 1400 accessions were planted at Nivitigalakele Substation and some accessions are ready to establish in bud wood nurseries at Neuchatel estate. Land preparation was started for establishment.

Accessions which are subjected to preliminary characterization under different categories such as early and late wintering, high girth, dwarf, tall and smooth bark are used to prepare the experimental material for further gene expression studies (S P Withanage, K K Liyanage, P V A Anushka, T T D Dahanayake, I D M J Sarath Kumara, B W A N Baddewithana and T M S K Gunasekara).

Testing of promising clones for sub-optimal conditions

Objectives of the project are, evaluation of adaptability and performance of new promising clones in non-traditional rubber growing areas (sub-optimal conditions). All trails are conducted as RRI/smallholder collaborative manner.

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

Seven experimental plots were established at Padiyathalawa/Maha Oya 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 17.

Table 17. *Details of smallholder/RRI collaborative trials at Eastern Province and sixth year mean girth data*

Trial	Smallholder Location	Agro-climatic 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 RRISL 203 RRISL 2005 RRISL 2006	43.5 38.9 42.5 36.4
SRT-EP 12/2	Indrani Kusumalatha Marawa Padiyathalawa	IL2	>1600	RRISL 203 RRIC 121 RRISL 2001 RRISL 2006	54.0 49.8 51.2 46.5
SRT-EP 12/3	AM Sumanawathi Helakomana Padiyathalawa	IL2	> 1600	RRISL 203 RRIC 100 RRISL 2005 RRISL 208	43.1 40.5 44.2 35.8
SRT- EP12/4	HM Wimalasena Kudaharasgala Mahaoya	IL2	> 1600	RRISL 208 RRISL 2005 RRIC 100 RRISL 203	41.6 44.0 40.4 38.0
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 RRISL211 RRISL 2005	56.2 54.4 58.2 62.1 54.0 53.9 54.7 55.1

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

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

Planting

Five experimental plots were established in Ampara area in the Eastern Province. However, two trials were terminated due to poor support received from the smallholders (Table 18).

Table 18. *Details of smallholder/RRI collaborative clone trials planted in 2013 in the Eastern Province and fourth year mean girth data*

Trial	Smallholder and Location	Agro-climatic Region	75% expectancy-value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)
SRT-EP 13/1	HM Jayarathna 17-1 C Lathugala Warankatagoda	DL2a	> 1300	RRIC 121 (210)	34.5
SRT-EP 13/4	HM Saman Kumara 17/1 B Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	33.5
SRT-EP 13/5	M Chandrani Ranasingha 51 B - 2 Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	29.0

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

Smallholder/RRI collaborative clone trials – Eastern Province established 2014

Details of four experimental plots that were established in Mahaoya area, with three RRISL 2000 series clones and clone RRIC 121 in October 2014 are given in Table 19 with their fourth year mean girth.

Table 19. *Details of smallholder/RRI collaborative clone trials planted in 2014 in the Eastern Province and fourth year mean girth data*

Trial	Smallholder and Location	Agro-climatic Region	75% expectancy-value of Annual Rainfall (mm)	Clones planted	Mean girth (cm)
SRT-EP 14/1	G Senevirathne Mahaoya	IL2	>1600	RRIC 121	25.2
SRT-EP 14/2	M Senevirathne Mahaoya	IL2	> 1600	RRISL 2001	22.6
SRT-EP 14/3	A M Jayasekara Mahaoya	IL2	>1600	RRISL 2006	25.4
SRT-EP 14/4	T M Amarasena Mahaoya	IL2	>1600	RRISL 2005	25.5

(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 Bibile area in collaboration with the World Vision Organization. Girth data were taken and given in Table 20. One trial was established in Kataragama. Girth data on the first year was taken and details are given in Table 21. In Kataragama trial, the majority of the first-year plants are destroyed due to the heavy dry spell and all the damaged plants were replaced again in 2018.

Table 20. *Details of smallholder/RRI collaborative clone trials planted in 2015 in Uva Province and second year mean girth data*

Trial	Smallholder & Location	Agro-climatic Region	75% expectancy-value of Annual Rainfall (mm)	Clones & the number of plants	Mean girth (cm)
Bibile (collaborate with World Vision)					
SRT-UP 15/1-WV	HM Punchibanda Ilukpathana	IL1c	>1300	RRISL 2001(215)	14.5
SRT-UP 15/2-WV	AM Karunawathie Ilukpathana	IL1c	>1300	RRISL 2001(215)	11.1
SRT-UP 15/3-WV	HMW Wijekumara Kudumirisketiya Ilukpathana	IL1c	>1300	RRISL 2001 (430)	14.4

Table 21. *Details of smallholder/RRI collaborative clone trials planted in 2016 in Uva Province and first year mean girth data*

Trial	Smallholder & Location	Agro-climatic 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)	7.8 8.9

(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 Polonnaruwa district and details are given in Table 22.

Table 22. *Details of smallholder/RRI collaborative clone trials planted in 2015 in North Central Province and second year mean girth data*

Trial	Smallholder and Location	Agro-climatic Region	75% expectancy-value of Annual Rainfall (mm)	Clones planted	Girth (One and half year) (cm)
SRT-NCP 15/1	Army camp Kandakaduwa Polonnaruwa	DL1c	>900	RRISL 2001 (500) RRISL 2006 (500)	13.5 9.0

(S P Withanage, K K Liyanage, P V A Anushka and T B Dissanayake**)**

Terminations

All three experimental trials established in Matale district were terminated due to the poor support given by the smallholders and due to improper management practices, especially in weeding (T T D Dahanayake, S P Withanage, P V A Anushka and T B Dissanayake).

PLANT SCIENCE

N M C Nayanakantha

DETAILED REVIEW

Staff

Dr N M C Nayanakantha, Head of the Department, Mr T U K Silva, Senior Research Officer, Mrs D S A Nakandala, Research Officer, Mrs G A S Wijesekera, Mrs R K Samarasekara, Mr M N de Alwis, 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 de Z Dissanayake, Miss W K S W Watawala, Miss H Subasinghe, Mr D Priyadarshana and Mrs N Udayakumari, Technical Officers, Mrs D E Jayawardena and Mrs P D A H M A de Almeida, Management Assistants were on duty throughout the year.

Resignation & Retirements:

Miss S S Panditharathna, Research Officer, resigned from RRISL with effect from 12.10.2018.

Research students

- Ms K D L Kumudu Kumari, Eastern University of Sri Lanka, conducted her final year research project on "Effect of sowing media on budgrafting and budded plant performance of rubber (*Hevea brasiliensis*) under nursery conditions" under the supervision of Dr N M C Nayanakantha.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Biotechnology	01	Research staff of RRISL	NMC Nayanakantha
Plantation Crop Production Technology (a new subject stream to GCE A/L) for 13 years continuous education	04	School teachers	NMC Nayanakantha
Induction Course (Plantation Crop Management)	01	School leavers	NMC Nayanakantha

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Rubber nursery management, immature upkeep and tapping	01	CEOs and Directors of Regional Plantation Companies	NMC Nayanakantha
Rubber cultivation and tapping	01	Officers of Plantation Management and Monitoring Department, MPI	NMC Nayanakantha
Tapping	11	Managers, Field staff and tappers of RPC's University students NIPM students Agricultural Diploma students Rubber Development Officers Smallholders	NMC Nayanakantha W Karunathilaka
Rubber based farming systems	03	Rubber Extension Officers School leavers (Induction course) Diploma students of NIPM	TUK Silva
Nursery management and field establishment	02	Field staff of Horana Plantation	MN de Alwis
Rain guard	05	Field staff and workers of Talgaswala estate, Mohomadi estate, Peenkanda estate, Elston estate, Agricultural Diploma students	W Karunathilaka
Tapping	01	Managers, Field staff and tappers of RPC's	RK Samarasekera W Karunathilaka

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
NMC Nayanakantha	2nd International Research Symposium	Uva Wellassa University, Badulla
	National Symposium on Sustainable Plantation Management	National Institute of Plantation Management, Athurugiriya
	5th International Conference on Agriculture (AGRICOS)	The International Institute of Knowledge Management, Colombo
	SLCARP International Agricultural Symposium	Sri Lanka Council for Agricultural Research Policy, Colombo
	Postgraduate Institute of Science Research Congress (RESCON)	University of Peradeniya, Peradeniya
	Workshop on National Agricultural Research System (NARS)	University of Peradeniya, Peradeniya
	Quality Management System (QMS)	National Institute of Plantation Management, Athurugiriya
	Training programme on leadership and capacity building for young rubber industry professionals	Ministry of Industry and Commerce
	Meeting on Natural Resources Management	Department of Agriculture, Gannoruwa
	Meeting with a group of Chinese representatives from Chinese Academy of Tropical Agricultural Sciences (CATAS)	Rubber Secretariat
	Meeting with a group of Chinese representatives from Sinoshine Company	Rubber Secretariat
	Progress Review Meeting	Ministry of Plantation Industries
	TEC Meetings for purchase of polybags for government nurseries	Rubber Development Department
	TEC Meetings for purchase of utensils for Thurusaviya Societies	Thurusaviya Fund

Officer	Subject	Organization
TUK Silva	Fruit Exhibition	Fruit research and development Institute, Kananvila, Horana
	Agtech 2018 Exhibition	University of Peradeniya, Sub-Campus, Mahailuppallama
TUK Silva DSA Nakandala	Workshop on effective writing of research papers	Sri Lanka Council for Agricultural Research Policy, Colombo
	International Work shop on Statistical Application and Forum on Socio-economic Issues	Jointly organized by IRRDB and RRISL
DSA Nakandala	TEC meetings for installation of micro-irrigation systems in RDD nursery, Padiyathalawa	Rubber Development Department
	IRRDB Fellowship training	Jointly organized by IRRDB and FIRCA, Cote d'Ivoire
	International Rubber Conference	Jointly organized by IRRDB and FIRCA, Cote d'Ivoire
DSA Nakandala EUM De Z Dissanayaka N Udayakumari	Biotechnology	RRISL Substation, Nivitigalakelle

Services

Testing the quality of polythene

Polybag samples from all government rubber nurseries were checked for quality and specifications. Polythene samples for rainguards were also checked for specifications in order to select bidders (N M C Nayanakantha, W Karunathilaka and P Seneviratne).

Supplying of marking plates

About 124 marking plates (d2 and d3) were issued to stakeholders (N M C Nayanakantha and W Karunathilaka).

Issuing authentic budwood

About 1600 meters of bud wood were issued to some departments of RRISL and for nurseries belong to RPCs (N M C Nayanakantha and R Handapangoda).

Sl. No.	Department/Estate	No. of bud wood issued (m)
1	Genetics and Plant Breeding Dept., RRISL	300
2	Plant Pathology and Microbiology Department, RRISL	300
3	Parambe estate	500
4	Atala estate	500

Nursery inspection

Government, RPC and Private nurseries were inspected and details are given in Tables 13, 14 & 15 (N M C Nayanakantha, B M S S Panditharathna, M N de Alwis, L N de Zoysa and R Handapangoda).

Visits

Advisory	-	42
Experimental	-	402
Nursery inspection	-	47
Total	-	491

LABORATORY INVESTIGATIONS

Tissue culture

No lab work was done during the period. BOQs were prepared and drawings were made for the renovation of the Tissue Culture Laboratory under the special capital project No. 22.01.17 (N M C Nayanakantha, D S A Nakandala and P Seneviratne).

FIELD EXPERIMENTS

An assessment on the vulnerability of *Hevea* seed production to climate change (CC/2003/1)

Wintering and flowering (CC/2003/1/a)

Wintering and flowering were observed in 26 clones at five estates and one smallholder field during the period. Majority of the clones completed wintering during 3rd week of February (N M C Nayanakantha and P D Pathirana).

Seed production (CC/2003/1/b)

Observations on seed production weremade for 26 clones during July-August. Poor seed production was recorded in all the sites due to unfavourable weather conditions and *Phytophthora* pod rot disease (N M C Nayanakantha and P D Pathirana).

Investigation on alternative and cost effective sowing media for river sand for germination of rubber seeds

This experiment was established in 2017. Rubber seeds were sown in different sowing media as shown below according to a randomized complete block design (RCBD) at Gurugoda nursery;

Control : River sand
Treatment 1 : Elephant dung (dried)
Treatment 2 : Coir dust (leached)
Treatment 3 : Rubber wood chips
Treatment 4 : River sand + Coir dust (leached) (1:1)
Treatment 5 : Rubber wood saw dust
Treatment 6 : River sand + Purified sea sand (1:1)
Treatment 7 : Gravel
Treatment 8 : Quarry dust (fine)
Treatment 9 : Purified sea sand

Germinated seeds were transplanted in to polybags filled with top soil and arranged in a nursery according to a randomized complete block design (RCBD). There were 50 plants (replicates) for each treatment. Growth and physiological attributes of seedlings *viz.*, stem height, stem diameter, number of leaves, leaf area, dry weight of roots and shoots were recorded after 12 weeks from transplanting (Tables 1 & 2).

Table 1. *Growth of seedlings after 12 weeks of transplanting into polybags*

Treatments	Stem height (cm)	Stem diameter (mm)	No. of leaves	Leaf area (cm^2)
Control	68.0±5.3	8.1±0.2	9.6±0.3	966.3±71.7
1	78.4±2.6	7.7±0.2	10.3±0.3	1187.6±195.4
2	68.6±5.2	7.5±0.4	9.4±0.6	941.2±113.9
3	69.2±1.8	7.3±0.1	9.0±0.6	836.0±47.4
4	70.8±4.2	7.8±0.3	8.8±0.6	900.1±68.9
5	75.4±1.9	7.9±0.3	9.2±0.7	1052.2±107.8
6	79.5±2.5	7.6±0.4	9.9±0.1	1010.5±52.1
7	78.6±2.6	7.5±0.4	11.1±0.4	1190.6±68.7
8	73.6±2.1	7.6±0.4	8.7±0.6	963.8 ±94.9
9	75.3±3.6	8.2±0.7	9.7±0.4	1018.8±16.4

Table 2. *Dry weight of shoots and roots of seedlings after 12 weeks of transplanting into polybags*

Treatments	Dry weight (g)			
	Shoot	**Tap root**	**ESR + SR**	**Total roots**
Control	9.5±1.4	2.4±0.2	1.2±0.3	3.6±0.3
1	11.9±1.6	3.0±0.2	1.1±0.2	4.1±0.4
2	8.3±1.5	2.3 ±0.5	1.1±0.2	3.4±0.6
3	9.3±2.0	2.3±0.2	1.2±0.1	3.5±0.2
4	11.1±1.9	3.3±0.2	1.4±0.3	4.7±0.5
5	10.3±1.0	3.1±0.5	1.7±0.3	4.8±0.6
6	12.1±1.6	3.2±0.3	1.5±0.2	4.7±0.3
7	11.6 ±1.8	3.2±0.1	1.4±0.2	4.6±0.3
8	12.5±1.9	2.8±0.3	1.3±0.1	4.1±0.3
9	9.2±1.9	3.6±0.5	1.7±0.2	5.3±0.4

ESR: Early secondary roots, SR: Secondary roots

(N M C Nayanakantha, B M S S Panditharathna and E U M De Z Dissanayaka)

Experiments were conducted with some selected sowing media as shown below in Gurugoda and Middeniya nurseries in 2018;

Control : River sand
Treatment 1 : Coir dust (leached)
Treatment 2 : Rubber wood saw dust
Treatment 3 : Elephant dung (dried)
Treatment 4 : Rubber wood chips
Treatment 5 : Purified sea sand

24,000 seeds were used for each experimental trial. Seeds were sown in germination beds according to a randomized complete block design (RCBD). Each treatment had 4000 seeds. Germination percentage was recorded at 12, 16 and 20 days after sowing and results are presented in Figures 1 & 2.

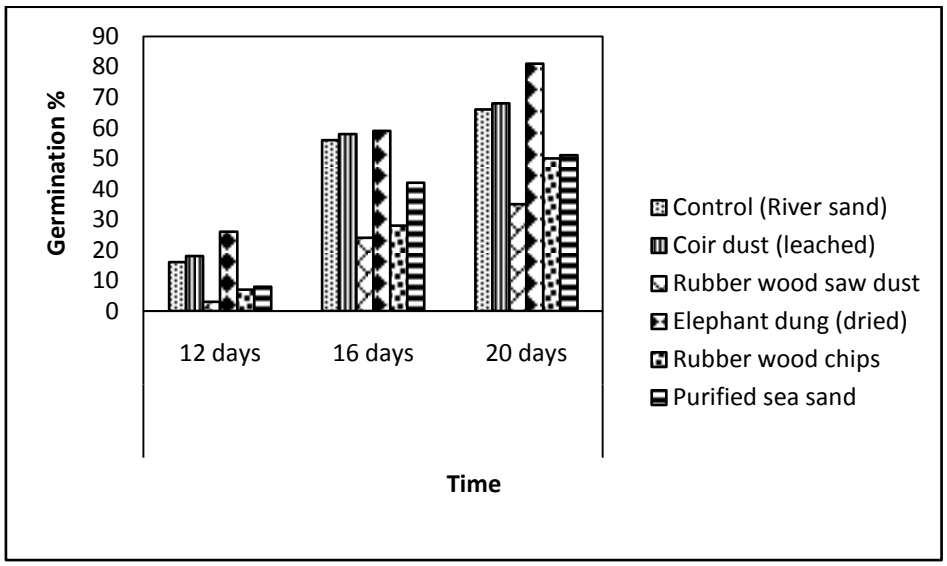


Fig.1. Effect of sowing media on germination of rubber (*Hevea brasiliensis*) seeds at Gurugoda nursery

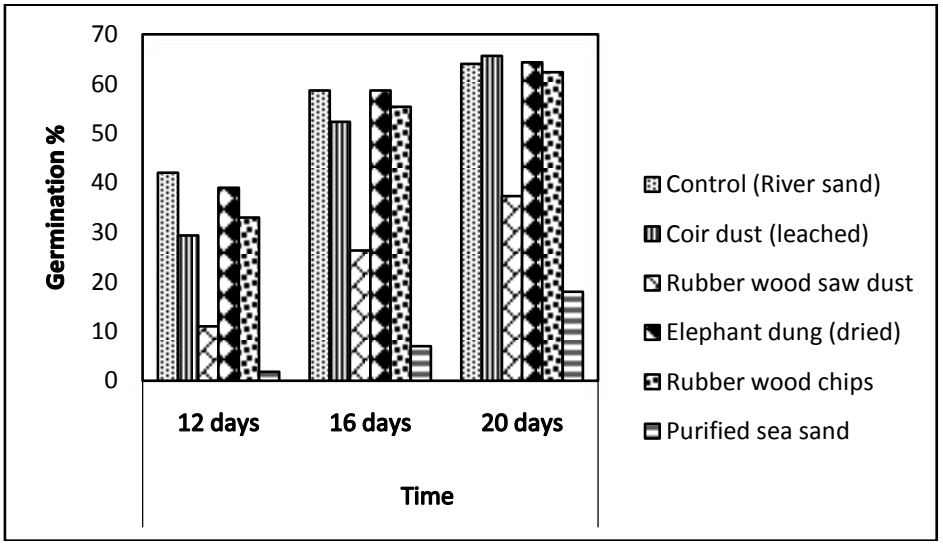


Fig. 2. Effect of sowing media on germination of rubber (*Hevea brasiliensis*) seeds at Middeniya nursery

After three weeks of sowing, a satisfactory germination was recorded from seeds sown in elephant dung and coir dust as compared to river sand. Seedlings were transplanted into polybags filled with top soil and arranged in a nursery according to a randomized complete block design (RCBD). There were 80 plants (replicates) for each treatment. Growth and physiological attributes of seedlings *viz.*, stem height, stem diameter, number of leaves, chlorophyll content, leaf area, dry weight of shoots, dry weight of tap roots and total roots, were recorded after 12 weeks from transplanting (N M C Nayanakantha, B M S S Panditharathna and E U M De Z Dissanayaka).

Effect of elephant dung as a sowing media on germination of rubber seeds

Another experimental trial was established with elephant dung as a sowing medium in comparison with river sand at Gurugoda and Middeniya nurseries. The objective of this trial was to investigate on the occurrence of fungal infections on seeds. Elephant dung was brought from Elephant Orphanage, Pinnawala. About 15,000 seeds were used for each nursery. 20 liters of fungicide solution of Captan (3g/liter) was prepared and was poured on germination beds in each nursery as a treatment. Control beds were left without fungicide treatment. Germination percentage was recorded at 12, 16 and 20 days after sowing (Tables 3 & 4).

Table 3. *Effect of elephant dung on germination of rubber seeds at Gurugoda nursery*

Treatment No.	Treatment	Germination %		
		After 12 days	After 16 days	After 20 days
T1	Elephant dung treated with fungicide	20	50	74
T2	Elephant dung devoid of fungicide treatment	18	52	75
T3	River sand (control)	17	57	66

Table 4. *Effect of elephant dung on germination of rubber seeds at Middeniya nursery*

Treatment No.	Treatment	Germination %		
		After 12 days	After 16 days	After 20 days
T1	Elephant dung treated with fungicide	39	55	67
T2	Elephant dung devoid of fungicide treatment	35	50	64
T3	River sand (control)	41	59	63

Fungal infections were not recorded in seeds sown on elephant dung treated with Captan or devoid of Captan treatment after three weeks of sowing. No

differences were recorded in germination percentages of seeds sown in elephant dung treated with Captan or devoid of Captan treatment. Germinated seed were transplanted into polybags filled with top soil and arranged in a nursery according to a randomized complete block design (RCBD). There were 250 plants (replicates) for each treatment. Growth and physiological parameters of seedling *viz.,* stem height, stem diameter, number of leaves, chlorophyll content, leaf area, dry weight of shoots, and total roots were recorded after 12 weeks from transplanting (N M C Nayanakantha, B M S S Panditharathna and E U M De Z Dissanayaka).

Priming of rubber seeds for improved germination dynamics, seedling and budded plant attributes and tolerance to abiotic stresses

Seeds were treated with chemicals such as Polyethylene Glycol (PEG), Thiourea and Zinc sulphate ($ZnSO_4$) at different concentrations as follows for 24 hours. Also, seeds were treated with banana or Sooriya (*Thespesia populnea*) leaf extract solutions at 10 and 15% concentrations for 24 hours. Next, seeds were kept under shade in an open area for 24 hours and stored in a room under dark at room temperature. Seeds were sown in germination beds at 0, 7 and 14 days of storage.

T1: Control
T2: Water
T3: PEG (5%)
T4: PEG (10%)
T5: Thiourea (5%)
T6: Thiourea (10%)
T7: $ZnSO_4$ (1%)
T8: $ZnSO_4$ (2%)

No satisfactory germination percentage was recorded from seeds irrespective of treatments even after 21 days of sowing and hence the experiment was planned to repeat with a new set of seeds and different treatments in 2019 (N M C Nayanakantha, B M S Panditharathna and U N Udayakumari).

Evaluation of clonal seedling (CS) populations for their rooting attributes and growth performance for better tolerance to abiotic stress conditions (CS/2013/DF)

Seeds were collected from 8 clones as follows and were established in a germination bed filled with sand in September 2017. Seedlings were transplanted into polybags and their growth parameters were recorded after 4 months. Seedlings were budgrafted with RRISL 203. Growth attributes of budded plants were recorded after 3 and 6 months of budgrafting (Tables 5 & 6).

Control	RRIC 100
T1	RRISL 226
T2	RRISL 206
T3	RRISL 201
T4	RRISL 217
T5	RRISL 2006
T6	PB 260
T7	RRIC 102

Table 5. *Shoot attributes of seedlings after 4 months*

Treatment	Stem height (cm)	Stem diameter (mm)	No. of leaves	Chlorophyll content (SPAD value)	Budgrafting %
Control	67.5±1.9	6.9±0.2	8.8±0.3	49.7±1.0	54.2
1	59.5±1.6	6.0±0.2	7.5±0.5	51.4±2.7	52.9
2	57.3±2.0	6.4±0.2	7.4±0.5	50.8±1.7	39.1
3	66.5±1.9	6.3±0.1	7.9±0.4	53.2±1.5	68.8
4	64.5±2.5	6.7±0.2	9.4±0.4	55.9±1.7	59.3
5	77.5±2.5	7.2±0.1	10.0±0.4	52.2±1.0	57.7
6	70.8±1.9	7.0±0.1	7.8±0.4	49.7±1.9	34.3
7	64.1±1.7	6.9±0.1	8.1±0.3	48.4±1.8	45.7

Table 6. *Budded plant attributes after 3 & 6 months*

Treatment	After 3 months		After 6 months	
	Shoot height (cm)	Shoot angle	Shoot height (cm)	Shoot diameter (mm)
Control	30.5±1.9	23.3±1.3	68.1±4.1	12±0.1
1	25.6±4.9	23.0±3.4	53.9±6.3	11±0.1
2	31.0±0.5	20.0±1.1	66.8±9.2	11±0.0
3	23.5± 2.7	20.6±2.0	67.1± 4.5	11±0.0
4	17.6±4.8	14.2±2.1	72.0±7.1	11±0.1
5	23.1±4.9	19.2±2.9	70.7±6.9	12±0.1
6	31.0±3.8	22.7±2.0	78.5±5.9	12±0.1
7	21.4±5.6	19.2±2.3	65.8±7.1	10±0.1

(N M C Nayanakantha, B M S S Panditharathna, G A S Wijesekera, U N Udayakumari)

Another experimental trial was conducted with seeds of following clones in August 2018. Seeds were sown in a germination bed filled with sand. Seedlings were transplanted into polybags. Growth attributes of seedlings were recorded after 5 months from transplanting.

Control : RRIC 100
T1 : RRISL 201
T2 : RRIC 117
T3 : RRISL 226
T4 : RRISL 2005
T5 : RRISL217
T6 : RRISL203
T7 : RRISL 2000
T8 : RRIC 121
T9 : RRIC 133

Table 7. *Shoot and root attributes of seedlings after 5 months of transplanting into polybags*

Treatments	Stem height (cm)	Stem diameter (mm)	Number of leaves	Dry weight of shoots(g)	Dry weight of roots(g)
Control	82.2±2.5	8±0.3	8.8±1.2	11.0±1.1	5.1±0.5
1	69.3±10.5	8±0.7	9.8±1.3	10.6±1.4	4.9±0.8
2	90.2±4.4	8±0.4	10.0±1.0	13.3±1.5	5.2±0.5
3	85.6±6.8	9±0.9	12.0±1.9	10.6±1.9	5.2±0.4
4	88.6±3.0	8±0.2	9.8±1.3	12.3±1.9	4.2±0.3
5	69.4±5.8	6±0.2	5.8±0.8	6.2±0.8	2.6±0.3
6	78.2±4.1	8±0.7	9.2±1.0	7.9±2.0	4.1±1.0
7	83.8±3.6	8±0.2	8.2±0.8	10.7±0.7	4.7±0.5
8	80.6±4.6	8±0.9	9.0±1.3	9.4±0.8	3.6±0.4
9	76.8±3.7	7±0.5	12.0±0.7	8.5±0.2	3.5±0.2

This experiment was terminated due to construction of a new plant house in the nursery area and the results obtained are required to be analyzed for any conclusion (N M C Nayanakantha, B M S Panditharathna, G A S Wijesekara and U N Udayakumari).

Investigation on the effect of height of germination bed on growth and root architecture of rubber seedlings

This experiment was commenced in 2017 to study the effect of height of germination bed on growth and root characteristics of rubber seedlings. The treatments were;

Control - 5cm
T1 - 10cm
T2 - 15cm
T3 - 30cm

Seeds were sown in germination beds of different heights. Seedlings were transplanted into polybags, arranged in a RCBD in a nursery. Budgrafting percentage of seedlings and budded plant attributes are shown in Table 8.

Table 8. *Budgrafting percentage and budded plant attributes*

Treatments	Budgrafting %	Growth attributes after 2 months		Growth attributes after 7 months	
		Shoot height (cm)	Shoot angle	Shoot height (cm)	Shoot diameter (mm)
Control	58.5	10.6±2.8	27.8±3.3	62.2±3.0	11±0.4
1	67.5	10.7±1.9	21.9±2.3	62.0±3.2	11±0.4
2	76.6	9.1±2.2	19.0±2.6	62.1±2.8	12±0.3
3	66.0	19.0±2.4	26.6±1.9	68.4±2.9	11±0.3

(N M C Nayanakantha, B M S S Panditharathna, G A S Wijesekara, U N Udayakumari)

Effect of polybag colour/material/size on growth of seedlings

An experiment was commenced in the rubber nursery, Egaloya, to investigate on the effect of polybag size on growth of seedlings. The objective of this study was to minimize the soil usage, material cost and optimize the polybag size while arresting the heat stress.

Effect of polybag size on growth of seedlings

Different polybag sizes were tested as depicted in Table 9. Germinated seeds were transplanted into polybags filled with top soil and arranged in a nursery according to a randomized complete block design (RCBD). There were 65 plants (replicates) for each treatment. Growth and physiological attributes of seedlings *viz*., stem height, stem diameter, number of leaves, chlorophyll content, leaf area, dry

weight of total roots and shoots were recorded after 12 weeks from transplanting (Tables 10 & 11).

Table 9. *Sizes of polybags used*

Treatments	Size of poly bag	Soil volume (cm^3)
control	6" x 15"	6629.5
1	3" x 15"	1657.4
2	4" x 13"	2553.6
3	4" x 15"	2946.4
4	5" x 13"	3990.0
5	5" x 15"	4603.8
6	6" x 13"	5745.5

Table 10. *Growth of seedlings after 12 weeks from transplanting into polybags*

Treatments	No.of leaves	Stem height (cm)	Stem diameter (mm)	Length of tap root (cm)	Leaf area (cm^2)
Control	13.2±1.1	83.9±5.2	9.0±0.7	34.4±1.1	1350.5±212.4
1	11.2±1.0	73.2±2.4	8.2±0.4	44.2±5.3	889.1±116.9
2	11.1± 1.1	68.7±4.5	7.8±0.4	37.6±1.2	843.1±126.4
3	12.4±1.6	80.9±4.8	8.1±0.5	41.1±3.2	1120.4±174.1
4	11.1±1.0	76.5± 4.0	8.2±0.4	36.2±1.8	949.0±142.6
5	10.2±1.2	82.2± 4.8	9.1±0.4	35.8±4.9	1135.5±240.2
6	10.3±0.7	73.9±3.4	8.3±0.3	42.0±3.7	988.9±136.2

Table 11. *Dry weight of shoots and roots of seedlings after 12 weeks from transplanting into polybags*

Treatments	Dry weight (g)			
	Shoot	Tap root	ESR + SR	Total roots
Control	11.7±1.0	3.5±0.3	1.3±0.2	4.8±0.3
1	8.5±0.8	3.2±0.4	0.8±0.1	4.0±0.4
2	8.2±0.7	2.9±0.4	0.8±0.1	3.7±0.4
3	10.4±1.1	4.1± 0.4	1.6±0.2	5.7±0.5
4	10.0±0.9	3.9±0.3	1.0±0.1	4.9±0.3
5	11.4±1.0	3.9±0.6	1.2±0.1	5.1±0.6
6	10.3±1.1	3.6±0.3	1.2±0.2	4.8±0.4

(N M C Nayanakantha, B M S S Panditharathna and E U M de Z Dissanayake)

Vegetative propagation of elite mature individuals - (CP/2001/2) - Dartonfield

The plant of the elite tree of clone 28/59 (Udabage) showed a satisfactory girth increment (16.1 cm) at a height of 120 cm. Plants of both elite seedlings of Nahalla and Dapiligoda did not show a satisfactory girth increment when compared to the control (RRISL 2001) trees (P Seneviratne and G A S Wijesekera).

Bud grafting

Rejuvenation of budwood plants - Egaloya Nursery

General maintenance was done for the plants produced from 19 successive graftings and established at Galewatta (P Seneviratne and G A S Wijesekera).

Irrigation systems for rubber nurseries

Drip and Sprinkler irrigation systems were designed for the RDD nursery at Padiyathalawa. A drip irrigation system was designed for 6ha of immature rubber field and a sprinkler irrigation system was designed for 4ha of the young budding nursery.

Micro-irrigation systems for immature rubber fields in the Dry Zone

Mini sprinkler or spray jet and drip irrigation systems are micro irrigation systems widely used for irrigating crops. Growth of immature rubber plants in the Dry Zone under micro-irrigation conditions was studied. The objective was to test different soil moisture depletion levels under drip and mini sprinkler or spray jet systems and to investigate on physiological and morphological parameters of immature rubber plants.

Morphological responses

Two micro irrigation systems (drip and spray jet) were tested under three levels of depletion as 30, 50 and 70% throughout the immature period of rubber. Table 12 shows the variation in morphological characters of rubber plants of eight months old in response to different depletion levels over two micro irrigation systems after three months of commencing irrigation.

Higher depletion levels (*i.e.* 50% and 70%) resulted in incorporation of drought stress to plants and therefore, a significantly ($p \leq 0.05$) low plant growth was recorded under such depletion levels.

Table 12. *Morphological characters of rubber plants under different depletion levels and two micro irrigation systems at eight months*

Type	Depletion level	Stem diameter (mm)	Stem height (cm)	Leaf area (cm^2)	Leaf count
Drip	30%	20.6±0.49[a]	141.0±9.30[a]	2862.5±581.29[a]	43.8±0.21[a]
	50%	17.5±0.51[b]	120.0 ±6.93[b]	2027.6±182.79[b]	38.7±0.22[b]
	70%	15.5±0.50[a]	110.9±8.59[b]	1368.1±82.72[c]	24.4±0.25[c]
Spray jet	30%	21.6±0.58[a]	183.9±9.11[a]	2532.8±372.68[a]	39.6±0.25[a]
	50%	16.5±0.64[b]	100.1±5.62[b]	2367.5±487.15[b]	32.7±0.22[b]
	70%	14.0±0.65[c]	95.1±6.94[b]	1559.1±222.39[c]	25.1±0.11[c]

(Means with the same letter along the column is not significantly different at 0.05 probability level)

Physiological responses

Figure 3 shows the variation of chlorophyll content in eight- months old rubber plants under drip and spray jet irrigation conditions at different depletion levels. Figure 4 shows the variation in stomatal conductance of plants at different temperatures.

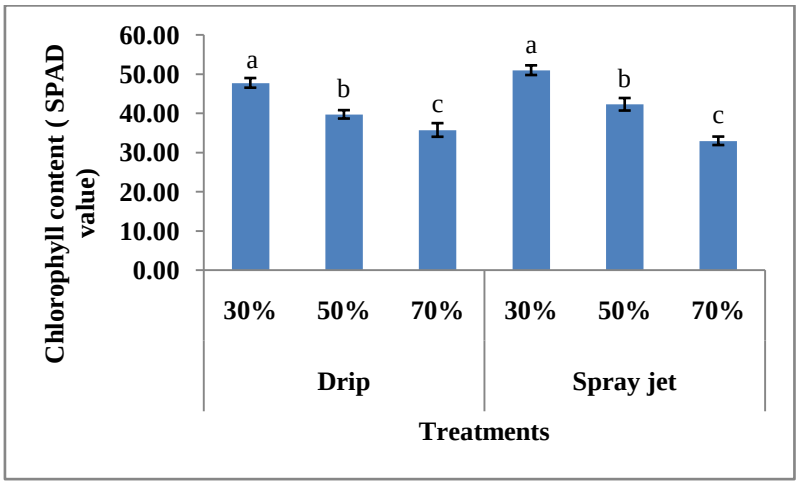


Fig. 3. Chlorophyll content of immature rubber plants at the age of eight months under irrigated conditions at different depletion levels of 30, 50 and 70% (Means with the same letter are not significantly different)

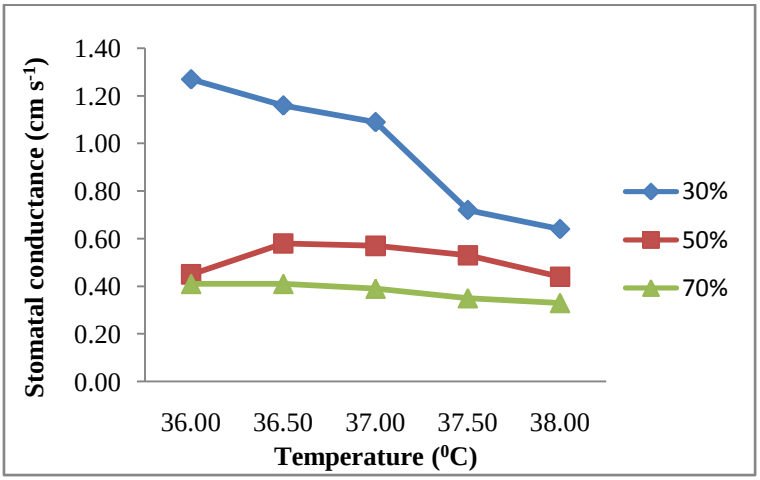


Fig. 4.Variation in stomatal conductance of plants at different temperatures

Results revealed that irrigation scheduling at 30% depletion level enhances the growth of immature rubber plants under micro-irrigated conditions (D S A Nakandala, M N de Alwis and D L N de Zoysa).

Budwood nurseries

BN/2008/Dolahena, BN/2012/DF, BN/2014/Gallewatta, BN/2017/Olikanda and BN/2017DF

Bud wood nurseries at Dolahena, Dartonfield, Olikanda and Gallewatta were regularly maintained. Weeding, manuaring, pollarding and application of fungicide were done. Authentic bud wood sticks (1600m) were issued from Olikanda and Gallewatta nurseries for other departments of RRISL during the year (N M C Nayanakantha, P Seneviratne and R Handapangoda).

Budwood nursery for clone identification purposes (2010/DF)

Pollarding and regular maintenance were done (N M C Nayanakantha and L N de Zoysa).

Monitoring and certification of rubber plants

Monitoring and certification of rubber plants in Government, RPCs' and Private nurseries were done during the year and details are given in Tables 13, 14 & 15.

Table 13. *Details of RPC nurseries established in 2018*

Regional Plantation Company	No. of estates having nurseries	No. of nurseries for the RPCs	No. of plants established in 2018	No. of plants certified as Y.B. in 2018
Kelanivalley	03	03	28,700	138,000
Kegalle	06	07	66,000	16,000
Kotagala	01	01	5,000	-
Pussellawa	01	01	10,000	-
Namunukula	02	03	32,000	2,500
JEDB	01	02	200,000	-
Balangoda	-	-	-	2,000
Total	**14**	**17**	**341,700**	**158,500**

Table 14. *Details of government nurseries established in August 2017, January 2018 and August 2018*

Name of the nursery	Season	No. of plants established	No. of plants certified
Egaloya	2017 Aug.	151,000	7,000
	2018 Jan.	300,000	-
	2018 Aug.	331,000	-
Gurugoda	2017 Aug.	123,000	40,000
	2018 Jan.	210,000	-
	2018 Aug.	241,000	-
Karapincha	2017 Aug.	100,000	40,000
	2018 Jan.	100,000	45,000
	2018 Aug.	125,000	-
Meerigama	2017 Aug.	150,000	41,000
Welikadamulla	2017 Aug.	300,000	145,000
	2018 Jan.	317,000	-
	2018 Aug.	417,000	-
Middeniya	2017 Aug.	100,000	34,000
	2018 Jan.	101,855	-
	2018 Aug.	92,000	-
Moneragala	2017 Aug.	350,000	120,000
	2018 Jan.	329,000	120,000
	2018 Aug.	333,000	-
Padiyathalawa	2017 Aug.	-	-
	2018 Jan.	88,000	30,000
	2018 Aug.	54,000	-
Grand Total		4,312,100	685,000

Table 15. *Details of private nurseries established in 2018*

Region	No. of nurseries	No. of plants established	No. of plants certified
Kegalle	12	172,000	-
Ratnapura	05	135,000	32,000
Total	17	307,000	32,000

(N M C Nayanakantha, M N de Alwis, D L N de Zoysa and R Handapangoda)

Planting techniques

Stumped buddings experiment (SB/2016/Moneragala)

This field was established at Moneragala Substation in November 2016. Weak plants below 10 cm girth were replaced after two years with special types of plants (whole plants with root boles in poly bags, 10 plants) and recommended stumped budded plants (control, 35 plants) in November 2018. Girth data were recorded at three months intervals and annual girth data are shown in Table 16.

Table 16. *Girth of plants under different planting materials*

Treatments	Girth (cm)	Girth increment (cm)
Whole plants with root boles	11.1±0.5	4.8±0.3
Stumpedbudded plants (control)	10.8±0.4	4.2±0.3
Normal plants (remaining plants in the field)	13.9±0.3	6.9±0.2

Performances of clones PB 86 and RRIC 100

Weeding, manuaring and other agronomic practices were done as per recommendations of RRISL. Girth data of two clones are given in Table 17.

Table 17. *Mean girth of two clones after four years*

Clone	Average girth (cm)
PB 86	38.2±0.76
RRIC 100	45.3±0.49

(P Seneviratne and R Handapangoda)

Study on growth, morphological characters and grafting success of rubber clones in different Agro- climatic Zones of Sri Lanka

RRIC 121 recorded the highest growth and number of usable buds followed by RRISL 2001 and RRISL 203. The lowest girth was recorded in RRIC 102 followed by RRISL 217 in bud wood nurseries established in Egaloya and Ampara. RRIC 121 showed the highest budgrafting success in Moneragala, whilst

RRIC 102 showed the highest budgraftinng success in Egaloya and PB 260 in Ampara. Nevertheless, RRISL 203 ranked the lowest for the same attribute in Moneragala whilst RRIC 100 in Ampara and Egaloya respectively (N M C Nayanakantha, P Seneviratne and R Handapangoda).

Northern Province Planting

Kilinochchi (PT/2015/Kilinochchi)

Growth data were recorded in plants of three clones *viz.*, RRIC 121, RRISL 203 and RRISL 2001 and results are shown in Table 18.

Table 18. *Mean annual girth after 3 years of planting*

Clone	Girth (cm)
RRIC 121	13.9± 0.5
RRISL 203	13.2 ± 0.5
RRISL 2001	12.9 ± 0.4

(N M C Nayanakantha, M N de Alwis and D L N de Zoysa)

Kilinochchi (PT/2017/Kilinochchi)

Experimental fields established in 2017 were maintained and data were recorded (Table 19).

Table 19. *Details of the experimental fields and girth of plants*

Farmer's Name	Extent (Acre)	Spacing	Clone	No. of plants	Girth (cm)
Ashokan	¾	2.5mx7.75m	RRIC 121 RRIC 102	160	5.5± 0.4
J. Kumar	¾	2.5m x 7.75m	RRIC 121	160	6.3± 0.5
Kirubaharan	2	2.5m x 7.75m 3.0 mx4.50m	RRIC 121 RRIC 102 RRIC 100 RRISL 203	365	4.4± 0.5
Parameshwaran	1	2.5m x 7.75m	RRIC 121	210	6.5± 0.3

(N M C Nayanakantha, D S A Nakandala, B M S S Panditharathna, M N de Alwis and D L N de Zoysa)

Kilinochchi (PT/2018/Kilinochchi)

A new experimental trial was established in four farmer fields in Kilinochchi with the objective of selecting a suitable planting material. Young budded plants at two leaf whorl and four leaf whorl stages and under different spacing systems were

established. Details of the experimental fields and annual mean girth are shown in Table 20.

Table 20. *Details of the experimental fields and mean girth*

Farmer's Name	Extent (Acre)	Spacing	Clone	No. of plants	Mean girth (cm)
Ravichandran	¾	2.5m x 7.75m	RRIC 121	160	3.8± 0.4
Subramanium	¾	2.5m x 7.75m	RRIC 121	160	3.8± 0.4
Padmanadan	1½	2.5m x 7.75m	RRIC 121	300	3.6± 0.2
Shashie	1	2.5m x 7.75m	RRIC 121	200	3.3± 0.3
Priyadarshani	½	2.5m x 7.75m	RRIC 121	110	3.4± 0.4

(N M C Nayanakantha, D S A Nakandala, M N de Alwis and D L N de Zoysa)

Cultural practices during immature phase

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

Table 21 shows growth and yield parameters of the clones tested under four different densities. Girth of trees decreased significantly with increase in planting density. Bark thickness did not vary among the treatments. The individual tree yield (g/t/t) decreased gradually with increase in planting density. The percentage trees in tapping are more or less similar among the treatments tested. No significant differences were recorded for YPH values among densities.

Table 21. *Effect of planting density on growth and yield parameters of rubber (a): Girth of trees (cm) and thickness of bark (mm) at 150cm height, (b:) yield of trees (g/t/t) and estimated YPH (kg/ha/year)*

(a)

Density	RRIC 100				RRIC 121			
	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha	Girth (cm)	BT (mm)	% Trees in tapping	Tappable trees/ha
500	77.7	11.5	54.6	273	92.5	11.6	49.1	246
600	78.9	11.4	51.0	306	86.1	10.8	59.2	355
700	70.6	11.0	47.9	335	82.0	11.4	52.6	369
800	71.0	11.6	51.0	408	79.5	10.4	50.4	403

(b)

Density (tree/ha)	RRIC 100		RRIC 121	
	Yield (g/t/t)	Yield (kg/ha/yr)	Yield (g/t/t)	Yield (kg/ha/yr)
500	43.1	1225	58.2	1460
600	50.6	1601	34.8	1313
700	28.6	933	45.4	1580
800	25.4	1032	31.0	1271

(T U K Silva, V H L Rodrigo and H Subasinghe)

Low density trial at Gallawatta and Nivithigalakele - 2012

Mean girth of trees of RRISL 2001 was higher than RRISL 203 at both spacings and locations (Galewatta and Nivithigalakelle) (Tables 22 & 23). In Gallewatta, test tappings were done and data were recorded in terms of g/t/t and YPH with four treatments (Table 24). In N'kelle, test tappings were done at D/2 and D/3 frequencies (Table 25).

Table 22. *Mean girth of trees of rubber clones at different densities at Gallewatta*

Clone	No. of tappable trees	Spacing	Mean girth (cm)
RRISL 2001	135	14'x15'	53.9 ±0.65
RRISL 203	242	14'x15'	53.7 ±0.60
RRISL 2001	205	16'x16'	53.6 ±0.69
RRISL 203	272	16'x16'	51.5 ±0.51

Table 23. *Mean girth of rubber clones at low density at Nivithigalakelle*

Clone	No. of tappable trees	Spacing	Mean girth (cm)
RRISL 2001	192	16'x16'	49.3±0.44
RRISL 203	272	16'x16'	49.2±0.39

Table 24. *Mean g/t/t and YPH values of rubber clones at different densities at Gallewatta*

Clone	Spacing	Assessment	Values
RRISL 2001	14'x15'	g/t/t	33.1
		YPH	2,318.1
RRISL 203	14'x15'	g/t/t	42.8
		YPH	2,996.1
RRISL 2001	16'x16'	g/t/t	37.3
		YPH	2,612.3
RRISL 203	16'x16'	g/t/t	47.7
		YPH	3,337.7

Table 25. *Mean g/t/t and YPH values of rubber clones at low density at Nivithigalakelle*

Clone	Assessment	D /2	D/3
RRISL 203	g/t/t	29.2	35.9
	YPH	2,040.4	1,651.4
RRISL 2001	g/t/t	27.7	31.8
	YPH	1,940.9	1,461.1

(P Seneviratne, N M C Nayanakantha and R Handapangoda)

Low density trail at Kandakadu, Polonnaruwa - 2013

Mean girth of plants measured at 120cm above ground level and intercropped with banana was 31.97±0.42. In the clearing established in 2015, more than 500 plants had been damaged by a herd of cattle and therefore, well grown plants had to be replaced with new plants. Weeding, manuaring, mulching and other agronomic practices were done as per the recommendations of RRISL (P Seneviratne, N M C Nayanakantha, M N de Alwis and R Handapangoda).

Exploitation

Longer tapping cycles through shorter tapping cuts - Pitiakanda estate

Yield measurements for the period from January to December 2018 are given in Table 26.

Table 26. *Yield measurements for the period from January to December 2018*

Treatments	No. of Trees	No. of tapping days	g/t/t	Brown bast%
T1: S/4 d3 + 5% Ethrel (once a month)	42	10	35.7	0.0
T2: S/3 d3 + 2.5% Ethrel (once a month)	44	10	30.5	8.5
T3: S/2 d3 + 2.5% Ethrel (4/year)	39	10	36.7	20.3

More or less same yield could be obtained from trees tapped under T1 with less bark consumption when compared to that of control (T3) (N M C Nayanakantha, P Seneviratna, R K Samarasekara and W K S W Watawala).

A new experimental trial was commenced in May 2018 to investigate on the effect of shorter tapping cuts on yield of rubber. A tapping block of RRIC 121 from 2011 clearing was selected. The treatments were the same as in the previous experiment and yield measurements are given in Table 27.

Table 27. *Yield measurements for the period from May to December 2018*

Treatments	No. of trees	No. of tapping days	g/t/t	Brown bast%
T1: S/4 d3 + 5% Ethrel (once a month)	33	10	25.1	-
T2: S/3 d3 + 2.5% Ethrel (once a month)	33	10	30.0	-
T3: S/2 d3 + 2.5% Ethrel (4/year)	33	10	37.4	-

A higher g/t/t was recorded in trees with T3 when compared to those with T1 & T2 (N M C Nayanakantha, R K Samarasekara and W K S W Watawala).

Winter rest experiments

Kuruwita (Clones RRIC 100, RRIC 121 & RRISL 203)

Yield measurements for the period from January to December 2018 are given in Table 28.

Table 28. *Yield measurements for the period from January to December 2018*

Treatments	RRIC 100	RRIC 121	RRISL 203
	g/t/t	g/t/t	g/t/t
T1 - Tapping without winter rest	30.0	54.2	35.1
T2 - Rested during winter period	38.6	64.9	44.0
T3 - d6 tapping practiced only during winter period	29.2	53.8	35.4

A higher g/t/t was recorded in trees of all three clones with T2 as compared to those with other treatments (N M C Nayanakantha, P Seneviratne, R K Samarasekara and W K S W Watawala).

Kumarawatta estate, Moneragala (clones RRIC 121 & RRISL 203)

Yield measurements for the period from January to December 2018 are given in Table 29.

Table 29. *Yield measurements for the period from January to December 2018*

Treatments	RRIC 121	RRISL 203
	g/t/t	g/t/t
T1 - Tapping without winter rest	28.4	31.9
T2 - Rested during winter period	29.2	31.6
T3 - d4 tapping practiced only during winter period	34	27.4

A higher g/t/t was recorded in RRIC 121 for T3, whilst the same was recorded in RRISL 203 for both T1 and T2 (N M C Nayanakantha, P Seneviratne, R K Samarasekara and W K S W Watawala).

Tapping Panel Dryness

Testing remedies to address tapping panel dryness problem (TPD/2016)

Application of antioxidants - Pitiakanda estate (Clone RRIC 121)

Yield measurements for the period from January to December 2018 are given in Table 30.

Table 30. *Yield measurements for the period from January to December 2018*

Treatments	g/t/t
T1: Control, S/2 d3 + 2.5% Ethrel (4/year)	31.1
T2: T1 + Moringa Leaf Extract 5% (Once a month)	32.6
T3: T1+ SNP 100 µM (once a month)	33.5
T4: T1+ Banana Leaf Extract 5% (once a month)	32.8
T5: T1+ Moringa Leaf Extract 10% (once a month)	33.2
T6: T1+ SNP 150 µM (once a month)	31.6
T7: T1+ Banana Leaf Extract 10% (once a month)	31.7

There was no effect of treatments on yield of rubber **(**N M C Nayanakantha, R K Samarasekara and W K S W Watawala).

Tapping of RRISL 203 at d2 and d3 frequencies (Padukka estate)

Table 31. *Effect of tapping frequency on g/t/t of RRISL 203*

Treatments	g/t/t
S/2 d3	23.3
S/2 d2	19.8

No remarkable differences were recorded in g/t/t among two tapping frequencies tested (N M C Nayanakantha, R K Samarasekera and W K S W Watawala).

Impact of different bark consumption rates associated with additional days of latex harvesting on growth, yield and economical implications of rubber plantations

This study was planned to determine the impact of different bark consumption rates associated with additional days of latex harvesting (over the recommended) on growth, yield and financial implications of rubber plantations.

(a) On station experiment (BCR/2013/Kuruwita)

Growth parameters, *i.e.* girth of trees and thickness of bark at 1.5 m height were measured. No significant differences were recorded for the above parameters in each clone (Figs. 5 & 6). Yield and yield determinants, *i.e.* daily latex yields in terms of latex volume and metrolac reading (% dry rubber content) and census of tapping panel dryness were recorded. Also, rainfall, no. of wet days and no. of tapped days were recorded. Five tapping systems (treatments) were employed as shown below for four clones, *i.e.* RRIC 100, RRIC 102, RRIC 121 and RRIC 133. Trees imposed with treatment four were stimulated with 2.5% ethephone (1.6g per tree) at three months interval.

T1. S/2 d2 With Rainguards (RG), No Recovery tappings (NRT)
T2. S/2 d2 With recommended number of RT per month (3 RT)
T3. S/2 d2 With 5 RT per tree per month
T4. S/2 d3+ ET 2.5% with rainguards (Tapping once in three days & NRT)
T5. S/2 d1 Daily tapping

Low yields in terms of g/t/t were recorded in trees imposed with T3 and T5 due to practice of excessive recovery tappings per month and daily tapping (Fig.7). The T2 recorded the highest yield than T1, T3 and T5 indicating the importance of following the recommended number of recovery tappings. However, a significantly higher g/t/t was recorded in trees with T4 tapped at d3 frequency than with other treatments. Out of the four clones, the highest yield per tree per annum was recorded in RRIC 121 (Fig. 8).

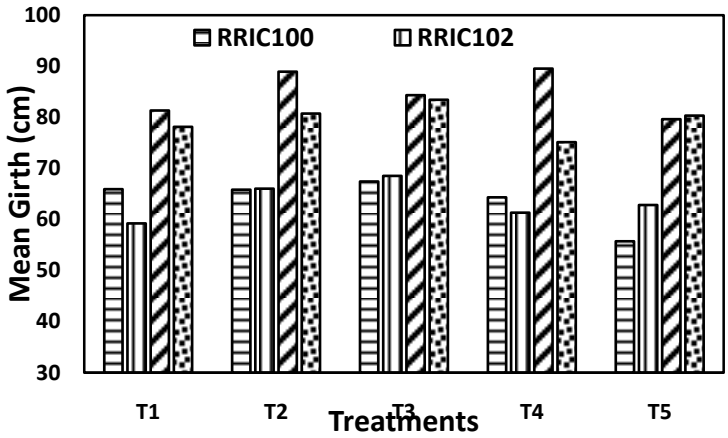


Fig. 5. Mean girth (cm) of different clones with different treatments at the end of year 2018

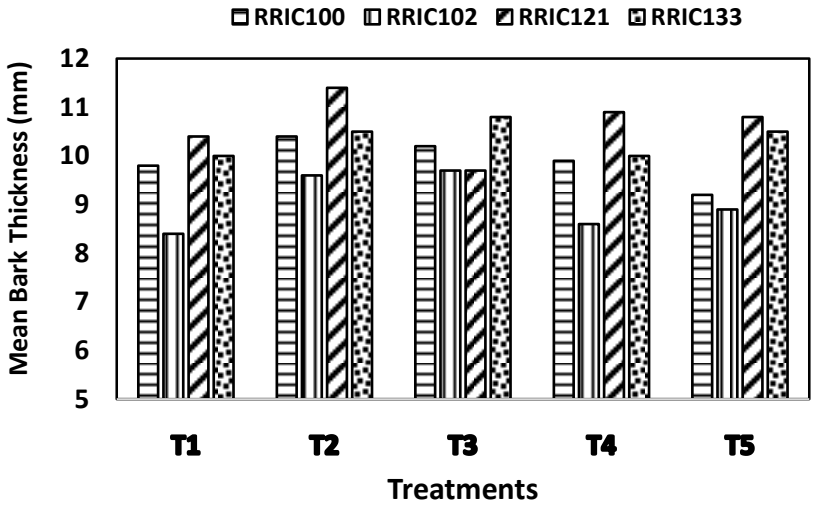


Fig. 6. Mean bark thickness (mm) of different clones with different treatments at the end of year 2018

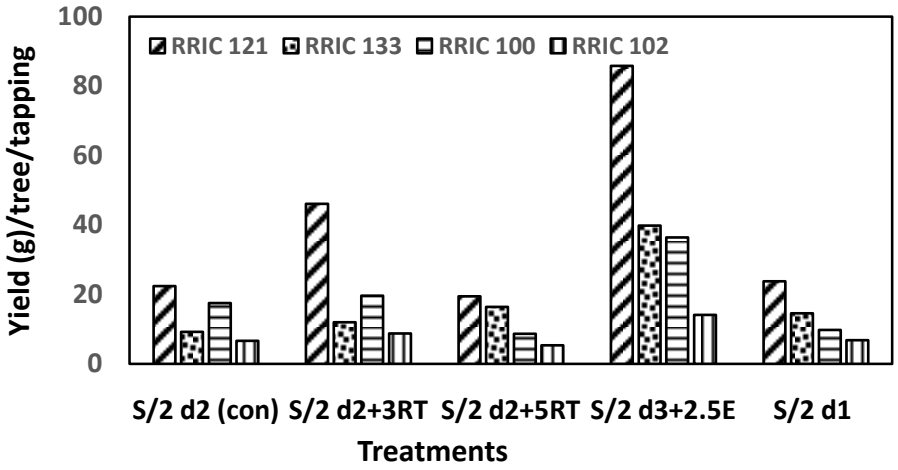


Fig.7. Mean dry rubber yield (g) per tree per tapping in four clones with five treatments recorded from January to December 2018

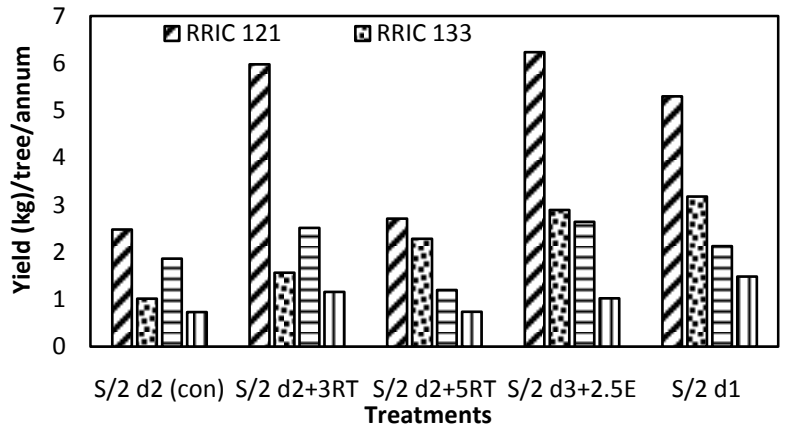


Fig. 8. Dry rubber yield (kg) per tree per annum in four clones with five treatments recorded from January to December 2018

(b) Multi location panel data assessments under different tapping systems practiced by growers

Data were not collected during the year and also the data collected so far are being analysed (T U K Silva, P Seneviratne, W Senevirathna and H Subasinghe).

Novel approach to optimize the bark management of rubber plantations (BCR/2017/Sirikandura)

The objective of this experiment was to investigate on possibilities to increase the productivity of rubber plantations through the management of bark consumption rates upon tapping. A rubber field established in 2006 with RRIC 121 at Sirikandura estate was selected to conduct this experiment. Six tapping systems were employed as treatments (Table 32) and were replicated three times according to a randomized complete block design (RCBD). Growth and yield in demarcated plots were recorded as pre-treatment measurements before imposing treatments.

Table 32. *Description of tapping systems employed as treatments*

Treatments	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/2 D d6 2.5% ET (Monthly)

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

Intercropping

Growing long term perennial crops on rubber lands - IC/S/2001/1 - Kuruwita

Growth of rubber trees with respect to the girth measured at 150 cm height was recorded (Table 33). Higher girth values were recorded in trees under wider within row systems, *i.e.* T3 and T4 than under other systems. The growth and the establishment rates of rambutan and jak were satisfactory and better than that of bud grafted (bg) and seedling (s) durian (Table 34). Nevertheless, no commercial yields from fruit crops were recorded during the year.

Table 33. *Mean girth (cm) of rubber trees under different treatments. Measurements were taken at 150 cm height*

Main treatments	Mean girth (cm) under sub treatments				
	Tea	**Cinnamon**	**Durian/Jak**	**Rambutan**	**Sole rubber**
T1 (3m×3m)-15m	72.5	74.1	74.2	74.9	77.0
T2 (3m×3m)-18m	81.9	73.4	71.9	76.0	77.3
T3 (3.5m×3.5m)-15m	85.1	81.9	79.0	78.2	77.5
T4 (3.5m×3.5m)-18m	84.9	75.1	84.6	82.5	83.2

Table 34. *Summary of the growth performance of Rambutan, Jak, bud grafted Durian (bg) and Durian seedlings (s) under different planting arrangements of rubber*

Main treatments	Basal girth (cm) at 10 cm height			
	Rambutan	**Jak**	**Durian (bg)**	**Durian (s)**
T1	82.7	68.8	50	39.7
T2	87.1	102.5	106	36.0
T3	78.7	67.3	80.5	45.6
T4	80.4	82.2	-	78.4

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

Growing economical crops along the rubber fence (IC/F/2010/1) - Hapugastenna

Five crops, *i.e.* cinnamon, areca, rattan, messengiana and cane palm were established along the fence in 2010. The basal girth of plants and height of different crops are given in Table 35. Cinnamon showed better performances and was harvested. Also, reasonable amount of cut leaves could be harvested from messengiana. Growth of areca trees was not satisfactory, but on set of fruits was observed frequently.

Table 35. *Growth parameters of crops planted along the rubber fence at the second year after planting*

Crop	Spacing (m) along the fence	Basal girth (cm)	Plant height (m)
Cinnamon (*Cinnamomum verum*)	0.6 x 0.6 paired rows	6.2	2.3
Rattan (*Calamus rotang*)	2.5	Not measured	0.9
Messengiana (*Dracaena messengiana*)	0.9	34.6	nm
Cane palm (*Dypsis lutescens*)	0.9	Not measured	nm
Arecanut palm (*Areca catechu*)	2.0	43.7	8.6
Main crop	**Spacing (m)**	**Girth at 120 cm**	
Rubber	2.5m x 7.75m	49.5	Not measured

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

Growing economical crops along the rubber fence (IC/F/2011) - Moneragala

Out of the four crops, *i.e.* cinnamon, rattan, areca and teak, better growth (53 cm girth) was recorded in teak with 100% survival. Apparently, Teak is suitable to grow along the boundaries of rubber plantations provided with a reasonable gap, *i.e.* 2-3m between rubber and teak trees in nontraditional areas (T U K Silva, D Priyadarshana and H Subasinghe).

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

This was established as an intercropping demonstration field in the RRISL Substation, Moneragala. Growth of rubber trees in terms of girth under different planting systems is given in Table 36. Basal girth and heights of different intercrops under two spatial arrangements of rubber are given in Table 37. A satisfactory plant height was recorded in each crop. Mango, guava and pomegranate showed a higher growth rate and a reasonable yield of mango could be harvested. Flowering and fruit setting were observed in some trees of Pomegranate.

Table 36. *Girth (cm) of rubber trees under different intercropping systems and spacing arrangements*

Intercropping system	Spacing (m) of rubber	Girth of rubber (cm)
Rubber x Pineapple	Single row system	56.7
Rubber x Banana	2.5m x 7.75m	46.7
Rubber x Pomegranate/Guava	Single row system	30.6
Rubber* x Pomegranate*/Guava*	2.5m x 12m	29.6
Rubber x Cinnamon	Paired row system	45.0
Rubber x Mango/Rambutan	(3m x 3m) – 18m	49.5

*planted in year 2011

Table 37. *Girth and height (cm) of different intercrops planted under different spacing arrangements of rubber*

Crop	Year established	Intercropping spacing (m)	Basal girth (cm)
Pomegranate	2010	3m x 3m	56.0
Guava			34.6
Pomegranate	2012		52.0
Guava			33.4
Cinnamon		0.6m x 1.2m	11.1
Mango	2010	10m	77.7
Rambutan*		10m	-

*Plants were resupplied

Special Capital Project (22-01-17)

A special capital project was obtained under the title "Intercropping diverse crop plants (medicinal, fruit crops and multipurpose crops) under rubber in non-traditional areas to ensure economically and environmentally sustainable land use practice for rubber cultivation".

Rubber x Intercropping trials in Moneragala and Ampara Districts

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

Two hectares of land was selected from a farmer at Kumbukkana, Moneragala. Four fruit crops (Orange, Sour soup, Guava and Papaya) were established under rubber with 2.5m x 7.75m spatial arrangement. Planting of both rubber and fruit crops were done following the recommendations of RRISL and Department of Agriculture (Table 38).

(b) ***Rubber x Fruit crops trial in Ampara (IC/FC/2018/2)***

Two hectares of land was selected from a farmer at Hingurana, Ampara. Four fruit crops (Orange, Sour soup, Guava and Papaya) were established under rubber with 2.5m x 7.75m spacing system. Planting of both rubber and fruit crops were done following the recommendations of RRISL and Department of Agriculture (Table 38).

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

Two hectares of land was selected from each farmer field at Hingurana and Mahaoya. Three crops, *i.e*. thibbatu, thumbakaravila and maize were selected and established under rubber with 2.5m x 7.75m spacing system at both sites (Table 38). However, maize plants in both sites were severely destroyed by army worm caterpillars. Farmers were advised to follow the instructions given by officials of the Department of Agriculture to control the menace. Planting of intercrops could not be completed in some areas of both sites due to dry weather conditions prevailed.

Table 38. *Details of lands and crops selected for establishing experimental trials under special capital project in Ampara and Moneragala*

	Area	Name of farmer	Extent (Acre)	Rubber clone	Spacing	Name of intercrop and (number of plants established from each crop)
1	Monaragala	MLUC Pinto	2	RRIC 121	2.5mx7.75m	Papaya (75) Guava (70) Sour soup(72) Orange (80)
2	Hingurana	WP Chamara	2	RRIC 121	2.5mx7.75m	Papaya (91) Guava (75) Sour soup (75) Orange (71)
3	Hingurana	RP Dharmarathna	2	RRIC 121	2.5mx7.75m	Thibbatu (200)Thumbakara wila (200)
4	Mahaoya	HM Premawathee	2	RRIC 121	2.5mx7.75m	Thibbatu (200)Thumbakara wila-(200)

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

Rubber x Short term crops trial in Kilinochchi (IC/ST/2018/4)

Three fields of ¾ ha were selected from three farmers at Malayalapuram, Kilinochchi. "Thibbatu" was established under rubber with 2.5m x 7.75m spacing arrangement (Table 39).

Table 39. *Details of lands and crops selected for establishing experimental trials under special capital project in Kilinochchi*

Name of farmer	Extent (acre)	Spacing	Clone	No of rubber plants	No. of "Thibbatu" Plants
S Wijekumari	¾	2.5mx7.75m	RRIC 121	130	110
Nawarathna Kumar	¾	2.5mx7.75m	RRIC 121	138	110
T Ravichandren	¾	2.5mx7.75m	RRIC 121	145	110

(N M C Nayanakantha and P D Pathirana)

Intercropping Agarwood with Rubber (IC/AW/2015)

Growth data were recorded at two months intervals from January to December 2018. In the double row system and single row system under full sunlight condition, the highest girth and girth increment were recorded in *A. crassna* and the lowest was recorded in *G. walla*. Under natural shading system, the highest girth was recorded in *A. crassna.* Nevertheless, girth increment was more or less same in both *A. crassna* and *A. subintegra* (Table 40).

In the double row system and under full sunlight condition, the highest stem height and height increment were recorded in *A. subintegra* and the lowest was recorded in *G. walla*. In the single row system, the highest stem height was recorded in *A. crassna.* The height increment was more or less same in both *Aquilaria* spp. The lowest stem height and height increment were recorded in *G. walla*. Under the natural shading system, the highest stem height was recorded in *A. crassna* and the highest height increment was recorded in *A. subintegra*. The lowest stem height and increment were recorded in *G. walla* (Table 40).

Table 40. *Growth attributes of three agarwood species after 40 months from planting. Gyrinops walla (GW), Aquilaria crassna (AC) and Aquilaria subintegra (AS) were grown as intercrops with rubber under three planting systems*

Planting system of Rubber	Agarwood species	Girth of plants (cm)	Girth increment (cm)	Height of plants (m)	Height increment (m)
Double Row	AC	45.0 ± 0.96	2.5±0.18	6.2±0.08	0.3±0.07
	GW	18.8 ± 0.88	1.4±0.17	2.8±0.10	0.1±0.02
	AS	41.5 ± 1.27	2.4±0.2	6.6±0.18	0.4±0.08
Single Row	AC	43.1 ± 1.8	2.5±0.18	6.7±0.18	0.3±0.03
	GW	15.7 ± 1.2	1.4±0.28	2.3±0.25	0.1±0.02
	AS	40.9±1.9	2.4±0.17	5.9±0.20	0.3±0.06
Natural shade	AC	24.6±2.28	1.9±0.25	5.0±0.44	0.2±0.04
	GW	11.3±1.95	0.8±0.15	2.4±0.27	0.1±0.02
	AS	23.4±2.2	1.9±0.23	4.9±0.35	0.3±0.03

(N M C Nayanakantha, A M W K Senevirathna, S Watawala and P K W Karunatillake in collaboration with University of Sri Jayawardhanapura and Sadaharitha Plantations Ltd.)

NRC Project (Grant No. 18-088)

A research grant was awarded from National Research Council (NRC) titled "Effect of priming of rubber (*Hevea brasiliensis*) plants with some natural or chemical compounds on growth and abiotic stress alleviation under sub-optimal climatic conditions in Ampara District of Sri Lanka.

A rubber field (1 acre) was selected from a farmer at Hingurana, Ampara. About 200 rubber plants of RRIC 121 were established with 2.5m x 7.75m spacing system. Growth data such as girth and height of the plants were recorded before imposing treatments (N M C Nayanakantha, T U K Silva, D S A Nakandala and P Seneviratne).

PLANT PATHOLOGY AND MICROBIOLOGY

T H P S Fernando

DETAILED REVIEW

Staff

Dr (Mrs) T H P S Fernando was promoted to Head, Department of Plant Pathology & Microbiology with effect from 19th June 2018. Mrs M K R Silva, Research Officer was on maternity leave from 31st January to 08th June 2018. Ms L H S N Gunerathne resigned from the institute with effect from 9th August 2018. Experimental Officers, Mrs B I Tennakoon, Mrs E A D D Siriwardene and Mr S C P Wijayaratne were on duty throughout the year. Mr E A D N Nishantha, Experimental Officer was on no-pay leave till 30th of September 2018. Mr P W Balasooriya and Miss R D N S Gunasekera, Technical Officers were on duty throughout the year. Mrs K A D Y Madushani Lanka, Management Assistant was on maternity leave till 26th of March 2018. Mr P L P B Nishantha and Miss B V A Umesha worked as Temporary Research Assistants under the Development Project – 23/1/15 and Ms K G M Sakunthala worked as a Technical Assistant under the NSF Project RG/2016/AG/01. Miss B V A Umesha and Mrs K G M Sakunthala resigned from duties with effect from 15th August & 28th September, 2018 respectively.

Research grants received

Source and Grant No	Duration	Title of the Project	Allocation	Status
Ministry of Plantation Industries **Development Project – 23/1/15**	May 2016 - 2021	Identification of the Potential Pest and Disease Problems of Rubber in Non-Traditional Areas to Develop Improved Management Strategies	20 Rs. Mn.	In progress
National Science Foundation **NSF Project: RG/2016/AG/01**	May 2016 - 2020	Investigations on biological control measures for WRD of rubber to improve integrated disease management strategies	2.071 Rs. Mn.	In progress

Source and Grant No.	Duration	Title of the Project	Allocation	Status
Ministry of Plantation Industries **Development Project - 23/1/17**	2018 - 2022	Improvement of strategies to manage White root disease in rubber plantations	42.99 Rs. Mn.	In progress

Research students

Dr (Mrs) T H P S Fernando supervised the final year research projects of the following undergraduate students and post graduate students.

Name	Duration	University	Project Title
PW Balasooriya	November 2016 - December 2019	University of Colombo	Application of indigenous soil micro flora as biological control measures for white root disease of rubber growing lands in Sri Lanka
PLPB Nishantha	May 2018 - June 2020	University of Colombo	Screening of selected *Hevea brasiliensis* clones grown under suboptimal ecological conditions in non-traditional rubber growing areas in Sri Lanka against foliar diseases and for physiological performance
LTGK Fernando	January 2018 - January 2021	University of Ruhuna	Formulation of ethephon based low cost yield stimulant for commercial rubber plantations in Sri Lanka

Committees attended

Officers	Subject	Organization
THPS Fernando MKR Silva	Scientific Committee Meeting	RRISL
THPS Fernando	National Plant Protection Committee	CARP
	Pesticide Technical's Advisory Committee	Department of Agriculture
	Pesticide Sub-Committee	Department of Agriculture

Training programmes attended (Foreign)

Officers	Training programme	Duration
BI Tennakoon	Training programme in Thailand	22nd October 2017 13th January 2018
MKR Silva	International Plant Protection Workshop	30th July 2018 2nd August 2018

Training programmes conducted

Dr (Mrs) T H P S Fernando and Mrs M K R Silva served as the resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Mrs B I Tennakoon, Mrs E A D D Siriwardene, Mr S C P Wijayaratne and Mr E A D N Nishantha 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	419
Advisory	52
Other	28
Total	**499**

LABORATORY AND FIELD INVESTIGATIONS

Chemical control of *Hevea* diseases (23/P/01)

Chemical control of White root disease to revise the present recommendation

Investigations were done to revise the present chemical recommendation against the white root disease. This was conducted in a three and a half years old immature rubber field. Tebuconazole (250 EW) at the concentrations of 1% and 0.5% (4 litres per each tree) and hexaconazole (50g/l) at the concentrations of 1%, 2%, 2.5% and 5% (4 litres per each tree) were tested for the efficacy having an initial disease index of each tree. The experiment was conducted at the Talgaswala Estate, Elpitiya. The results showed that 1% tebuconazole effectively controlled the disease while 5% hexaconazole was also capable in controlling the disease effectively.

teboconazole (Folicur 250 EC)

T1 – 40 ml of the chemical dissolved in 4 liters of water
T2 – 20 ml of the chemical dissolved in 4 liters of water

hexaconazole (Hayleys hexaconazole 50 g/L)
T3 – 40 ml of the chemical dissolved in 4 liters of water
T4 – 80 ml of the chemical dissolved in 4 liters of water
T5 – 100 ml of the chemical dissolved in 4 liters of water
T6 – 200 ml of the chemical dissolved in 4 liters of water
T7 – Control (no fungicide application)

(T H P S Fernando and S C P Wijayaratne, Funded by the Development Project - Grant 23/1/17)

Another trial was conducted at a smallholding in Baduraliya to test different chemical concentrations as given above. The curative effect was assessed. The fungicide, tebuconazole was effective at the 1% concentration and hexaconazole showed less effectiveness on curative effects. Higher concentrations of the chemical were effective in controlling the disease. The results from this trial also showed that 1% teboconazole was effective in controlling the disease while 5% hexaconazole was also effective (T H P S Fernando and B I Tennakoon collaboratively with ASD and RDD, Funded by Development Project - Grant 23/1/17).

Establishment of demonstration plots for white root disease management

Demonstration plots have been established to show the effectiveness of the research findings in the management of white root disease. The details of the demonstrations plots are given in the Tables 1 & 2. The fungicide tebuconazole 1% *a.i.* was used for the treatment. The volume of the chemicals was changed based on the age of the plants.

Table 1. *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

District		Area	Smallholders	No of affected plants	Chemical application	No of recovery plants
03	Matara	Morawaka	Gunapala	200	1st Application 2nd Application	200
04	Ratnapura	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

(T H P S Fernando, M K R Silva, E A D D Siriwardena collaboratively with ASD & RDD: Funded by Development Project - Grant 23/1/17)

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

	District	Area	Name of the Smallholder	No of affected plants	Chemical application	Sulphur
01	Kegalla	Ruwanvella	Nalanda Estate	42	1st App. 2nd App.	100kg
02	Kalutara	Maggona	Shantha Visenthi	60	1st App. 2nd App.	100kg
03	Kalutara	Millewa	Koshan	70	1st App. 2nd App.	50kg
04	Kalutara	Millewa	Hemachandra	18	1st App.	-
05	Gampaha	Delgoda	KGH Dharmawardena	42	1st App.	50kg
06	Galle	Baddegama	Sarath Amarasiri	52	1st App. 2nd App.	50kg

	District	Area	Contact	No of affected plants	Chemical application	Sulphur
07	Kalutara	Nivithigala Kele	N'Kele	Patch rehabilitation		100kg
08	Kalutara	Galewatta	D/F	Patch rehabilitation		100kg
09	Kalutara	Rannagala	Rannagala Estate	12	1st App.	-
10	Kalutara	Yatadola	Premasiri	32	1st App.	500kg
11	Kalutara	Bulath-singhala	NG Jayasena	23	1st App.	-
12	Kalutara	Lihiniyawa	Sarath Fernando	170	1st App.	150kg

(T H P S Fernando, M K R Silva, B I Tennakoon & S C P Wijayaratne: Funded by Development Project 23/1/17)

Rehabilitation of White root disease patches - Dartonfield estate

White root disease patches were rehabilitated at Galewatta, Dartonfield Estate. All the infected plants were removed and infected root pieces were burnt *in situ*. Then sulphur sprinkling was carried out to make conditions unfavorable for the growth of the fungus *Rigidoporus microporus.* Later, indicator plants were established (Gliricidia sp. & Crotalaria sp.) to trace out any remaining inocula. A pineapple cultivation was established in view of providing in additional income for the grower (Fig. 1) (T H P S Fernando and S C P Wijayaratne: Funded by Development Project 23/1/17).

Fig. 1. The white root disease patch rehabilitated using mechanical/chemical and biological measures at Galewatta, Dartonfield estate, RRISL

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

In the collaborative trial carried out with the Adaptive Research Unit, data on the incidence of mammalian pest attack were collected, after applying the recommended chemical repellent in altered time intervals. This trial is being carried out in three sites in Polgahawela to evaluate the chemical repellent under smallholder conditions in the Intermediate Zone (M K R Silva, T H P S Fernando and B I Tennakoon).

Tree injection against white root disease – I Vogan estate

In the experiment conducted to test the effectiveness of tree injection using tebuconazole against white root disease, three concentrations *i.e.* 8, 12, 15% were tested using chem.-jet injectors. As a control, the recommended concentration (1%) tebuconazole drenching was done. The trees were monitored for the disease severity level of the collar and foliar symptoms. The plants treated with 8% tebuconazole showed promising results. The trial will be done in several more experimental sites to confirm the observations (T H P S Fernando and S C P Wijayaratne).

Alternative chemicals for the management of the bark cracking disorder

Trials established in Pussalla estate, Woodend estate and Sorana estate are being monitored for the recovery. Assessments were on the bark rot level at the collar region, foliar symptoms and formation of latex pads. Disease severity assessments are recorded to monitor the recovering of the plants. This experiment is continuing and will include the results in 2019 (L H S N Gunaratne, T H P S Fernando and E A D N Nishantha).

Screening of effective chemicals to control Brown root disease

A field trial was established to screen the effectiveness of the two systemic fungicides: tebuconazole and hexaconazole on the control of the brown root disease. This experiment was in a four year-old clearing at Badalkumbura. The initial infection level was assessed and a rank was given for each tree prior to the application of the fungicides. The treatments used were tebuconazole (Folicur 250 EW) in 1% concentration, hexaconazole (Hayzole 50 EC) in 1% concentration and hexaconazole (Hayzole 50 EC) in 2% concentration.

In the *in-vitro* screening of the three fungicides tebuconazole, hexaconazole and propiconazole, it was found that the three fungicides showed a varying reaction over the fungus at different concentrations. This trial was performed in two laboratory methods; Poisoned Food Technique (PFT) and Soil Fungicide Screening Test (SFST) and the percentage inhibition of the fungus over the control was tested with two *Phellinus* isolates: isolate 9 and isolate 7. At the PFT, five concentrations: 0.1ppm,

1ppm and 5ppm, 25ppm and 50ppm of all 3 fungicides were tested and the fungus could not grow at any concentration. At the SFST, the same fungicides and the fungal isolates were used and the diameter reduction was recorded at four low concentrations: 0.1ppm, 0.5ppm, 1ppm and 2ppm. The three fungicides showed a significantly different effectiveness levels at all four concentrations against both isolates of the fungus. The results are summarized in the Figure 2 (M K R Silva, T H P S Fernando, R L C Wijesundera, B I Tennakoon - Partially funded by Development Project 23/1/15).

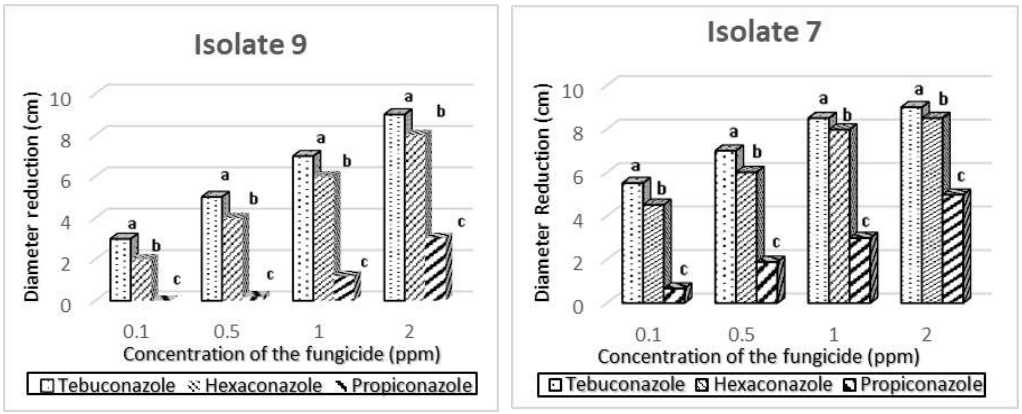


Fig. 2. Reduction in the growth caused by different concentrations of tebuconazole, hexaconazole and propiconazole at SFST *Values of the bars with the same letter are not significantly different at DMRT at P=0.05

Biology of pests (23/P/02)

***White Root Disease Survey to confirm the disease spread through on the cover crop,* Mucuna bractiata**

The incidence of White Root Disease on the cover crop, *Mucuna bractiata* was revealed (Table 3). The gaps of knowledge in view of improving the management strategies of white root disease were also reported.

Fungicide sensitivity of *R. microporus*

Isolates; R1, R2, R4 and R6 of *Rigidoporus microporus* reached EC_{100} (total inhibition) at the concentration of 25ppm of tebuconazole but resumed the growth after transferring on to the Malt Extract Agar plates. The other isolates (R3, R5, R7, R8, R 9 and R10) reached EC_{100} at the concentrations of 50ppm and above. In the agar amended with hexaconazole, the radial expansion of the isolates R1, R2, R4, R5 and R7 were inhibited at 100 ppm and above concentrations and all the other isolates

stopped their radial expansion at the concentration of 50 ppm (T H P S Fernando, E A D D Siriwardene, S C P Wijayaratne and I Madushani).

Table 3. *WRD survey with reference to* Mucuna bractiata, *cover crop*

Estate	**Presence/Absence of disease on the cover crop, *Mucuna bractiata***	**Estate**	**Presence/Absence of disease on the cover crop, *Mucuna bractiata***
Udabage Estate	√	Padukka Estate	√
Udapola Estate	X	Payagala Estate	X
Eladuwa Estate	X	Dartonfield Estate	√
Delkith Estate	√	Arappolakanda Estate	√
Raigam Estate	√	Vogan Estate	√
Rathnapura, Elapatha (SH)	√	Kalvariya Estate Maggona	√

SH - smallholding

Variation of the pathogenicity of the brown root disease-causing fungus, Phellinus noxius

In the pot trial established at Dartonfield to investigate the pathogenicity of the different isolates of the fungus *Phellinus noxius*, a variation could be observed among the 24 isolates under investigation. This trial was carried out by artificial inoculation of three months-old rubber seedlings with a mixture of inocula (with respective fungal isolates grown on MEA) of rice bran and saw dust. Forty seedlings were inoculated with each isolate. Another forty seedlings without inoculation were kept as the control. After four months of inoculation under the natural field conditions ten destructive samplings were done at two months intervals to observe the pathogenicity levels of different pathogen isolates. In each observation, the fungus was re-isolated onto MEA from the roots of the artificially inoculated seedlings.

For the underground signs and symptoms of the uprooted plants, pathogenicity scores were given as; 0 (no infection), 1 (mycelial crust without root decay), 2 (mycelial crust with root decay) and 3 (plant death). Accordingly the pathogenicity levels recorded as ranks were subjected to Kruskal - Wallis analysis and subsequently to the Wilcoxon rank-sum test, as the scores obtained for the different isolates were significant. A variation of pathogenicity was observed among the 24 *Phellinus noxius* isolates. As all the isolates had initiated to show a stabilized pathogenicity value at three and half months of the inoculation, a cluster analysis was performed for the mean score values of the pathogenicity rank. The dendrogram showed that the test isolates were separated into two main clusters at the similarity level 0.8 (Fig. 3).

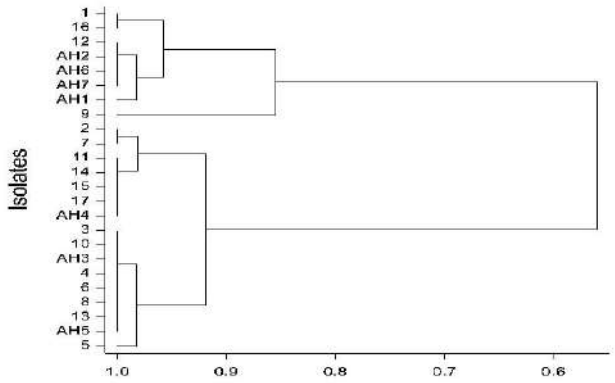


Fig. 3. Dendogram showing the clusters of *Phellinus noxius* isolates based on the pathogenicity

Fungicide sensitivity of* Phellinus noxius*, the causative agent of the Brown root disease of rubber

On all three fungicides, tebuconazole, hexaconazole and propiconazole, all the 24 isolates of *Phellinus noxius* reached EC_{100} (Total inhibition) at 0.1 ppm when the poisoned food technique was employed. Moreover, all the isolates did not resume the growth at this concentration. At the soil fungicide screening test (SFST), the fungal isolates showed a differential reaction over the three fungicides at different concentrations. SFST was performed at five different concentrations (1 ppm, 2 ppm, 3 ppm, 4 ppm, and 5 ppm) of the fungicides, tebuconazole, hexaconazole and propiconazole and the percentage inhibition of mycelial growth with respect to the control was calculated.

On tebuconazole, all the isolates attained the total inhibition at a concentration of 2 ppm. Moreover, all the isolates exposed to this concentration did not resume their growth when the mycelial disc was placed on the culture medium and therefore it was concluded that this concentration of tebuconazole was detrimental to *P. noxius* at SFST. On hexaconazole all the isolates attained the total inhibition at a concentration of 3 ppm. The total inhibition of growth of all the isolates was observed at 5 ppm on propiconazole. However, on propiconazole a slight fungal growth on inoculated discs was observed in all the isolates when the mycelial disc was placed on the culture medium free of the fungicides (M K R Silva, T H P S Fernando and B I Tennakoon).

Influence of Agro-climatic conditions on the development of the brown root disease

The field trial established at Moneragala to investigate the influence of agro-climatic conditions on the spread of the disease was generally maintained. The incidence and the severity of the disease are to be monitored at three months intervals (M K R Silva, T H P S Fernando and B I Tennakoon).

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 2018. The pathogen isolates were obtained from non-traditional rubber growing areas *viz*, Padiyathalawa and Monaragala (T H P S Fernando, E A D D Siriwardena, E A D N Nishantha and Buddika Nishantha - Funded by Development Project 23/1/15).

Table 4. *Results of the Survey on Corynespora leaf fall disease conducted in 2018*

Clone	ADSI *	Clone	ADSI *
RRIC 121	0	RRISL221	0
RRIC 102	0	RRISL222	0
RRIC 130	0	RRISL 202	2.0
RRISL 203	0	RRISL 200	3.2
PB 260	0	RRISL2000	0
RRIC 133	0.8	RRISL2002	0
RRISL 201	1.0	RRISL2004	0
RRISL 205	0	RRISL2005	0
RRISL206	0	RRISL2006	0
RRISL210	0	GPS 1	0
RRISL211	0	PB 255	1.0
RRISL215	0	PR 255	0
RRISL216	0	PR 305	0
RRISL217	0.8	RRII 105	1.0
RRISL219	0	PB235	0
RRISL2001	0	BPM 24	0
RRISL2003	0	RRISL 200	3.0
RRISL 218	1.2	Centennial 2	0
RRISL 204	0	Centennial 3	1.0
RRISL 202	2.2	Centennial 4	0
RRISL 208	1.4	Centennial 5	0
RRISL 220	0		

*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 - Funded by Development Project 23/1/15).

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 - Funded by Development Project 23/1/15).

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, E A D D Siriwardena: Funded by Development Project 23/1/15).

Establishment of a nursery for screening purposes - Sapumalkanda estate

Fourty eight *Hevea* clones have been established at Sapumalkanda estate for clonal evaluation against Corynespora leaf fall disease and the other potential diseases (T H P S Fernando, M K R Silva and B I Tennakoon - Funded by Development Project 23/1/15).

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 - Funded by Development Project 23/1/15).

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

The WRD survey - Government Nurseries

Preliminary survey was done in the government nurseries to detect the white root disease condition. Various disease conditions have been revealed and the disease should be managed under the white root disease management project to be started in 2019 (T H P S Fernando, M K R Silva, L H S N Gunaratne, B I Tennakoon, E A D D Siriwardena, S C P Wijayaratne and Buddika Nishantha - Funded by WRD Project 23/1/17).

Identification of potential pests and disease problems of rubber lands in non-traditional areas to develop improved management strategies (Development Project Funded by the Ministry of Plantation Industries P 23/1/15)

Selected sites

Site	Ownership
Kandakaduwa Farm, Polonnaruwa	Army Camp
Padiyathalawa	Rubber Development Department premises
Baduraliya	Smallholder
Vavuniya	Smallholder
Monaragala	Smallholder
Dartonfield Estate (Reference cultivation)	RRISL
Anuradhapura	Smallholder
Anuradhapura	Smallholder

(T H P S Fernando, P Senevirathne, M K R Silva, B I Tennakoon, E A D D Siriwardena, S C P Wijayaratne and P Balasuriya collaboratively with Biochemistry and Physiology Department)

Surveillance of potential pests and disease outbreaks to avoid unwanted sudden disease epidemics in view of maintaining the productivity levels

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

Identification of indigenous soil microflora as biological control measures for White root disease of rubber growing lands in Sri Lanka

An effective biopesticide to control* Hevea *root diseases

A medium is being tested for the combinations of identified native bio control agents. Different compounds such as rubber serum, sugar, molasses, *etc.* were used in a liquid broth culture in order to test the *in vitro* combination effects of antagonist bacteria. Rubber serum was found as the best medium for the liquid bio pesticide (T H P S Fernando, P Seneviratne and P Balasooriya).

Identification of antagonistic fungi to control Brown root disease

A study was carried out to evaluate the *in vitro* efficacy of the fungi isolated from Sri Lankan rubber soils against *Phellinus noxius.* Soil samples were collected from rubber rhizosphere in Moneragala, Padiyathalawa, Vavuniya and Mathugama, Sri Lanka. Dual plate culture technique was used to test the antagonistic ability.

Four isolates of *Phellinus noxius* were selected to be tested against six prospective-antagonistic fungal isolates. The antagonistic ability was assessed based on the reduction of the linear growth of *Phellinus noxius.* The index: percentage inhibition of radial growth (PIRG) was used as the test parameter. Analysis of

variance was done for the PIRG and subsequently, mean separation was done with Duncan's Multiple Range Test (DMRT).

In the ANOVA, the six antagonistic isolates, showed a significant variation in the PIGR values at all four *P. noxius* isolates. Moreover, interactions of those two variables were observed (Table 5).

Table 5. *Mean PIRG values of the six antagonistic isolates against the four* P. noxius *isolates*

Antagonistic Isolate**	Mean PIRG values of the different *P. noxius* isolates*			
	7	**9**	**AH2**	**AH4**
AF1	0.64448^{b}	0.79962^{b}	0.8238^{b}	0.44888^{cd}
AF2	0.73143^{b}	0.90404^{b}	0.9569^{ab}	0.68622^{b}
AF3	0.39353^{c}	0.37591^{c}	0.8462^{b}	0.37591^{d}
AF4	0.98642^{a}	0.20875^{a}	1.1297^{a}	0.95686^{a}
AF5	0.62312^{b}	0.48624^{c}	0.4906^{c}	0.54819^{bc}
AF6	0.15091^{d}	0.37591^{c}	0.3959^{c}	0.46826^{cd}

*Values in the same column followed by the same letters are not significantly different at DMRT at P=0.05

** AF - Antagonistic fungus

According to the results, the prospective antagonistic fungus AF4 has shown a significantly higher level of antagonism against three isolates of *Phellinus noxius*: 7, 9 and AH4. On AH2, it has shown a significant different level of antagonism with four other isolates and however, the difference of the level of antagonism with AF2 was insignificant. When the isolate AF2 is concerned, it also shows a comparatively higher mean PIGR values than the four antagonistic fungi other than AF4. However, the values were not significant with AF1 at three *Phellinus noxius* isolates, with AF5 at two *Phellinus noxius* isolates and with AF3 at one *Phellinus noxius* isolate. The growth of four isolates of *P. noxius* with each antagonistic spp. (after 03 days and 12 days of the inoculation of *P. noxius*) is shown in the Figures 4 and 5 respectively (M K R Silva, T H P S Fernando and Prof. R L C Wijesundera).

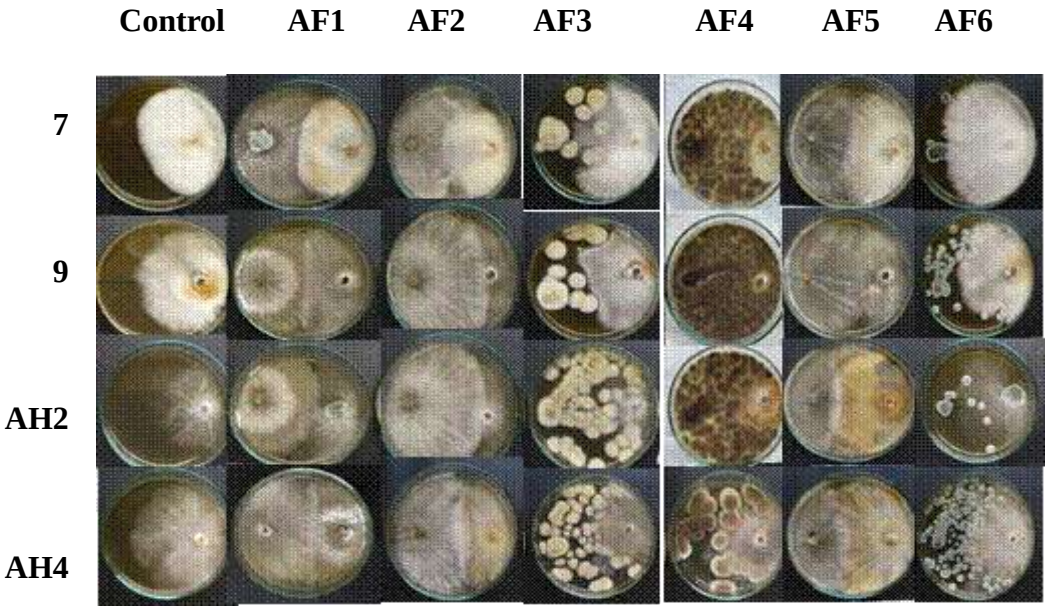


Fig. 4. The growth of *P. noxius* with each antagonistic spp. (after 03 days of the inoculation of *P. noxius*)

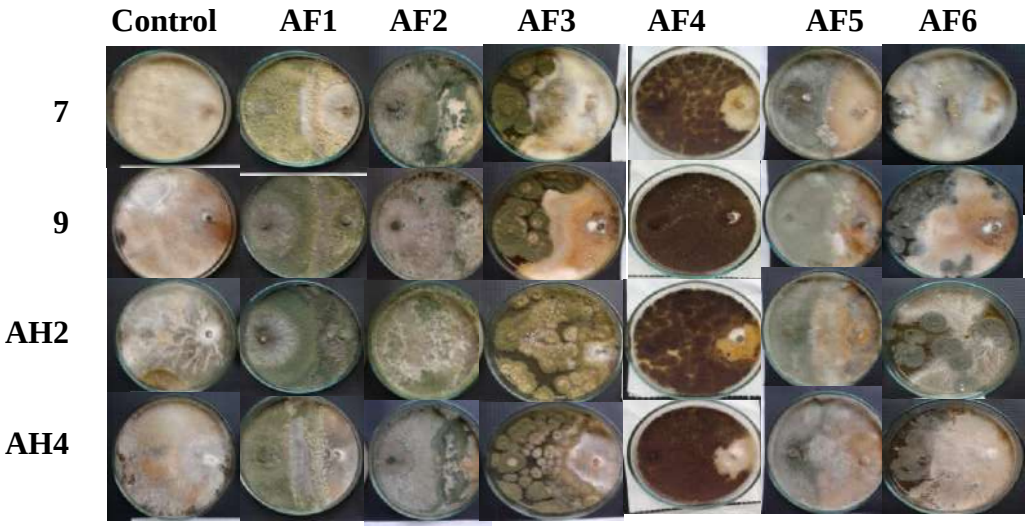


Fig. 5. The growth of *P. noxius* with each antagonistic spp. (after 12 days of the inoculation of *P. noxius*)

Surveillance of potential pests and disease outbreaks to avoid unwanted sudden disease epidemics in view of maintaining the productivity levels (PP/04)

A sudden disease outbreak was reported from Malaysia and the disease was regarded as the Fusicoccum Leaf Disease. This disease had been reported from Malaysia since 1986 and in Sri Lanka Fusicoccum Leaf disease was considered as a pest of quarantine. However in Malaysia the disease is spreading and Mrs M K R Silva got an opportunity to attend to a Workshop on this disease in Thailand. Based on the information provided by them, leaflets were prepared to disseminate the knowledge among the Extension Staff and also the stakeholders. A brief survey was also conducted to find out whether this disease is currently inhabiting in Sri Lankan rubber plantations. Several suspected fungi isolates have been received and are under investigation (T H P S Fernando and the staff of Plant Pathology & Microbiology Dept. - Partially funded by the development Project 23/1/15).

Developing a national level fungal culture collection

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*) (T H P S Fernando and the staff of Plant Pathology & Microbiology Dept.)

Advisory visits and training programmes (PP - 08)

The staff of the department made 52 advisory visits mainly to handle complicated disease problems. 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 20 no. of training programmes on White root disease management 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. - Funded by WRD Project 23/1/17).

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 on 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

R P Hettiarachchi

DETAILED REVIEW

Staff

Dr (Mrs) R P Hettiarachchi, Senior Soils Chemist was promoted to the post of Principal Research Officer with effect from 17th December 2018 and Mrs H A R K Jayawardana, Research Officer was on maternity leave from 8th August to 11th December. Miss V Edirimanna, Miss A Thevarapperuma, Mr T Gunathileke, Mr J A S Chandrasiri Experimental Officers, Mrs K E de Silva, Mr G C Malawaraarachchi, Mrs K M M E K Kulatunga, Mrs P D S D O Rathnasooriya, Miss R M Baddevithane, Mr M W H Gayan and Mrs N S Siriwardena Technical Officers and Mrs L Rupasinghe English Stenographer were on duty throughout the year.

Research students

- P C U Wanninayake, a student from Faculty of Applied Sciences, Rajarata University of Sri Lanka conducted a part of her final year research project on "Assessment of cadmium accumulation and uptake in maize with the application of different phosphorus fertilizers" under the supervision of Dr (Mrs) R P Hettiarachchi.

- S N P Perera, a student from Faculty of Agriculture, Rajarata University of Sri Lanka conducted a part of her final year research project on "Solubilization of phosphorus from different phosphorus sources by using phosphorus solubilizing bacteria associated with rubber rhizosphere (*Hevea brasiliensis*)" under the supervision of Dr (Mrs) R P Hettiarachchi.

Seminars/Trainings/Workshops/Conferences/Meeting conducted

Officer	Subject	Organization
RP Hettiarachchi	Presentation on Soil fertility management for high productivity of rubber	National Institute of Plantation Management
	Presentation on Enhancing nutrient uptake of rubber nursery plants by the application of biofilmed biofertilizers	SLCARP International Agricultural Research Symposium
	Presentation on Fertilizer to Rubber & Soil and Moisture Conservation	National Institute of Plantation Management

Officer	Subject	Organization
RP Hettiarachchi	Cost effective applications of good agricultural practices	Rubber & Oil palm for Regional Plantations Companies
HARK Jayawardana	Research Symposium, NIPM	NIPM, Athurugiriya
	Current Research Activities	Board Meeting, RRISL, Ratmalana

Seminars/Training Programmes/Workshops/Exhibition attended

Officer	Subject	Organization
RP Hettiarachchi	Fertilizer Advisory Committee Meeting	Ministry of Agriculture
	3rd Technical Coordinating Committee Meeting on Implementation of National Action Programme (NAP) 2015-2024 for combating land degradation in Sri Lanka	Ministry of Mahaweli Development & Environment
	4th Technical Coordinating Committee Meeting on Implementation of National Action Programme (NAP) 2015-2024 for combating land degradation in Sri Lanka	Ministry of Mahaweli Development & Environment
	International Workshop on Statistical Applications in Socio-economic Research & Forum on Current Socio-economic Issues and their Impact on Rubber Production Sector Performance	RRISL & IRRDB
HARK Jayawardana	Training program on TEC report writing Workshop on agrochemicals	RRISL, Ratmalana Institute of Chemistry, Rajagiriya
	Research Discussion	RRISL, Ratmalana

Visits

Advisory	4
Experimental	80
Others	55

LABORATORY AND FIELD INVESTIGATIONS

Soil fertility management

Mass production of* Mucuna bracteata *plants

Mucuna nursery was established in RRISL Substations in Nivithigalakele and

126 poly bagged *Mucuna* plants were issued to Dartonfield estate and one smallholdings at Rs.25.00 per plant (R P Hettiarachchi, A Thewarapperuma and T Gunathilake).

Qualitative estimation of phosphorus solubilization on solid media

Microorganisms that produce clear zones around their colonies on precipitated insoluble phosphate agar are capable of solubilizing insoluble phosphate.

Out of total bacteria isolated from rubber rhizosphere, some bacterial isolates were able to solubilize insoluble sources and resulted halos on their solid medium, whilst other bacteria did not produce a solubilization halo around their colonies.

Quantitative estimation of phosphorus solubilization

Bacterial isolates grown separately were transferred into mediums with $CaHPO_4$, HERP and ERP. Each incubated broth cultures with four replicates were sampled periodically at one day interval and the supernatant of the culture was taken by centrifuging and pH of supernatant was measured using pH meter. Analysis of phosphorus was done by using the SKALAR San^{++} Auto Analyzer.

In liquid medium with $CaHPO_4$, 17 bacterial isolates resulted high P solubilization with $CaHPO_4$ (> 100ppm) and it was ranging from 100 - 320 ppm. Lower solubilization index with solid medium with the formation of little solubilization halos around the bacterial isolates was promoted in liquid medium. Out of 17, four bacterial isolates *i.e.* B3, B5, B6 and B7 were capable of solubilizing more than 20 ppm phosphorus at the end of the incubation period with HERP and ERP. Considering the solubilizing capacity for the three insoluble inorganic phosphates in liquid medium, the strains B6 exhibited higher values, B3, B5 and B7 gave moderate values and the others gave lower values (Table 1).

Table 1. *Quantity of soluble P released by different bacterial isolates from sparingly soluble phosphate sources, $CaHPO_4$, HERP and ERP*

Isolate No.	Soluble phosphorus (ppm) with $CaHPO_4$	Soluble phosphorus (ppm) with HERP	Soluble phosphorus (ppm) with ERP
1B	123^{efg}	15^{fg}	7.5^{fg}
2B	150^{d}	16.1^{ef}	6.3^{gh}
3B	263^{b}	22.7^{c}	18.7^{c}
4B	133^{def}	17.1^{def}	6.2^{gh}
5B	307.6^{a}	25^{b}	21.8^{b}
6B	317.6^{a}	46.2^{a}	40.2^{a}
7B	116^{fg}	21.7^{c}	18.4^{c}
8B	142^{de}	17.5^{de}	11.5^{d}
9B	215^{c}	9.1^{j}	6.5^{fgh}
10B	153^{d}	17.1^{def}	9.6^{e}

Isolate No.	Soluble phosphorus (ppm) with $CaHPO_4$	Soluble phosphorus (ppm) with HERP	Soluble phosphorus (ppm) with ERP
11B	251^{b}	18.5^{d}	11.3^{d}
12B	122^{efg}	15.6^{efg}	7.1^{fgh}
13B	133^{def}	13.6^{gh}	5.7^{h}
14B	114^{fg}	15.1^{fg}	8.1^{ef}
15B	124^{efg}	11^{ij}	3.5^{i}
16B	133^{def}	16.5^{def}	8.2^{ef}
17B	106^{g}	12.2^{hi}	8.1^{ef}

Phosphorus solubilization and growth medium acidity (pH)

The majority of strains acidified liquid medium containing three insoluble inorganic phosphates. There was a significant negative correlation between the pH of the medium and the amount of soluble phosphate for $CaHPO_4$. The medium with HERP showed a lower correlation compared to $CaHPO_4$ and no correlation was observed in medium with ERP (R P Hettiarachchi and K E de Silva).

Quantitative response of inorganic fertilizers to immature field plants with biofilm biofertilizers

This experiment was started at Millawa estate to study the effectiveness of BFBF (B25F2) with reduced amount of chemical fertilizers for immature rubber plants at field conditions. Different treatments were tested according to the details reported in 2015 Annual Review. However, this experimental area in the estate was selected for industrialization zone by the government and therefore the trial was terminated at the end of 2017 (R P Hettiarachchi and K E de Silva).

Vermicompost application for rubber nursery plants

Different treatments were tested according to the details reported in 2017 Annual Review and this experiment was terminated at the end of the nursery stage. Results showed that the application of vermi wash with recommended fertilizer application and vermi wash only treatment gave significantly higher plant diameter values compared to recommended fertilizer only control treatment at the end of four months period. Moreover, vermi wash only application plants showed yellowish colorization of leaflets compared to other treatments. Therefore, totally organic manuring is not practicable and combined use of organic and inorganic integrated plant nutrient system is more beneficial than application of organic or inorganic manures only (R P Hettiarachchi and K M M E K Kulatunga).

Compost production by domestic garbage

Composted material is less bulky than the original material, and easier and more pleasant to handle. During the composting process, carbon dioxide and water are lost to the atmosphere and the size of the pile decrease by 30-60%. In addition many weed seeds may be killed by the high temperature in the pile. Unpleasant odors are eliminated. Composting is also very useful for recycling kitchen waste. If you have a large amount of organic waste but not much land, composting may be very much helpful and may create a valuable commercial product that improve soil fertility up to their optimum level. Utilization of domestic garbage for the preparation of compost provides value for organic materials which generates at your home daily.

Study was conducted to select the most suitable species for vermicomposting. To enrich composting different larvae stages of housefly and black solider fly were inoculated to the medium and evaluated their effectiveness throughout the experimental period of three months. Samples were collected at one month interval to assess the rate of composting; particle size distribution and population of larvae. Larvae stages of housefly could be utilized for the preparation of compost effectively. These larvae stages fed on rotting materials such as food scraps and chew up the waste in minimum time period compared to others (R P Hettiarachchi and K M M E K Kulatunga).

Rehabilitation of degraded lands

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

This experiment was started in 2015 at Panawatta and Ekerella estates. Details of the experiment were included in 2015 Annual Review. Thirty months after the establishment of the treatments, significant enhancement of all measured soil fertility parameters such as pH, organic carbon, total N, available P, cation exchange capacity (CEC), exchangeable K, Mg and Ca could be observed with the combine use of agro management practices compared to normal estate practices. At this stage higher girth of immature rubber plants could be observed with combine use of agro management practices compared to normal estate practices. Further, this type of integrated plant nutrient system (IPNS) clearly contributes to reverse land degradation, a generic issue that has been lasted for decades under rubber growing soils in Sri Lanka (Table 2) (R P Hettiarachchi, V Edirimannne, T Gunathilake and G C Malawaraarachchi).

Table 2. *Soil fertility parameters after 30 months of the establishment of combined use of agro management practices compared to normal estate practices at Ekerella estate*

Assessment	Combined use of agro management practices	Normal estate practices
pH	5.5[a]	5.3[b]
Organic carbon (%)	1.6[a]	1.07[b]
Total N (%)	0.14[a]	0.09[b]
Available P (ppm)	31[a]	26[b]
Cation exchange capacity (cmol+/Kg)	3.4[a]	2.5[b]
Exchangeable K (ppm)	154[a]	95[b]
Exchangeable Mg (ppm)	40[a]	28[b]
Exchangeable Ca (ppm)	92[a]	75[b]

Means with same letters in a rows are not significantly different at $p < 0.05$

Organic manure application for rubber nursery plants

Evaluation of the effectiveness of compost on rubber nursery plants

This experiment was started in 2016 and the experimental design was explained in Annual Review for 2016. This experiment was repeated to confirm previous results before bud grafting stage and to observe the treatment effect after bud grafting stage.

At the end of four months after planting higher plant height and diameter measurements could be observed with 100g compost applied treatment, T2 compared to other treatments, T1, T3 and T4. This experiment was terminated at the end of four months period as the plants were severely affected by fungal leaf diseases (Table 3).

Table 3. *Effect of different compost applications on plant height and diameter of rubber nursery plants before bud grafting period*

Treatments	Combination	Plant diameter (mm)	Plant height (cm)
T1	Soil + 50g compost	6.4	84.5
T2	Soil + 100g compost	6.6	85.7
T3	Soil + 150g compost	6.1	74.0
T4	Soil + 200g compost	6.5	74.3

(R P Hettiarachchi, G C Malawaraarachchi and M W H Gayan)

Soil amendment with half burned paddy husk in different ratios on the growth of poly bagged nursery plants

An experiment was started in August 2017 to investigate the effect of soil media amendment with different ratios of half burned paddy husk (HBPH) on the growth of poly bagged nursery plants and the experimental design was explained in Table 4.

Table 4. *The treatment combination of the experiment*

T1	Soil + HBPH (3:1) media + recommended inorganic fertilizer
T2	Soil + HBPH (2:1) media + recommended inorganic fertilizer
T3	Soil + HBPH (1:1) media + recommended inorganic fertilizer
T4	(Control) Soil only + recommended inorganic fertilizer and compost

Leaf and soil samples collected at the end of 4 months after planting were analyzed for their properties, leaf N, P, K, Mg content and soil pH. There was no significant difference observed in leaf nutrients. However, it was observed that soil pH was significantly greater in control treatment than the other treatments in Dartonfield nursery (Tables 5 & 6).

Table 5. *Effect of different paddy husk amendments on plant and soil parameters at 4 months after planting at Dartonfield nursery*

Treatments	**Parameters**				
	Leaf N (%)	**Leaf P (%)**	**Leaf K (%)**	**Leaf Mg (%)**	**Soil pH**
T1	2.55^{a}	0.23^{a}	1.10^{a}	0.097^{a}	5.18^{bc}
T2	2.56^{a}	0.21^{a}	1.11^{a}	0.080^{a}	5.10^{c}
T3	2.56^{a}	0.25^{a}	1.10^{a}	0.083^{a}	5.30^{b}
T4	2.70^{a}	0.24^{a}	1.03^{a}	0.080^{a}	5.64^{a}

Mean values followed by same letters in each column are not significantly different at $p< 0.05$ as determined by Duncan's multiple range test

Table 6. *Effect of different paddy husk amendments on plant and soil parameters at 4 months after planting at Welikadamulla nursery*

Treatments	**Parameters**				
	Leaf N (%)	**Leaf P (%)**	**Leaf K (%)**	**Leaf Mg (%)**	**Soil pH**
T1	2.92^{a}	0.233^{a}	1.06^{a}	0.103^{a}	5.06^{b}
T2	2.25^{a}	0.193^{a}	1.00^{a}	0.093^{a}	5.28^{ab}
T3	2.80^{a}	0.273^{a}	1.19^{a}	0.093^{a}	5.31^{ab}
T4	2.70^{a}	0.230^{a}	1.02^{a}	0.160^{a}	5.55^{a}

Mean values followed by same letters in each column are not significantly different at $p< 0.05$ as determined by Duncan's multiple range test

Plant dry matter weight at 4 months after planting and at the end of experiment was also measured. At 4 months after planting, dry weights of leaf, tap root and feeder root were not significantly affected by the treatments in both nurseries but feeder root weight was significantly higher in T2 treatment compared to control treatment (T1) at

Welikadamulla. At the end of experiment, plant dry matter weight showed significant differences among the treatments highlighting that T1 treatment recorded the highest values of plant dry matter weight at Dartonfield (Tables 7 & 8).

Table 7. *Plant dry matter weight recorded in different treatments at Dartonfield nursery*

Treatments	Dry weight at 4 months (g)			Dry weight at the end of Experiment (g)		
	Leaf with petiole	Tap root	Feeder roots	Leaf with petiole	Tap root	Feeder roots
T1	7.0[a]	7.20[a]	1.69[a]	14.0[a]	28.7[a]	3.8[a]
T2	7.0[a]	4.38[a]	1.67[a]	13.2[a]	13.9[b]	2.0[ab]
T3	6.3[a]	3.71[a]	2.38[a]	7.90[b]	14.7[b]	1.9[b]
T4	7.0[a]	6.06[a]	1.57[a]	13.3[a]	20.9[b]	2.5[ab]

Means with same letters in each column under each parameter are not significantly different at $p< 0.05$ as determined by Duncan's multiple range test

Table 8. *Plant dry matter weight recorded in different treatments at Welikadamulla nursery*

Treatments	Dry weight at 4 MAP (g)			Dry weight at the end of Experiment (g)		
	Leaf with petiole	Tap root	Feeder roots	Leaf without petiole	Tap root	Feeder roots
T1	8.3[a]	3.66[a]	2.99[ab]	3.8[a]	17.5[b]	18.0[a]
T2	9.6[a]	4.85[a]	4.03[a]	4.4[a]	21.8[ab]	31.7[a]
T3	6.7[a]	5.10[a]	2.12[b]	4.5[a]	19.4[ab]	26.0[a]
T4	7.7[a]	5.35[a]	1.86[b]	3.6[a]	25.3[a]	30.0[a]

Means with same letters in each column under each parameter are not significantly different at $p< 0.05$ as determined by Duncan's multiple range test

(H A R K Jayawardana, T Gunatilleke, J A S Chandrasiri, P D S D O Rathnasooriya and R M Baddevidana).

Organic and inorganic mulching for weed control in immature rubber plantations

The study was started in 2017. In this study, paddy straw, Oil palm refuse, polythene cover and shade nets were tested for weed control around the plant in comparison to normal estate weed management practices.

Table 9. *The treatment combination of the experiment*

Treatment combination	
T1	Shade net
T2	Polythene sheet
T3	Oil palm refuse
T4	Paddy straw
Control	Normal estate practices

Four different mulching materials were tested on weed control and weed regeneration compared to normal estate practices *i.e.* allow naturals and manual weeding at fertilizer application. Treatments were arranged in randomized complete block design (RCBD) with 4 replicates consisting 5 plants per replicate. The percentage of weeds regeneration recorded during first three months of the experiment showed more or less similar pattern at both experimental sites, Geekiyanakanda and Raigam estates. All the treatments showed significantly higher weed control than the control. Oil palm mulch treatment significantly controlled all the weeds by two weeks of mulch application. However, the weeds have started regeneration at 10 weeks after oil palm treatment. Paddy straw mulch showed 100% weed control from 4 weeks of its application but started weed regeneration after 8 weeks of its application showing significantly lower efficiency of weed control than oil palm mulch as paddy husk decayed quicker than Oil palm refuse (Tables 10 & 11).

Control treatment showed weed regeneration in two weeks although there were no weeds initially. Both polythene and shade net treatments recorded significant control of weed showing total weed control from 4 weeks of application. In fact, weed regeneration was not observed in polythene and shade net treatments even at the end of year 2018. However, it should be noted that there was cover crops growing on the surface of polythene and shade net from 6 weeks period but these creepers did not penetrate and grow under the mulch and they could be removed with less effort and less labor in three months interval. In addition, for the application and maintenance of both shade net or polythene mulch required approximately half of labor compared to control treatment (Table 12). According to the results it was decided to apply paddy straw and Oil palm refuse in 03 months intervals. There were no material cost for oil palm refuse and the paddy straw, but the material cost of shade net and polythene was Rs.32.30 and Rs.132.00 respectively per plant.

Table 10. *Percentage of weeds observed in each treatment during first three months of the experiment at Geekiyanakanda estate*

Stage	Percentage of weeds				
	Shade net	**Polythene**	**Oil palm refuse**	**Paddy straw**	**Control**
Initial	100.00[a]	100.00[a]	100.00[a]	100.00[a]	0.00[b]
2 weeks after treatment	10.50[c]	8.00[d]	0.00[e]	21.50[a]	12.25[b*]
4 weeks after treatment	0.25[b]	0.00[b]	0.00[b]	0.00[b]	21.00[a]
8 weeks after treatment	0.00[b]	0.00[b]	0.00[b]	0.00[b]	98.00[a]
10 weeks after treatment	0.00[d]	0.00[d]	12.25[c*]	26.00[b*]	100.00[a]
12 weeks after treatment	0.00[d]	0.00[d]	23.25[c]	54.50[b]	100.00[a]

Means with same letters in each row are not significantly different at $p < 0.05$.*Weed regeneration.

Table 11. *Percentage of weeds observed in each treatment during first three months of the experiment at Raigama estate*

Stage	Percentage of weeds				
	Shade net	**Polythene**	**Oil palm refuse**	**Paddy straw**	**Control**
Initial	100.00[a]	100[a]	100[a]	100[a]	0[b]
2 weeks after treatment	20.00[b]	15.00[c]	0[e]	24.25[a]	10.00[d*]
4 weeks after treatment	0.00[b]	0.00[b]	0.00[b]	0.00[b]	24.25[a]
8 weeks after treatment	0.00[b]	0.00[b]	0.00[b]	0.00[b]	99.00[a]
10 weeks after treatment	0.00[d]	0.00[d]	10.00[c*]	22.50[b*]	100.00[a]
12 weeks after treatment	0.00[d]	0.00[d]	25.00[c]	55.00[b]	100.00[a]

Means with same letters in each row are not significantly different at $p < 0.05$.*Weed regeneration

Oil palm	Paddy straw	Polythene	Shade net

Fig. 1. weed control under different mulch materials at 8 weeks after application

Table 12. *Number of labour rquired for application and maintenance of treatments for one year period as calculated for an area of 01 ha*

Stage	**Control**	**Paddy straw**	**Oil palm refuse**	**Shade net**	**Polythene**
Initial mulch application	07/ha	04/ha	04/ha	10/ha	10/ha
At 3 months	07/ha	04/ha	04/ha	02/ha	02/ha
At 9 months	07/ha	04/ha	04/ha	02/ha	02/ha
At 12 months	07/ha	04/ha	04/ha	02/ha	02/ha
Total labour/first year	35/ha	20/ha	20/ha	18/ha	18/ha

*calculations have been done considering plant spacing =510 plants/ha, manual weeding capacity = 70 plants by 1 labour day

(H A R K Jayawardana, T Gunatilleke and A P Thewarapperuma)

Plant nutrition and fertilizer use

Nutrient requirement of Hevea grown in the low country Intermediate Zone

This experiment was started in 2016 and the experimental design was explained in the Annual Review 2016. Two sites in each area of Mahaoya, Padiyathalawa and Moneragala were included to evaluate the effectiveness of different fertilizer treatments on immature rubber plants. One site was at first year and the other site was at second year of establishment at Padiyathalawa and Mahaoya. However, both were at first year at Moneragala area.

First year plants at Moneragala and Padiyathalawa areas showed no significant differences of plant diameter between treatments *i.e.* R/SA 7:9:9:3, R/SA 7:9:9:3 + 2K, modified new fertilizer mixture R/SA 7:4:18:6 and R/U 12:14:14 at the end of first year. However, the highest diameter value could be observed with the treatment having modified new fertilizer mixture R/SA 7:4:18:6 and the lowest value for R/U 12:14:14. The plant diameter was measured 6 inches above the ground level (Table 13).

Second year plants at Mahaoya and Padiyathalawa areas showed significant differences of plant girth between treatments. The plant girth was measured 120 cm above the ground level and treatment with R/SA 7:9:9:3 mixture showed significantly higher plant girth compared to the treatment with R/U 12:14:14. Moreover, there was no significant differences among treatments of *i.e.* R/SA 7:9:9:3, R/SA 7:9:9:3 + 2K and modified new fertilizer mixture R/SA 7:4:18:6 at the end of second year (Table 13). Finally, data showed that sulphate of ammonia based fertilizer mixtures (R/SA) gave higher growth parameters of immature rubber plants compared to urea based fertilizer mixtures (R/U) (Table 14) (R P Hettiarachchi, V Edirimannne, T Gunathilake and G C Malawaraarachchi).

Table 13. *Effect of different fertilizer mixtures on plant diameter of first year immature rubber plants*

Treatment	Plant diameter (mm)
(T1) R/SA 7:9:9:3	30.2[a]
(T2) R/SA 7:9:9:3 +2K	30.1[a]
(T3) R/SA 7:4:18:6 (New mixture)	30.6[a]
(T4) R/U 12:14:14	29.0[a]

Table 14. *Effect of different fertilizer mixtures on plant girth of second year immature rubber plants*

Treatment	Plant girth (cm)
(T1) R/SA 7:9:9:3	11.8[a]
(T2) R/SA 7:9:9:3 +2K	10.1[ab]
(T3) R/SA 7:4:18:6 (New mixture)	10.4[ab]
(T4) R/U 12:14:14	9.7[b]

Slow release fertilizer application

Coir based slow release fertilizer application for immature rubber plants

The experimental design was similar to the experimental design at Millawa estate which was explained in the annual review 2016. The immature plants at Raigama estate showed no significant differences of plant girth between treatments *i.e.* conventional fertilizer application (T1), slow release fertilizer type 1 (T2) and slow release fertilizer type 2 (T3) at the end of two years and two and half years. However, higher girth values could be observed with the treatment having slow release fertilizer T2 and T3 compared to conventional fertilizer application treatment (T1) (Table 15). Leaf analysis data showed no significant differences for N, P, K & Mg contents with slow release fertilizer treatments (T2 and T3) compared to conventional treatment (T1). Moreover, slow release fertilizer type 2 gave significantly higher value of leaf Mg content compared to slow

release fertilizer type 1 (Table 16). Soil fertility parameters such as; pH, total N, available P, exchangeable K, Mg and Ca showed no significant differences among treatments (Table 17).

Plant growth, major leaf nutrients and some important soil fertility parameters showed no significant differences among different fertilizer applications; *i.e.* conventional fertilizer application and slow release fertilizer type 1 & 2. Moreover, application of SRF type 1 and 2 reduced the application of total fertilizer quantity by 45% and 35% respectively compared to the quantity of conventional fertilizer. Economically viable, environmental friendly this type of product may help to enhance fertilizer use efficiency that is one of the major issues related for fertility management in rubber growing soils in Sri Lanka.

Similar to this experiment another new experiment was started at Geekiyanakanda estate to evaluate the effectiveness of slow release fertilizer and confirm the data which are being observed related to immature rubber growth, plant nutrients and some important soil fertility parameters (R P Hettiarachchi, J A S Chandrasiri and K E de Silva).

Table 15. *Girth of immature rubber plants at Raigama estate*

Treatments	**Mean girth (cm)**	
	At the end of 2 years	**At the end of 2 ½ years**
(T1) Conventional fertilizer application	15.66[a]	18.30[a]
(T2) Slow release fertilizer type 1	16.50[a]	19.03[a]
(T3) Slow release fertilizer type 2	17.35[a]	20.42[a]

Table 16. *Leaf nutrient data of immature rubber plants at Raigama estate*

Treatments	**Leaf nutrients (%)**			
	N	**P**	**K**	**Mg**
(T1) Conventional fertilizer application	3.01[a]	0.157[a]	0.982[a]	0.272[ab]
(T2) Slow release fertilizer type 1	2.93[a]	0.147[a]	0.905[a]	0.262[b]
(T3) Slow release fertilizer type 2	3.02[a]	0.160[a]	0.957[a]	0.287[a]

Table 17. *Soil fertility parameters after 2½ years of the establishment of the experiment at Raigama estate*

Assessment	(T1) Conventional fertilizer application	(T2) Slow release fertilizer type 1	(T3) Slow release fertilizer type 2
pH	5.08[a]	5.39[a]	5.08[a]
Total N (%)	0.09[a]	0.085[a]	0.085[a]
Available P (ppm)	16.49[a]	22.39[a]	21.07[a]
Exchangeable K (ppm)	24.4[a]	22.2[a]	24.6[a]
Exchangeable Mg (ppm)	41.5[a]	48.9[a]	40.17[a]
Exchangeable Ca (ppm)	371.3[a]	309.2[a]	288.2[a]

Slow release fertilizer based reusable porous tube application for immature rubber plants

Porous tube prepared with rubber industry waste materials and filled with normal fertilizer mixture was used for immature rubber plants.

One experiment was started at Ganepalle estate to study the effectiveness of this reusable porous tube on soil fertility and their influence on mineral composition of rubber leaves and growth of immature rubber plants. Plants at first year were manured according to the experimental design shown in Table 18 and treatments were imposed at the end of five months after planting. Nitrogen (N), phosphorus (P), potassium (K) and magnesium (Mg) fertilizers were applied as conventional split application for control treatment (T1) and other two treatments were maintained with two different types of porous tubes. The design of this experiment was randomized completely block design with five replicates. Each replicate had 25 effective trees (R P Hettiarachchi, V Edirimannne, T Gunathilake and M W H Gayan).

Table 18. *Treatment combinations of the experiment*

Treatment	Treatment combination
T1	Conventional split fertilizer application
T2	Reusable porous tube type 1
T3	Reusable porous tube type 2

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

Twelve, six and eleven different soil units were identified and mapped in Kalutara, Kegalle and Ratnapura districts respectively (Figs. 2, 3 and 4). Sampling sites were randomly selected in main soil units and samples were collected for analysis of fertility parameters. Moreover, field parameters such as yield, growth, topography of the

land, fertilizer application history and soil management practices were collected from the same sites to determine fertility levels of the lands accurately (Tables 19, 20 & 21).

Fig. 2. Identification of different soil units in Kalutara district

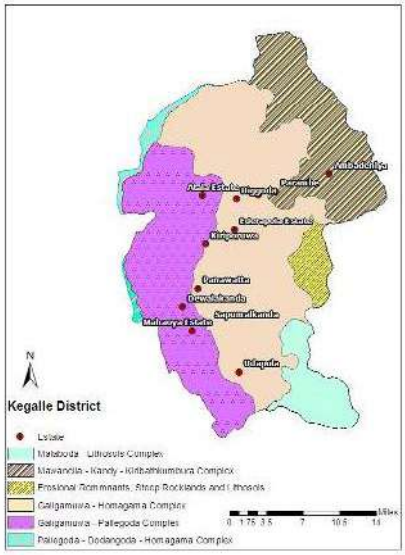


Fig. 3. Identification of different soil units in Kegalle district

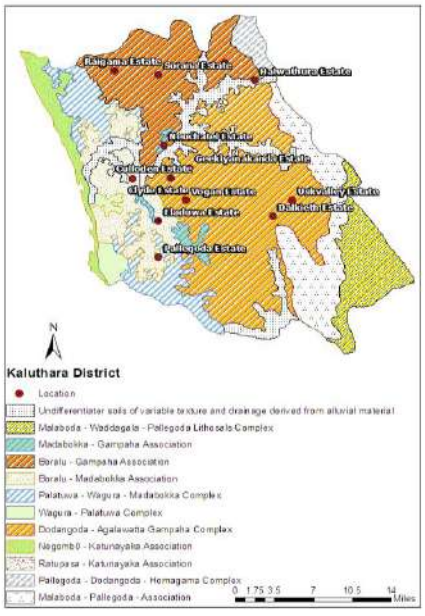


Fig. 4. Identification of different soil units in Ratnapura district

Table 19. *Identified sampling units in Kalutara district and details of sample collection*

Sample unit	Site (Estate)	Extent (ha)	Data collection		Parameters analyzed
			Soil	Leaf	
Boralu-Gampaha Association	Raigama	135	26	26	390
	Sorana	60	3	3	45
	Neuchattle	100	10	10	150
	Frocester	40	6	6	90
	Edurugala	60	10	10	150
Dodangoda-Agalawatta-Gampaha Complex	Geekiyanakanda	210	15	15	225
	Clyde	130	17	17	255
	Vogan	60	15	6	189
	Dalkith	158	27	27	405
Boralu-Madabokka Assosiation	Pallegoda	20	4	4	60
	Eladuwa	37.4	5	5	75
	Halwathura	80	9	9	135

Table 20. *Identified sampling units in Kegalle district and details of sample collection*

Sample unit	Site (Estate)	Extent (ha)	Data collection		Parameters analyzed
			Soil	Leaf	
Galigamuwa-Homagama Complex	Ganepalla	175	18	18	270
	Edurapola	85	19	19	285
	Udapola – Lalan	332	32	32	480
	Lavent	170	21	5	251
	Higgoda	101	11	11	165
	Yataderiya	50	8	5	108
	Kelani	200	24	24	360
Pallegoda-Dodangoda-Homagama Complex	Madeniya	67	10	10	150
Galigamuwa-Pallegoda Complex	Atale	198	12	12	180
	Mahaoya	125	16	6	200
Mawanella-Kandy-Kiribathkumbura complex	Ambadeniya	268	15	15	225
	Hathbawa	55	11	11	165
	Parambe	200	21	21	315

Table 21. *Identified sampling units in Ratnapura district and details of sample collection*

Sample unit	Site (Estate)	Extent (ha)	Data collection		Parameters analyzed
			Soil	Leaf	
Pallegoda-Dodangoda-Boralu-Gampaha Association	Palmgarden	100	15	15	225
	Sunderland	175	14	14	210
	Millavitiya	100	12	12	180
Malaboda-Weddagala-Pallegoda Lithosois Complex	Galathura	115	22	22	330
	Peenkanda	112	13	13	195

Services

Site-specific fertilizer recommendation by soil and foliar survey programme

Under this programme 5,246 hectares of mature rubber fields were surveyed and 34 fertilizer recommendations were given for the next three years. Details of the survey are given in Table 22 (R P Hettiarachchi, A Thewarapperuma and all the staff of the department).

Table 22. *Details of the analytical service and site specific fertilizer recommendation in 2018*

Estate	Analytical Services		Site specific fertilizer recommendation (SSFR) service		Income	
	No. of samples	No. of reports	Surveyed extent (ha)	No. of reports	Analytical service (Rs.)	SSFR service (Rs.)
1. Sapumalkanda	43	20	117.5	01	31605.00	15275.00
2. Kobowella	05	01	5.00	01	3375.00	650.00
3. Bibile	04	01			2700.00	
4. Udabage	19	8			14025.00	
5. Mahaoya	33	16			22275.00	
6. Waymba University	48	01			62400.00	
7. Kahawatta	01	01			675.00	
8. Miyanawita	12	08			8100.00	
9. Halwatura	09	02	207.00	01	6075.00	26910.00
10. Neuchatel	12.	03	168.87	01	6900.00	21953.10
11. Miriswatta	20	04			13500.00	
12. Pelawatta	13	06			11275.00	
13. Pallegoda	04	03			2700.00	
14. Mirishena	05	01	116.79	01	3375.00	15182.70
15. Higgoda	05	02			3375.00	

Estate	Analytical Services		Site specific fertilizer recommendation (SSFR) service		Income	
	No. of samples	No. of reports	Surveyed extent (ha)	No. of reports	Analytical service (Rs.)	SSFR service (Rs.)
16. Parambe	05	02			3375.00	
17. Madeniya	10	03			6750.00	
18. Edella	08	02	106.61	01	5400.00	13859.30
19. Sirikandura	04	03	26.75	01	2700.00	3477.50
20. Yatadola	10	02			6750.00	
21. Pallegama	10	02			675.00	
22. Atale	13	05			8775.00	
23. Etana	04	02			2700.00	
24. Hulandawa	06	02			4050.00	
25. Hathbawa	07	02			4725.00	
26. Eladuwa	12	03			6075.00	
27. Elston	05	01			3375.00	
28. Frocester	02	01	50.95	01	150.00	6623.50
29. Ambedeniya	07	01			4725.00	
30. Payagala	01	01			675.00	
31. Baddegama	04	01			2700.00	
32. Ayr	07	01	192.81	01	4725.00	25065.30
33. Salawa	08	01			5400.00	
34. Raigama	03	01	340.6	01	2025.00	44278.00
35. Weniwella	09	04			6075.00	
36. Sunderland	04	01			2700.00	
37. Halpe	06	01			4050.00	
38. Sanquhar	07	01			4725.00	
39. Keeragla	02	01			1350.00	
40. HORDI Gannoruwa	03	01			9675.00	
41. National Fertilizer Sec.	30	01			20250.00	
42. N' Kele	09	01			Free	
43. Strar Project	01	01			Free	
44. ASD	01	01			Free	
45. Udapola	07	02			4725.00	
46. Hunuwella	02	01			3150.00	
47. Edurugala			158.98	01		20667.40
48. Peenkanda			217.76	01		28308.80
49. Hillstream			40.64	01		5283.20
50. Muthuwagala			180.52	01		23467.60
51. Niriella			349.2	01		45396.00

Estate	Analytical services		Site specific fertilizer recommendation (SSFR) service		Income	
	No. of samples	No. of reports	Surveyed extent (ha)	No. of reports	Analytical service (Rs.)	SSFR service (Rs.)
52. Bentota			69.56	01		9042.80
53. Rambuk-kanda			195.79	01		25452.70
54. Mohammadi			130.06	01		16907.80
55. Galaboda			46.96	01		6104.80
56. Divithura			75.32	01		9791.60
57. Ganepalla			179.48	01		23332.40
58. Poronuwa			242.83	01		31567.90
59. Akuressa			26.52	01		3447.60
60. Millavitiya			106.37	01		13828.10
61. Galathura			185.93	01		24170.90
62. Gulugaha-kanda			61.79	01		8032.70
63. Hemingford			74.02	01		9622.60
64. Mahawela			73.01	01		9491.30
65. Springwood			134.08	01		17430.40
66. Sorana			251	01		32630.00
67. Palm Garden			263.67	01		34277.10
68. Dumbara			193.5	01		25155.00
69. Sunderland			205.42	01		26704.60
70. Weeoya			450.47	01		58561.10
Total	129	440	5245.76	34	328980.00	681948.80
				Grand Total		1010928.80

Land selection and suitability for rubber cultivation

Under the routine land selection programme 150 hectares of land were surveyed for the suitability of rubber cultivation and four land suitability reports were issued. Details of the surveys are given in Table 23 (R P Hettiarachchi, G C Malawaraarachchi and all the staff of the department).

Table 23. *Details of the Land Selection program in 2018*

Place (GS Division)	Extent surveyed (ha)
Pollebadtha (Uhana)	40
Pulukunawa (Chenkaladi)	35
Kadiragalakanda (Chenkaladi)	20
Samanagala (Uhana)	55
Total	150

Analytical services

Under this programme various samples which were received from Estates, smallholders, Universities and other private organizations were analyzed according to the SLS methods. Approximately 964 samples (3,827 parameters) including 363 fertilizer samples from rubber growers were analyzed to assure application of good quality fertilizers to their rubber lands. Details of the analytical service are given in Table 22 (R P Hettiarachchi, V Edirimanna, K E de Silva and all the staff of the department).

BIOCHEMISTRY AND PHYSIOLOGY

K V V S Kudaligama

DETAILED REVIEW

Staff

Dr (Mrs) K V V S Kudaligama, Senior Research Officer covered the duties of the Head of Biochemistry & Physiology department whilst managing the research and development work of the department was promoted to Principal Research Officer with effect from 17.12.2018. Mrs N P S N Karunarathne, Research Officer, Mr M K P Perera, Experimental Officer, Mrs P D T L Madushani, Technical Officer and Mrs H A M E Hettiarachchi, Management Assistant were on duty throughout the year. Mrs N N Abewardhana, Technical Officer resigned from the Institute with effect from 05.11.2018.

Research students

Name	Research topic	University
AKD Malsha Binuwangi	Induction training programme for Bachelor of Science	University of Kelaniya
AMPD Abeykoon	Induction training programme for Bachelor of Science (Agriculture)	University of Ruhuna
BGIP Thilakasiri KMP Kumara KPCD Weerasooriya SMINP Senanayeka	Induction training programme of National Diploma in Technology (Agriculture)	Sri Lanka School of Agriculture, Labuduwa, Galle

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
KVVS Kudaligama	National Symposium on Sustainable Plantation Management 2018	NIPM
	IRRDB Conference - 2018	IRRDB
	Forum on Current Socio-economic Issues and Their Impact on Rubber Production Sector Performance	RRISL
NPSN Karunarathne	National Symposium on Sustainable Plantation Management 2018	NIPM
	International workshop on Statistical Applications in Socio-economic Research	RRISL

Officer/s	Subject/Theme	Organization
NPSN Karunarathne	Forum on Current Socio-economic Issues and Their Impact on Rubber Production Sector Performance	RRISL
	Workshop on effective publication writing	University of Sri Jayawardenapura
	Workshop on Molecular Biology	Genetics & Plant Breeding Dept., RRISL

Training programmes conducted

Officer/s	Subject/Theme	
KVVS Kudaligama	Low intensity harvesting methods	Training program for Faculty of Agricultural Sciences, Aquinas University Collage
	Use of stimulant in low intensity harvesting	Induction Course for Planter Trainees, NIPM
	Use of stimulant in low intensity harvesting	Plantation Crop Production Technology- training program for teachers
	Effective introduction of new LIH systems to address current issues in rubber plantation industry (capital project)	Training programs and technology transfer programs for RPCs, smallholders, REOs, RDOs and Thurusaviya Officers

Field visits

Advisory - 66 visits
Experimental - 192 visits
Miscellaneous - 08 visits

Sample testing

% Dry rubber content of latex - 60 samples
Commercial ethephon mixtures - 16 samples

LABORATORY AND FIELD INVESTIGATIONS

Low intensity harvesting to improve 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 with

2.5% oil based ethephon as the yield stimulant was continued in 04 tapping blocks of RRIC 121 genotype in Gallewatte division, Dartonfield estate which was replanted in 2010 (Field No: 2010/5.58). Daily yields were monitored as dry rubber content and volume of latex together with scrap weight. Average actual tapping days under S/2 d4 system was 76. In all four blocks average DRC% of latex was 40%. Variation of yield of blocks were mainly due to the degree of mixing clones (Table 1).

Table 1. *Average yield of four tapping blocks harvested with S/2 d4 system at Gallewatta division of Dartonfield estate*

Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
S/2 d4-Block 1	77	40	48.26	14.48	5.72	1115
S/2 d4-Block 2	76	40	63.86	19.16	6.68	1456
S/2 d4-Block 3	76	40	56.51	16.95	6.61	1288
S/2 d4-Block 4	76	40	47.70	14.31	4.48	1088
Average	**76**	**40**	**54.08**	**16.23**	**5.87**	**1237**

Eight tapping blocks from 2010 replanted (Field No:2010/5.17) at Nivithigalakele division of Dartonfield Estate had been selected for commercial level testing of S/2 d4 fields mixed with RRIC 121 and RRISL 203. Total number of tapping days under d4 frequency was 86 and average productivity of the field was 1871 kg. With the proportion of mixing of clones, productivity of the blocks varied (Table 2).

Table 2. *Average yield of eight tapping blocks harvested with S/2 d4 system at Nivithigalakele division of Dartonfield estate*

Tapping system	Actual tapping days	DRC (%)	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
S/2 d4 Block 1	86	37.48	61.54	18.46	5.32	2128
S/2 d4 Block 2	86	35.57	42.47	12.74	3.67	1468
S/2 d4 Block 3	86	35.05	53.90	16.17	4.63	1854
S/2 d4 Block 4	86	36.95	59.25	17.78	5.11	2043
S/2 d4 Block 5	86	36.20	52.43	15.73	4.53	1811
S/2 d4 Block 6	86	38.97	60.91	18.27	5.27	2109
S/2 d4 Block 7	86	37.26	49.07	14.72	4.22	1689
S/2 d4 Block 8	86	37.77	53.93	16.18	4.66	1864
Average	**86**	**36.91**	**54.19**	**16.26**	**4.68**	**1871**

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

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

Rs.109.564 Mn worth funds were received through a special capital project to popularize recommended low intensity harvesting systems to rubber growers in Sri Lanka. Overall objective of the project is to provide evidence based approach through demonstrations to popularize new low intensity harvesting systems in both smallholder and plantation sectors to address current issues and thereby to obtain associated benefits. Awareness programmes were conducted for Rubber Development Officers of Rubber Development Department attached to Kegalle, Rathnapura, Kalutara, Colombo, Gampaha, Kurunegala, Matale and Kandy districts. To improve the knowledge on adaptation, 17 awareness programmes were conducted on RDO ranges of above districts and 103 ha of smallholdings were established with LIH systems (Table 3). Rubber Extension Officers of Advisory Services Department of RRISL were also trained on this.

Table 3. *District wise details of the smallholders established low intensity harvesting systems*

District	No of smallholders	Extent (ha)
Kalutara	48	14.09
Kegalle	33	50.30
Rathnapura	5	2.56
Colombo	3	1.13
Gampaha	20	15.98
Kurunegala	11	8.99
Kandy	8	6.11
Total	**133**	**102.79**

In three estates which belong to Regional Plantation Companies, about 44 ha were established with S/2 d4 system (Table 4).

Table 4. *Details of estates established low intensity harvesting systems*

Estate	Extent (ha)
Geekiyanakanda	14.00
Millewa	15.00
Elston	15.00
Total	**44.00**

Above field established at Elston estate, Puwakpitiya has been selected to investigate effectiveness of two commercial ethephon mixtures available in the local

market (*i.e.* Imported-M and Imported-E) together with locally formulated new formulation (Local-W) on S/2 d4 system in commercial scale. This field was replanted with RRIC 121 clone in 2011 and opened for tapping in 2018. Experiment was started in June, 2018. Tapping task size is 317 trees/tapper and for each formulation three tapping blocks were allocated. Intake per harvester in blocks applied with Local-W and Imported-M was more or less similar. However it was about 2kg higher in blocks applied with Imported-E. Actual yield per ha during the 7 month period investigated was 701kg with Local-W formulation and it was 688kg and 502kg with Imported-M and Imported-E formulations, respectively (Table 5). This reduction in productivity with Imported-E formulation was due to lesser no. of tapping days in the particular blocks.

Table 5. *Variation of yield under S/2 d4 system using different types of ethephon formulations*

Ethephon formulation	Actual tapping days	Intake per harvester (kg)	Actual yield per hectare (kg)
Local-W	46	15.95	701
Imported-M	45	15.48	688
Imported-E	31	18.36	502

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

Effectiveness of commercially available water-based and oil-based ethephon formulations as yield stimulants for rubber

Two types of commercial ethephon mixtures *i.e.* water-based and oil-based presently marketed in Sri Lanka as yield stimulants of rubber were tested for effectiveness. Though the yield performance of these mixtures had been studied, no proper investigation had been done on effectiveness on factors affecting latex regeneration and latex flow.

Mature rubber plantation with RRIC 121 genotype tapped on BO-1 with S/2 d4 (half spiral once in four days) system with monthly application of 1.6g of 2.5% was selected for the study. Yield related factors and latex physiological parameters of trees stimulated with two types of commercial ethephon mixtures were determined on each tapping day during June – August, 2018.

Daily latex volume per tree, daily dry rubber yield per tree (g/t/t), latex thiol content, latex polyphenol content, plugging index showed a similar pattern of variation between the trees stimulated with water-based and oil-based ethephon over the period observed and the variations were statistically insignificant between the two types of stimulations (Table 6).

Table 6. *Comparison of yield and physiological parameters of oil based and water based ethephon stimulated trees over the period studied*

Yield and physiological parameter	June, 2018		July, 2018		August, 2018	
	Oil based	Water based	Oil based	Water based	Oil based	Water based
Sucrose content (mM)	4.94± 0.31[a]	4.08 ± 0.23[b]	3.51± 0.25[a]	3.40± 0.17[a]	3.85± 0.26[a]	3.92± 0.28[a]
Inorganic phosphorus content (mM)	16.93± 0.50[a]	20.75± 0.54[b]	18.56± 0.71[a]	22.87± 0.47[b]	17.07± 0.55[a]	20.68± 0.33[b]
Thiol content (mM)	0.35± 0.02[a]	0.37± 0.02[a]	0.37± 0.02[a]	0.39± 0.02[a]	0.39± 0.02[a]	0.42± 0.02[a]
Polyphenol content (mM)	1.71± 0.04[a]	1.74± 0.03[a]	1.49± 0.06[a]	1.56± 0.07[a]	1.69± 0.08[a]	1.71± 0.08[a]
Dry rubber content in latex %	43.80± 0.37[a]	40.63± 0.36[b]	42.69 ±0.47[a]	39.39 ±0.42[b]	42.13± 0.50[a]	39.59± 0.36[b]
Latex volume per tree (ml)	171.24± 11.61[a]	161.43± 11.96[a]	217.43± 15.26[a]	220.86± 15.65[a]	237.71± 12.59[a]	239.33± 12.14[a]
Latex yield per tree per tapping (g)	82.66± 4.28[a]	71.64± 3.64[a]	92.19± 5.80[a]	86.25± 5.57[a]	101.61± 5.45[a]	96.91± 5.03[a]
Plugging index	2.44± 0.09[a]	2.45± 0.12[a]	2.42± 0.11[a]	2.42± 0.12[a]	2.57± 0.93[a]	2.31± 0.93[a]
Latex flow duration (min)	151.85± 2.46[a]	151.33± 2.33[a]	164.19± 1.11[a]	148.29± 1.77 [b]	161.76± 0.75[a]	151.61± 2.14[b]

Note: Monthly means with same letters of each parameter are not significantly different at $p< 0.05$

Oil-based ethephon stimulated trees had a significantly higher latex dry rubber content than water-based ethephon. Average inorganic phosphorous content was significantly higher in trees stimulated with water-based ethephon than with oil-based ethephon. In most of the tapping days, flow duration with oil based stimulation is more than that with water based stimulation (Table 5). Even though the physiological parameters of latex showed some variations between the two types of ethephon, yielding capacity for a particular period did not vary significantly between trees applied with water-based and the oil-based ethephon (N P S N Karunarathne, K V V S Kudaligama, 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 in Kandakadu (Dry zone)

Growth and physiological performances of five different genotypes were

assessed during 2018 in the field established at Kandakadu Army Farm. Stomatal conductance of leaves of different clones was assessed with different environmental factors (Table 7). Highest stomatal conductance was observed in RRIC 121 throughout the day whilst lowest was reported in PB 260 clone. The highest gap of variation of stomatal conductance during the morning and evening time of the day (23.92 cm/s) was observed in RRISL 2001 clone. Further, it could be observed that diurnal performance of RRISL 2001 in stomatal conductance with other environmental parameters is opposite from other *Hevea* genotypes tested during the study. Stomatal conductance of RRISL 2001 was observed to be reduced with increasing environmental temperature, increasing wind speed and decreasing relative humidity whilst other genotypes showed the opposite relationships (Fig. 1 & Table 7).

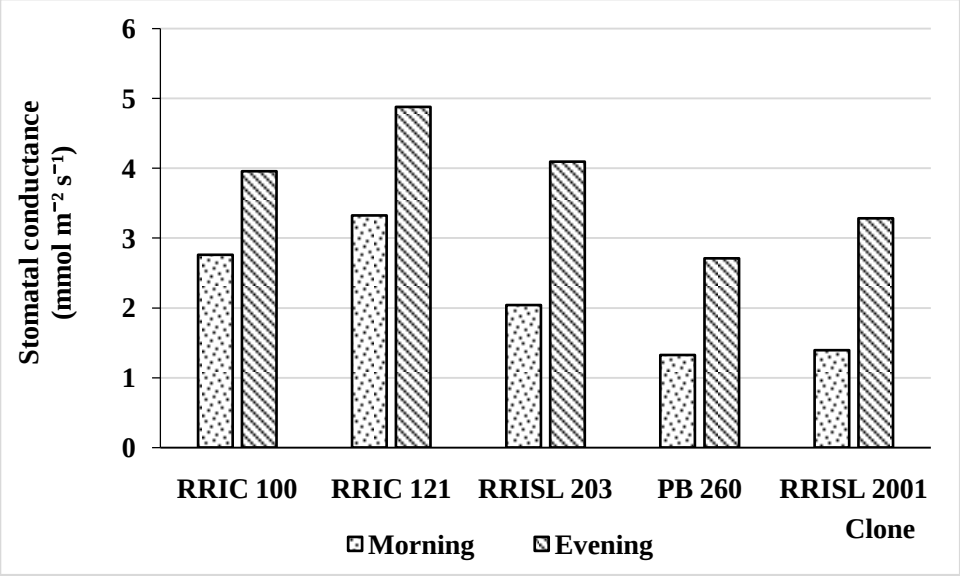


Fig. 1. Average stomatal conductance of different *Hevea* clones planted at Kandakadu experimental site

Table 7. *Average environmental condition at the time of measuring*

	Morning	Evening
Wind speed (kmph)	5.81	11.11
Temperature (ºC)	32.32	34.13
Relative humidity (%)	66.63	56.95

According to the results obtained, variation of height of different clones planted in fields at Kandakadu is PB 260> RRIC 121> RRIC 100> RRISL 203> RRISL 2001 as shown in Table 8. When considering height, number of whorls and stem diameters at different heights, better growth performance was observed in RRIC 121 out of five *Hevea* genotypes planted at Kandakadu (K V V S Kudaligama, N P S N Karunarathne, M K P Perera and P D T L Madushani).

Table 8. *Average growth performances of the clones planted in Kandakadu experimental field*

Clone	# of Whorls	Stem diameter at different heights (cm)			Height (cm)
		at 01 inch	at 01 foot	at 02 feet	
RRIC 100	4	4.172	3.333	2.932	310.31
RRIC 121	4	4.504	3.553	3.125	352.10
RRISL 203	3	3.763	2.972	2.595	270.13
RRISL 2001	3	3.641	2.933	2.578	263.33
PB 260	3	3.167	2.524	2.205	370.00

Growth and physiological performance of different clones planted in Padiyathalawa (Intermediate zone)

Comparison amongst 10 different *Hevea* clones established in Intermediate Zone with regard to height, number of whorls and stem diameters at different heights is given in Table 9. RRIC 121 > RRISL 203> RRISL 2001> Centennial 3> RRISL 201> Centennial 4> RRIC 100> RRISL 2100> RRIC 102 are in the descending order in height of the tested clones reported during 2018. When considering height and stem diameters at different heights, RRIC 121 clone had performed better than the other clones tested.

Table 9. *Average growth performances of the clones planted in Padiyathalawa experimental field*

Clone	# of Whorls	Stem diameter at different heights (cm)			Height (cm)
		01 inch	01 foot	02 feet	
Centennial 4	4	3.793	2.998	2.622	289.94
RRIC 102	2	2.224	2.208	1.840	128.61
RRISL 203	4	3.477	2.894	2.583	327.57
RRIC 121	4	3.605	3.114	2.666	349.31
RRIC 100	3	3.363	2.955	2.482	259.15
RRISL 2001	5	3.767	3.048	2.725	315.91
Centennial 3	4	3.462	2.910	3.050	311.73
RRISL 201	4	3.467	2.708	2.393	310.30
RRISL 2100	3	2.873	2.243	1.897	221.21

Growth and physiological performance of different clones planted in Meerigama (Wet zone)

The descending order of heights of different clones planted at Meerigama is RRISL 203> RRIC 121> RRISL 2001> PB 260 as shown in Table 10. Out of different *Hevea* genotypes, RRISL 203 performed better in growth parameters tested.

Table 10. *Average growth performances of the clones planted in Meerigama experimental field*

Clone	# of Whorls	Stem diameter at different heights (cm)			Height (cm)
		01 inch	01 foot	02 feet	
RRISL 203	5	6.017	5.003	4.413	493.46
RRISL 2001	5	5.584	4.722	4.132	409.18
RRIC 121	4	5.383	4.498	4.045	472.77
PB 260	4	4.287	3.529	3.045	305.91

(K V V S Kudaligama, N P S N Karunarathne, M K P Perera and P D T L Madushani)

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

Effect of biochemical components of latex that affect on quality of raw rubber

The aim of this study is to investigate the effect of different biochemical constituents on quality of raw rubber and to identify the relationship between each biochemical constituent with raw rubber properties. Polyphenols, proteins, thiols and carotenoids are major non- rubber components found in latex and available in different concentrations in different clones. During this study, contents of these constituents of five different clones were investigated along with raw rubber properties during high yielding (August - October) and wintering (February - April) periods of 2017 and 2018 (Fig. 2).

In all clones polyphenol content during wintering season was higher than that during high yielding period. Highest polyphenol content which causes enzymatic browning of rubber could be observed in latex of RRISL 203 genotype during both high yielding and wintering periods amongst the *Hevea* genotypes tested. In both high yielding and wintering periods, the highest protein content was found in RRISL 2001 rubber clone. Even though, higher carotenoid contents could be observed in RRISL 203 and Centennial 3 clones during wintering season, Centennial 4 had the highest carotenoid content during the high yielding period. An increase of thiol content was observed during the wintering season than the high yielding season in most of the clones. Of the clones tested, RRISL 203 and Centennial 4 had relatively higher contents of thiol during wintering period whilst no significant change was observed during high yielding period (Fig. 2) (N P S N Karunarathne, K V V S Kudaligama, P D T L Madushani and N N Abewardhana).

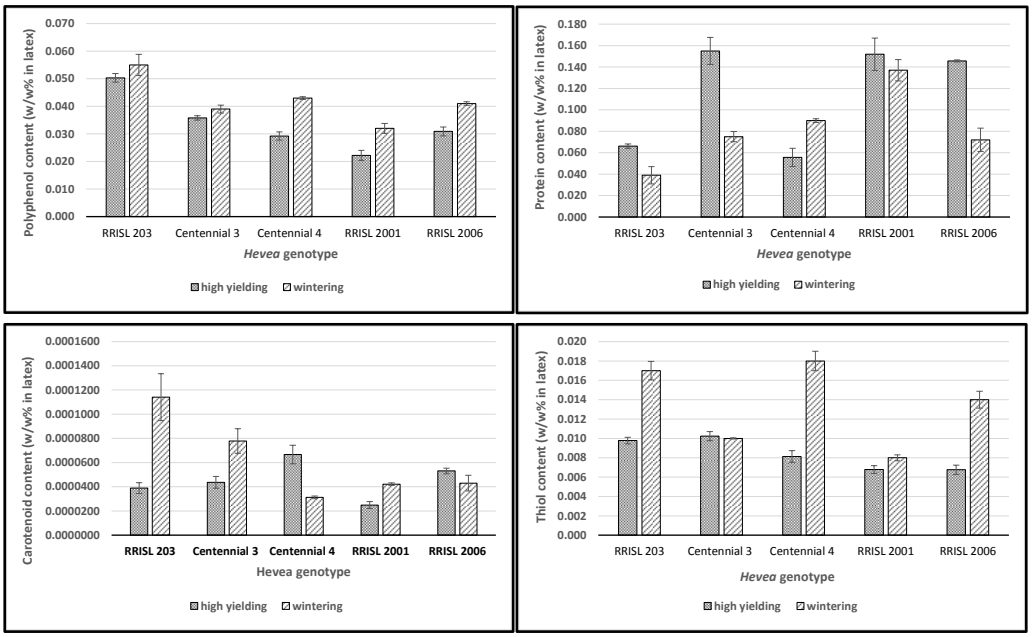


Fig. 2. Changes of biochemical components in rubber latex of selected *Hevea* genotypes during high yielding and wintering periods

Biochemical and physiological screening of HP progenies

Biochemical and physiological assessment of latex of nine *Hevea* HP progenies along with RRISL 203 *Hevea* genotype as the control was carried out at Yatadola estate on request of Department of Genetics & Plant Breeding. The contents of sucrose, inorganic phosphorus, thiol, polyphenol and dry rubber were determined as latex diagnostic tests during high yielding and wintering periods of 2018 (Table 11).

According to the results, 95/23 and 95/47 HP progenies physiologically performed better compared to other HP progenies with higher latex inorganic phosphorus content, thiol content and DRC%. Even though, high DRC% and thiol content were found in HP 95/1 progeny, a very low value could be observed for latex inorganic phosphorus content. HP 95/29 progeny showed high inorganic phosphorus and thiol contents in latex whilst DRC% was lower during high yielding period. However, DRC% was found at a higher value compared to the other progenies during wintering period (Table 11) (N P S N Karunarathne, K V V S Kudaligama, P D T L Madushani and N N Abewardhana).

Table 11. *Average sucrose (Suc), inorganic phosphorus (Pi), thiol (RSH), polyphenols (PP) and dry rubber content (DRC) of latex of different Hevea HP progenies and RRISL 203clone during wintering (W) and high yielding (HY) periods*

HP Progeny	HP progenies evaluation - Yatadola estate									
	Suc (mM)		Pi (mM)		RSH (mM)		PP (mM)		DRC %	
	HY	W	HY	W	HY	W	HY	W	HY	W
95/19	3.50	22.18	5.14	8.30	0.40	0.79	2.89	4.60	47.23	38.99
95/21	7.39	3.80	4.60	7.57	0.35	0.59	2.01	2.40	43.72	37.86
81/69	9.55	21.74	1.25	7.22	0.40	0.44	2.49	2.61	51.92	36.48
95/33	3.54	8.47	1.22	3.66	0.19	0.37	2.28	2.91	50.98	35.66
95/23	9.46	7.83	8.75	11.23	0.45	0.43	2.16	2.19	54.04	37.30
95/13	8.28	16.15	0.69	3.66	0.34	0.68	1.62	3.19	50.51	37.55
95/1	4.39	4.40	1.01	12.05	0.53	0.58	2.12	2.65	52.87	34.79
95/47	2.70	2.06	7.03	5.99	0.74	0.69	2.34	2.28	52.15	28.12
95/29	4.74	7.18	12.42	4.05	0.58	0.56	1.96	2.29	41.30	42.83
RRISL 203	10.47	7.08	1.77	8.33	0.57	0.27	2.28	3.59	50.12	30.16

Development of in-country ethephon formulations to promote low cost harvesting systems for rubber plantations in Sri Lanka (National Science Foundation funded project No: RG/2017/AG/1)

Efficacy of a new ethephon formulation was tested against a commercially available formulation with small scale field trial. No significant variation had been observed in sucrose availability in laticifers with new ethephon formulation. Significantly higher thiol and lower inorganic phosphorous content of latex in trees may ensure long term sustainability of new ethephon formulation as a yield stimulant in *Hevea* (Fig. 3).

Duration of latex flow with existing ethephon formulation was significantly lower than that with new formulation. Average initial flow rate of trees applied with new ethephon showed statistically significant decrease over existing formulation. Respective average initial flow rate values of new and existing formulations were 4.34 ml/min. and 4.74 ml/min. Plugging index of trees showed a significant difference among two ethephon formulations with averages of 2.00 and 2.47 with new and existing formulations, respectively (Table 12).

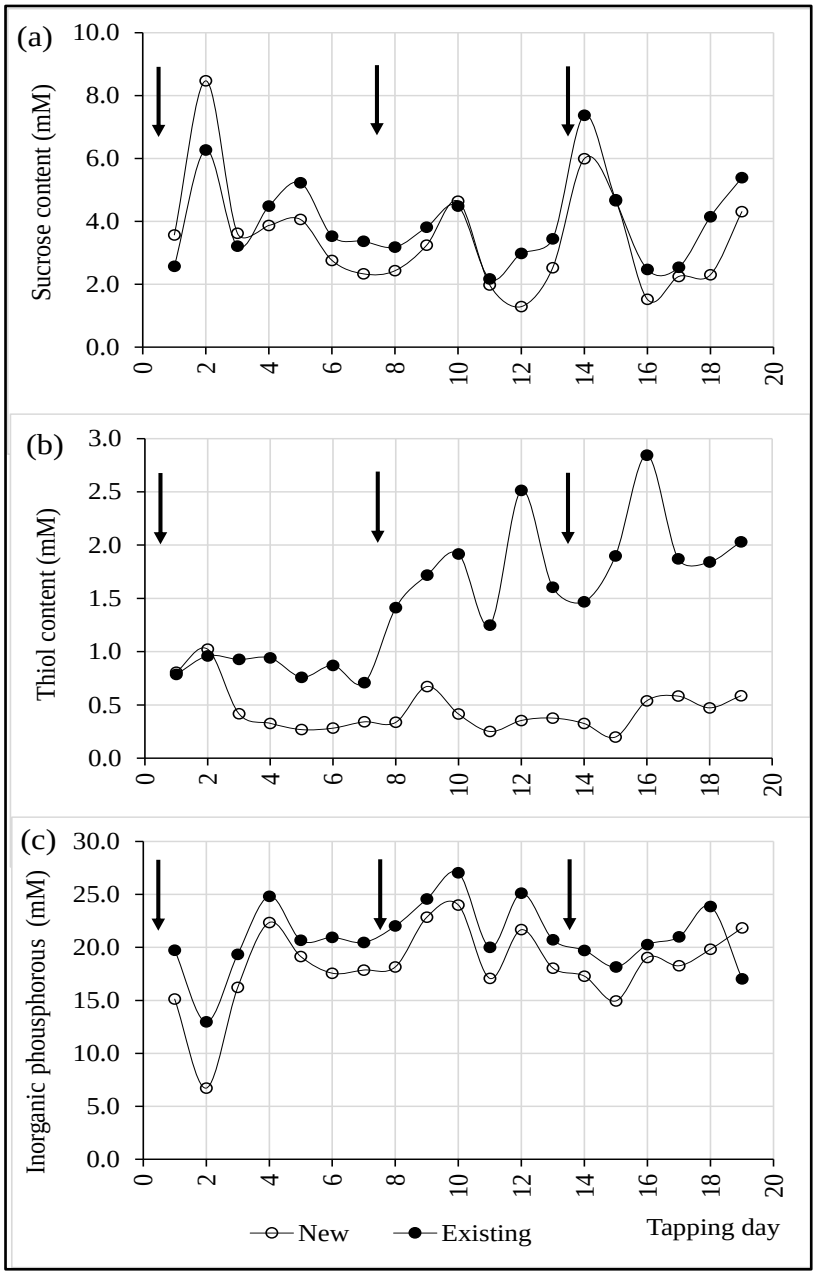


Fig. 3. Variation of latex (a). sucrose, (b). thiol and (c). inorganic phosphorous content of trees stimulated with two ethephon formulations (Time of ethephon application is indicated by arrows)

Average daily volume of latex per tree with application of new and existing formulations was 208ml and 223ml, respectively and statistically comparable. DRC of latex varied in a similar pattern with both ethephon formulations and a significant variation had not been observed among two formulations. Dry rubber yield obtained from a tree with both ethephon formulations was statistically comparable. Average daily dry rubber yield of a tree was 83.32g and 87.75g, respectively with new and existing formulations (Table 12).

Table 12. *Average values of yield and latex flow parameters of trees stimulated with two ethephon formulations*

Yield and latex flow parameters	**New ethephon formulation**	**Existing ethephon formulation**
Latex volume per tree (ml)	207.90 ± 14.73	222.70 ± 15.68
Dry rubber content (%)	40.63 ± 0.50	39.78 ± 0.50
Latex yield per tree per tapping (g)	83.32 ± 4.97	87.75 ± 5.42
Latex flow duration (min)	180 ± 0.92	155 ± 0.81
Initial flow rate (ml/min)	4.34 ±0.17	4.74 ±0.18
Plugging index	2.00 ±0.08	2.47 ±0.14

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

ADVISORY SERVICES

A Dissanayake

DETAILED REVIEW

Staff

The Head of the Department, two Regional Advisory Officers (RAOo), twenty one Rubber Extension Officers (REOo) and the Assistant Training Officer were on duty throughout the year. Mr Sameera Gayanath, Mr N L Darmasena, Mr W M A S L Wanigasooriya, Mr U N Jayasoriya, Mr E G U Danawardhana, Mr G D N Seneviratne Rubber Extension Officers and Mr D B Kularatne, Office Attendant retired from the service of ASD during the year under review.

Conferences/Meetings/Seminars/Workshops/Foreign toursattended

Officer/s	Subject/s	Organization/s
Anura Dissanayake	IRRDB Conference (IRC)	Alidjan, Coat'divvire
	International Workshop (IRRDB)	RRISL
Anura Dissanayake PKKS Gunaratna	Progress Review Meetings	Ministry of Plantation Industries
Anura Dissanayake PKKS Gunaratna RAD Ranawake	Scientific Committee Meetings Technology update programmes Research Meetings	RRISL
PKKS Gunaratna	International Agriculture Research Symposium – 2018	SLCARP
	Awareness Workshop on Biomass Energy 2020: Fuelling the economy-Protect Forests	FAO
PKKS Gunaratna AR Kulatunga KDKL Siriwardana SGG Wijesinghe	Training programme on Sustainable fuelwood production in Sri Lanka	FAO
Anura Dissanayake PKKS Gunaratna	Field Familiarization Programme on "Awareness on Fuelwood growing and harvesting" at Nuwaraeliya	FAO/RRISL

PROGRESS OF PROJECTS AND SERVICES

Extension and advisory programmes were carried out under 04 thrust areas, to improve the productivity of the rubber smallholder sector, through enhancing the adoption rate of recommended technologies by RRISL.

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

Project 1 (ASD/01/A) Participatory development of selected rubber holdings 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). Thename boards of rubber holdings were fixed in fully developed 26 immature and 26 mature holdings (Fig. 1).

Fig. 1. Mature model rubber holding - Mr C H H Fernando (Polgahawela REO range)

Table 1. *Details of participatory development of selected rubber holdings*

Region	**No. of developed holdings**	
	Mature	**Immature**
Colombo/Gampaha	2	2
Kegalle	25	30
Kalutara	20	18
Ratnapura	8	9
Galle/Matara	6	10
Total	61	69
	130	

Project 2 (ASD/01/B) Participatory development of rubber processing centers as models

Advisory and extension support services were providedto maintain 32 "Model rubber processing centres" to demonstrate the importance of the adoption of recommended practices to improve the quality of RSS to obtain maximum economic

returns (Table 2). Name boards were fixed for 12 developed processing centers (Fig. 2).

Fig. 2. Model rubber processing center - Mrs W M S D Kumari (Kegalle REO range)

Table 2. *Participatory development of rubber processing centers*

Region	No. of model centers developed
Colombo/Gampaha	2
Kegalle	12
Kalutara	10
Ratnapura	4
Galle/Matara	4
Total	32

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 smallholders, 38 demonstration plots were established under the supervision of Rubber Extension Officers (Table 3).

Table 3. *Details of rainguard demonstration holdings*

Region	No. of demonstration holdings established
Colombo/Gampaha	2
Kegalle	8
Kalutara	20
Ratnapura	3
Galle/Matara	5
Total	38

Project 4 (ASD/01/D) Construction, rehabilitation and modification of new and substandard rubber processing centers

Advisory and extension services were provided for constructionof 14 new RSS production centres and rehabilitation of 08 substandard processing centres, to maintain them as cost effective units according to the requests of owners (Table 4) (Fig. 3).

Fig. 3. Construction of a rubber processing center – Mr W A Gunapala (Ruwanwella REO range)

Table 4. *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	0
Kegalle	6	1
Kalutara	4	4
Ratnapura	1	2
Galle/Matara	2	1
Total	14	8

Project 5 (ASD/01/E) Promotion of area specific intercropping and mixed cropping systems

To popularize area specific intercropping systems to increase the income during immature period of rubber smallholdings, 9 intercropping demonstration plots were established (Table 5).

Table 5. *Area-specific intercropping and mixed cropping demonstration holdings*

Region	No. of demonstrations	Type of intercrops
Kegalle	3	Pineapple - 03
Kalutara	5	Cocoa - 01 Banana - 04
Ratnapura	1	Banana 01
Total	**9**	

Project 6 (ASD/01/F) Rehabilitation of substandard immature and mature rubber holdings

Advisory and extension support services were provided to rehabilitate 36 each immature and mature substandard rubber holdings (Table 6).

Table 6. *Rehabilitation of substandard rubber holdings*

Region	No. of immature holdings rehabilitated	No. of mature holdings rehabilited
Kegalle	9	12
Kalutara	15	12
Ratnapura	8	9
Galle/Matara	4	3
Total	**4**	**36**

Project 7 (ASD/01/G) Participatory development of "Forward march" model rubber villages

The concept of establishment of "forward march rubber villages" is widen with the selection 03 villages (IhalaNaragala – Bulathsinhala REO range, Amithirigala – Yatiyanthota REO range and Yatiyana – Hakmana REO range) to up-grade as model villages. Basic data and information were collected and action plans were prepared. The project is in progress.

Project 8 (ASD/01/H) Projects related advisory visits in traditional rubber growing areas

Two thousand five hundred and eighty six pre-planned advisory visits were conducted by Rubber Extension Officers to solve technology adoption problems in the smallholdings selected for different projects of the ASD (Table 7).

Table 7. *Details of projects related advisory visits*

Region	Nature of advisory visit							
	Model farm development	**Rehabilitation of substandard 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	18	-	-	11	5	2	-	**36**
Kalutara	442	209	28	168	98	31	9	**985**
Kegalle	318	178	11	32	73	79	12	**703**
Rathnapura	154	123	13	45	26	24	2	**387**
Galle/Matara	209	156	-	28	39	26	17	**475**
Total	**1141**	**666**	**52**	**284**	**241**	**162**	**40**	**2586**

Thrust area 02: Advisory programmes to solve technology adoption problems of all stakeholders of the rubber smallholder sector

Project 9 (ASD/2/A) Individual advisory visits on requests of rubber smallholders

Three hundred and eleven advisory visits were made by REOo to solve technology adoption problems of rubber smallholders in relation to all agronomic and processing aspects. A separate report was prepared by REOo on each visit and follow up actions were attended where necessary (Table 8).

Table 8. *Details of individual advisory visits conducted on requests of stakeholders*

Region	No. of advisory visits made by REOo
Colombo/Gampaha	22
Kegalle	97
Kalutara	113
Ratnapura	17
Galle/Matara	62
Total	311

The above advisory visits were categorized as follows (Figs. 4, 5 and 6).

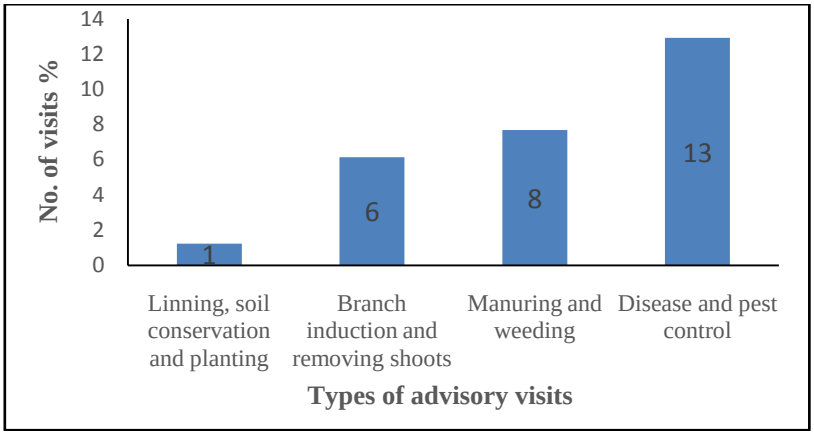


Fig. 4. Number of advisory visits conducted in immature holdings

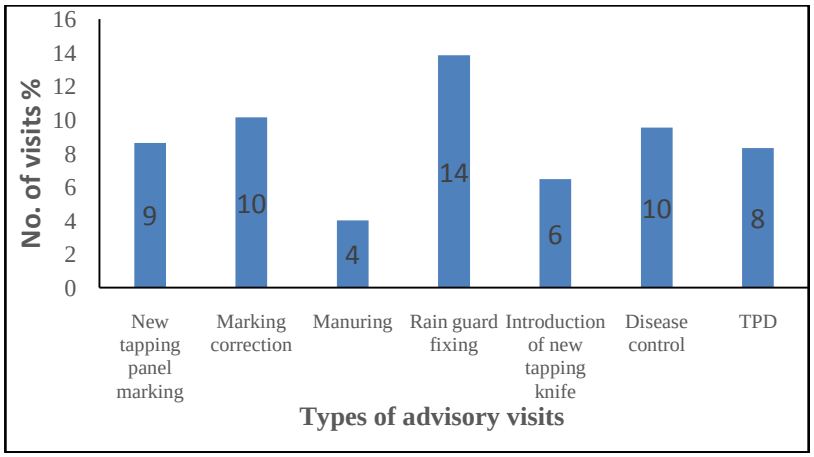


Fig. 5. Number of advisory visits conducted in mature holdings

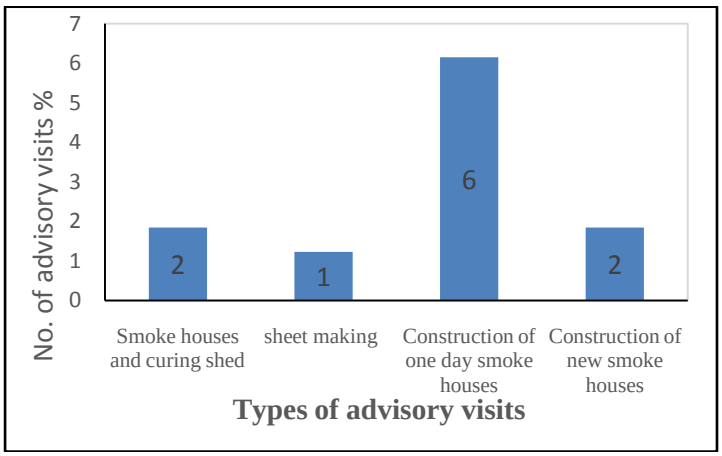


Fig. 6. Number of advisory visits conducted in processing centers

Project 10 (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, two "Vihidum Sathkara" (VS) group advisory programmes were conducted for the benefit of 65 rubber smallholdings in traditional rubber growing areas. A schematic representation of this activity is given in Figure 7.

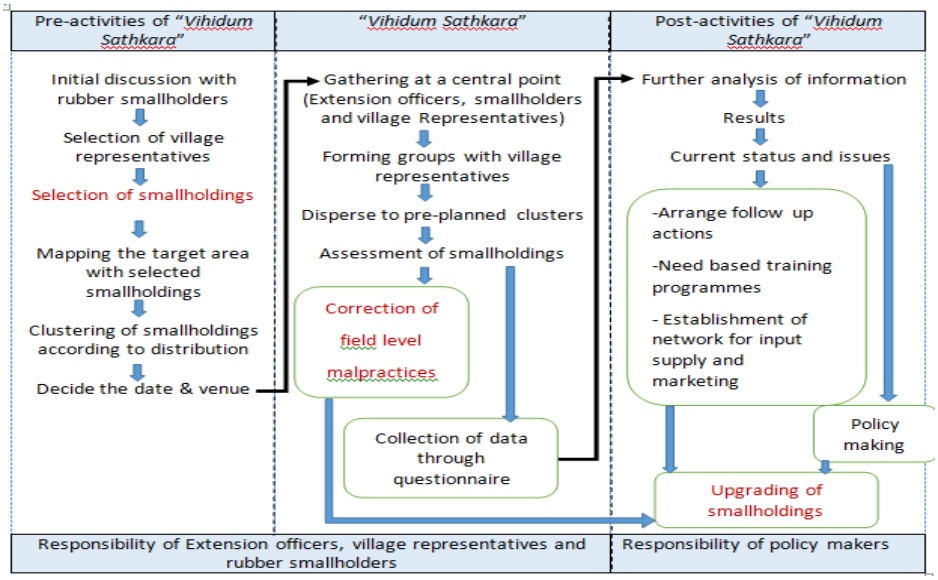


Fig. 7. Schematic representation of "Vihidum Sathkara" group advisory programme

Thrust area 03: Human resource development of all stake holders of the rubber smallholder sector

Project 11 (ASD/03/A) Awareness raising programmes

Five awareness raising programmes were conducted to educate 122 rubber growers in traditional rubber growing areas on general aspects of rubber cultivation and immature up keep (Fig. 8).

Fig. 8. Conducting field level awareness raising programme at Ruwanwella (Ruwanwella REO Range)

Project 12 (ASD/03/B) Mobile tapper training schools

As a solution to the tapper shortage in rubber growing areas, a programme covering both practical and theoretical aspects was conducted and 11 new harvesting assistants were introduced to the rubber industry after 10 days of training (Fig. 9).

Fig. 9. Mobile tapper training school at Godigamuwa (Mawanella REO Range)

Project 13 (ASD/3/C) Skills development of rubber tappers

To upgrade the knowledge and skill levels of semi-skilled harvesting assistants, 03 skill development training programmes were conducted to improve the quality of tapping of 47 selected harvesting assistants (Table 9) (Fig. 10).

Fig. 10. Tapping skill development programme conducted at Amithirigala (Ruwanwella REO Range)

Table 9. *Details of skill development programmes conducted for semi-skilled rubber tappers*

Region	No. of programmes	No. of semi-skilled tappers trained
Kegalle	01	20
Kalutara	01	04
Galle/Matara	01	23
Total	03	47

Project 14 (ASD/3/D) Quality improvements of RSS

To improve the product quality of RSS produced by rubber smallholders, a full day training programme was conducted for the benefit of 10 selected RSS producers in Kegalle district.

Project 15 (ASD/03/E) Training programmes on identification, control and eradication of white root disease

Six farmer training programmes were conducted to educate 33 rubber growers on identification, control and preventive measures of white root disease (Fig. 11).

Fig. 11. Training programmes on identification, control and eradication of white root disease at Amithirigala (Ruwanwella REO Range)

Project 16 (ASD/03/G) Involvement of exhibitions

Contribution was made in two public exhibitions (03 days) conducted at Divisional Secretarial Office Horana and Wewita Maitree Maha Vidyalaya, Wewita, Bandaragama.

Project 17 (ASD/03/F) Involvement of resource personnel

On request of different organizations following programmes were attended by REOs as resource personnel (Table 10).

Table 10. *Details of the services provided by REOs*

Name of the programme	Organization	Number of programmes
Quality improvement of RSS (One day)	Thurusaviya Fund	12
Farmer awareness (One day)	Thurusaviya Fund	12
Harvesters training (Fourteen days)	Thurusaviya Fund	06
Tapper Tanning School (One day)	Rubber Development Department	04
Tapper skill development (One day) at Padiyathalawa and Vavuniya	Adaptive Research Unit of RRISL	02
Quality improvement of RSS (One day) at Padiyathalawa and Vavuniya	Adaptive Research Unit of RRISL	02
Awareness programs for STARR officers (One day) in Monaragala and Ampara districts	STARR Project	04
Farmer awareness and training program (One day) in Monaragala and Ampara districts	STARR Project	11

Name of the programme	Organization	Number of programmes
Awareness and tanning programs for Economic Development Officers (One day) at DS division level	District Secretariat office-Kegalle	17
Awareness program for farmers (One day)	Associated Specialty Rubbers (Pvt) Ltd, (ASR Factory), Yatideriya	02
Awareness programs for students (One day)	Associated Specialty Rubbers (Pvt) Ltd, (ASR Factory), Yatideriya	02
Awareness programs for university students (One day)	Sabaragamuwa University of Sri Lanka	01
Awareness programs for university students (One day)	Wayamba University of Sri Lanka	01
Awareness programme for Agrarian Development Officers (One day)	Agrarian Development Office, Bandaragama	01

Thrust area 04: Development of effective extension network in the smallholder rubber sector

a) Establishment of Technology Transfer Centers

One technology transfer center in Kegalle was completed and other two centers at Nivitigalakale and Rathnapura are in progress.

b) GIS based mapping for effective planning of extension programmes

The GIS maps were prepared related to model rubber holdings and processing centers, fuel wood growing models of rubber lands and field training/workshops (Fig. 12). The project in progress.

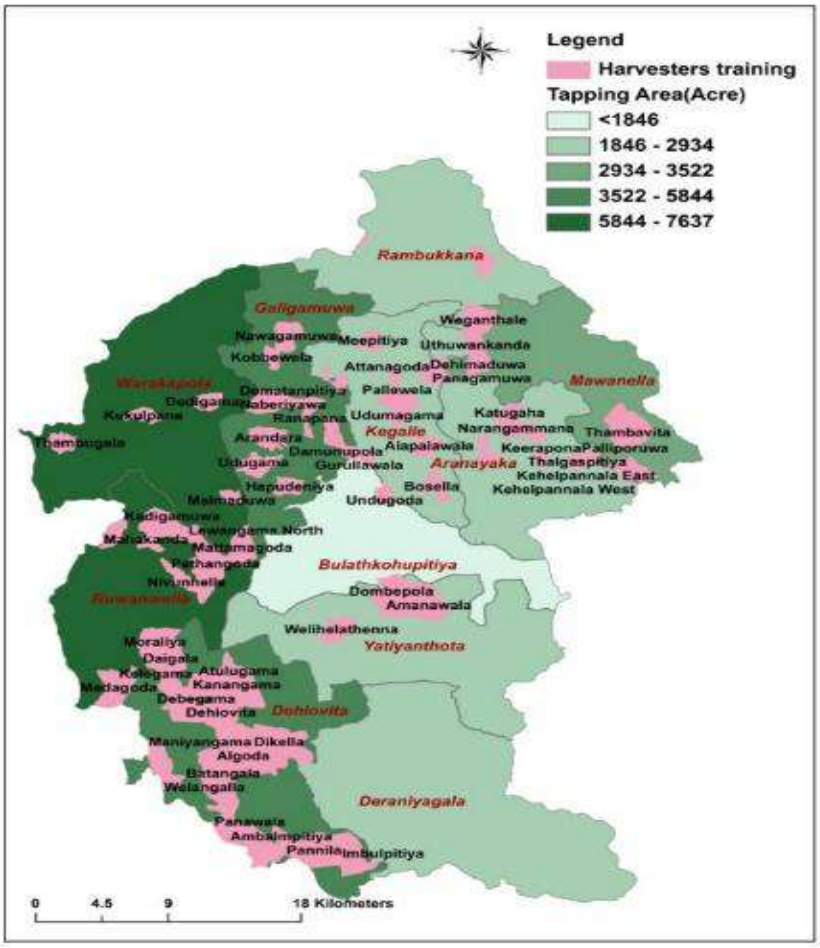


Fig. 12. The GIS map of the training programmes and workshops conducted in Kegalle district (2010-2018)

c) Rubber Techno Park at Monaragala substation

Monaragala substation was selected to develop as Rubber Techno Park. Exhibition sites, exhibits and other related activities were developed. The project is in progress.

d) Introduction and establishment of new fuelwood growing models in selected lands of smallholder rubber farmers

A new project was started in 2017 as "Introduction and Establishment of new fuelwood growing models in selected lands of smallholder rubber farmers" under

FAO funds with the collaboration of Biometry and Economics divisions. Eight different growing models were established for rubber smallholders as follows.

1. Rubber – Gliricidia – Pepper: Rubber spacing (8’ x 27’) (RGP)
2. Rubber – Gliricidia – Pepper: Rubber spacing (8’ x 40’) (RGP)
3. Rubber – Gliricidia – Pepper: Rubber spacing (8’x 60’) (RGP)
4. Rubber – Gliricidia: Rubber spacing (8’x 27’) (RG)
5. Rubber – Gliricidia: Rubber spacing (8’ x 40’) (RG)
6. Rubber – Gliricidia: Rubber spacing (8 ‘x 60’) (RG)
7. Gliricidia – Pepper (8’x 8’)
8. Gliricidia only (3’ x 3’)

At the end of year 2018 Rs.2.7 M has been spent for 131 farmers to establish of different fuelwood growing models. The project is in progress (Fig. 13 and 14).

Fig. 13. Gliricidia only (Model #08) at different growing stages

Fig. 13. Gliricidia - Pepper (Model #07) at different growing stages

Three farmer workshops on planting and maintenance practices of different growing models were conducted in Kegalle and Kalutara district (Table 11) (Fig. 15).

Table 11. *Details of programmes conducted on planting and maintenance practices of different growing models*

Region	No. of programmes	No. participants
Kegalle	2	70
Kalutara	1	75
Total	**3**	**145**

Fig. 15. Awareness programme on planting and maintenance of *Gliricidia* growing models in Kegalle

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

DETAILED REVIEW

Staff

Dr (Mrs) D G Edirisinghe, Head of the Department and Mr W D M Sampath, Research Officer were on duty throughout the year.

Mr P L Perera and Mrs S I Yapa, Experimental Officers retired from the Institute on 25.01.2018 and 07.12.2018, respectively. Mr P D A Gunasekera, Technical Officer resigned from the Institute in July 2018.

Mr S L G Ranjith and Mrs Priyanthi Perera, Experimental Officers and Mr D G M J Abeywardena, Miss Gayathri Bhagyawedha, Mr K I D P Perera and Miss Ishani JayaratneTechnical Officers were on duty throughout the year. Miss S M D Shashee Rekha De Alwis Wijerathne, Management Assistant was also on duty throughout the year.

Research students

Postgraduate students

- Vinod Silva, a MSc (Polymer Technology) student from the University of Moratuwa completed his research project on "Development of a PAH comply black tread compound" under the supervision of Dr (Mrs) D G Edirisinghe.

- Nadun Perera, a MSc (Polymer Science and Technology) student from the University of Sri Jayewardenapura completed his research project on "Effect of particle size of antioxidants on properties of natural rubber latex films" under the supervision of Dr (Mrs) D G Edirisinghe.

- Ishara Wijesinghe, a MSc (Polymer Science and Technology) student from the University of Sri Jayewardenapura conducted his research project on "Development of an oil resistant NR/NBR blend compound filled with silica extracted from rice husk ash (RHA silica)" under the supervision of Dr (Mrs) D G Edirisinghe.

Undergraduate students

- K P I Madushika, a BSc (Palm and Latex Technology) undergraduate student from the Uva Wellassa University of Sri Lanka conducted his research project on "Effect of partial replacement of carbon black with areca nut husk fibre on

properties of natural rubber composites" under the supervision of Dr (Mrs) D G Edirisinghe.

- Miss W G Nipuni Kalpana Seneviratne, a BTech. (Textile Engineering) undergraduate student from Open University of Sri Lanka conducted her research on "Development of a rubber based composite using textile waste fibres" under the supervision of Dr (Mrs) D G Edirisinghe.

Seminars/Training/Conferences/Workshops/Meetings attended

Officer/s	Subject/Theme	Organization
DG Edirisinghe	Meeting -Value Addition of Rubber	Divisional Secretariat, Kegalle
	Meetings -Sinoshine Project	Ministry of Plantation industries/Rubber Secretariat
	Meeting - Review of Public Funding for Programs Supporting Innovation & Entrepreneurship	Ministry of Plantation Industries
	Sectoral Committee Meeting on "Chemical & Polymer Technology"	Sri Lanka Standards Institute
	Presidential Awards Ceremony at BMICH	Sri Lanka Inventors Commission
	Meeting in regard to formulation of National Competency Standards and Curriculum for Higher Diploma Course	National Institute of Plantation Management
DGMJ Abeywardena	Seminar on "Economics of Rubberized Road" at Maruary Garden Hotel, Bangkok, Thailand	Ministry of Plantation Industries
WDM Sampath	Workshop on "Advanced Instruments"	Techno Solutions (Pvt.) Ltd.
	Three day training on "Leadership and Capacity Building Program for Young Rubber Industry Professionals" in Ratnapura	Ministry of Industry & Commerce
	Workshop on "Quality Management Systems"	National Institute of Plantation Management
DG Edirisinghe & WDM Sampath	Scientific Committee Meetings	Rubber Research Institute of Sri Lanka
	Lecture on "Recycled Material for Rubber Compound Uses"	Plastics & Rubber Institute of Sri Lanka

Officer/s	Subject/Theme	Organization
DG Edirisinghe & WDM Sampath	Inauguration ceremony of workshop on "Statistical Applications"	Rubber Research Institute of Sri Lanka
	Workshop on Product Innovation Technology and R & D for Sri Lanka Tyre Manufacturing Industry	Export Development Board
Staff of the department	Human resource development training program	Rubber Research Institute of Sri Lanka

Lectures/Seminars/Conferences/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
DG Edirisinghe	Latex technology	Students of the Diploma Course in Polymer Technology - PRISL
	Manufacture of rubberized-coir products	Students of the Graduate ship Course in Polymer Technology - PRISL
WDM Sampath	Compounding ingredients (Dry rubber)	Students of the Certificate Course in Rubber Technology - PRISL
	Composition of NR latex Value addition to raw rubber	Induction Course for Planter Trainees - NIPM
	Rubber product manufacture	National Diploma in Plantation Crop Technology - NIPM
	Presentation on Rubber based Applications	Divisional Secretariat, Kegalle
	V2025 Enterprise Sri Lanka Exhibition in Monaragala	Ministry of Finance & Media
WDM Sampath, SLG Ranjith, Priyanthi Perera & KIDP Perera	Comexpo International Manufacturing Exhibition	Industrial Development Board
Priyanthi Perera	Structures of different polymers and their relationship to properties	Students of the Certificate Course in Rubber Technology - PRISL
KIDP Perera	Compound formulations and processing techniques of plastics	Students of the Certificate Course in Rubber Technology - PRISL
SLG Ranjith	Rubber product manufacture as a cottage industry	Rubber Development Officers - Rubber Development Department
SLG Ranjith, SI Yapa, KIDP Perera and PD A Gunasekera	"Vidasa" Science & Technology Exhibition	Sirimavo Bandaranaike Vidyalaya, Colombo 7.

Officer/s	Subject/Theme	Beneficiary/Client
Priyanthi Perera and PDA Gunasekera	Workshop on "Rubber based products manufacture" in Ratnapura, Parakaduwa	Thurusaviya Fund/Rubber smallholders
SLG Ranjith and PDA Gunasekera	Workshop on “Rubber based products manufacture” in Weeraketiya	Thurusaviya Fund/Members of Thurusaviya Societies
Staff of the department	Practical training program for teachers on new A’Level subject titled “Plantation Crop Production Technology” at RRISL, Ratmalana	National Institute of Education
	Field training on "Value addition to rubber products"	Undergraduate students of Faculty of Agriculture, Rajarata University
	Field training on "Rubber product manufacture"	Undergraduate students of Palm & Latex Technology and Value Addition – Uva Wellassa University
	Workshop on "Rubber based products manufacture" at RRISL, Ratmalana	SMEs of Divisional Secretariat, Dehiowita
	Workshop on "Rubber based products manufacture" at RRISL, Ratmalana	Divisional Secretariat, Yatiyantota
	Practical demonstration on “Rubber based products manufacture” at RRISL, Ratmalana	BSc (Agri. Sp.) undergraduates of the Department of Plantation Management, Wayamba University of Sri Lanka

Industrial visits

The following Institutes/Industries/Factories were visited during the year for development/trouble shooting work.

Officer	Industry/Organization
DG Edirisinghe and KIDP Perera	D. Samson International PLC., Galle
KIDP Perera	D. Samson Industries, Kalutara
WDM Sampath and DGMJ Abeywardena	Lankem Ceylon PLC., Sapugaskanda
KIDP Perera	Industrial Clothings (Pvt.) Ltd.

LABORATORY INVESTIGATIONS

Dry rubber technology

Development of environmental friendly natural fibre filled rubber composites

(a) Development of surface treated pandanas fibre filled rubber composites

A series of composites was prepared with different sizes, *i.e.* 0.2, 0.5 and 1 inch of pandanas (watakeiya) fiber and physico-mechanical and aging properties were evaluated. According to the physico-mechanical property results, the composite prepared with 0.2 inch pandanas fiber was superior than the other two counterparts. In addition, it showedgood heat resistance as indicated by the results of the ageing test (D G Edirisinghe, W D M Sampath, Gayathri Baghyawedha and Ishani Jayaratne).

(b) Development of surface treated pineapple crown fibre filled rubber composites

Natural fibres degrade faster than synthetic fibres in natural environments, minimizing environmental pollution and biodegradation of natural fibre can decrease the life time of fibre reinforced polymer composites. In this study, pineapple crown fibre (PCF) was used to prepare naturalrubber composites. The composites were formulated by varying the PCF loading from 10 phr to 40 phr at 10 phr intervals. The composite prepared with carbon black loading of 60 phr was taken as the Control. The ratios of PCF and carbon black are given in Table 1. The physico-mechanical (Table 2) and ageing properties of the Control and four PCF filled composites were evaluated according to ISO standards.

Table 1. *PCF: carbon black ratios of the rubber composites*

Sample No.	**P_0**	**P_{10}**	**P_{20}**	**P_{30}**	**P_{40}**
PCF	0	10	20	30	40
Carbon black	60	50	40	30	20

The composite prepared without PCF (P_0) was superior in relation to hardness, tensile properties, tear strength, abrasion resistance and compression set than the PCF filled composites. On the other hand the composites prepared with PCF show an improvement of resilience, which indicates lower heat build-up in comparison to that prepared without PCF.

Table 2. *Physico-mechanical properties of PCF filled rubber composites*

Property	Sample No.				
	P_0	P_{10}	P_{20}	P_{30}	P_{40}
Hardness (IRHD)	69.2	66.7	62.9	53.9	53.5
Resilience (%)	45	53	56	58	58
Compression set (%)	13.39	15.84	20.10	25.38	28.71
Abrasion volume loss (mm^3)	88.43	110.41	126.34	162.30	186.23
Tensile strength (MPa)	20.46	14.10	11.44	6.85	4.96
Modulus at 100% elongation (MPa)	11.77	8.28	7.46	3.40	2.44
Elongation at break (%)	182	158	154	167	172
Tear strength (N/mm)	85.66	60.31	43.61	31.44	28.07

Table 3 shows the percentage retention of properties of all the composites after ageing at 100 ºC for 22 hrs. The composites prepared with 20 phr and 40 phr loadings of PCF show better resistance to thermal oxidation than the other composites. Results in overall indicate that the composite prepared with 40 phr carbon black and 20 phr PCF would be suitable to manufacture shoe soles, carpets, table mats, *etc.* As the properties of the composites prepared with 10 phr and 20 phr loadings of PCF were closer to those of the Control, these two composites were selected to carry out the evaluation of the effect of surface treatment of PCF with different latices.

Table 3. *Percentage retention of properties of the PCF filled rubber composites after ageing*

Sample No.	Modulus at 100 % elongation (%)	Tensile strength (%)	Elongation at break (%)	Tear strength(%)
P_0	115	74	61	52
P_{10}	122	78	64	65
P_{20}	80	89	101	81
P_{30}	99	67	78	68
P_{40}	142	102	82	116

Natural rubber (NR) and styrene-butadiene rubber (SBR) lattices were used to treat PCF. 10 phr and 20 phr of PCF were treated with NR latex and SBR latex separately and the four treatments are given in Table 4. Physico-mechanical and ageing properties of NR and SBR latex treated PCF filled rubber composites were evaluated and the results are given in Table 5 and Table 6, respectively.

Table 4. *Different treatments of surface treated PCF filled rubber composites*

Sample No.	Treatment
T_1	NR latex treated 10 phr PCF
T_2	SBR latex treated 10 phr PCF
T_3	NR latex treated 20 phr PCF
T_4	SBR latex treated 20 phr PCF

Table 5 shows that there is no significant difference between the hardness and resilience of the composites of the four treatments. The composite prepared with NR latex treated 10 phr loading of PCF is the best in terms of compression set and abrasion volume loss. On the other hand, the composite prepared with NR latex treated 20 phr loading of PCF shows the highest strength properties and elongation at break probably due to greater adhesion between NR matrix and NR latex treated PCF.

Table 5. *Physico-mechanical properties of NR and SBR latex treated PCF filled rubber composites*

Property	Treatment			
	T_1	T_2	T_3	T_4
Hardness (IRHD)	67	66	60	66
Resilience (%)	51	49	50	49
Compression set (%)	13.05	15.33	15.97	19.91
Abrasion volume loss (mm^3)	96.23	99.33	135.46	138.27
Tensile strength (MPa)	9.21	12.69	13.90	11.81
Mod at 100% (MPa)	1.61	2.16	2.07	2.48
Mod at 300% (MPa)	6.19	8.31	7.33	8.63
Elongation at break (%)	393	404	443	376
Tear strength (N/mm)	27.20	58.14	65.19	36.42

Percentage retention of properties of the NR and SBR latex treated composites after ageing is shown in Table 6. Percentage retention of properties of all the rubber composites is closer to 100% or above 100%. This indicates that all NR and SBR latex treated PCF filled composites have good resistance to thermal ageing.

Table 6. *Percentage retention of properties of the NR and SBR latex treated PCF filled rubber composites after ageing*

Sample No.	Modulus at 100 % elongation (%)	Modulus at 300% elongation (%)	Tensile strength (%)	Elongation at break (%)	Tear strength (%)
T_1	144	153	132	92	235
T_2	115	115	104	94	113
T_3	113	122	95	88	82
T_4	116	163	108	96	131

(D G Edirisinghe, W D M Sampath, Gayathri Baghyawedha and Ishani Jayaratne)

(c) Development of surface treated arecanut husk fibre filled rubber composites

Arecanut husk is one of the good sources of natural fibers. It is abundantly present in Sri Lanka as a waste. It is composed of cellulose with varying proportions of hemicelluloses, lignin, pectin and protopectin. Two series of NR composites were prepared for this study. One series was prepared with six NR composites using carbon black (N 330) and surface treated arecanut husk fibre (SAF) by varying the SAF loading from 0 to 50 phr at 10 phr intervals, whilst maintaining the total filler loading at 60 phr. Another series was also prepared with six NR composites using the same formulation, but replacing SAF with untreated arecanut husk fibre (UAF). UAF, SAF compounds and vulcanizates were characterized using Fourier Transform Infrared Spectroscopy (FTIR). FTIR analysis confirmed the chemical nature of the materials. Cure characteristics and physico-mechanical properties of these composites were tested to select the best material to partially replace carbon black.

It was found that two thirds of the carbon black in NR composites could be replaced with arecanut husk fibre without significantly affecting properties such as hardness, resilience and compression set to manufacture products such as inner soles of shoes. Out of the two types of materials UAF and SAF, UAF is the most suitable arecanut husk material to partially replace carbon black in NR composites. The best filler ratio in terms of properties is 40:20 CB: arecanut husk fibre (K P I Madushika - Undergraduate student, Uva Wellassa University of Sri Lanka, D G Edirisinghe, H G I M Wijesinghe - Lecturer, Dept. of Export Agriculture, Uva Wellassa University of Sri Lanka and A M W K Senevirathna - Senior Lecturer, Dept. of Export Agriculture, Uva Wellassa University of Sri Lanka).

Development of rubber compounds with modified rubber waste or any other waste material

(a) Development of rubber-bitumen masterbatches with modified rubber waste

A series of 35/15/50 natural rubber (NR)/modified ground rubber tyre (GRT)*/ bitumen masterbatches was prepared by varying the sulphur loading as given in Table 7. The Control was prepared without sulphur. These materbatches were prepared using a Brabender Plasticorder at a temperature of 70 ºC. Thereafter, rubberized-bitumen composites were prepared by mixing 5% masterbatch with 95% bitumen (60/70 grade). Physical and mechanical characteristics were evaluated at the laboratory of the Road Development Authority (RDA).

Table 7. *Formulations of NR/GRT/bitumen masterbatches*

Ingredient	**S_0**	**S_1**	**S_2**	**S_3**	**S_4**
Bitumen	50	50	50	50	50
NR	35	35	35	35	35
Modified GRT*	15	15	15	15	15
Sulphur	0	1	1.5	2	2.5
IPPD	0.35	0.35	0.35	0.35	0.35

*GRT was mixed with 6 phr TMTD and milled for 5 minutes around ambient temperature using a laboratory two – roll mill

The physico-mechanical characteristics of 35/15/50 NR/modified GRT/bitumen masterbatches were evaluated and the results obtained are shown in Figures 1-4. The masterbatch prepared with the highest, *i.e.* 2.5 phr loading of sulphur shows the highest penetration value (Fig. 1).

It is observed that the penetration value of sulphur loaded masterbatches is higher than that of the masterbatch prepared without sulphur (Control). The softening point of all rubberized-bitumen masterbatches is greater than 57 ºC (Fig. 2). Further, the masterbatch prepared with 2 phr loading of sulphur shows the highest softening point and hence good heat resistance behaviour compared to the other counterparts.

Furthermore, the recovery percentage of masterbatch prepared with 2 phr loading of sulphur is better than that of the other masterbatches (Fig. 3). This could be the reason for the increased flexibility and elastic nature of the material. Figure 4 shows the variation of viscosity of rubberized-bitumen masterbatches. Masterbatch prepared with 2.5 phr loading of sulphur shows the highest viscosity probably due to highest crosslink density. However, viscosity of all masterbatches does not vary markedly and the values range between 0.66 Pas and 0.72 Pas. In overall, the masterbatch prepared with 2 phr loading of sulphur is the best and its properties may be at the acceptable level for road surfaces.

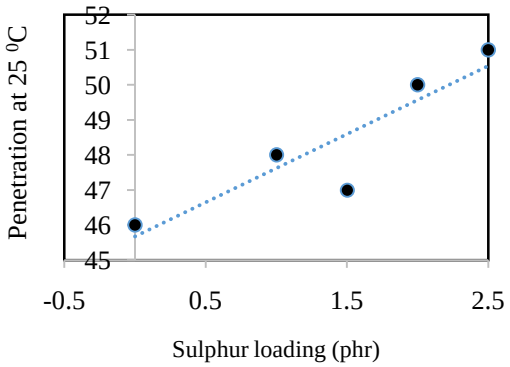


Fig. 1. Penetration of rubberized-bitumen masterbatches

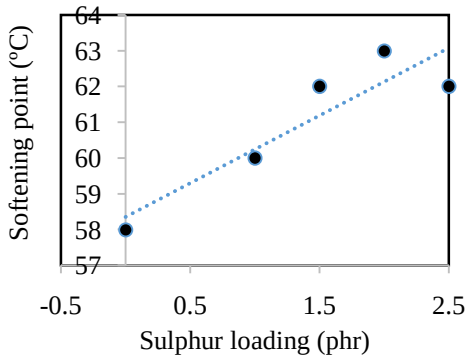


Fig. 2. Softening point of rubberized- bitumen masterbatches

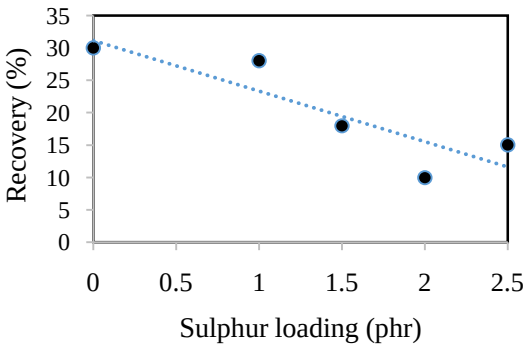


Fig. 3. Recovery of rubberized-bitumen masterbatches

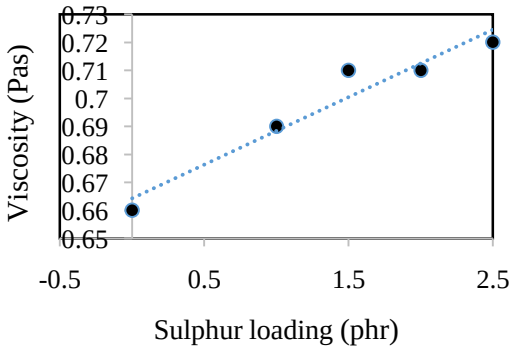


Fig. 4. Viscosity of rubberized- bitumen masterbatches

(b) Development of rubber composites with modified nitrile rubber glove waste

A request was made by Dipped Products PLC. to modify nitrile rubber (NBR) glove waste to use as a rubber component in blends with virgin NBR to manufacture rubber products such as oil resistant mats/carpets, oil seals, *etc.*

As the second stage of the project, six rubber composites were prepared by blending the reclaimed NBR glove waste with virgin NBR according to the ASTM oil seal formulation and the blend ratios are given in Table 8. Reclaimed NBR glove waste was prepared by milling for 5 minutes with 6 g of the amino compound, which were the optimum conditions obtained from the results of the first stage of the project. Cure characteristics, physico-mechanical properties and ageing properties of the above composites were determined.

Table 8. *Virgin NBR: reclaimed NBR glove waste ratios used in the preparation of blend composites*

Sample No.	Control	R_{10}	R_{15}	R_{20}	R_{25}	R_{30}
Virgin NBR	100	90	85	80	75	70
Reclaimed NBR glove waste	0	10	15	20	25	30

Table 9. *Cure characteristics of virgin NBR/reclaimed NBR glove waste composites prepared according to different blend ratios*

Sample No.	Scorch time (sec)	ML (dNm)	MH (dNm)	MH- ML (dNm)	T90 (sec)
Control	144	8.95	98.52	89.57	432
R_{10}	119	12.13	101.85	89.72	339
R_{15}	113	16.46	105.23	88.77	333
R_{20}	103	15.10	104.89	89.79	323
R_{25}	97	17.82	108.04	90.22	368
R_{30}	97	20.88	115.85	94.97	350

Table 10 indicates that compression set of the composites prepared with the amino compound is lower than that of the Control prepared with 100% virgin NBR. Table 11 shows that percentage retention of strength properties of the composites prepared with the amino compound, after ageing is comparable to those of the Control.

Table 10. *Physico-mechanical properties of virgin NBR/reclaimed NBR glove waste composites prepared according to different blend ratios*

Sample No.	Hardness (IRHD)	Resilience (%)	Abrasion volume loss (mm^3)	Compression set (%)	Tensile strength (MPa)	Mod. at 100% (MPa)	Elongation at break (%)	Tearstrength (N/mm)
Control	69	32	72.9	14.1	17.5	5.0	279	54.7
R_{10}	72	30	73.1	**12.77**	14.2	6.2	242	41.5
R_{15}	73	29	67.9	**11.29**	14.3	6.7	212	41.5
R_{20}	74	28	69.4	**10.94**	12.6	6.2	204	45.7
R_{25}	76	27	81.2	**11.96**	13.0	7.6	170	43.8
R_{30}	78	27	87.1	**12.14**	13.3	7.4	178	37.2

Further, Table 10 indicates that 20% of the virgin NBR in NBR based composites could be replaced with the reclaimed NBR glove waste material in applications requiring low compression set and high abrasion resistance coupled with high hardness and acceptable strength properties such as oil resistant mats and carpets.

Table 11. *Percentage retention of physico-mechanical properties of virgin NBR/ reclaimed NBR glove waste composites after ageing at 70 ^{0}C for 72 hrs*

Sample No.	Tensile strength (%)	Modulus at 100% elongation (%)	Elongation at break (%)	Tear strength (%)
Control	104	82	96	89
R_{10}	103	152	51	88
R_{15}	105	152	67	108
R_{20}	110	178	59	74
R_{25}	103	139	74	89
R_{30}	101	156	67	95

(c) Development of rubber composites with textile waste

The average daily output of textile wastes from textile mills in Sri Lanka is about 15.5kg and this causes severe environmental pollution. Most of these wastes are generally destroyed without recycling. To ascertain an economical benefit, a series of NR composites were prepared according to a shoe sole formulation with the filler calcium carbonate ($CaCO_3$) and textile waste (98% cotton and 2% polyester) by varying the loading of textile waste from 0 to 40 phr at 10 phr intervals. The total amount of filler loading was kept constant at 40 phr.

Minimum torque and maximum torque increased up to 30 phr replacement of $CaCO_3$ with textile waste, but the hardness increased progressively with the increase of the loading of textile waste.There was no significant difference between the tear strength of the composites. Also, it was interesting to note that the abrasion volume loss of the composites prepared with textile waste was markedly lower than that of the composite prepared only with $CaCO_3$. Hence, the textile waste fiber would be suitable as a cost effective filler in the production of shoe soles (D G Edirisinghe, Nipuni Kalpana Seneviratne – BTech. (Textile Engineering) undergraduate student, Open University of Sri Lanka, K I D P Perera and M A I Perera – Lecturer, Dept. of Textile and Apparel Technology, Open University of Sri Lanka).

Industrial Extension

The following properties were tested and test reports were issued to the companies at their request.

Hardness of sole crepe samples	Physico-mechanical properties of rubber/plastic compounds	Physico-mechanical properties of rubber/plastic products
• Kegalle Plantations, Atale Estate • Kegalle Plantations, Pallegama Estate • Elpitiya Estate • Panawatta Estate • Dewalakanda Estate • Kelani Valley Plantations PLC. • Elston Estate • Pussellawa Plantations Ltd. • Hopehigh International Trading Co. Ltd.	• Associated Motorways (Pvt.) Ltd. • Polymer Products Impex (Pvt.) Ltd. • Ceytra (Pvt.) Ltd. • US Lanka Rubber Solutions (Pvt.) Ltd. • Dharmasiri Tyre House • Samson Rubber Products (Pvt.) Ltd. • Microcells (Pvt.) Ltd. • Chemanex PLC. • Hirivinne Estate • Road Development Authority • R.A.P. Engineering Solutions (Pvt.) Ltd.	• Textrip (Pvt.) Ltd. • D.R. Home Appliances (Pvt.) Ltd. • Samson Compounds (Pvt.) Ltd. • Screenline (Pvt.) Ltd. • PE Plus (Pvt.) Ltd.

Development of rubber compounds/processes

The following rubber compound developments/processes were conducted on request.

Compound development	Client
Non-conductive NBR based grommet SBR based compounds for condenser end mount and wiring bunch bush EPDM based compound for suction end mount	R.A.P. Engineering Solutions (Pvt.) Ltd.
Mechano-chemical reclaiming process for NR based carpet waste using an amino compound	D. Samson International PLC.

POLYMER CHEMISTRY

Y R Somarathna

DETAILED REVIEW

Staff

Mr Y R Somarathna, Research Officer was covering up the duties of the Head of Department of Polymer Chemistry Department throughout the year. Mrs I H K Samarasinghe, Research Officer was on study leave throughout the year. Mrs Nirmala Jayawardena, Experimental Officer and Mrs H M H Dhanukamalee, Technical Officer were on duty throughout the year. Mrs P S V Rupasinghe, Mr D V D Mallikaarachchi and Ms H L T Tharaka,Technical Officers were on duty throughout the year. Mr M A D W K Thilakarathne, Management Assistant was transferred to Internal Audit Division with effect from January 2018. Mr N W E Chanu Maduranga, Management Assistant was transferred to Polymer Chemistry Department from Internal Audit Division with effect from 24thJanuary 2018 and was on duty throughout the year.

Lectures/Seminars/Training/Workshops/Conferences attended

Subject/Theme	Organization	Officer/s
Orientation Programme on capacity building	Sri Lanka Council for Agricultural Research Policy	IHK Samarasinghe
Scientific Committee Meetings	Rubber Research Institute of Sri Lanka	IHK Samarasinghe YR Somarathna
Workshop on Writing a Quality Research Paper	Rice Research and Development Institute	IHK Samarasinghe
Gust lecture on Rubber-to-Metal bonding	Plastic Rubber Institute	IHK Samarasinghe YR Somarathna
Workshop on Advanced Instruments	Techno Solutions (Pvt) Ltd.	YR Somarathna
Application training on TG/FTIR	Perkin-Elmar India (Pvt) Ltd. Mumbai	YR Somarathna HLT Tharaka

Lectures/Seminars/Training/Workshops/Conferences conducted

Officer/s	Subject/Theme	Beneficiary/Client
YR Somarathna	Rubber Wood Treatment	Students of Advance Certificate Course in Plantation Management from National Institute of Plantation Management
YR Somarathna	Introduction of advanced testing facilities available at Polymer Chemistry Department	Industrialists and academics participated in the Workshop organized by Export Development Board of Sri Lanka
YR Somarathna	Certificate Course in Rubber Technology	Students of the certificate course in rubber technology from Plastics & Rubber Institute
Staff of the Department	Field training program on Polymer Technology	Undergraduate students of Palm & Latex Technology and Value Addition- Uva Wellassa University
YR Somarathna Nirmala Jayawardena	Adhesive Manufacturing Workshop	Small and medium scale entrepreneurs

LABORATORY INVESTIGATIONS

Development of property correlations for nitrosamine safe binary accelerator systems in sulfur vulcanized natural rubber

Today, the use of nitrosamine safe accelerators have gained significant interest, since most of the traditional accelerators are the major sources of generating carcinogenic nitrosamines in rubber vulcanizates. In addition, stringent rules and regulations have been imposed to control the use of such accelerators in rubber products as well as in the rubber factories to regulate the work place exposure. As a result alternate accelerators were developed to overcome the issues of traditional accelerators and some of them are already commercialized in the rubber industry. However, systematic investigation on these substituent accelerators has not been carried out. Diisopropyl Xanthogen Polysulfide (DIXP) is a nitrogen free commercially available novel accelerator, and the effect of accelerator and the quantity on cure and static mechanical properties were evaluated. Results revealed that the most of the processing properties and mechanical properties of the compounds prepared with this accelerator are inferior with compared to traditional accelerators (I H K Samarasinghe, D G Edirisinghe, S Walpolage and S M Egodage - Senior Lecturer, Dept. of Chemical and Process Engineering, University of Moratuwa).

In-situ filler incorporated natural rubber latex

A novel method was developed for *in-situ* incorporation of filler particles in centrifuged natural rubber latex as a value addition step to natural rubber and Sri Lankan dolomite. Characterization of *in-situ* filler incorporated latex films were carried out using Thermogravimetric Analyzer (TGA) and Scanning Electron Microscope (SEM) to confirm the filler formation. The compounded *in-situ* filler incorporated latex films and a series of *ex-situ* filler incorporated latex films with different filler loadings were made. Evaluation and comparison of the physical properties of these filler incorporated films were initiated (Y R Somarathna, S Siriwardena and D V D Mallikaarachchi).

Application of nano-scale zinc oxide (ZnO) and tetramethylthiuram disulphide (TMTD) as an effective preservative system for concentrated natural rubber latex (NRL)

Natural rubber latex (NRL) preserved with low ammonia as the primary preservative together with Tetramethylthiuram disulphide (TMTD) and Zinc Oxide (ZnO) as the secondary preservative, widely known as LATZ is the most common preservative system used in the latex industry due to its low ammonia content with reduced cost and less hazardous nature in the working environment. However, the LATZ preservation system has its inherent drawback as TMTD produces carcinogenic nitrosamines during the product manufacturing, while ZnO may contribute to aquatic pollution. Because of the growing human health and environment concerns, worldwide attention has been focused to find alternative less risk preservatives for NRL. In literature, certain nano materials, especially oxides of some metals such as Ti, Zn, Ag, Cu *etc*., have shown excellent antimicrobial properties when compared to their conventional micro-scale counterparts. This study employed nano ZnO as a novel preservative agent to enhance the antimicrobial properties of NRL.

CNRL samples were prepared using different combinations of TMTD/ZnO along with addition of 0.2% (w/w) ammonia to all systems as mentioned in the Table 1.

Table 1. *Preservative systems and their chemical additive combinations*

Dispersion system	**Chemical combination**			
	TMTD % (w/w)	Conventional ZnO % (w/w)	Nano ZnO % (w/w)	Percentage of dispersion of TMTD/ZnO % (w/w)
Control	12.5	12.5	-	25
Nano 1	12.5	-	12.5	25
Nano 2	10.0	-	10.0	20
Nano 3	7.5	-	7.5	15
Nano 4	5.0	-	5.0	10
Nano 5	2.5	-	2.5	5

According to VFA development results shown in Figure 1, the systems with nano ZnO had low levels of VFA development, when compared to that of the control sample. It was also revealed that the rate of VFA development increases with reduction of nano ZnO loading over the studied time period.

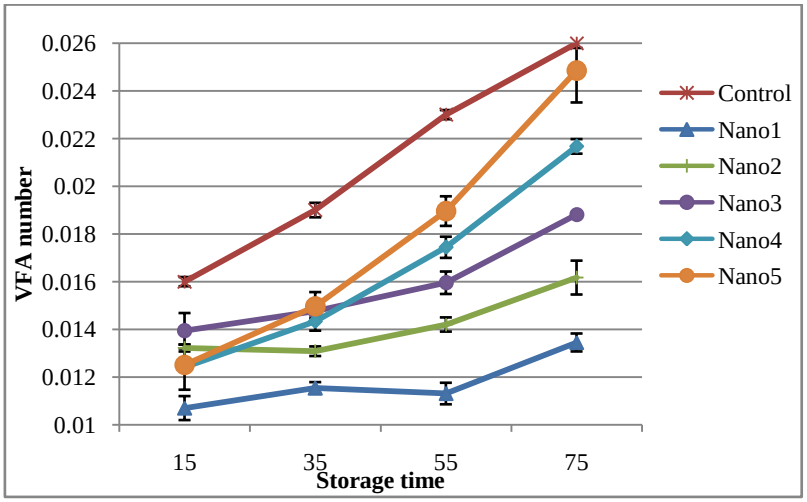


Fig. 1. Variation of VFA number of centrifuged latex samples with storage time

MST of CNRL samples after 20 and 30 days of centrifugation are mentioned in Table 2. Accordingly, MST of all the samples with nano ZnO rapidly increased unlike in the Control after 30 days (Y R Somarathna, Nirmala Jayawardena, H M H Dhanukamalee, P S V Rupasinghe and H L T Tharaka).

Table 2. *MST of CNRL samples after 20 and 30 days of centrifugation*

Sample Name	MST (seconds)	
	After 20 days	After 30 days
Control	1205	1446
Nano 1	1786	> 1800
Nano 2	1702	> 1800
Nano 3	1659	> 1800
Nano 4	1230	> 1800
Nano 5	1515	> 1800

Industrial extensions

Following clients obtained both technical and consultancy services from the Department during 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
- Ceylon Electricity Board
- Samson Rubber Industries (Pvt) Ltd
- Textrip (Pvt) Ltd
- Polymer Products Impex (Private) Limited
- Samson International PLC
- Samson Rubber Products (Pvt) Ltd
- Associated Specialty Rubbers (Pvt) Ltd
- Samson Compounds (Pvt) Ltd
- Jefferjee Brothers Export (Pvt) Ltd
- University of Ruhuna
- University of Sri Jayewardenepura
- University of Colombo
- University of Peradeniya

RAW RUBBER AND CHEMICAL ANALYSIS

Anusha Attanayake

DETAILED REVIEW

Staff

Dr (Mrs) A P Attanayake, Senior Research Officer was on duty throughout the year as the officer in-charge. Mr A M K S P Adhikari, Research Officer was on duty throughout the year.

Mrs H V K Gamage, Mr L P Vitharana, Mrs C S Lokuge and Miss M Wijesekera, Experimental Officers were on duty throughout the year. Miss S P Wijewardana, Miss N C Y Kithmini, M U D S Weerasinghe, Mr H D M S Wijewardana, Mr K A S T Koswatta Technical Officers was on duty throughout the year. Management Assistant Miss W D D Samanmali, was on duty throughout the year.

Research students

- Miss N N M Arachchi, Bsc (Animal Science and Export Agriculture) undergraduate from Uva Wellassa University of Sri Lanka, completed her final year research projects on Reduction of enzymatic discolouration in natural rubber latex by using antioxidants and *Moringa Oleifera* leaf extract.
- Miss D D N C Karunaratne, undergraduate from University of Sri Jayewardenapura, Faculty of Applied Science, Sri Lanka, completed her final year research projects on Development a test method for the estimation of higher fatty acid content in natural rubber latex.
- Miss T H Pabasara Oshadhi Mendis, Graduate from University of Colombo conducted a research project on Identification of new chemical as a replacement for bleaching agent used for crepe rubber.

Training programmes

Training programmes were carried out for the following officers/students as detailed below.

Client	Subject
Thirty five students - Uwa Wellassa University	Raw rubber & latex testing
Mr WMAR Wanasinghe - Hopten Estate	DRC testing
Team of teachers	Raw rubber & latex testing
Six Officers - NIPM	Raw rubber & latex testing

Client	Subject
Three Officers - Textrip (Pvt) Ltd.	Latex testing
Miss RA Harindi Gayara	Institute of Chemistry Ceylon
Twenty students - Sabaragamuwa University & Wayamba University	DRC, Nitrogen content, PRI
Sixteen students - University of Jayewardenepura	Raw rubber & latex testing
Mr LHAWI Rathnayake - Aroma Latex (Pvt) Ltd	Latex testing
Miss Tharaka Sewwandi - BGN Rubber Factory	Raw rubber testing
Miss Bhagya Sandamali - Lak Latex Centrifuged (Pvt) Ltd.	Magnesium content in natural rubber latex
Miss Navodya Karunarathne University of Jayewardenepura	Latex testing

Lectures/Seminars/Workshops/Meetings attended

Officer/s	Subject	Organization
AP Attanayake	Workshop on Proposal Writing	University of Sri Jayewardenepura
	Technology Update Programme	Dartonfield, RRISL
	Advisory Committee Meeting on Rubber & Rubber based Products & Plastic Sector	Export Development Board, Colombo
	Progress Review Meeting	Ministry of Plantation Industries
	Special Workshop on Quality Management Systems	National Institute of Plantation Management – Athurugiriya
	IRRDB Workshop – Inauguration	Dartonfield, RRISL
	Meeting on ethephon stimulation on raw rubber properties	Colombo Rubber Traders' Association
	Workshop on effect of low frequency harvesting system on raw rubber properties	Kotagala Plantations PLC
	Workshop	Export Development Board, Colombo
	Workshop on Advanced Instrumental Analysis	Water's Edge Hotel - Battaramulla
AP Attanayake Kasun Adhikari	Research Review Meeting	Dartonfield, RRISL
	SSOA Committee Meeting	Dartonfield, RRISL
	MPI Secretary visit	Dartonfield, RRISL
	Executive Officers Meeting	Dartonfield, RRISL

LABORATORY INVESTIGATIONS

Reduction of enzymatic discolouration in natural rubber latex by using antioxidants and *Moringa oleifera* leaf extract

Latex crepe rubber is the purest form of natural rubber (NR). Discolouration with the presence of non rubber should be avoided to maintain its quality. Enzymatic discolouration (ED) can be prevented by inhibiting the enzymatic reaction with addition of antioxidants. This study was conducted to find a suitable chemical to reduce enzymatic discolouration in natural rubber latex. NR latex was tested with the natural chemicals such as plant extract and commercially available medicinal substances. Among the rubber clones available in Sri Lanka, RRISL 203 clone shows the highest degree of ED due to the presence of phenolic substances. Therefore this clone was selected to study this problem with comparison to RRISL 121 clone.

Three treatments: *M. oleifera* leaf extract {Leaf extract of *Moringa oleifera* which is said to have a powerful antioxidant (quercertin)}. Vitamin C (a solution made by dissolving vitamin C tablets) and 'antioxidant G' (is a natural antioxidant) were used for the study.

Samples were collected from three tapping blocks with three replicates. Each solution of antioxidant was added separately prior to add formic acid to latex. Samples were prepared as unfractionated-unbleached crepe rubber with a control sample. Lovibond colour index (Fig. 1), Plasticity Retention Index (Fig. 2), Mooney viscosity (Fig. 3), Nitrogen content (Fig. 4), Volatile Matter Content (Fig. 5) and Ash Content (Fig. 6) were tested for treatments.

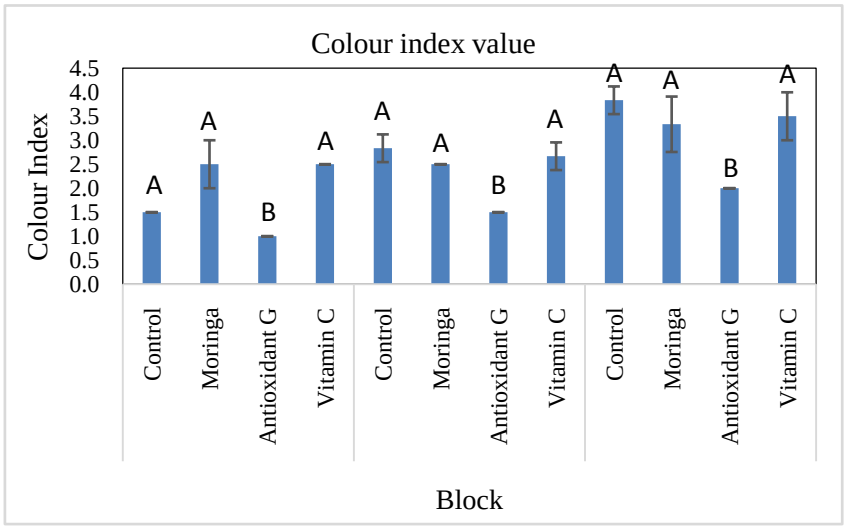


Fig. 1. Lovibond colour index with four treatments in three tapping blocks

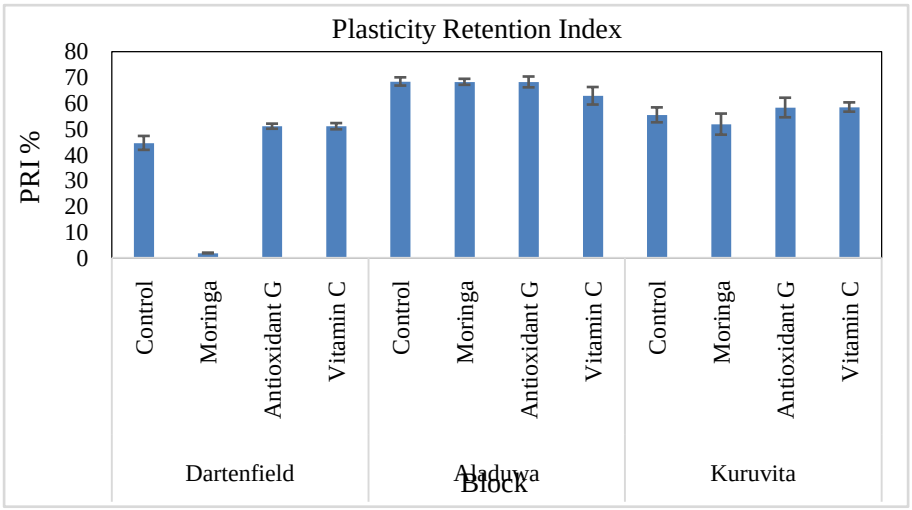


Fig. 2. Plasticity retention index with four treatments in three tapping blocks

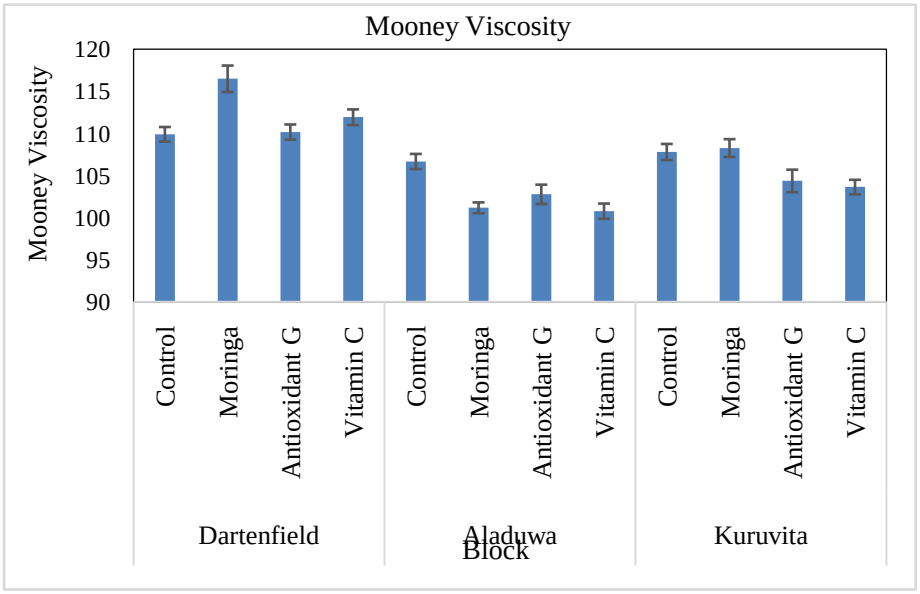


Fig. 3. Mooney viscosity with four treatments in three tapping blocks

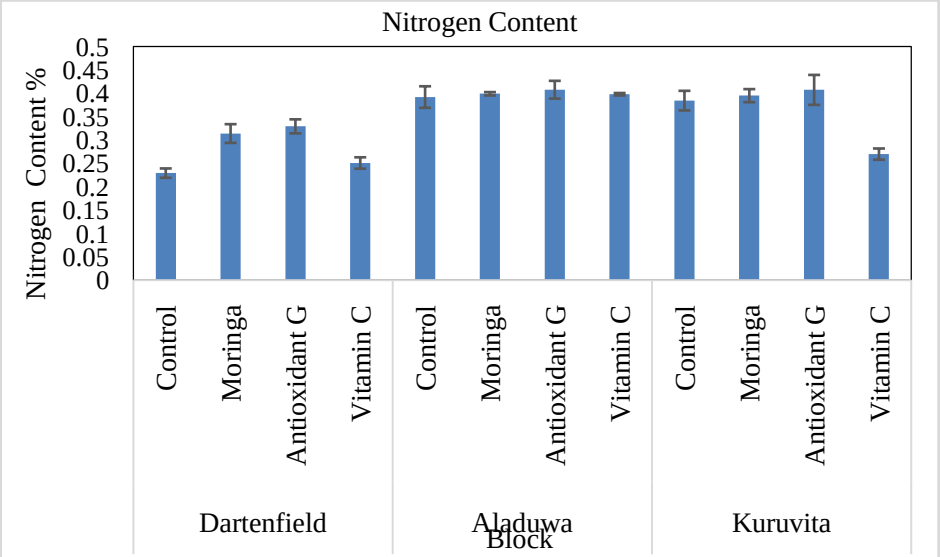


Fig. 4. Nitrogen content with four treatments in three tapping blocks

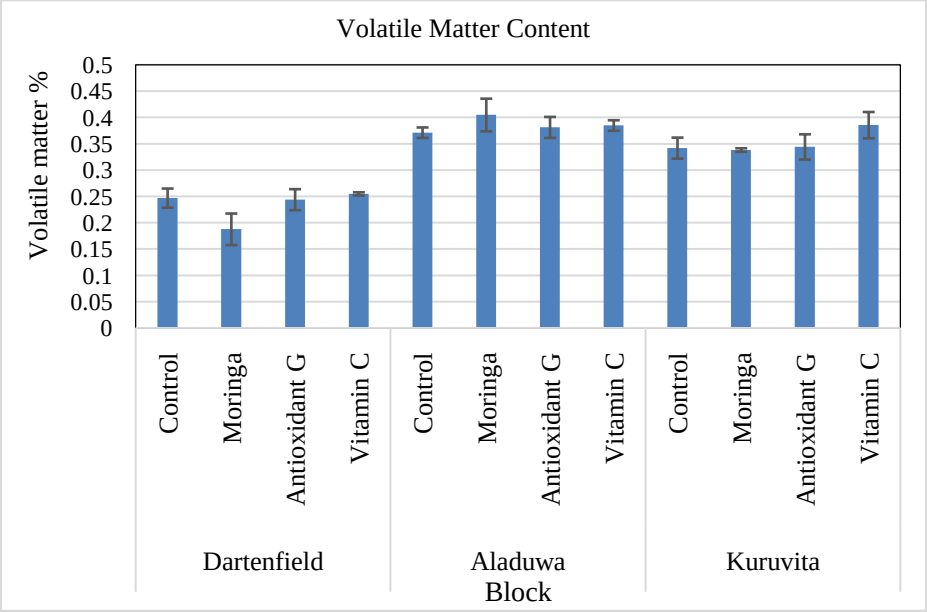


Fig. 5. Volatile matter content with four treatments in three tapping blocks

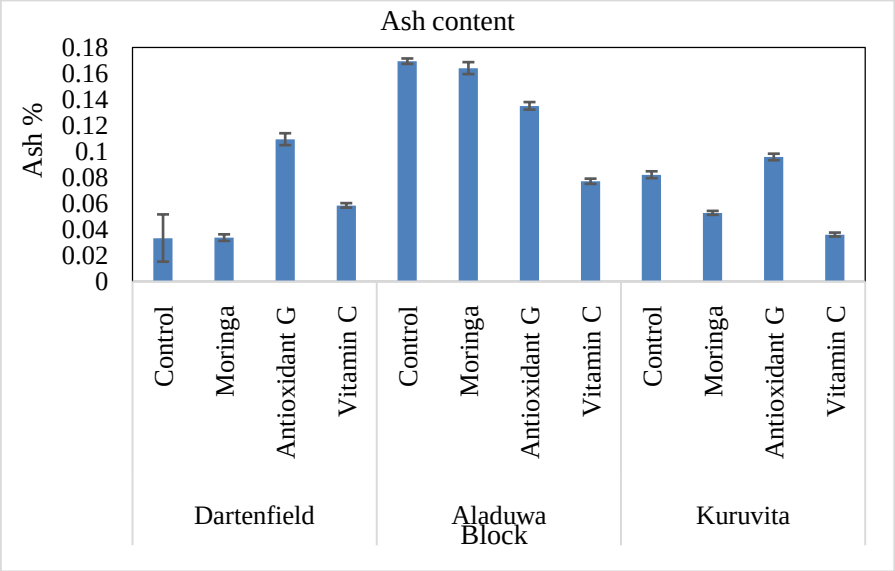


Fig. 6. Ash content with four treatments in three tapping blocks

The P value (>0.05) proved that there was no significant differences in raw rubber properties among the treatments except Lovibond colour index. The lowest colour index value achieved with 'antioxidant G with respect to the other treatments. The results revealed that 'antioxidant G' effectively reduces the discolouration while maintaining its raw rubber properties. The other two treatments were not effective with compared to "G" (A P Attanayake, N N Munasinhaarachchi and M U D S Weerasinghe).

Identification of probable reasons for de-lamination of multilayer latex dipped products

This study was started as a collaborative project with private sector. Percentage of de-lamination of latex dipped products was varying with the use of different sources of latex. Samples which recorded higher percentage of de-lamination was tested for serum phosphate content and higher fatty acid content. As shown in Table 1 the suspected samples showed higher percentage of phosphate and total fatty acid quantity. Therefore, we can suggest thataddition of high soap quantity to achieve higher MST value and addition of excess DAHP to remove magnesium ions in latex without analysis of Mg^{2+} content would be the reasons for the delamination of multilayer dipped products.

Table 1. *Specific latex properties for samples sent from two suppliers*

Sample Number	Supplier A (low delamination %)	Supplier B (High delamination %)
KOH number	0.65	0.8
Serum Phosphate content	377.14 mg/kg	534.26 mg/kg
Serum Magnesium content	20.81 ppm	Not in detectable level

(A P Attanayake, C Lokuge and S P Wijewardena)

Determination of soap (higher fatty acid) content in natural rubber latex

A test method was developed to estimate higher fatty acid content in natural rubber latex. Fatty acids were extracted into boiling acetone (Fig. 7). The residue was separated by the evaporation of solvent. Dried extract dissolved in neutralized alcohol was titrated with 0.1 M sodium hydroxide to a pale pink end point while hot. Report the results as percent free acid (%FFA) in the latex concentrate, expresses as stearic acid, using the equation:

$$\%FFA = \frac{V*C*MW*B*100}{A*D} \quad \text{.....Eq(1)}$$

V - The volume of titer (L)
C - The concentration of the titer (mole/L)
MW - The molecular weight of stearic acid (g/mole)
B - The total extract weight
A - The weight of extract use in the analysis (g)
D - The latex sample weight (g)

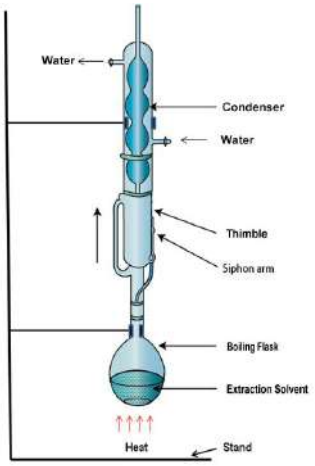


Fig. 7. Apparatus used for the fatty acid extraction

(A P Attanayake, M U D S Weeresinghe and D D N C Karunaratne)

Study on impact of application of fumigation gases (methyl bromide) for the quality of cuplumps

Fumigation is compulsory for the cuplumps imported to any rubber growing country as a quarantine requirement. However, there is no any in-depth study carried out to study the effect of fumigation gases for the raw rubber properties. This study was carried out as a collaborative project with Plant Pathology and Microbiology department and B.G.N. Rubber Industries as the industrial partner. According to our preliminary study the following results were obtained.

Table 2. *Raw rubber properties of tested samples*

	Control	**Methyl bromide treated sample**
Plasticity Number	57.0±3.32	53.50±3.38
Aged Plasticity	34.25±1.32	**23.38±2.03**
Plasticity Retention Index	60.18±2.67	**43.75±3.58**
Mooney Viscosity	92.73±1.45	87.09±0.95

(A P Attanayake, T P H S Fernando, C Lokuge and B G Nandena)

According to the above results (Table 2), ageing properties of raw rubber has reduced with the fumigation of methyl bromide. However some of the properties were not reduced below the limits of SLR 20, except the highlighted results.

Quality analysis of latex, raw rubber and rubber processing chemicals (RR & CA/2018/01)

Testing and certification services were provided to all sectors in the rubber industry and they are summarized below:

Sample analysis	**No. of test**
Raw rubber	2,932
Latex	1,011
Chemicals	45
Gloves	5
Polythene	16
Certificates of analysis issued	309

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Y C Y Sudusingha

DETAILED REVIEW

Staff

Mr Y C Y Sudusingha, Research Officer was covered up the duties of the Head of the Raw Rubber Process Development & Chemical Engineering Department throughout the year. Experimental Officers, Messrs Chandrika Nalini, U M S Priyanka, V C Rohanadeepa, A K D Warnajith and Technical Officers, Messrs R D Illeperuma, P K N N Sandamali and W R U de Silva were on duty throughout the year. Mrs A R Mealni de Alwis, Management Assistant was transferred to the Administration Section and Mrs H A Janani Lakshika was appointed as Management Assistant with effect from 12th January 2018.

Research students

- Ms D N D A De Zoysa, a BSc student from Uva Wellassa University of Sri Lanka, completed her research project titled "A Novel Method to Manufacture Skim Crepe Rubber with Low Nitrogen Content using Pineapple Juice Treated Skim Latex" under the supervision of Mr Yohan Sudusingha and Dr Susantha.
- Mr G K H Waruna, Mr W G Manoj Gayashan Kumarasinghe and Mr K U D Chaturanga, BSc students from Sri Jayawardenapura University of Sri Lanka, completed their industrial training at Raw Rubber Process Development and Chemical Engineering Dept.

Seminars/Training programs/Workshops/Conferences/Meetings attended

Officer/s	Subject	Organization
YCY Sudusingha	Scientific Writing	Sri Lanka Council for Agricultural Research
	SLCARP International Agricultural Research Symposium	Sri Lanka Council for Agricultural Research
UMS Priyanka RD Illeperuma WRU de Silva PKNN Sandamali	Waste Water Management	Institute of Ceylon Chemistry
PKNN Sandamali	Awareness Workshop for laboratories registered in CEA for the year 2107/2018	Central Environmental Authority (CEA)

Seminars/Training programs/Workshops/Exhibitions conducted

Officer/s	Subject	Organization
YCY Sudusingha	Certificate course in Rubber and Plastic Technology	Plastic and Rubber Institute
	Raw rubber processing and waste water treatment technologies	National Institute of Plantation
	Testing facilities at Raw Rubber Process Development & Chemical Engineering Dept.	Export Development Board of Sri Lanka
YCY Sudusingha AKD Warnajith	Workshop on Latex preservation, safe chemical handling and how to avoid discoloration	Pussellawa Plantation Ltd.
YCY Sudusingha AKD Warnajith UMS Priyanka	Training Program on raw rubber processing for Development Officers	Rubber Development Department
YCY Sudusingha AKD Warnajith WRU de Silva RD Illeperuma	Training Program on raw rubber processing for undergraduates	Faculty of Technology of University of Sri Jayawardenapura
AKD Warnajith	Certificate course in Rubber and Plastic Technology	Plastic and Rubber Institute
	Field training program on Crepe Rubber Manufacture for planter trainees	National Institute of Plantation Management
	Training Program on Raw Rubber Processing and Practices for undergraduates	Faculty of Animal Science and Export Agriculture, University of Uva Wellassa
	Training Program on Raw Rubber Processing for Diploma holders	Agunakolapelessa Agriculture School and Karapincha Agriculture School
	Training Program on Raw Rubber Processing for Msc students	University of Kelaniya
	Training Program on RSS Manufacturing for Smallholders (Eight Programmes)	Thurusaviya Trust Fund
WRU de Silva AKD Warnajith	Training Program on RSS processing for Field Officers	Ykumbura estate
VC Rohanadeepa PKNN Sandamali	Training Program on Crepe Rubber Manufacture for undergraduates	Students of Uva WellassaUniversity
Staff of the Department	Seminar on How to control VFA at the field level	Field latex suppliers of Glenross Centrifuged Factory
	Training program on Raw rubber processing for Rubber Development Officers	National Institute of Plantation Management Rubber Development Department

Advisory visits

Services provided:

Services provided	No. of factories/visits
Process and quality improvements	06 (17)
Waste water treatment	04 (6)
Waste water sample collection for testing	43 (46)
Plans issued for construction of new SS drying systems with capacity less than 100kg	11
Miscellaneous advisory and troubleshooting	10 (4)

Waste water analysis

Collection of waste water samples from raw rubber processing and allied industries and analysis of waste water parameters were carried out throughout the year.

Samples tested and certificates issued:

Sample tested	No. of samples/Certificates
Waste water- rubber related	59/55
Waste water- Non rubber related	26/24
Processing water	8/5
Miscellaneous sample (Metal ions, ZnO *etc*.)	8/6
Analysis of extractable proteins	27/7
No of certificates of epidemic prevention issued for sole crepe	39

Miscellaneous

Technical assistance was continued to provide to Thurusaviya annual programs by extending of the services of resource personal and technical expert panels for evaluating quotations, issuing smoke house plans, inspection of construction and operation activities of sheet rubber processing centers and single day smoke drying units.

LABORATORY AND FIELD INVESTIGATIONS

Curing characteristics, physico mechanical and dynamic mechanical properties of NR/SBR (80:20) Composites for Solid Tire Base Compounds: Effect of Skim Rubber Content in Natural Rubber Phase

A series of NR/SBR (80/20) composites were prepared replacing RSS from skim rubber by varying the skim rubber (SR) percentage in the NR phase from 0 to 40% with 10% intervals while keeping the SBR content at a constant value. A

standard formulation was used to prepare a solid tire base compound and compounding was carried out on a conventional two roll mill. Curing characteristics, physico-mechanical and dynamic mechanical properties of the composites were measured. The objective of the study is to find out the potential of partial substitution of RSS from SR in order to reduce material cost. This Study revealed partial replacement of RSS from SR has no significant impact on the processability in term of scorch time and cure time. However, processability of rubber compounds found to be become more difficult as the SR content increases in the rubber phase as indicated by the minimum torque (M_L) values. It was also found that partial replacement of RSS from SR increases the hardness of the vulcanizates as the SR was increased and, difference between maximum torque and minimum torque (M_H-M_L) had been raised from 15.06 to 19.08 Nm. This trend has been confirmed by the increasing gap between the storage and the loss modulus in the rubber region. Therefore, This could be occurred due to the presence of higher cross link density of the skim composites compared to the crosslink density of composite without SR, as upsurge of non-rubber including protein, with addition of more SR. The compression set percentage of each vulcanizates was lower than composite without SR while set percentage raised along with increase the loadings of SR from 0 to 40%. This implies that 10% SR composite with higher damping factor has better dimensional stability than other composites while registering the highest tensile strength. Furthermore, blend with 10% rubber composite shows better tear strength, abrasion resistance and elongation at break percentage with compared to the other composites with SR. Based on the overall results, it could be concluded that 10% of RSS could be replaced from SR in solid tire base compounds without any adverse effects on the performance of the product.

Table 1. *Cure characteristics of the rubber compounds*

Batch	**Ratio NR/SKIM**	**Temp. (^{0}C)**	**ML (Nm)**	**MH (Nm)**	**MH-ML (Nm)**	**TS2 (min)**	**TC90 (min)**	**CRI**
1	80/0	150	1.58	19.0	17.42	7.56	13.47	16.92
2	70/10	150	1.53	19.05	17.52	5.57	11.28	17.51
3	60/20	150	1.51	19.66	18.15	4.53	9.45	20.33
4	50/30	150	1.61	20.82	19.21	4.41	9.49	19.69
5	40/40	150	1.61	19.56	17.95	4.42	10.07	17.70

Table 2. *Physico-mechanical properties of the rubber composites*

Batch	Ratio NR/SKIM	Hardness (IRHD)	Compression %	Abrasion loss(mm^3)	Tensile strength (MPa)	Modulus at 100% elongation (MPa)	Elongation at break
1	80/0	80.1	22.58	477.1	10.96	5.65	195.33
2	70/10	80.0	26.11	473.3	14.20	5.87	236.38
3	60/20	81.4	27.63	411.5	15.27	6.10	253.06
4	50/30	81.1	26.90	424.7	14.39	6.93	233.59
5	40/40	83.4	26.38	414.6	12.96	6.54	241.64

A novel method to manufacture skim crepe rubber with low nitrogen content using pineapple juice treated skim latex

Skim Natural Rubber Latex (SNRL), a by-product obtained during the manufacture of centrifuged latex, contains small rubber particles with low dry rubber content (<05%). Direct coagulation of SNRL with concentrated sulfuric acid is the conventional method widely used to manufacture Skim Crepe Rubber (SCR). SCR fetches a low market value due to its inferiority in quality inherited by the presence of higher non-rubber content compared to that in other raw rubber types. This study focused to develop a healthier and environmental friendly manufacturing process for SCR with lower nitrogen content and higher quality through removal of protein in SNRL. Pineapple juice (PAJ) was initially treated with Potassium oleate before it was mixed with SNRL and kept for 48 hours at room temperature (28 ^{o}C). Then a creaming agent was added at 25 phr to PAJ treated SNRL after adjusting pH to 7.5 and creamed for 36 hours. Three different acidic coagulants of 20% (w/w): sulfuric, oxalic and formic acid were employed to coagulate deproteinized creamed fraction. The control sample of SCR was also prepared by adding 20% (w/w) sulfuric acid to fresh SNRL. Raw rubber properties of deproteinized and control SCR samples were evaluated according to the ISO standards. All SCR samples prepared by using creaming followed by the PAJ treatment have low nitrogen content (0.30-0.40% w/w) and Mooney viscosity (90-75MU) along with higher ash content (0.4-0.5% w/w) than those values obtained for the control sample where above parameters were 1.44% (w/w), 91.55MU and 0.17% (w/w) respectively. It was also found that total acid requirement could be reduced by 50% when the novel method was used. Moreover, it was found that deproteinized SCR manufactured using oxalic acid as the coagulant has low nitrogen percentage (0.38% w/w) and highest PRI (61.17%) with fairly high

initial P_0. This method might be a possible solution for removal of protein substances and unfavorable metal ions from SNRL enhancing the quality of SCR. Therefore, this novel method would allow to obtain a better competitive commercial value for SCR.

Table 3. *Raw rubber properties of skim rubber samples*

Treatment / Property	**Cream + Oxalic**	**Cream+ H_2SO_4**	**Cream+ Formic**	**Control**
N content (% w/w)	0.302	0.409	0.335	1.449
Plasticity	42.500	40.167	48.333	47.333
PRI	26.000	2.006	1.333	2.833
Ash Content (%w/w)	0.434	0.500	0.578	17.943
Dirt Content (%w/w) **(% w/w)**	0.081	0.046	0.069	0.128
Volatile Matter (% w/w)	0.165	0.152	0.087	1.369
Mooney Viscosity [ML (1+4) 100 ^{0}C]	90.790	92.590	85.320	91.550

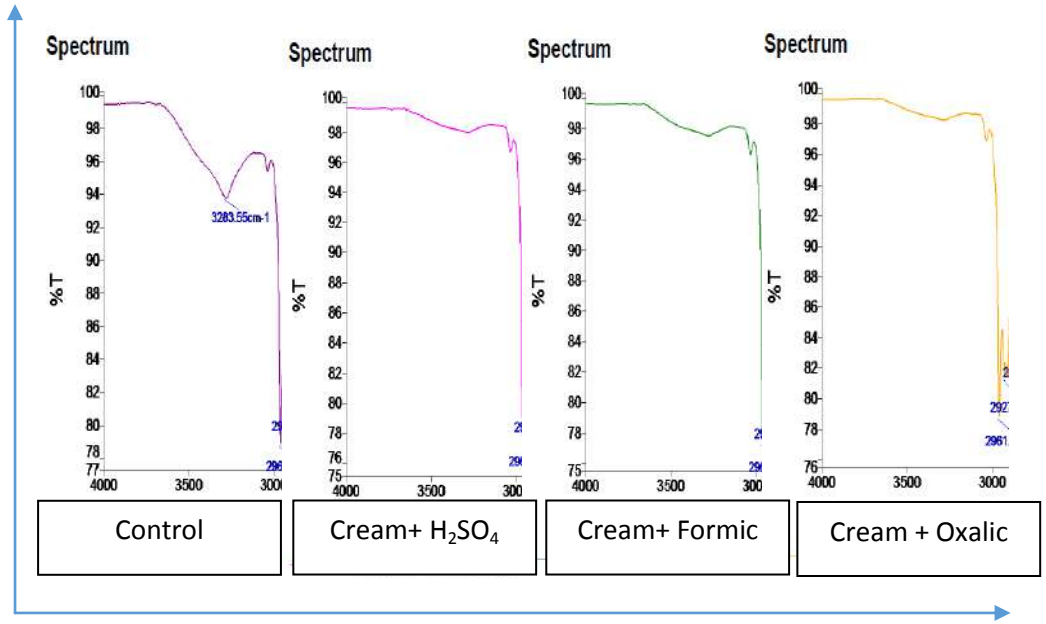


Fig. 1. FTIR analysis of skim samples

IR peak at 3,283 cm^{-1} which is responsible to NH_2 group was observed in IR spectrum of all the skim samples. It was noted that control sample has higher absorption values for above mentioned characteristics peak for proteins than deproteinized skim crepe rubber samples. Further, it coincides with nitrogen values obtained for skim rubber samples.

Quality improvement of effluent water discharge from technical specified rubber (TSR) manufacturing factory

Waste water generated at raw rubber factories should be treated to satisfy the regulatory standards stipulated by Central Environmental Authority (CEA) in Sri Lanka prior to disposal of effluent in order to lessen pollutant impact of waste water. However, due to growing concern on environment pollution, scarcity of quality water and low efficiency of available waste treatment plants in rubber industry, further quality improvement of discharge effluent has been identified as an important issue, should be addressed nowadays.

Effluent water discharge samples were collected from raw rubber processing factories; crepe rubber, technical specified rubber and centrifuged latex were treated with 1% Alum solution and 0.01% Polyacrylamide (PAM solution). A series of treatment was prepared by varying the amount of Alum from 0 ml to 30 ml and, at the same time, the PAM amount was also varied from 30 ml to 0 ml. pH of effluent samples obtained from the TSR factory were adjusted up to 6.5 before treatment. After 24 hours storage time, water quality of treated samples were tested in term of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Dissolve in waster (TDS), Total Ammonical Nitrogen (TAN) of Alum/PAM treated and untreated samples were tested according to the standard procedures.

It was observed that Alum and PAM both have a significant impact to improve the quality effluent discharge. But alum causes reduction of pH of the effluent discharge from 6.83 to 4.40 and PAM causes to increase the pH up to 7.95. Alum treatment reduces the COD and BOD by 60% and 41.4%, respectively. And PAM treatment causes 40% COD and 34.9% BOD reduction. PAM and Alum individual treatments have not a significant impact for drop of TAN and TSS values of effluent water discharge. But PAM may has more ability to reduce TSS than Alum.

Alum coagulants are added to water the Al ions hydrolyze rapidly but in a somewhat uncontrolled manner, forming a series of metal hydrolysis species. The effectiveness of aluminum coagulants arises principally from its ability to form multi-charged polynuclear complexes with enhanced adsorption characteristics. The nature of the complexes formed is controlled by the pH of the system. PAM has the ability to bridge together particles suspended in solution by an adsorption process. PAM often has electrostatic charges that allow for surface particle neutralization resulting in flocculation.

Combine treatment of Alum and PAM shows better quality improvement of effluent discharge than individual treatments, in term of COD, BOD, TSS and TAN. However, it was observed that pH of samples decreases with increment of Alum ratio in combine treatment of Alum and PAM. Therefore, it can be suggested that pH adjustment is required for all the treatments except the PAM 30.00 ml treatment. The lowest values of COD and BOD were obtained from Alum 20.00 ml + PAM 10.00 ml. Meanwhile, Alum 10.00ml +PAM 20.00ml treatment reduces TSS significantly by 90%. It can be concluded that combine treatment of Alum and PAM treatments are more effective than individual treatments of PAM and Alum to improve quality of waste water discharged further.

Table 4. *Water quality parameters of treated and untreated effluent discharge*

sample / **parameter**	**Non-treated sample**	**Alum 30.00 ml**	**PAM 30.00 ml**	**Alum 10.00 ml +PAM 20.00 ml**	**Alum 20.00 ml + PAM 10.00 ml**	**Alum 15.00 ml +PAM 15.00 ml**
COD (mg/l)	100	40	60	40	20	20
BOD (mg/l)	21.40	12.50	14.00	16.70	11.30	14.00
pH	6.83	4.40	7.95	5.13	4.50	4.65
TAN (mg/l)	28.00	23.10	24.50	22.40	24.15	23.80
TSS (mg/l)	80	68	60	8	32	16

Skim Natural Rubber for preparation of Thermoplastic Natural Rubber (TPNR) – A study on processability

This study was carried out to prepare Thermoplastic Natural Rubber (TPNR) blends based on polypropylene (PP) and skim natural rubber (SNR) compared with compared to the Standard Lanka Rubber 20 (SLR20). Main objectives of the study are; value addition to skim natural rubber, improvement of impact strength of PP while governing the processability and recyclability. Firstly SLR 20, SNR and PP were characterized using standard methods. PP/NR blends were prepared by melt mixing technique using an internal mixture under high shearing action according to pre-determined processing conditions and vulcanized through sulphur curing. The blend ratio of PP/NR was varied from 30/70 to 70/30 at 10% intervals and the mixing torque development, Melt Flow Index (MFI), Moving Die Rheometer (MDR) torque development and Thermo Gravimetric Analysis (TGA) of the TPNRs were investigated. To observe the long term torque development, another similar set of blends were prepared by increasing the mixing time up to 30 minutes. Plateau torques were observed for each blend type excluding both PP/SNR and PP/SLR blends of 30/70 blend ratio. It was observed that torque is declined after Sulphur addition in both PP/SNR and PP/SLR blends of 30/70 blend due to degradation of the blends.

Similar results were noticed for longer mixing period as previous. However, other blends could be recycled because of plateau torque was remained until 30 minutes mixing and 30/70 ratio of both PP/NR blends are not suitable for product developing due to poor recyclability. MFI values obtained for PP/SLR vulcanized blend were substantially low and significant variation was not observed among blends. While decreasing the rubber content, the MFI value is increasing in PP/SNR vulcanized blends but 40/60 and 50/50 ratio of PP/SNR blends showed similar MFI values to PP/SLR blends. According to the MFI results, the viscosities of PP/SNR blends are lower than PP/SLR blends. The MDR torque development graphs showed no value for Maximum torque (M_H), Lowest torque (M_L) and scorch time (TS_2). It could be predicted that there is no excess sulphur/cross-linking agents in every blends.

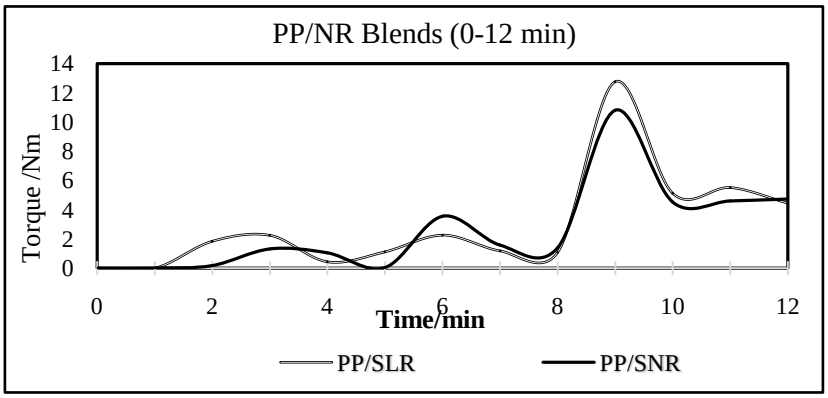


Fig. 2. Variation of mixing torque of PP/NR blends at 0-12 min (Typical graph)

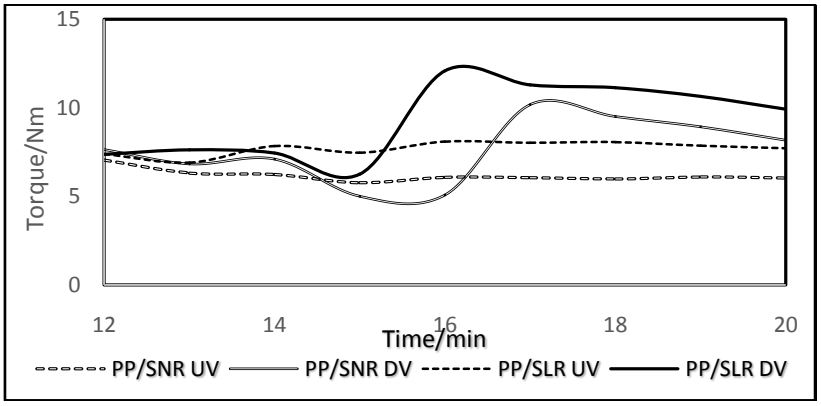


Fig. 3. Variations of mixing torque of PP/NR blends at 12-20 min (Typical graph)

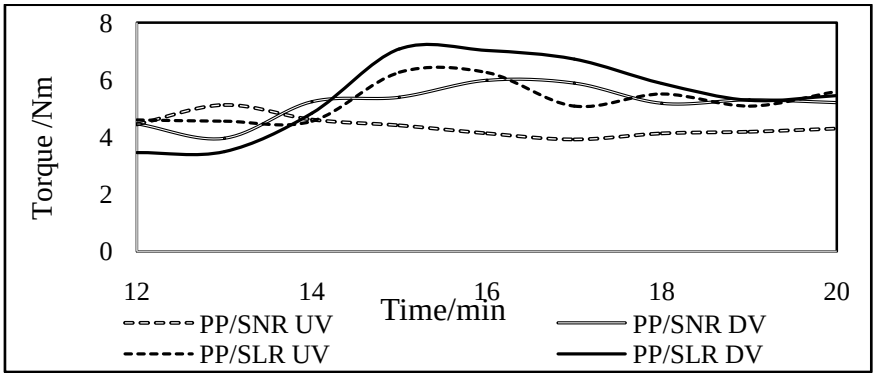


Fig. 4. Variations of mixing torque of PP/NR (50/50) blends at 12-20 min

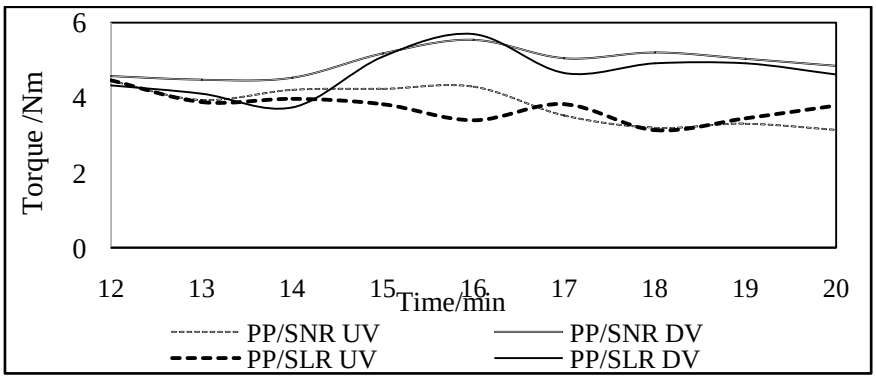


Fig. 5. Variations of mixing torque of PP/NR (70/30) blends at 12-20 min

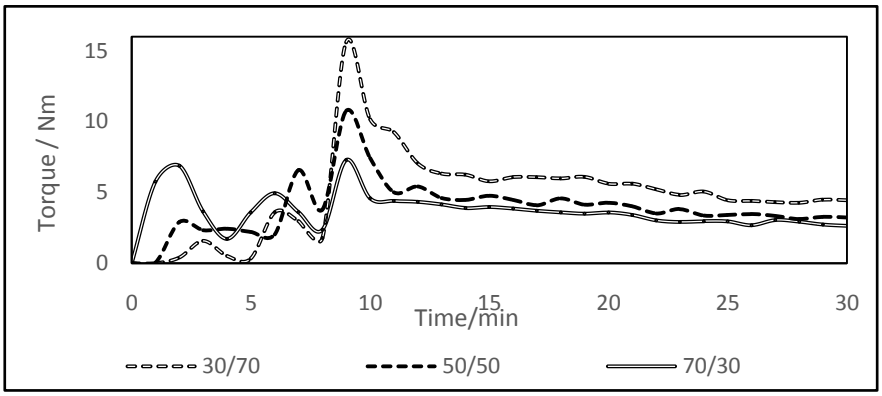


Fig. 6. PP/SNR Unvulcanized blends- long term mixing

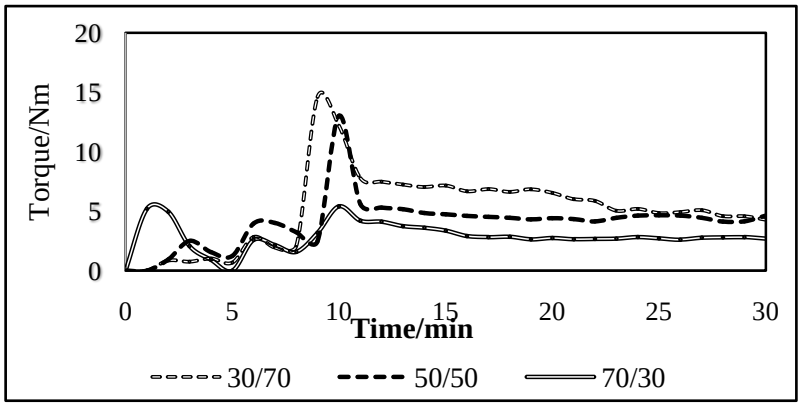


Fig. 7. PP/SLR Unvulcanized blends- long term mixing

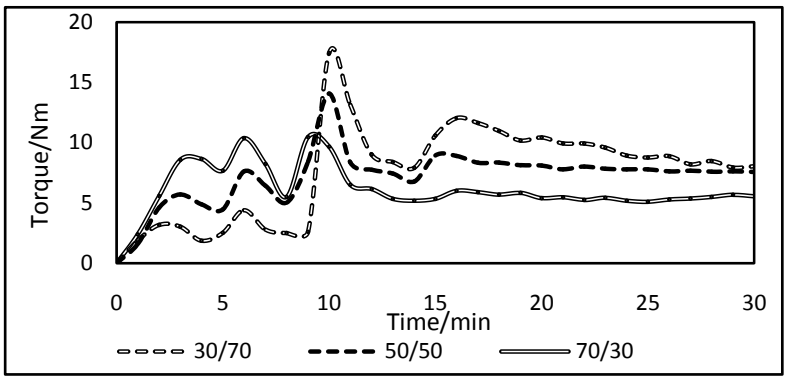


Fig. 8. PP/SNR Vulcanized blends- long term mixing

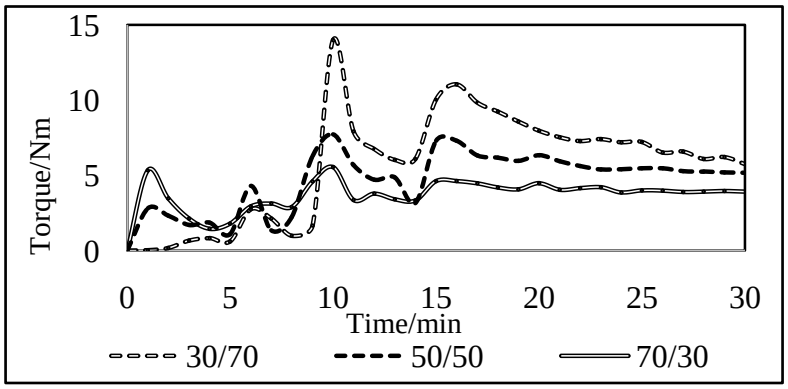


Fig. 9. PP/SLR Vulcanized blends- long term mixing

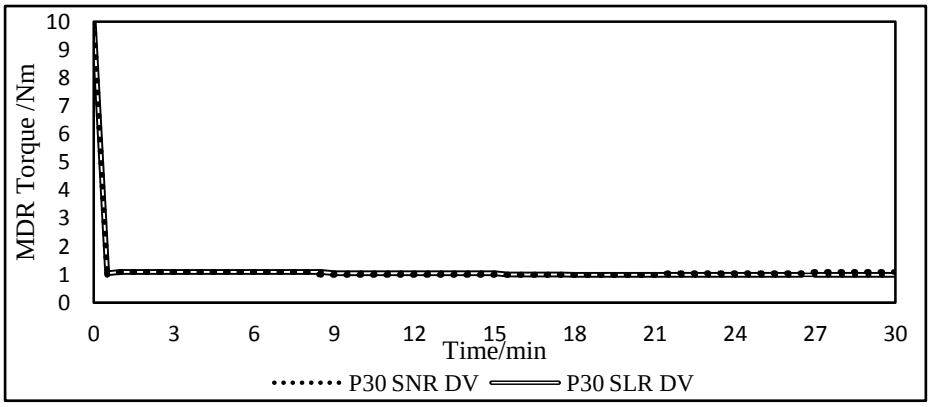


Fig. 10. MDR torque graph of PP/NR (30/70) Vulcanized blends

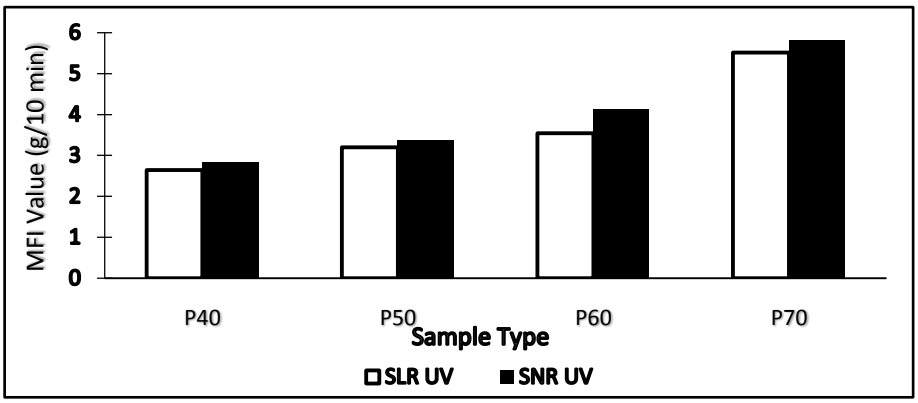


Fig. 11. MFI results of PP/NR unvulcanized blends

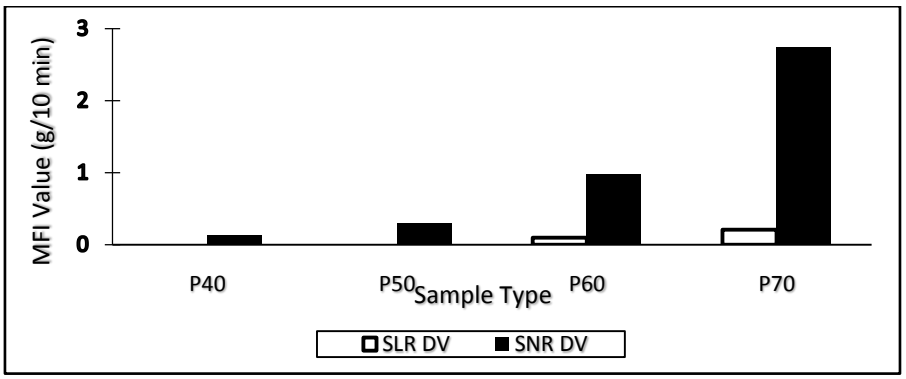


Fig. 12. MFI results of PP/NR vulcanized blends

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	Industrial training programme on rubber cultivation in non traditional areas	Undergraduate students of Sabaragamuwa University, Ruhuna University and Jaffna University, Diploma students of NIPM & Rubber Development Officers
	In plant training on adaptive research	Students of Labuduwa and Angunakolapelassa Agriculture Schools
	Job training on Agricultural Production Technology	School teachers

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
ES Munasinghe	Workshop on Australia Award Fellowship follow-up Research Conference	SLIDA
	Workshop on Research Dissemination	SLIDA
	Progress Review Meeting on rubber cultivation in Eastern Province	District Secretariat of Ampara and MPI
	Workshop on Quality Management System	NIPM
	Consultative Committee Meetings on non-traditional rubber cultivation	RRB
	Workshop on Procurement Procedures	RRISL

Officer/s	Subject/Theme	Organization
	Research Extension dialog	RRISL
	Research Advisory Committee Meeting	RRISL
	Project Implementing & Monitoring Committee Meeting of Carbon Trading Project	RRISL
	SLCARP Symposium	SLCARP
BMDC Balasooriya	Wayamba University Research Symposium	Wayamba University of Sri Lanka
	Workshop on Effect of Drought on the Agriculture Sector	SLCARP

Field visits

Experimental - 65
Advisory - 12
Other - 27

FIELD INVESTIGATIONS

Expansion of rubber cultivation to non traditional areas (ARU/01)

- ***Identification of the pattern of daily time allocation of farmers in rubber growing villages of the Eastern province***

  The study was conducted to characterize the daily time allocation of farmers in rubber growing villages of the Eastern province. The study was carried out in Padiyathalawa and Mahaoya Divisional Secretariat areas of Ampara District. Details of time allocation for different activities throughout the day/week were collected from 18 farmers each having mature and immature rubber fields. A similar number of non-rubber farmers in the area was interviewed for the same for comparison purpose.

  Findings of the study revealed that both non rubber farmers and farmers having immature rubber fields have allocated 53% of their daily time for farming. Of that non rubber farmers have consumed greater proportion (88%) for cash crop cultivation whilst farmers having immature rubber fields used their farming time for both cash crop cultivation (60%) and home gardening (32%). On the other hand, farmers having mature rubber fields have spent only 38% of their time for farming with the major share (58%) for rubber cultivation (Fig. 1). Being supported by basic infrastructure, modern appliances and efficient energy sources, time taken for household activities by them had kept the lowest among three farmer groups.

While spending less time for farming and household work, rubber farmers have been allocated more time to attend their children's education, family health care and leisure time activities than those of non rubber farmers and farmers having immature rubber fields. Further, they have devoted time for association of friends and relatives, attending religious activities and charity work over the others.

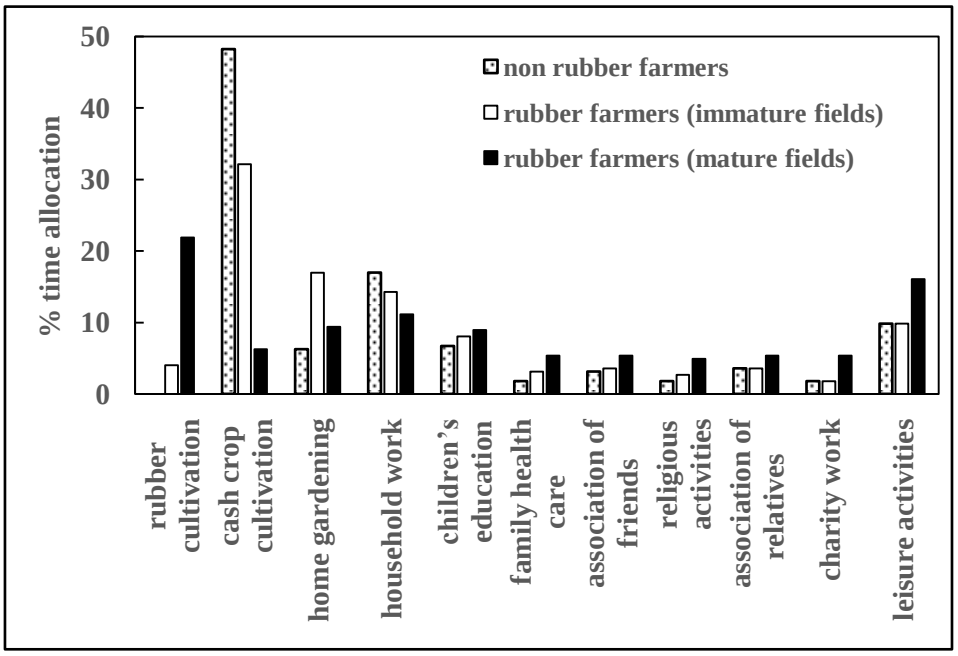


Fig. 1. Distribution of daily time allocation of farmers in rubber growing villages in the Eastern province
(E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena)

- ***Assessments on yield potential and seasonal variation of rubber yield in the Eastern province***

  In order to identify the yield potential and seasonal variation of yield at smallholder condition, daily yield records of eight rubber fields in Padiyathalawa and Mahaoya Divisional Secretariat areas have been monitored throughout the year. The highest yield was observed in the month of July (Fig. 2). Accordingly, average annual latex yield was recorded as 1,410kg/ha at early stage of harvesting (Panel B) and average number of tapping days was 146 per year.

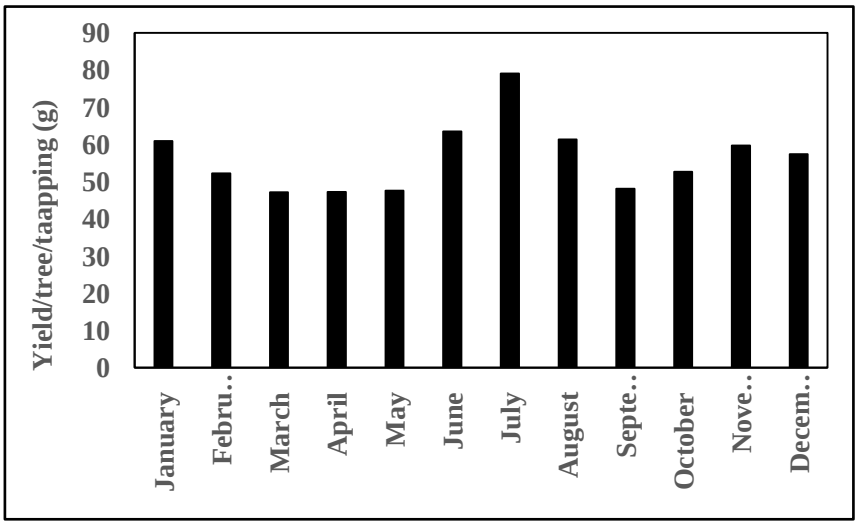


Fig. 2. Seasonal yield variation under smallholder condition of Eastern province

(E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena)

- ***Incorporation of crop residues as a moisture conservation method***
  This study was conducted to assess the effectiveness of incorporating crop residues as a moisture conservation method in Intermediate zone of the country. The experiment was laid out in mature (15 years old) rubber fields of Padiyathalawa with three replicates, each having *ca.* 300 trees of clone RRIC 121. Experiment comprised two spatial systems of placing pits for filling crop residues, *i.e.* 1) one pit per plant placing at the centre of interrows and 2) one pit per two plant placing at the centre of interrows allowing maximum distance to rubber plants. Pits were made with the dimensions of 120 x 60 x 60 cm and filled with crop reduces available in the area. Only the preliminary data were collected (E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena).

- ***Improving the protocols available to cultivate rubber in Dry Zone***
  With the aim of improving suitable protocols available to cultivate rubber in dry zone, farmer participatory adaptive research trials were established in Northern and North Central provinces of the country.
  Growth performance (in terms of tree girth) of rubber plants of sites in Vavuniya, Kilinochchi and Anuradhapura was assessed (Table 1).

Table 1. *Growth of rubber plants in Dry zone*

Sites	Year of planting	Site code	Land Extent	Clone	Mean girth (cm)	Mean Height (cm)
Vavuniya	2010	2010/V1	2 Ac	RRIC 121	47.5	Not taken
	2011	2011/V1	8 Ac	RRIC 121	42.5	Not taken
Kilinochchi	2017	2017/K1	½ Ac	RRISL 203	4.7	143.0
	2017	2017/K2	½ Ac	RRISL 203	6.2	161.4
	2017	2017/K3	½ Ac	RRIC 121	5.3	153.8
Anuradhapura	2017	2017/A1	2Ac	RRISL 203	6.1	149.1
			2Ac	RRIC 121	6.1	178.1

Since rubber clearings in Vavuniya has achieved satisfactory growth level, training programmes were conducted to educate farmers on latex harvesting and manufacturing of Ribbed Smoked Sheets at domestic level in collaboration with Advisory Services Department (E S Munasinghe, V H L Rodrigo, P M M Jayathilake and N M Piyasena).

Increase land productivity through technology adoption (ARU/02)

- ***Impact of late planting on growth and development of rubber plants in the Intermediate Zone***

  This experiment was commenced as a rubber/sugarcane intercropping demonstration plot at Moneragala Sub-station in 2009 together with an objective of assessing the impact of late planting on growth and development of rubber plants in the Intermediate Zone. Experiment comprises six main treatments of planting time points beginning onset of Maha season and thereafter in every two weeks. As sub treatments two types of planting materials, *i.e.* one and two leaf whorl rubber plants were planted with split plot arrangement in four experimental blocks. The experiment was replicated with a rubber/banana demonstration plot in 2011.

  Girth (at 120 cm height) of rubber plants were measured. Though girth values showed decreasing trend towards delay in planting time, the differences were not significant (Table 2).

  Since the trees have achieved satisfactory growth level, 2009 clearing was prepared for latex harvesting.

Table 2. *Growth of rubber plants*

	Mean girth (cm) - at 120 cm height (2009 clearing)		Mean girth (cm) - at 120 cm height (2011 clearing)	
	one leaf whorl plants	**two leaf whorl plants**	**one leaf whorl plants**	**two leaf whorl plants**
Onset of rain	56.1	56.3	44.2	44.5
2 weeks after	55.9	56.1	43.2	44.0
4 weeks after	55.3	55.7	42.9	43.6
6 weeks after	54.7	55.4	42.6	42.9
8 weeks after	54.6	54.9	41.6	42.3
10 weeks after	52.8	53.3	39.5	41.9

(E S Munasinghe, V H L Rodrigo, P M M Jayathilake, N M Piyasena and V G D N Gunaseela)

- ***Farmer perceptions and economics of technology adoption in the smallholder rubber sector in Sri Lanka***

  The study was initiated with the objective of identifying research, development and extension needs of the smallholder rubber farmers in Sri Lanka. It was planned to carry out the study in four major traditional rubber growing districts: Kegalle, Gampaha, Kurunegala and Kandy. Pre tested semi structured questionnaire survey was planned for the data collection and stratified random sampling technique was used for the sample selection. Sample size was 1250. During the year, 350 smallholders in Kegalle district were interviewed for the data collection.

  Out of 350 interviewed farmers, forty nine percent was engaged in rubber cultivation full time basis, 46% part time basis and 5% not involved in rubber related activities. Moderately steep rubber lands were prominent in the area that was about 77% of the sample. Use of flat lands for rubber cultivation was found to be very low (about 10%). Though it is not recommended to cultivate rubber in very steep lands, about 13% of the sample had cultivated rubber in steep lands. Findings show that about 99% of the smallholders was using recommended planting materials. Recommended size planting holes have been used by 81%. Establishment of planting materials has been done at correct time by 87% of the smallholders. Nineteen percent of the smallholders has not adopted the correct depth of planting. Awareness and Adoption of agronomic practices in mature clearings are shown in Figure 3.

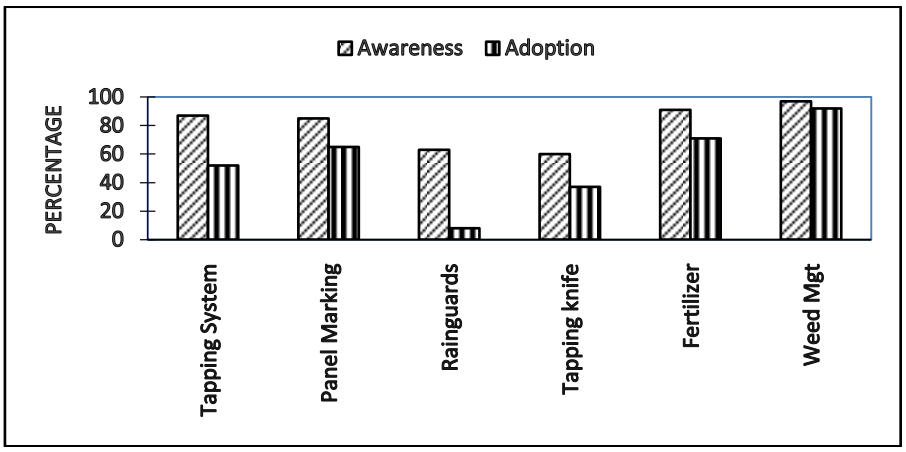


Fig. 3. Adoption and awareness percentages of different agronomic practices recommended for mature stage

The highest adoption rate is observed in weed management and the poorest adoption rate is observed in the application of rain guards, and they are 92% and 8% respectively. The adoption rate is lower than awareness level in all the technologies studied. The study is in progress (B M D C Balasooriya, P Seneviratna and N M Piyasena).

- ***Adaptability of new animal repellent under smallholder conditions***

  Adaptive research trial was started with the collaboration of Plant Pathology and Microbiology Department to identify the suitable application time and application frequency of newly introduced animal repellent. Details of the study was given in Annual Review 2017.

  At the initial stage, four sites were selected for animal repellent application. Sixty trees were selected for the treatment in each field and same number of trees kept as the control (without applying the repellent). Damages were recorded in treated and untreated plots (Table 3).

Table 3. *Percentage of animal pest damaged trees in animal repellent applied fields*

Field	Planting year	Clone	Damage %			
			Treated		Not treated	
			After 6 Months	After 12 Months	After 6 Months	After 12 Months
Smallholder field 1	2015	RRISL 203	0%	8%	5%	10%
Smallholder field 2	2014	RRIC 121	0%	17%	10%	12%
Smallholder field 3	2012	RRIC 121	0%	33%	13%	35%
Polgahawela Sub-station field	2012	RRIC 121	0%	8%	5%	8%

Three smallholder fields were selected to study whether wild boar and porcupine attacks are reduced with tapping. According to the results, animal damages have become very low during tapping. In one field there were no damages at all and in other two fields it was only 1% and 6% whereas more than 70% damages were recorded before the commencement of tapping. This may be due to increased human activities reported in respective fields after commencement of tapping. Any other reasons should be further investigated (B M D C Balasooriya and N M Piyasena with the collaboration of Plant Pathology and Microbiology Department).

Developing a project to approach the voluntary carbon market with the rubber cultivation in Eastern and Uva Provinces for sustainable rubber industry (Treasury Funded Development Project)

The project was initiated with the objective of developing carbon trading project to obtain Voluntary Carbon Standards (VCS) for new rubber cultivations in Uva and Eastern provinces. An extent of 3,000 ha scheduled to be planted under the Smallholder Tea and Rubber Revitalization (STaRR) Project and 2,500 ha of that extent are expected to be used for carbon trading. In order to get VCS, preparation of Project Description Document (PDD) was commenced in collaboration with Carbon Consulting Company (V H L Rodrigo and E S Munasinghe).

BIOMETRY

Wasana Wijesuriya

DETAILED REVIEW

Staff

Dr (Mrs) Wasana Wijesuriya, Principal Research Officer and Experimental Officer, Mr Vidura Abeywardene were on duty throughout the year. Mrs Chintha Munasinghe, an Experimental Officer who served the institute for 32 years, retired on the 03rd December 2018. Mrs Subha Munasinghe has been transferred from the Internal Audit Unit to the Biometry section with effect from 16th April.

Research students

The following students are registered for postgraduate studies under the guidance of Dr (Mrs) Wasana Wijesuriya.

- M W H Gayan - Continued working on "Suitability of different drought indices under Sri Lankan conditions based on statistical considerations and practical use" for his MSc degree at the Faculty of Agriculture, University of Ruhuna.
- L A T S Liyanaarachchi - Registered for a MPhil in the Wayamba University based on a study titled "Indicator based identification, forecasting and mapping of droughts in Sri Lanka".
- S D Rathnayake - Progressed on "Occurrence of extreme rainfall events in rubber growing areas" for his undergraduate research for the degree of BSc in Agricultural Technology and Management.
- Ms Kaumadee Weerasinghe - Continued working on "Monitoring and forecasting of droughts in Sri Lanka: Spatio-Temporal Bayesian modelling approach for her undergraduate research for the degree of BSc in Agriculture.

Seminars/Trainings/Workshops addressed/conducted

Mrs Wasana Wijesuriya conducted the following trainings organized by RRISL.

Subject/Theme	Beneficiary/Client
Climatic conditions and rainfall distribution in rubber growing areas	Participants of the Advanced Certificate Course in Plantation Management, Officers of Rubber Development Department

Seminars/Conferences/Meetings/Workshops attended

Mrs Wasana Wijesuriya attended the following Meetings/Conferences.

Subject/Theme	Organization
Research Coordination Committee Meetings of NSF National Thematic Research Programme (NTRP) on food security	National Science Foundation (NSF)
Research Coordination Committee Meetings of the project "Assessment of Spatial Impacts of Climate Change on the Plantation Sector in Sri Lanka"	National Science Foundation (NSF)
Review meetings of the project on "Introduction and Establishment of New Fuelwood Growing Models in Selected Lands of Smallholder Rubber Farmers"	FAO/RRISL
International Plant Protection Workshop on Disease Management in Rubber Plantations	IRRDB, Palembang, Indonesia

Mr Vidura Abeywardene attended the following Workshops.

Subject/Theme	Organization
Awareness programmes of the project on "Introduction and Establishment of New Fuelwood Growing Models in Selected Lands of Smallholder Rubber Farmers"	FAO/RRISL
Seminar on Agriculture products circulation technology for developing countries, 2018	China-Aid Training Programs Organized by Hunan Agricultural Group Co. Ltd and Sponsored by Ministry of Commerce of People's Republic of China, China

Seminars/Conferences/Workshops/Meetings/Training sessions addressed

Mrs Wasana Wijesuriya addressed the following Seminars/Conferences/ Workshops/Meetings.

Subject/Theme	Organization
Experiences during the 2018 Southwest monsoon season (May to September 2018)	Department of Meteorology, Colombo
Strategic plan (2019-20123) for the Socio-economic specialist group of IRRDB	Meeting of the Liaison Officers and Advisory Committee to finalize IRRDB strategic plan 2019 -2023, International Rubber Research & Development Board (IRRDB), Belitung Island, Indonesia

Subject/Theme	Organization
Socio-economic issues of the rubber sector in different rubber growing countries	Recipients of the IRRDB Fellowship 2019, Cote d' Ivoire
Liaison Officer's report for 2017/18 for the Socio-economic specialist group of IRRDB	Meeting of Chairmen and Directors of IRRDB, Cote d' Ivoire
Statistical Insight Improves the Interpretability of Data Generated through Participatory Approaches: Experiences from the Smallholder Rubber Sector of Sri Lanka	IRC 2018, International Rubber Conference of IRRDB, Cote d' Ivoire

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 & 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 of experiments and questionnaires, statistical analyses, designing and developing databases and interpretation of experimental results to the fellow scientists at RRISL and industry stakeholders on request (W Wijesuriya and O V Abeywardene).

Development, modification and application of appropriate statistical methods for agronomic, socio-economic and industrial experiments in the rubber sector (BM 01/b)

The objective of this activity is to familiarize the statistical techniques among the researchers and to encourage proper use of these methods.

During this year, an international workshop was conducted on "Statistical Applications in Socio-economic Research" with the support of IRRDB. More details are available under the IRRDB activities in this review.

Improving the knowledge base on climate, climate change & variability for better decision making in rubber growing areas (BM 02)

Maintenance and establishment of meteorological & agro-meteorological stations (BM/02/a)

Maintenance and data recording is being done in the meteorological stations

owned by RRISL by visiting and inspection of these sites and by providing instruments when necessary. These include the AGROMET station at Dartonfield and rainfall stations in Moneragala, Kuruwita, Nivitigalakele, Polgahawela and Galewatta (W Wijesuriya and 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 properly 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 is given in Table 1 (W Wijesuriya, C Munasinghe and V Abeywardene).

Analysis of data to identify changes in patterns and trend in rainfalls, identification of drought impacts and spatial analysis of droughts using GIS (BM/02/b)

Forecasting of drought indices

Analysis and modeling of spatio-temporal point pattern data where random observations are measured over time at a number of spatial locations, can be implemented by applying Markov Chain Monte Carlo (MCMC) based Bayesian modeling. A Gaussian Process (GP) is a collection of random variables indexed by time or space which is known as a stochastic process such that every finite collection of those random variables has a multivariate normal distribution in probability theory and statistics. The spatio-temporal forecasting across Sri Lanka was carried out for 2017 on monthly basis.

The precipitation measures which are observed at twenty-five weather stations are applied to calculate the Standardized Precipitation Index (SPI) in different time scales for each month from year 1983 to 2017 to reflect the dependent variable in Gaussian process model fitting. As model drivers or covariates; longitude, latitude, elevation, maximum temperature, minimum temperature, sea surface temperature, anddipole mode index were included, which are spatial and temporal in nature. The spatio–temporal model for Standardized Precipitation Index (SPI) was developed and spatial predictions for 2017 were made at 10 km spatial resolution with monthly time steps. Model fitting and prediction are done by 'spTimer' package available in R software.

Fig. 1 shows the median SPI forecast and associated uncertainty in terms of prediction standard deviations for the Northeast monsoon season (December to February) of 2017/18. According to Fig. 1, near normal precipitation experienced during this season (SPI: -0.99 to 0.99). There is substantial forecast efficiency as evident from different criteria, and further investigations are in progress to compare different prediction models.

This work is carried out under the project "Indicator based identification and forecasting of droughts in Sri Lanka" (Wasana Wijesuriya, Senani Karunaratne, Keminda Herath and J K Sajeep Sankalpa - Research Student Kaumadee Weerasinghe, Department of Agribusiness Management, Wayamba University of Sri Lanka).

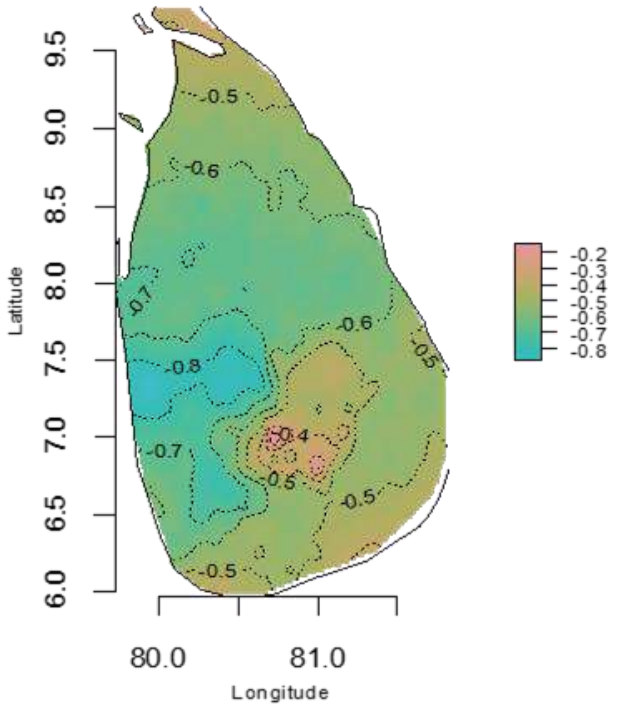


Fig. 1. Spatially interpolated plots for SPI 3-month scale from the GP model for the Northeast season of 2017/18

Collaborative Research

1. ***Indicator based identification and forecasting of droughts in Sri Lanka***

   This study is funded by NRC which was commenced in September 2015. It is a collaborative study with 2 Universities; Peradeniya and Wayamba and 2

Institutions; Natural Resources Management Centre (NRMC) and Department of Meteorology (DoM). This study was concluded in December 2018 (Wasana Wijesuriya and J K S Sankalpa from RRISL, B L Peiris from University of Peradeniya, Keminda Herath from Wayamba University, B V R Punyawardene from NRMC and S Premalal from DoM).

2. ***Introduction and establishment of new fuelwood growing models in selected lands of smallholder rubber farmers***

This project is funded by Food and Agriculture Organization under its strategic area "Promoting sustainable Biomass energy production and modern bio-energy technologies". The main objective of this project is to introduce a synergistic and strategic approach to establish fuel wood species in smallholder rubber lands which assure a sustainable biomass energy production system while improving the livelihoods of smallholder rubber farmers. Biometry section is involved in this project in designing and carrying out of socio-economic surveys and constructing indices for combined benefit and monetary advantage. The details of activities conducted during the year under review are presented in the review of the Advisory Services Department. This is a collaborative project between Advisory Services Department, Agricultural Economics Unit and the Biometry Section.

3. ***Assessment of Spatial Impacts of Climate Change on the Plantation Sector in Sri Lanka***

This study has been selected for funding by the National Science Foundation (NSF) under the National Thematic Research Projects (NTRP) related to Thrust Area 2 - "Climate Change Resilience on Settlements, Human Health and Infrastructure". The main objective of this project is to assess the spatial impacts of climate change in terms of Geographic, Economic and Social Vulnerability on the Plantation Sector of Sri Lanka. Several discussion rounds were undertaken between the team members on deciding the sampling methods. Data collection through questionnaire surveys and focused group interviews is progress.

This project is a collaborative one including Wayamba University, Department of Meteorology, Department of the Environment and Energy, the Government of Australia, Tea Research Institute, Coconut Research Institute, Sugarcane Research Institute and RRISL (Wasana Wijesuriya and Dammika Balasooriya represents the research team of this project)

Involvements in IRRDB activities

Dr Wasana Wijesuriya continued to assist IRRDB in attending to the duties of the Liaison Officer of the Socioeconomic Specialist Group during 2018.

International Workshop on Statistical Applications in Socio-economic Research, 01 – 02 October 2018

This Workshop was attended by 08 member countries; namely, Malaysia, India, Indonesia, Myanmar, China, Cambodia, Thailand and Sri Lanka. A total of 12 foreign participants and 21 local participants representing the Ministry of Plantation Industries, Rubber Development Department and RRISL have participated in the workshop. The workshop covered the following areas of statistical methods; *viz.* Correlation, linear and non-linear regression, Rank and count data analysis and Multivariate statistics, together with practical sessions with hands-on support. Four special topics, *viz.* Sustainability Valuation, Time series applications in the rubber sector, Survey design and sampling methods for Socio-economic research and Quantifying Causal Maps through Decision Support Systems were also covered during the workshop.

International Forum on Current Socio-economic Issues and their Impact on Rubber Production Sector Performance, 03– 05 October 2018

This forum was attended by 41 participants, including the foreign participants who attended the workshop on Statistics and local participants representing the Ministry of Plantation Industries, Rubber Development Department, Rubber Secretariat, National Institute of Plantation Management, Sri Lanka Council for Agricultural Policy (SLCARP), Smallholder Tea and Rubber Revitalization (STaRR) Project, Planters' Association of Sri Lanka and the Rubber Research Institute of Sri Lanka.

Dr Abdul Aziz, the Secretary General of IRRDB made the introductory remarks on the Forum on Socio-economic Issues and their Impact on Rubber Production Sector Performance. As guest speakers, Dr Jacob Mathew, IRRDB Fellow and Dr Suthee Intraskul, Former Chairman, The Expert Group on Establishment of a Regional Rubber Market, IRCO Thailand addressed the audience on their experiences, *viz.* Participatory Learning and Action Method to assist in community level organization and implementation of development projects by rubber farmers and solving socio-economic problems of rubber growers in Thailand through effective technology transfer mechanisms, respectively. In the two technical sessions, there were 08 presentations from China, India, Indonesia, Thailand, Malaysia, Cambodia and Sri Lanka. The Forum concluded with a field visit to a promising smallholder field and a tour to the Southern part of Sri Lanka, where the participants experienced the mangrove caves, the jungle beach and the famous Dutch Fort in Galle.

AGRICULTURAL ECONOMICS

J K S Sankalpa

DETAILED REIVIEW

Staff

Mr J K S Sankalpa and Ms P G N Ishani, Research Officers (Agricultural Economists) were on duty throughout the year

Seminars/Conferences/Meetings/Workshops attended

Mr Sankalpa attended the following during the year under review.

Activity	Organization
Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
Socio-economic Committee Meetings in Agriculture sector	Sri Lanka Council for Agricultural Research Policy
Technology update	Rubber Research Institute of Sri Lanka
World Rubber Summit 2018	International Rubber Study Group and Ministry of Planation Industries Sri Lanka

Miss P G N Ishani attended the following during the year under review.

Activity	Organization
Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
Seminar on Agriculture products circulation technology for developing countries, 2018	China-Aid Training Programs organized by Hunan Agricultural Group Co. Ltd and Sponsored by Ministry of Commerce of People's Republic of China, China
Monsoon Forum	Department of Meteorology
Workshop on INFORM Database Management	SLCARP
Awareness programmes of the project on "Introduction and Establishment of New Fuel wood Growing Models in Selected Lands of Smallholder Rubber Farmers"	Food and Agricultural Organization
Scientific Writing Workshop	SLCARP
World Rubber Summit 2018	International Rubber Study Group and Ministry of Planation Industries

Services

Research support

Various cost-benefit and economic analyses were carried out on the request of other researchers.

Database management

A database on auction prices in Sri Lanka and International rubber prices were updated throughout the year. Agricultural Economics Unit analyzed the rubber price and rubber products exports performance quarterly and presented the information to both the industry and the plantation sector.

Rubber marketing in Sri Lanka

Colombo auction is the main mode of disposal of rubber manufactured in factories. Number of auctions conducted by Ceylon Chamber of Commerce under Colombo Rubber Traders' Association (CRTA) was 94 during this year. All these were updated and recorded in a database. Monthly average prices of major raw rubber categories are given in the Table 1.

Prices of Ribbed Smoked Sheets (RSS)

Monthly average of RSS1 and RSS 3 are given in Figure 1(a) and 1(b), respectively. The highest average price of RSS 1 was Rs.310, recorded in June. Prices of all grades of RSS were less than that of the previous year (2017). Average RSS1 price difference against the previous year was around Rs.55. Yearly average RSS1 price has decreased by 16% when compared to 2017. This was mainly due to lower demand prevailed at the international market.

(a) (b)

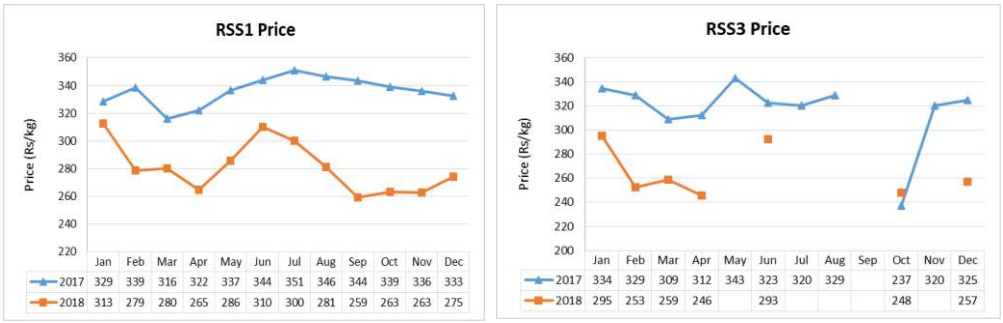
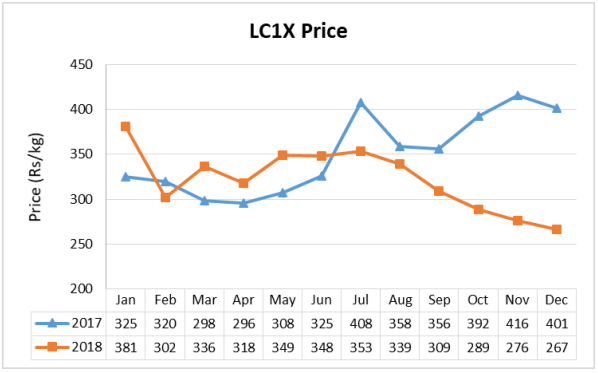


Fig.1. Monthly average prices of RSS 1 (a) and RSS 3 (b) in 2017 & 2018

Prices of Latex Crepe (LC)

Prices of Latex Crepe1X for 2017 and 2018 are shown in Figure 2. LC1X prices have remarkably decreased during the latter part of 2018. However, the gap between the LC prices were low until month of August. The average LC1X price ranged from Rs.267 (December) to Rs.381 (January) during 2018. The average price of LC1X was Rs.322 which was an 8% reduction compared to the previous year.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2017	325	320	298	296	308	325	408	358	356	392	416	401
2018	381	302	336	318	349	348	353	339	309	289	276	267

Fig. 2. Monthly average of nominal LC1X price in years 2017 and 2018

RESEARCH

The following studies were conducted during 2018.

Analysis on income diversification of rubber farmers (AE/01)

This project was completed for the selected non-traditional areas and it was compared with the scenario in the traditional rubber growing areas. Table 2 shows the income generated from the rubber intercropping in the Moneragla District and diverse crop selection was observed with the traditional rubber growing areas. Farmer and farm characteristics of rubber-based farming systems varied significantly. While 41% of farmers cultivated banana as an intercrop in their immature rubber farms in Moneragala District, 19% of farmers cultivated maize as an intercrop. Cocoa was found in 15% of the farms as an intercrop. Other intercrops were pepper (9%), groundnut (4%), cowpea (2%), passion-fruit (4%), vegetables (2%) and pineapple (2%). About 3% of farmers used part of their rubber land to rare milking cows.

Analysis of poverty reduction through rubber-based farming systems (AE/02)

This study was conducted in the Moneragala district with the aim of analyzing the poverty incidence of rubber smallholder farmers who are presently engaged in rubber-based farming systems in the immature phase of cultivation. Approximately 1500 farmers own any type of agroforestry system in the study area according to the International Fund for Agricultural Development (IFAD) and Rubber Research Institute of Sri Lanka (RRISL). Using a stratified random sampling procedure, 220 farmers were selected to gather information using a structured questionnaire. Gross return of the household was calculated using rubber-based agroforestry income, other agricultural income, and rural non-farm income and cost of cultivation data. Seven agroforestry systems were found in the study sample including cowpea (*Vigna unguiculata*), banana (*Musa spp*), cocoa (*Theobroma cacao*), pepper (*Piper nigrum*), dairy cattle (domestic breeds), passion fruit (*Passiflora edulis*), and groundnut (*Arachis hypogaea*).

The binary logistic regression used in this analysis describes the probability of observation falling into one of observations out of two categorical dependent variables (being poor or rich) with more independent variables. Calculated total income and household minimum financial requirement were used to determine the rich or poor status (minimum household financial requirement per year =LKR 3293 x family members in household x 12). Odds Ratio (OR) of binary logistic regression explains the association between each independent variable and the outcome of the logistic regression model. Descriptive statistics of agroforestry systems is given in Table 3. Average net return is around LKR. 247,157/ha/yr while about 20% of farmers show more than LKR 370,736/ha/yr net return. About 88% of farmers in the study population throughout the systems were categorized as agriculture as a major source of income.

Logistic regression results are depicted in Table 4. Household characteristics including education, other agri-income, and non-farm income show a positive significant relationship with the reduction of poverty while the households with higher number of persons contributed to higher poverty in the household. Respectively, a positive significant relationship with reducing poverty changed from rubber-based dairy cattle, groundnut, pepper and cocoa systems. Out of the agroforestry systems observed in the study area, rubber-based banana, maize and passion fruit, and banana were found to be not significant in poverty reduction at the household level. Such agroforestry systems should be focused more on new strategies to reduce poverty at the household level.

Table 4. *Logistic regression results - probability of household being in poverty in context of household characteristics and farming systems*

Variable	B (Coefficient)	S.E. (Standard Error)	Wald statistic	Sig.	Exp(B) (Odds Ratio)
Constant	-0.59	0.69	0.74	0.39	0.55
Household characteristics					
Land area	-0.35	0.17	4.14	0.04	0.70
Household size	0.86	0.16	28.03	0.01 *	2.37
Other-agricultural income except rubber based agroforestry	-1.24	0.47	7.12	0.01 *	0.29
Non-farm income	-4.70	0.85	30.78	0.01 *	0.01
Education (secondary level)	-1.99	0.57	12.31	0.01 *	0.14
Agroforestry systems					
Groundnut	-2.17	0.82	6.97	0.01 *	0.11
Livestock/dairy cattle	-3.62	1.34	7.32	0.01 *	0.03
Pepper	-1.90	0.56	11.29	0.01 *	0.15
Cocoa	-1.87	0.46	16.20	0.01 *	0.16

* Significant at 95% confidence interval, other agri. income includes cash crops, paddy, and banana *etc.* non-farm income includes mainly government service and private sector employment, carpenters, Business works sector *etc*.

(J K S Sankalpa, P G N Ishani, Wasana Wijesuriya and O V Abeywardena)

Use of GIS in rubber plantation management (AE/03)

AEU has involved in many collaborative research activities with the Biometry section and it was in progress to develop yield and field maps including management information for the Polgahawela substation. AEU has involved in further collaborative works with the Advisory Services Department in the project titled "Introduction and Establishment of New Fuelwood Growing Models in Selected Lands of Smallholder Rubber Farmers". AEU has involved in GIS mapping of new fuel wood growing models around the country. These databases are helpful in the decision making process pertaining to efficient extension planning.

Updating databases on rubber industry and analysis on rubber end products manufacturing sector & other economic evaluations (AE/04)

Agricultural Economics unit has conducted several studies to analyze the rubber international trade and rubber price prevailed in the international and local markets. The aim was to present the prevailing status at the local and international markets and thereby assisting the stakeholders in taking suitable measures to improve the gains from the rubber industry. Fig. 3 (a) shows the raw rubber exports and imports of Sri Lanka from 2015 to 2018.

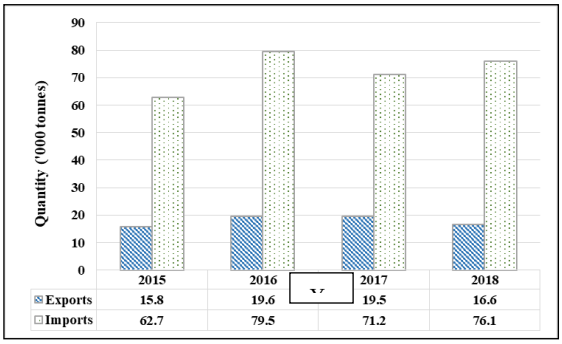


Fig. 3 (a). Raw rubber exports and imports

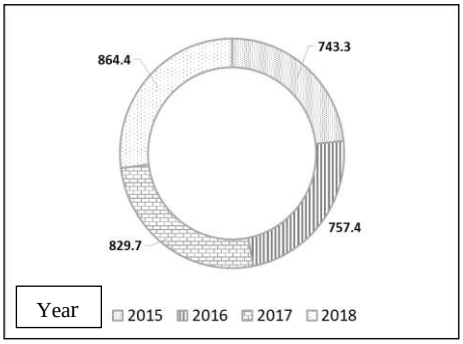


Fig. 3 (b). Earnings from End products in US$ Million

Fig. 3 (b) shows the earnings from rubber end products from 2015 to 2018. Earnings have increased by 4%, year on year from 2017 to 2018. Rubber trade balance was calculated to find the net income gain or loss in the country considering exports over imports. Total exports earnings recorded was US$ 899.3 Mn while, it was US$ 366.6 Mn for the total imports category including synthetic rubber. Our analysis depicted that rubber trade balance was US$ 532.7 Mn in the year 2018 while it was US$ 484.6 Mn, US$ 401 Mn, US$ 385.2 Mn respectively in years from 2015 to 2017.

Analysis of price changes of NR was done to compare the rubber prices at major international and local markets. Analysis of price behaviour between the local and international markets can be used as a guide in international trade tax policy decision making. Fig. 4(a) shows the rubber price (RSS 3) change in the Colombo auction and the RSS 3 future price change at the Singapore Commodity Exchange (SICOM). Also, RSS 3 price change in the Tokyo Commodity Exchange (TOCOM) and the RSS3 price changes in the Colombo Auction were compared (Fig. 4b).

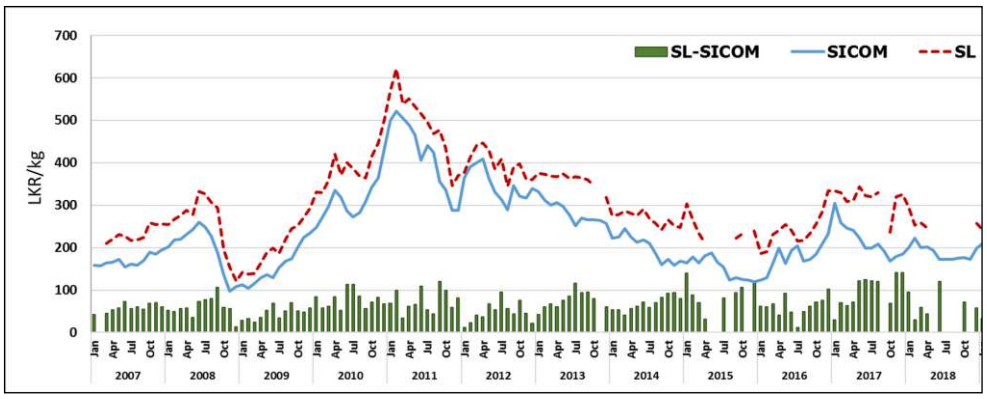


Fig. 4 (a). RSS 3 price at the Colombo Auction and RSS 3 futures in the Singapore (SICOM)

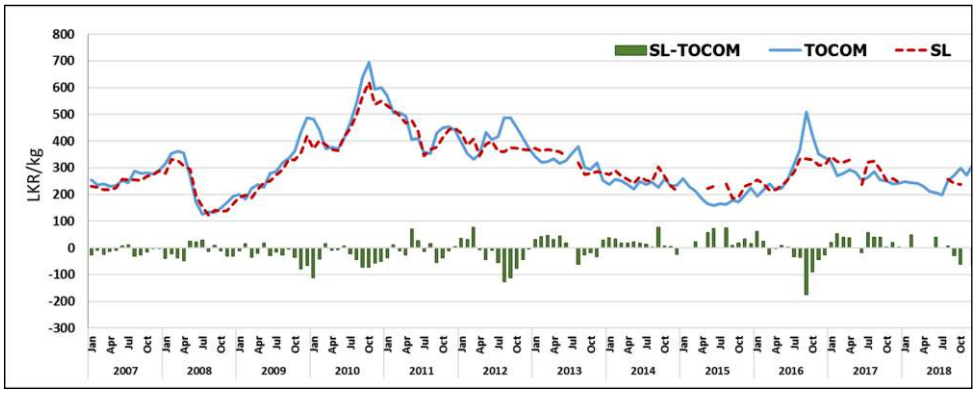


Fig. 4 (b). RSS 3 price at the Colombo Auction and RSS 3 futures in the Tokyo (TOCOM)

(J K S Sankalpa, P G N Ishani and Wasana Wijesuriya)

Analysis of tax policy changes on raw rubber exports in Sri Lanka (AE/05/a)

Analysis of imports tax changes and their impact on rubber industry was in progress during the year under review. The total CESS collection in the year 2017 was recorded as Rs.2,775 Mn. From the total CESS collection, 90% which is Rs.2,492 Mn was from CESS on rubber and rubber products imports. The CESS collection from local consumption of raw rubber was recorded as Rs.208 Mn in the 2017 which was 7% from the total CESS collection. The CESS collection from natural rubber exports were only 3% from the total CESS collection in the year 2017.

Figure 5 show the CESS collections from raw rubber exports, rubber and rubber products imports and local consumption of natural rubber from the year 2008 to 2017. When consider the CESS collection from natural rubber exports it was observed a gradual decrease from year 2014 to 2017. Highest CESS collection from natural rubber exports was recorded as Rs.581 Mn in 2012. When consider the CESS collection from rubber and rubber products imports, it was observed a gradual increase from year 2004 to 2017. Highest CESS collection from imports were recorded as Rs.2,625 Mn in 2016. The CESS collection from local consumption of natural rubber is quite constant. Highest CESS collection from local consumption was recorded as Rs.265 Mn in year 2013.

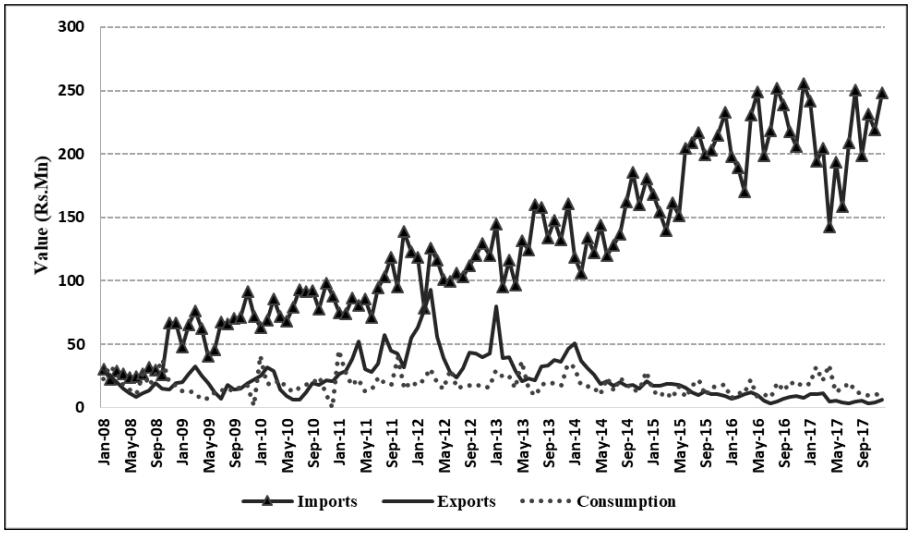


Fig. 5. Value of CESS collection from raw rubber exports, imports and local consumption
(P G N Ishani, J K S Sankalpa, W Wijesuriya and O V Abeywardena)

Analysis of technical efficiency (TE) of rubber smallholder farmers (AE/05/b)

A study was conducted to examine the relationship between technical efficiency and poverty among the smallholder rubber farmers in Kegalle District, which can be exploited as a basis for poverty reduction strategy. Randomly selected 195 smallholdings were stratified according to the number of holdings in each Divisional Secretariat (DS) in the survey. Farmers were interviewed through a structured questionnaire to collect primary data. Stochastic Frontier Analysis was conducted to estimate the technical efficiency and to identify the determinants of technical inefficiency.

The results revealed that the technical efficiencies estimated using Cobb-Douglas production frontier ranged from 34 to 97%. The mean technical efficiency in the sample is 80% indicating that 20% of the potential maximum productivity is lost due to technical inefficiency of the farmers in Kegalle District. Hence, there is a possibility to increase the TE further by 20%. Around 60% of farmers in the sample have TE higher than the average value of 80%. Relatively higher percentage of farmers were observed in the range of 81 to 90%. While 22% of the farmers had efficiency levels higher than 90%, there were only 3% of sample had technical efficiency less than 50%. The frequency distribution of estimated technical efficiency of rubber smallholders is given in Fig. 6.

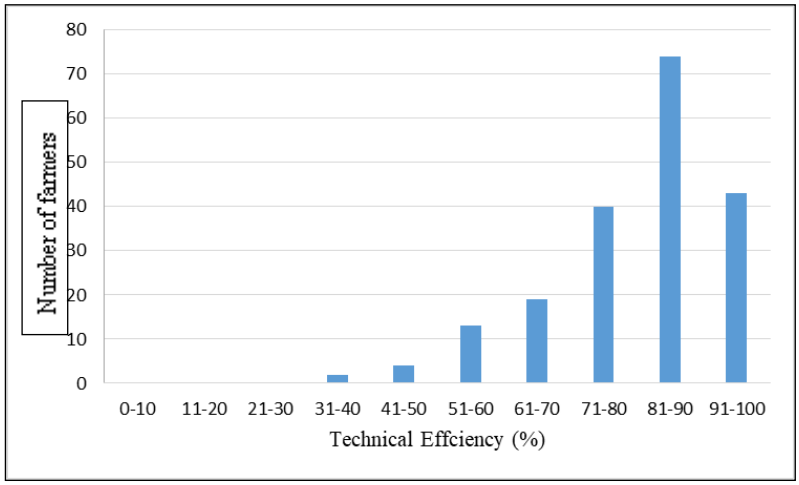


Fig. 6. Frequency distribution of TE of smallholder farmers in Kegalle district

The study was in progress to study the relationship between TE of farmers and their socio-economic characteristics. Also, it is aimed to build the relationship of TE of farmers and poverty status. Research was in progress and further analysis was done to estimate the Cobb Douglas production function (P G N Ishani, J K Sankalpa, W Wijesuriya and O V Abeywardena).

Table 1. *Monthly Auction Prices of Rubber in year 2018*

Month	RSS Prices (Rs.)					Latex Crepe prices (Rs.)					Scrap Crepe Prices (Rs.)				
	RSS1	RSS2	RSS3	RSS4	RSS5	LC-1X	LC-1	LC-2	LC-3	LC-4	1Xbr	2Xbr	3Xbr	4Xbr	Flat Bark
Jan	313	308	295	260	.	381	381	360	347	223	216	208	211	206	205
Feb	279	260	253	240	239	302	298	290	291	199	193	192	192	188	183
Mar	280	272	259	240	.	336	330	312	302	201	194	191	190	186	179
Apr	265	248	246	236	238	318	313	284	272	212	203	198	197	189	180
May	286	288		263	.	349	336	298	283	230	212	209	207	203	185
Jun	310		293	275	.	348	333	279	260	224	216	215	215	211	201
Jul	300	280	.	.	.	353	337	286	239	218	214	213	212	209	203
Aug	281	.	.	.	.	339	332	262	238	233	230	227	232	228	.
Sep	259	253	.	240	.	309	301	242	226	221	218	211	217	217	.
Oct	263	260	248	242	.	289	280	221	217	215	215	213	214	211	207
Nov	263	263	.	.	.	276	266	212	210	209	207	204	207	205	195
Dec	275	262	257	.	.	267	261	223	219	217	210	211	208	204	196
2018 Average	281	269	264	249	239	322	314	272	259	217	211	207	208	205	193

Table 2. *Income from Rubber (R)-based farming*

	R-banana	R-cocoa	R-maize	R-pepper	R-groundnut	R-passion fruit	R-cowpea	R-cattle	R-pineapple	R-vegetable
Average income (LKR/ha)	256,940	518,810	308,850	326,105	504,020	222,140	416,410	279,415	326,479	140,590
Average cost (LKR/ha)	89,156	91,506	95,604	89,837	124,291	85,974	68,257	88,503	101,130	80,667
Average profit (LKR/ha)	167,783	427,304	213,246	236,267	379,728	136,165	348,153	190,912	225,349	59,923
Average other agri. Income (LKR/yr)	77,464	71,029	69,625	122,070	-	80,000	147,500	4,000	-	104,400
Average non-farm income (LKR/yr)	525,000	680,000	359,167	336,000	-	360,000	-	-	-	208,000
Age of NR land	5	5	4	5	3	5	3	4	5	4
Average land extent per farmer (ha)	0.61	0.67	0.95	0.57	0.75	0.67	0.74	0.71	0.53	0.57

(J K S Sankalpa, P G N Ishani, Wasana Wijesuriya and O V Abeywardena)

Table 3. Descriptive statistics of agroforestry systems

	Banana	Cocoa	Maize	Pepper	Groundnut	Cattle	Passion fruit
Economic variables							
Net return from agroforestry (LKR/ha)	167,783	427,304	213,246	236,267	379,728	190,912	134,046
Average other agri. Income (LKR/yr)	77,464	71,029	69,625	122,070	-	4,000	-
Average non-farm income (LKR/yr)	525,000	680,00	359,167	336,000	-	-	360,000
Household characteristics							
Average age of household	49	48	42	44	48	53	45
Average family members	4	4	4	4	5	3	4
Education of household head (%)							
Primary	45	46	45	60	33	25	8
Middle	33	43	43	16	50	50	42
Secondary	22	11	12	24	17	25	50
Average land extent per farmer (ha)	0.61	0.67	0.95	0.57	0.75	0.71	0.62

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 Attendants were on duty throughout year.

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
NCD Wijesekara	National Library Research Symposium	National Library & Documentation Services Board
	ABCD web based Information Management Software	Department of Library & Information Science, University of Kelaniya
	Record Management	Department of National Archives

Publications

The following RRISL regular publications were published during the year.

- RRISL Bulletin Vol.53(2016)
- Programme Book – International Workshop on Statistical Applications in Socio-economic Research & Forum on Current Socio-economic Issues and their Impact on Rubber Production Sector Performance
- Annual Review 2016
- Annual Report 2016

List of books purchased during the year

No	Title	Publisher	Year of publication
01	Physical Testing of Rubber	New York, Springer, Sc+ Bus. Media Inc.	2006
02	Natural Rubber: Biology Cultivation and Technology-Development in Crop Science 23	Amsterdam, Elsevier Science Publishers	1992

No	Title	Publisher	Year of publication
03	Springer Series in Statistics - Statistical Design and Analysis for Intercropping Experiments	New York, Springer Verlag,1993	1993
04	Polymer Blends and Alloys	Boca Raton, CRC Press, Taylor & Francis Group	2006
05	Cost – Benefit Analysis – Financial and Economic Appraisal Spreadsheets 2ed.	London, Rutledge, Taylor & Francis Group	2016
06	Blends of Natural Rubber – Novel Techniques for Blending Specialty Polymer	London, Chapman & Hall	1998
07	Allelopathy in Ecological Agriculture and Forestry – Proceeding of the III International Congress on Allelopathy in Ecological Agriculture and Forestry Dharwad, India 18 – 21 August 1998	India, Springer, Science + Business Media, B.V.	1998
08	Bergey's Manual of Systematic Bacteriology 2ed. – Vol. Five, The Actinobacteria, Part A	New York, Springer	2012
09	Bergey's Manual of Systematic Bacteriology 2ed. – Vol. Five, The Actinobacteria, Part B	New York, Springer	2012
10	National Symposium on Sustainable Plantation Management	National Institute of Plantation Management, Athurugiriya	2018
11	National Symposium on Sustainable Plantation Management	National Institute of Plantation Management, Athurugiriya	2018
12	National Symposium on Sustainable Plantation Management	National Institute of Plantation Management, Athurugiriya	2018
13	National Symposium on Sustainable Plantation Management	National Institute of Plantation Management, Athurugiriya	2018
14	Natural Rubber Material Vol. 1. Blend and IPNS	RSC Publishing	2013
15	Biochar for Environmental Management Science, Technology and Implementation	Earthsan – from Routlege	2015
16	Plant Physiology	Wadeworth Inc.	1992
17	Introduction to Plant Physiology 4th ed.	John Wiley & Sons Inc.	2009
18	Hand Book of Water and Waste Water Treatment Plant Operations 3rd ed.	CRC Press, Taylor & Francis Group	2014
19	Rubber Recycling	CRC Press, Taylor & Francis Group	2005
20	Rubber Curing and Properties	CRC Press, Taylor & Francis Group	2000

No	Title	Publisher	Year of publication
21	Handbook of Elastomers 2nd ed. Revised expended	CRC Press, Taylor & Francis Group	2001
22	Smoothing Methods in Statistics	Springer	1996
23	Nanoparticles in the Fight Against Parasites	Springer	2016
24	Statistical Information on Plantation Crops	Ministry of Plantation Industries	2016
25	Statistical Information on Plantation Crops	Ministry of Plantation Industries	2016
26	Statistical Information on Plantation Crops	Ministry of Plantation Industries	2016
27	Statistical Information on Plantation Crops	Ministry of Plantation Industries	2016
28	Rubber Nanocomposites – Preparation and Applications	John Wiley & Sons (Asia) Pvt. Ltd.	-
29	The Agronomy and Economy of Important tree Crops of the Developing World	Elsevier Insights	2010
30	Natural Rubber Materials Vol.2. Composite and Nanocomposites	RSC Publishing	2014
31	Natural Products manufacturing Technology	Murcel Dekker, Inc., New York	1994
32	Using Eviews for Principles of Econometrics 4th ed.	John Wily Sons Inc.	2012
33	දෙමළ බස උගනිමු	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2018
34	සිංහලෙන් දෙමළ ඉගෙන ගනිමු	වාසනා පොත් ප්‍රකාශකයෝ	2013
35	නිරෝගී දිවියකට (ආහාර, පෝෂණය සහ සෞඛ්‍ය තොරතුරු රාශියකින් සමන්විත)	වාසනා පොත් ප්‍රකාශකයෝ	2013
36	දේශීය ඖෂධ පැළෑටි	වාසනා පොත් ප්‍රකාශකයෝ	2015
37	දියවැඩියාව රුධිරගත කොලෙස්ටරෝල් සහ හෘදරෝග	වාසනා පොත් ප්‍රකාශකයෝ	2016
38	The Cambridge guide to English Usage	Cambridge University Press	2004
39	How to Stop Worrying and Tart Living	Piratos, India	-
40	Life Changing – Secrets from the Masters of Science	Manjula Publishing House	2017
41	Perfect Negotiation	Rupa Publications India Pvt. Ltd.	2017
42	Spelling	Rupa Publications India Pvt. Ltd.	2012
43	The only Leadership – Book you'll ever Need	Rupa Publications India Pvt. Ltd.	2017

No	Title	Publisher	Year of publication
44	ඉංග්‍රීසි ඉගෙනීමේ අත්පොත	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2017
45	යටිසිත ඔබේ විස්මිත මෙහෙකරු	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2018
46	ගැහැනුන්ගේ ආදරය සහ පිරිමින්ගේ ආදරය	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	
47	යටිසිත 2: සිතිමෙන් සුවය, ධනය සහ සතුට අත්හැරගනිමු	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2017
48	සතුටින් ජීවත්වන්නේ කෙසේද	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2018
49	බලාපොරොත්තුවේ ප්‍රීතිය	විජේසූරිය ග්‍රන්ථ කේන්ද්‍රය	2017
50	එදා හෙලදිව	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2018
51	බැංකු ගණුදෙනු කරුවා සහ නීතිය	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
52	දෙමළ - 3	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
53	ඉංග්‍රීසි- සිංහල - දෙමළ ශබ්ද කෝෂය	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2018
54	Pharmacy (Guide to Book Pharmacy Examination)	M.D. Gunasena and Company Pvt. Ltd.	2018
55	සිංහල - දෙමළ කථා පුහුණුව	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2018
56	තරඟ විභාග නිසැක ජය - අභියෝග්‍යතාවය	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
57	තරඟ විභාග නිසැක ජයගැනීම සඳහා - අභියෝග්‍යතා පරීක්ෂණ	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
58	දෙමළ - 1	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
59	දෙමළ - 2	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2015
60	Globe in a Nutshell – Geopolitics – Its Shapes and Feature	M.D. Gunasena & Company Pvt. Ltd.	2017
61	ක්‍රියාපද දෙදහසක් සමඟින් දෙමළ ව්‍යාකරණ	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017

No	Title	Publisher	Year of publication
62	නූතන අවශ්‍යතා සඳහා ඉංග්‍රීසි ලියුම්	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2016
63	මට ඇඳුම දැන්සුවයි	සූරිය ප්‍රකාශකයෝ	2018
64	මනෝ විද්‍යා උපදේශන ප්‍රවේශය	සූරිය ප්‍රකාශකයෝ	2018
65	Steps to Mastery of English Grammar	M.D. Gunasena & Company Pvt. Ltd.	2018
66	නවීන ගුණසේන - පිලිප් ලෝක සිතියම් පොත	සීමාසහිත ඇම්.ඩී. ගුණසේන (පුද්ගලික) සමාගම	2017
67	Social Life Cycle Assessment	Springer	-
68	The Oil Palm (Fifth Edition)	Wiley Blackwell	2016
69	Natural Rubber Materials – Vol. 1	RSC Publishing	2014
70	Rubber Products Manufacturing Technology	Mdi Dekker	1994
73	The World Rubber Industry	Routledge Revivals	1994
74	Intensive Agriculture and Sustainability	UBC Press, Vancourer, Toronto	2004
75	Sustainable Agricultural Development	Springer	2011
76	Scientific Writing and Communication in Agriculture and Natural Resources	Springer	2013
77	Environmental and Material Flow Cost Accounting	Springer	2009
78	The Triumph of the Fungi A Rotten History	Oxford	2007

DARTONFIELD GROUP

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman Senior Estate Manager, Mr Dinesh Achinda, Mr T D Harsha and Mr M N S Pavinda Management Assistants, Mr B M Siriwardena Field Officer and Mr K A Sarath Kumara, Mr Jagath Nakandala and Mr N L D Premechandra Junior Assistant Field Officers were on duty throughout the year.

The Group cadre stood as follows at the end of the year.

Senior staff	01
Assistant staff	07
Minor staff	05
Total	**1**3

Hectarage summary - Dartonfield group

Hectarage summary of the Dartonfield Group is given in Table 1.

Table 1. *Land distribution (ha) of Dartonfield group*

	Dartonfield division	**Gallewatte division**	**Nivitigalakele division**	**Total**
Mature area	23.16	121.10	33.76	178.02
Immature area	13.19	37.96	9.18	60.33
Cinnamon under power line	0.80	-	-	0.80
State land take in	0.27	-	-	0.27
Nurseries	7.27	2.62	2.00	11.89
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	7.02	3.04	12.20
Roads	2.92	6.86	0.36	10.14
Building	16.92	5.43	7.79	30.14
Play Ground	1.00	-	-	1.00
Proposed replanting area	-	-	12.69	12.69
Proposed Cinnamon Ns.	0.20	-	-	0.20
Streams	-	-	2.17	2.17
Grand total	**74.49**	**184.15**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 3,773.3 mm with 195 wet days (Table 2).

Table 2. *Annual rainfall and wet days of the group for last five years*

	2014	2015	2016	2017	2018
Rainfall (mm)	4,568.6	4,014.5	2,682.1	4,068.4	3,773.3
Wet days	199	210	181	188	195

Crop

A total crop for 178,535 kg have been harvested against the estimated crop of 193,037 kg (92.5%) which is a decrease of 14,502 kg (Table 3).

Table 3. *The crop and YPH (kg) of the Dartonfield group from 2014 to 2018*

Hect.	2014		2015		2016		2017		2018	
	179.32		181.28		181.28		181.28		178.02	
Division	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH	Crop	YPH
Dartonfield	28,885	897	26,878	834	23,635	734	19,124	649	19,477	841
Gallewatta	115,248	952	109,247	901	123,207	1,016	106,531	938	119,458	986
N'kele	28,682	1,101	25,545	919	29,294	1,053	35,800	1,086	39,600	1,173
Group total	172,815	964	161,670	892	176,136	972	161,455	917	178,535	1,003
Group estimate	199,296	1,111	200,688	1,107	197,474	1,089	185,606	1,054	193,037	1,084

Tappers productivity

The average IPT during the last five years are given in Table 4.

Table 4. *The average IPT (kg) of Dartonfield group from 2014 to 2018*

	2014	2015	2016	2017	2018
Dartonfield	5.5	5.6	5.7	6.4	7.1
Gallewatte	6.9	7.2	7.9	7.6	7.9
Nivitigalakele	7.0	7.2	7.3	8.4	8.7
Group average	**6.6**	**6.9**	**7.4**	**7.6**	**8.0**

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*

	2014	2015	2016	2017	2018
Normal tapping	219	204	258	224	222
Late tapping	11	12	07	02	6
Cash/Double tapping	(21)	(23)	(29)	(18)	(25)
No tapping	55	70	39	69	52
Rain guard tapping	80	79	62	69	85
Slight Rain	-	-	-	01	-
Total no of tapping days	310	295	327	296	313

Rain guards

Total areas of 178.02 hectares were rain guarded during the year and an additional crop of 33,469 kg was harvested which amounts to 18.7% of total crop harvested. Additional tapping days done with rain guards during the year were 74, 112 and 70 for Dartonfield, Galewaththa and Nivithigalakele respectively. Profit generated due to rain guarding was Rs.1,075,582.39 and profit per hectare was Rs.6,041.92.

Table 6. *Additional income generated by fixing rainguards (Rs/kg)*

	Dartonfield Division	Gallewatta Division	Nivithigalakale Division	Total
Hectare	23.16	121.10	33.76	178.02
No. of rainguards fitted	5,577	40,047	8,850	54,474
Additional crop (kg)	3,674	17,507	12,288	33,469
Rainguard cost per kg.	69.53	99.35	40.84	74.59
Tapping cost per kg.	115.63	115.63	115.63	115.63
C.O.M. Rs/kg	33.08	33.08	33.08	33.08
Total cost Rs/kg	201.24	248.06	189.55	223.30
N.S.A. Rs./kg	255.44	255.44	255.44	255.44
Additional profit Rs./kg	37.20	7.38	65.89	32.14
Additional profit from rainguards (Rs.)	136,663.93	129,240.81	809,677.65	1,075,582.39
Additional profit per hectare (Rs.)	5,900.86	1,067.22	23,983.34	6,041.92

Total profit and profitability per hectare

The total loss and loss per hectare were Rs.2,319,169.65 and Rs.13,027.58 for the year under review (Table 7).

Table 7. *Comparative statement of the revenue profit per kg and profit per hectare*

	Years				
	2014	**2015**	**2016**	**2017**	**2018**
Mature area (ha)	179.32	181.28	181.28	181.28	178.02
Total profit (Rs.)	1,987,373.99	(2,475,167.70)	(1,107,895.44)	6,207,944.75	(2,319,169.65)
Profit per ha. (Rs.)	11,082.83	(13,653.84)	(6,111.52)	35,262.40	(13,027.58)

Cost of production and productivity

Table 8. *Labour rates and break down of cost of production from 2014 to 2018 (Rs./kg)*

	2014	**2015**	**2016**	**2017**	**2018**
1. Labour wages	687.50	687.50	687.50 up to Sept. and 805 from Oct.	805	805
2. Cost of production	245.06	270.57	241.13	280.55	268.43
2.1 Tapping	118.61	113.94	116.46	122.77	115.63
2.2 Manufacture	35.82	36.43	32.35	34.47	33.08
2.3 General charges	74.49	103.07	74.43	97.29	98.10
2.4 Mature/area upkeep	16.14	17.13	17.89	26.02	21.62
3. N.S.A.	256.56	255.26	234.84	319	255.44
4. Profit per kg	11.50	(15.31)	(6.29)	38.45	(12.99)

Manufacture

Out of the latex crop of 153,678 kg harvested, 28,600 kg has been sent as Latex Crepe No.1 which is 64% and 100,755 kg as RSS No. 01 which is 89%. Details are given in Table 9.

Table 9. *Summary of grades manufactured during the year*

Grade	**Quantity (kg.)**	**Percentage %**
Latex crepe No.1	28,600	64
Latex crepe No.2	3,751	08
Latex crepe No.3	6,867	15
Latex crepe No 4	5,852	13
Total	**45,070**	**100**
RSS No.01	100,755	88
RSS No.02	7,366	07
RSS No.03	3,917	03
RSS No.04/05	2,171	02
Total	**114,209**	**100**

Grade	Quantity (kg.)	Percentage %
Scrap crepe No. 1	15,434	80
Scrap crepe No.2	2,840	15
Scrap crepe No.3/4	982	05
Total	**19,256**	**100**
Grand total	**178,535**	**-**

Different types of rubber manufactured, percentage of grades received for pale crepe and RSS are shown in Figures 1(a), (b) and (c).

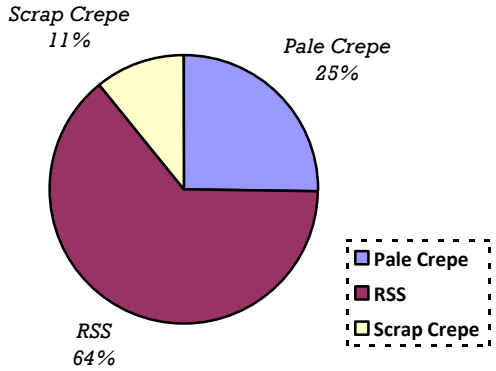


Fig. 1(a). Percentage of different types of rubber manufactured

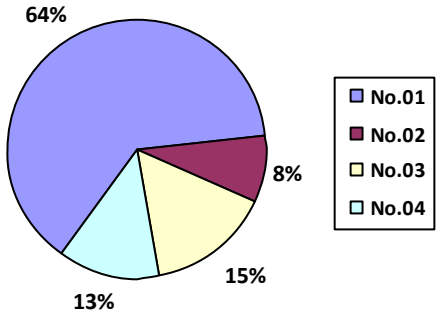


Fig.1 (b). Percentage of different grades of Pale crepe manufactured

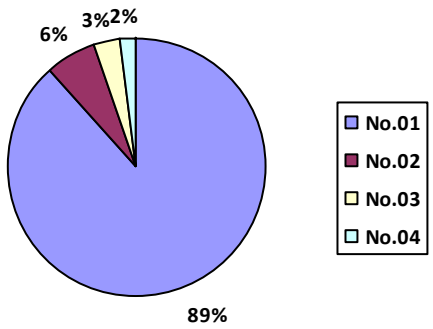


Fig. 1(c). Percentage of grade of RSS manufacture

KURUWITA - SUB STATION

P A Lukshaman

DETAILED REVIEW

Staff

Mr P A Lukshaman Senior Manager (Estate), Mr D S Jayasinghe, Mr K D P Senarathne, Management Assistants, Mr D D A Jayathunga Field Officer, K K S Dinesh and Mrs E P S L Erawwala Field Supervisors were on duty throughout the year.

The estate cadre stood as follows at the end of the year.

Senior Staff	-	01
Assistant Staff	-	03
Minor Staff	-	02
Total	-	**06**

Hectarage

A summary of the hectarage is given in Table 1.

Table 1. *Land distribution (ha.) in Kuruwita Sub station*

Land type	Extent (ha.)
Mature area	79.16
Immature area	3.00
Nurseries	2.25
Tea area	3.49
Paddy	1.00
Buildings, Gardens and Road	10.23
Water Tank	0.01
Unsuitable for planting	0.86
Total	**100.00**

Crop

A total crop of 81,148 kg was harvested during the year, recording a decrease of 3,243 kg on previous year's crop.

The actual yield per hectare (YPH) was 1,025.11 kg which is an decrease of 61.5 kg when comparing with previous year's crop.

The yield per hectare (YPH) for the past five years are given in the Table 2.

Table 2. *Yield per hectare for the past five years*

YPH (kg)	Year				
	2014	**2015**	**2016**	**2017**	**2018**
Estimated	1,419.82	1,378.65	1,339.54	1,318.57	1,320.61
Actual	1,378.34	1,367.32	1,383.17	1,086.67	1,025.11

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	122.9
February	72.4
March	83.3
April	56.3
May	58.7
June	57.5
July	111.6
August	106.1
September	87.9
October	75.3
November	76.6
December	116.51

Tapper productivity

The average intake per tapper at the end of the year was 8.6 kg. 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				
	2014	**2015**	**2016**	**2017**	**2018**
Intake per tapper	8.9	8.9	9.1	9.0	8.6

Rainfall

The annual rainfall recorded during the year was 4,560.8 mm with 244 wet days (Table 5).

Table 5. *Annual rainfall figures and the number of wet days of the estate for the past 5 years*

	Year				
	2014	**2015**	**2016**	**2017**	**2018**
Rainfall (mm)	5,093.10	4,002.14	3,342.80	4,768.40	4560.8
Wet days	239	251	222	246	244

Tapping days

There were 321 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				
	2014	**2015**	**2016**	**2017**	**2018**
01.Total tapping days	**335**	**348**	**352**	**321**	**324**
1.1 Normal	151	174	260	203	232
1.2 Late	38	32	08	00	00
1.3 Rain Interference	15	02	-	40	00
1.4 Rainguarded Tapping	131	140	84	78	92
02. Recovery Tapping	(08)	(08)	-	-	-
03. No tapping	30	17	14	44	41

When compared with the last year there was an increase in normal tapping days from 203 to 232 days during the year.

Rainguard

Due to the use of rainguards an additional 92 tapping days were recorded during the year. This contributed to 23% of the total crop yielding an additional profit of Rs.1,657,525.81.

An analysis of the use of rainguards for the years 2016, 2017 & 2018 are given in Table 7.

Table 7. *An analysis of the use of rainguards (Rs/kg)*

	Year			
	2015	**2016**	**2017**	**2018**
Hectarage (ha.)	71.00	73.41	63.46	64.96
No. of raiguards fitted	21,890	22,262	19,904	22758
Additional tapping days	140	84	78	92

	Year			
	2015	**2016**	**2017**	**2018**
No. of kilos harvested	36,837	20,454	18,710	18419
Raiguard cost per (kg.)	25.65	43.41	39.20	49.76
Tapping cost (Rs./kg.)	87.77	89.65	99.08	105.14
Total cost (Rs./kg.)	113.42	133.06	138.28	154.90
N.S.A (Rs./kg.)	207.86	217.11	294.18	244.89
Additional profit (Rs./kg.)	94.44	84.05	155.90	89.99
Additional profit from rainguards (Rs.)	3,478,886.28	1,719,158.70	2,916,889.00	1,657,525.81
Additional profit per hectare (Rs.)	48,998.39	23,418.59	45,964.21	25516.10

Total profit and profitability per hectare

The total loss and loss per hectare were Rs.2,908,957.77 and Rs.36,747.82 respectively for the year 2018.

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				
	2014	**2015**	**2016**	**2017**	**2018**
Mature extent (ha.)	71.84	73.26	75.66	77.66	79.16
Total profit (Rs.)	5,339,158.40	1,667,830.50	3,959,993.84	3,727,550.47	(2,908,957.77)
Profit per hectare (Rs.)	74,320.13	22,765.91	52,339.33	47,998.33	(36,747.82)

Cost of production and profitability

The cost of production has increased by Rs.29.35 per kg when comparing with the previous year (Table 9).

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 break down of the cost of production from 2014 to 2018 (Rs./kg.)*

	Year				
	2014	**2015**	**2016**	**2017**	**2018**
Labour rate	687.50	687.50	Jan. - Nov. 687.50 From December 805.00	805.00	Jan.-Oct. 805.00 From Nov 855.00
Cost of production	198.00	191.21	179.27	250.01	279.36
Tapping cost	96.70	87.77	89.65	99.08	108.80
Manufacturing	-	22.14	21.49	32.65	36.33
General chargers	79.58	64.72	54.48	92.38	97.16
Field & cultivation cost	21.72	16.58	13.65	25.90	37.07
N.S.A	251.92	207.86	217.11	294.18	244.89
Profit per kg.	53.92	16.65	37.84	44.17	(34.47)

POLGAHAWELA SUB STATUION

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman, Senior Estate Manager overlooked the activities of the Sub station and Mr Nuwan Disanayake, Management Assistant were on duty throughout the year.

Crop

Total crops of 14,710kg have been harvested against the estimated crop of 19,104kg which is a decrease of 4,394kg. The total crop, YPH and IPT for 2015, 2016, 2017 and 2018 are given in Table 1.

Table 1. *Total crop (kg) and YPH (kg) and IPT (kg) for the years of 2015, 2016, 2017 & 2018*

Year	Hectare	Crop (kg)	YPH (kg)	IPT (kg)
2015	10.75	12,206	1,136	9.2
2016	11.75	13,753	1,170	10.1
2017	11.75	7,661	652	9.6
2018	11.75	14,710	1,070	10.72

Rainfall

The annual rainfall recorded for the year was 2,683.7 mm with 153 wet days.

Table 2. *Annual rainfall and wet days of the estate for last four years*

	2015	2016	2017	2018
Rainfall	2,817.01	1,947.07	1,974.8	2,683.7
Wet days	162	109	164	153

Tapping days

Annual breakdown of Tapping days and No tapping days are given in Table 3.

Table 3. *Annual tapping days and No. of tapping days*

	2015	2016	2017	2018
Tapping days	291	246	223	292
No tapping days	74	119	142	73

Meteorological Summary

Dartonfield Station

Wasana Wijesuriya

During the last 19 years, an average annual rainfall of 4,074 mm was observed in the Dartonfield meteorological station located in the Agro Ecological Region, WL_{1a}. Out of the 19 years since 2000, a total rainfall of less than 3,000 mm has been recorded only during 2016 which was 2,966 mm. In 2000, the total rainfall slightly exceeded 3,000 mm (Fig. 1). The rainfall recorded in 2018 was 3,994 mm, which accounted for a decrease of 6%, compared to the previous year. The rainfall in 2018 is very close to the average which is marked as a straight line in Fig. 1.

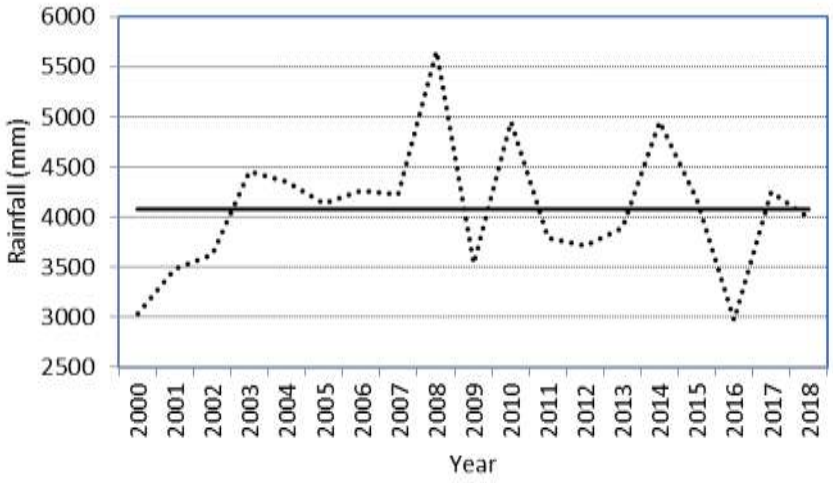


Fig. 1. Variation in annual rainfall at Dartonfield from 2000 to 2018

As indicated in Fig. 2, the rainfall distribution at Dartonfield during this year departed from the usual rainfall pattern. Above average monthly rainfall values were observed in February, May and October while below average values were recorded in January, July to September and December. The rest of the months were very close to the long-term average. The minimum monthly rainfall of 91 mm and the maximum monthly rainfall of 830 mm were recorded in January and October, respectively.

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 (1,564 mm) during 2018. This rainfall amount contributed 41% to the total rainfall, which is, comparatively lower than the long-term average contribution (48%). Rainfall during IM2 (October & November) in 2018 brought 1,186 mm whilst IM1 (March & April) recorded a low rainfall of 673 mm. During the North East season (November to January 2019), 415 mm of rain was recorded, which is again comparatively lower than the long-term average contribution of this season.

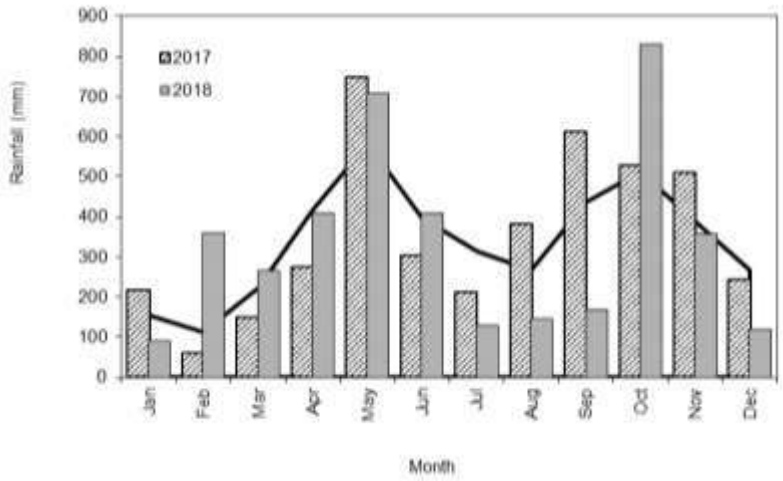


Fig. 2. Distribution of monthly rainfall in 2017 and 2018 at Dartonfield (The line graph indicates the long-term average)

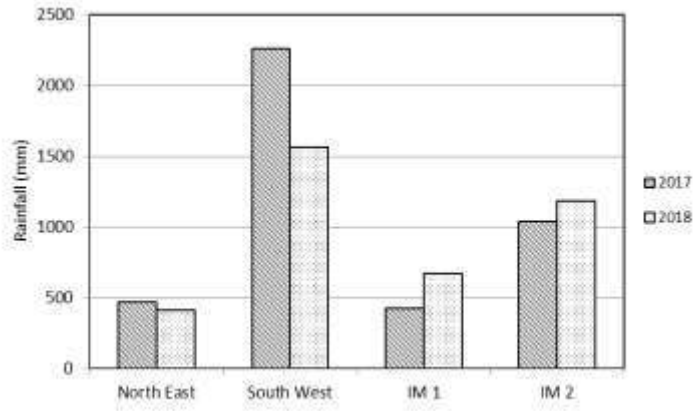


Fig. 3. Seasonal distribution of rainfall at Dartonfield in 2018

The distribution of weekly rainfall is illustrated in Fig. 4. Twelve dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year. The highest weekly rainfall of 338 mm was observed in the 20th standard week, in the month of May.

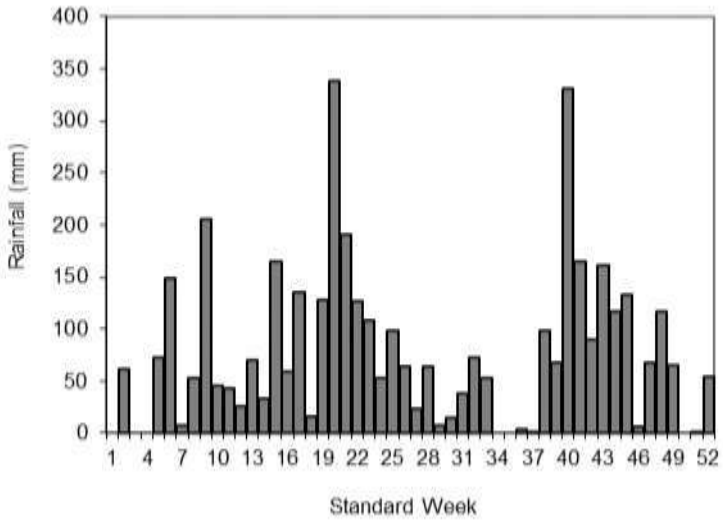


Fig. 4. Weekly variation in rainfall in 2018

There were 5 rainfall events that exceeded the hazardous limits for land slides (100 mm of rainfall during a day) reported during the year under review. The amount of rainfall and number of rainy days under low, moderate and high rainfall categories are listed in Table 1. The observed total number of rainy days of the year was 230, which was more than the long-term average of 220 days. A dry spell lasted over a month or more can have adverse impacts on rubber plantations. There were only 7 dry spells greater than or equal to 7 days; the longest being 20 days, from 8th August to 5th September. The dry spells 4 and 5 were only separated by a 3 mm rainfall on the 6th of September. The details of the dry spells are given in Table below.

Details of dry spells at Dartonfield

Dry spell No.	Period	No. of days
1	1st - 9th January	10
2	15th - 30th January	16
3	16th - 24th February	9
4	8th August - 5th September	20
5	7th - 16th September	10
6	10th - 16th November	7
7	9th December - 20th December	12

Rainfall at RRISL Substations:

There are four Substations maintained by RRISL in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}), Moneragala (IL_{1c}) and Nivithigalakele (WL_{1a}). A total rainfall of 4,529 mm, 2,683 mm, 1,708 mm and 3,344 mm were recorded, respectively, in Kuruwita, Narampola, Moneragala and Nivithigalakele stations during 2018. The details of rainfall in these stations are given in Tables 2 to 5.

Table 2. *Monthly variation of rainfall and rainy days in 2018 - 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	55	6	0	6	0
February	237	14	6	6	2
March	291	20	4	16	0
April	509	27	6	18	3
May	787	26	2	20	4
June	607	29	3	23	3
July	177	23	10	10	0
August	244	19	5	12	2
September	386	16	2	12	2
October	440	27	8	17	2
November	672	20	4	11	5
December	124	10	4	6	0
Total	**4529**	**237**	**54**	**160**	**23**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 3. *Monthly variation of rainfall and rainy days in 2018 - Nivithigalakale*

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	23	1	0	1	0
February	283	11	2	7	2
March	147	13	0	13	0
April	369	18	0	18	0
May	628	22	1	19	2
June	268	25	3	22	0
July	91	12	3	9	0
August	142	11	4	6	1
September	197	12	2	9	1
October	674	20	2	15	3
November	420	17	2	13	1
December	102	9	0	9	0
Total	**3,344**	**171**	**19**	**141**	**10**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 4. *Monthly variation of rainfall and rainy days in 2018 - 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	0.3	1	1	0	0
February	73	4	1	3	0
March	197	14	2	11	1
April	183	19	4	15	0
May	530	23	6	14	3
June	264	26	5	20	1
July	23	10	8	2	0
August	104	9	2	7	0
September	178	9	0	8	1
October	508	21	2	16	3
November	559	12	1	7	4
December	64	05	1	4	0
Total	**2683**	**153**	**33**	**107**	**13**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 5. *Monthly variation of rainfall and rainy days in 2018 – Kumbukkana, Monaragala*

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	63	6	2	4	0
February	40	4	1	3	0
March	175	8	1	8	0
April	159	11	3	8	0
May	219	8	0	6	2
June	74	3	0	3	0
July	80	5	0	5	0
August	77	3	2	0	1
September	102	5	1	3	1
October	393	26	0	23	3
November	239	17	4	12	1
December	87	7	1	6	0
Total	**1708**	**103**	**15**	**81**	**8**

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Other meteorological parameters:

Table 6 depicts the monthly values of some important meteorological observations together with 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 20^0C in 11 days; 9 days in January and 1 day each in February and December.

The daily average temperature pattern was fairly steady with a mean annual temperature of 27.3^{0}C and a standard deviation of 0.8, which could be a favourable condition for rubber plantations. The lowest mean minimum temperature of 21^{0}C was observed in January while the highest mean maximum temperature of 33.1^{0}C was observed in April. However, any signs of adverse conditions with respect to the temperature regime at Dartonfield were not reported during the year.

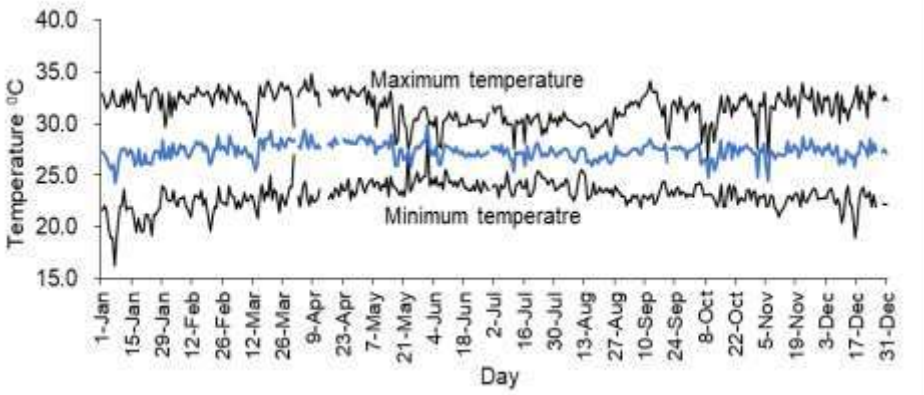


Fig. 5. Daily minimum, maximum and average temperature distributions in 2018

A total of 1,767 bright sunshine hours was received at an average rate of 4.8 hours/day which was comparatively lower 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 43% of the days, while in 26% 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 2018 was observed in the range, 64% to 98%. The mean RH values recorded at 08:30 and 15:30 were 86% (SD=6.0) and 73% (SD=12.0), respectively.

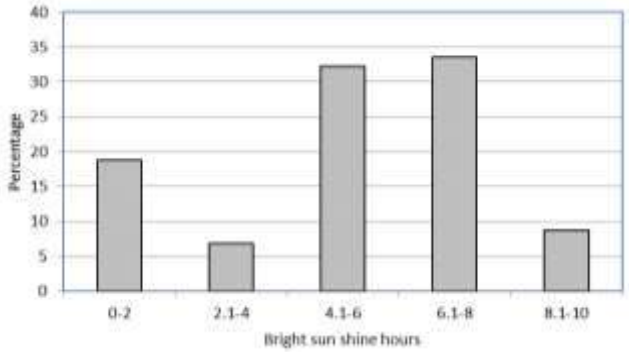


Fig. 6. Distribution of bright sunshine hours in 2018

Table 1. *Monthly variation of rainfall and rainy days at Dartonfield in 2018*

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	91	(156)	6	(11)	2	4	-	91
February	359	(114)	17	(09)	2	12	3	88
March	265	(222)	20	(13)	3	17	-	97
April	409	(415)	25	(18)	7	16	2	100
May	708	(584)	25	(24)	5	16	4	90
June	410	(398)	29	(23)	4	23	2	82
July	129	(313)	21	(22)	7	14	-	70
August	146	(268)	15	(20)	8	6	1	79
September	170	(436)	15	(22)	5	10	-	102
October	830	(513)	26	(23)	7	15	4	59
November	357	(387)	19	(20)	4	13	2	76
December	120	(266)	12	(15)	3	9	-	77
Total	3,994	(4,072.0)	230	(220)	57	155	18	1,011

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm
** Average values for 1980-2005 are shown in parentheses

Table 6. *Variation of observed meteorological factors at Dartonfield (Latitude $6^0 32'$; Longitude 80.09 E; Altitude 65.50m) in 2018*

Month	Temperature (^{0}C)					Relative humidity (%)			Wind speed
	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	Mean (kmph^{-1})
January	32.3	21.0	26.7 (26.7)	9	5.6	85 (88)	5	59 (68)	3.7
February	32.6	22.4	27.5(27.1)	1	5.1	87 (86)	12	69 (65)	1.5
March	32.5	23.0	27.8 (27.6)	-	5.6	87 (85)	11	66 (68)	1.5
April	33.1	23.3	28.2 (27.8)	-	5.5	85 (85)	6	74 (75)	1.5
May	31.2	24.2	27.7 (27.6)	-	3.5	86 (88)	9	76 (77)	1.8
June	30.1	24.3	27.2 (26.9)	-	3.8	89 (89)	17	78 (77)	2.0
July	30.3	24.1	27.2 (26.7)	-	4.3	88 (89)	10	77 (75)	2.2
August	30.1	23.7	26.9 (26.6)	-	2.3	88 (88)	13	79 (74)	2.3
September	31.8	23.1	27.5 (26.7)	-	5.9	85 (88)	7	71 (75)	1.8
October	32.0	23.2	27.1 (26.6)	-	3.7	86 (86)	10	81 (77)	1.2
November	31.8	22.6	27.2 (26.6)	-	5.3	84 (85)	7	73 (77)	1.2
December	32.0	22.5	27.2 (26.7)	1	4.7	86 (85)	11	69 (73)	1.3

** 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., Karunanayake, L. and Nilmini, A.H.R.L. (2018). Effect of ethephon stimulation on natural rubber latex properties; new insight into ethephon stimulation. *Journal of the National Science Foundation of Sri Lanka* **46** (2), 179-185. DOI:http://doi.org/10.4038/jnsfsr.v46i2.8418.

Hettiarachchi, R.P., Edirimanna, V., Thewarapperuma, A., Gunathilake, T., **De Silva E.**, **Chandrasiri, J.A.S**. and **Malawaraarachchi, G.C.** (**2016**). Effect of using sub soil with organic materials as a substitute to top soil in potting medium of rubber nurseries. *Journal of Rubber Research Institute of Sri Lanka* **96**, 59-68.

Iqbal, S.M.M., Rodrigao, V.H.L., Munasighe, E.S., Balasooriya, B.M.D.C., Kudaligama, K.V.V.S., Jayathilake, P.M.M. and Randunu, R.P.S. (2016). Early growth of rubber in the Dry Zone of Sri Lanka: an investigation in Vauniya district. *Journal of Rubber Research Institute of Sri Lanka* **96**, 12-23.

Lakshman, R.G.N., **Kudaligama, K.V.V.S., Rodrigo, V.H.L.,** Nugawela, A., **Attanayake, A.P., Perera, M.K.P.** and **Madushani, P.D.T.L.** (2016). Effectiveness of low frequency harvesting systems in rubber smallholder sector of Eastern Province (IL2) of Sri Lanka. *Journal of Rubber Research Institute of Sri Lanka* **96**, 24-32.

Nakandala, S.A., Weerasinghe, K.D.N., **Seneviratne, P**., **Iqbal, S.M.M.,** Lakmini, W.G.D. and Vijithasiri, P.M.P.S. (2016). Exogenous application of Salicylic acid allevates drought stress of rubber nursery plants in the Intermediate Zone of Sri Lanka. *Journal of Rubber Research Institute of Sri Lanka* **96**, 50-58.

Nayanakantha, N.M.C., Madhushani, K.D., Amarathunga, L.A.R., Wijesekera, G.A.S., Pathirana, P.D., Karunathilaka, W., De Zoysa, D.L.N., De Alwis, M.N., Handapangoda, R. and **Seneviratne, P.** (2016). Treatment with nitric oxide and seed coat removal improve germination and growth of rubber (*Hevea brasiliensis*). *Journal of Rubber Research Institute of Sri Lanka* **96**, 33-49.

Kirushanthi, T., Etampawala, Thusitha N., **Edirisinghe**, **Dilhara,** Pitawala, Jagath and Ratnaweera, D.R. (2018). Development of agro-industrial waste reinforced natural rubber composite: A potential formulation for rubber flooring product. *Journal of Advanced Chemical Sciences* **4,** Issue 3, 571-575.

Kondarage, Y.G., Pitawala, H.M.J.C., Kirushanthi, T., **Edirisinghe**, **D.** and Etampawala and Thusitha, N. (2018). Ceramic waste-based natural rubber composites: An exciting way for improving mechanical properties. *Journal of Advanced Chemical Sciences* **4**, Issue 3, 576-582.

Sampath, W.D.M., Edirisinghe, D.G. and Egodage, S.M. (2016). Property improvements of natural rubber and low density polyethylene blends through dynamic vulcanization. *Journal of the Rubber Research Institute of Sri Lanka* **96**, 1-11.

Bulletin/Conferences/Seminars/Workshops/Reports

Abeysiriwardana, D.D.S.D.Z., **Withanage, S.P**. and Attanayake, D.P.S.T.G. (2018). Screening of drought tolerance in selected clones of *Hevea brasiliensis. Proceedings of 17th Agricultural Research Symposium Part I,* pp.91-95. 28th - 29th November 2018. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, B.M.D.C., Edirisinghe, J.C. and **Seneviratne, P.** (2018). Impact of perception, awareness and adoption of technologies in reducing production variability in smallholder rubber cultivations in Kurunegala district. *Proceedings of the Wayamba University Research Congress,* pp.56-57. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, P.W., **Fernando, T.H.P.S.** and Weerasena, O.V.D.S.J. (2018). Phosphorus solubilizing ability of antagonistic fungi on *Rigidoporus microporus* isolated from Sri Lankan rubber growing lands. *Proceedings of the 7th Young Scientist Forum 2018.* p.19. Wayamba University of Sri Lanka, Makandura, Gonawila.

Balasooriya, P.W., **Fernando, T.H.P.S.** and Weerasena, O.V.D.S.J. (2018). Production of toxic metabolite by native antagonistic fungi, against *Rigidoporus microporus,* the causative fungi of White Root Disease of rubber (*Hevea brasiliensis*). *Proceedings of the 10thAnnual Scientific Sessions,* p.29. Institute of Biochemistry, Molecular Biology and Biochemistry, University of Colombo.

Dilrukshi, P.G.T., Subasinghe, S.M.C.U.P., **Nayanakantha, N.M.C**. and Senevirathna, A.M.W.K. (2018). Evaluation of growth performance of agarwood producing species under three shade settings in different rubber intercropping systems. *Proceedings of the 23rd International Forestry and Environment Symposium,* p.57. 23rd-24th November 2018. University of Sri Jayawardenapura,

Dissanayake, D.M.A.P. (2018). Strategic technology transfer methods: Experience from the smallholder rubber sector of Sri Lanka. *International Workshop on Statistical Applications in Socioeconomic Research and Forum on Current Socioeconomic Issues and their Impact on Rubber Production Sector Performance*. p.32. 1-5 October 2018, Rubber Research Institute of Sri Lanka.

Dissanayake, D.M.A.P., Wijesuriya, B.W., Gunarathne, P.K.K.S. and **Ranawaka, R.A.D.** (2018). Empowering rubber farmers in non-traditional rubber growing areas of Sri Lanka through knowledge on combating adverse impacts on environment for rubber cultivation. *Proceedings of International Rubber Conference* – IRC 2018, p.85. Abjidan, Cote' d Ivoire.

Fernando, T.H.P.S., Seneviratne, P., Tennakoon, B.I., Siriwardena, D. and **Wijeratne, C.** (2018). The battle against white root disease: An integrated approaches for success. *Proceedings of the First National Symposium on Sustainable Plantation Management* pp.129-139, National Institute of Plantation Management, Colombo, Sri Lanka

Gayashan, N.D.K., **Nayanakantha**, **N.M.C., Seneviratne, P.**, Senevirathna, A.M.W.K., Jayasinghe, H.A.S.L. and **Panditharathna, B.M.S.S.** (2018). Effect of polybag size on growth and physiological attributes of rubber (*Hevea brasiliensis*) seedlings. p.20. *Proceedings of 2nd International Research Symposium,* Uva Wellassa University, 1st-3rd February 2018.

Gunarathne, P.K.K.S., Dissanayake, D.M.A.P., Wijesuriya, W. and **Ranawaka, R.A.D.** (2018). Livelihoods of rubber latex harvesters in Kegalle District: comparative analysis of harvesting own lands versus operating on hired basis. *Proceedings of the SLCARP International Symposium.* p.93. Colombo, Sri Lanka.

Hettiarachchi, H.A.I.U., **Balasooriya, B.M.D.C.** and Edirisinghe, J.C. (2018). Scale efficiency in smallholder rubber sector in Kegalle district: A data envelopment analysis. *Proceedings of 17th Agricultural Research Symposium Part II,* pp.330-334, 28th - 29th November 2018. Wayamba University of Sri Lanka, Makandura, Gonawila.

Hettiarachchi, R.P., Dharmakeerthi, R.S., Seneviratne, G., Jayakody, A.N., **De Silva E.**, **Gunathilaka, T., Thewarapperuma, A., Edirimanna, V., Chandrasiri, J.A.S.** and **Malawaraarachchi, G.C.** (2018). Enhancing nutrient uptake of rubber nursery plants by the application of biofilmed biofertilizers. *Proceedings of Sri Lanka Council for Agricultural Research Policy International Agricultural Research Symposium.* p.50. 13th-14th August 2018). Colombo, Sri Lanka.

Jeewanthi, P.W., **Wijesuriya, W**. and Amarakoon, A.M.C. (2018). Identifying changes in rainfall distribution using Standardized Precipitation Index (SPI): An application in Uva Province Sri Lanka. p.5. *Proceeding of Second International Conference on Climate Change*. 15th-16th February 2018, Colombo Sri Lanka.

Karunarathne, N.P.S.N., Kudaligama, K.V.V.S., Abewardhane, N.N. and **Madushani, P.D.T.L.** (2018). Possibility of using wood of RRIC 121 rubber clone as an alternative to forest timber. *Proceedings of the First National Symposium on Sustainable Plantation Management* pp.77-86, National Institute of Plantation Management, Colombo, Sri Lanka.

Kirushanthi, T., Pitawala, H.M.J.C., **Edirisinghe, D.,** Ratnaweera, D.R. and Etampawala, T.N.B. (2018). Silica from rice husk as an alternative to commercially available silica fillers in tyre compounding. *Proceedings of the IRSUWU, Uva Wellassa University*, p.385, 1-2nd February, 2018.

Kondrage, Y.G., Pitawala, H.M.J.C., Thangavel, K., **Edirisinghe, D.** and Etampawala, T.N.B. (2018). Ceramic waste – based natural rubber composites: An exciting way for improving mechanical properties. *Proceedings of the IRSUWU*, p.386, 1-2nd February, 2018. Uva Wellassa University, Badulla.

Kudaligama, K.V.V.S., Rodrigo, V.H.L., Perera, M.K.P. and **Madushani, P.D.T.L.** (2018). Low intensity harvesting systems assured improved financial benefits to growers & harvesters. *Proceedings of the International Rubber Conference*, p.72. 22-24*th* October 2018, National Institute of Plantation Management, Abidjan, Ivory Coast.

Munasinghe, E.S. and **Rodrigo, V.H.L**. (2018). Rubber cultivation shows positive impact on rural livelihood in the Eastern province of Sri Lanka. *Dissemination of Research Findings - Private Sector Engagement for Sustainable Development in Sri Lanka: Evidence-based Policy and Practice.* pp.41-44. Sri Lanka Institute of Development Administration, Sri Lanka.

Munasinghe, E.S., Rodrigo, V.H.L., Jayathilake, P.M.M. and **Piyasena, N.M.** (2018). Rubber cultivation shows positive impact on rural livelihood in the Eastern province of Sri Lanka. *Proceedings of the Second International Agricultural Research Symposium 2018*. p.126. Sri Lanka Council for Agricultural Research Policy.

Nadeeshani, A.A.A., Palihakkara, I.R. and **Kudaligama, K.V.V.S**. (2018). Variation of some physiological and growth parameters in commonly grown young *Hevea*

clones in WL1a agro ecological zone in Sri Lanka. *Proceedings of the First National Symposium on Sustainable Plantation Management*, pp.47-55. National Institute of Plantation Management, Colombo, Sri Lanka.

Nakandala, S.A., **Nayanakantha**, **N.M.C., Seneviratne, P., De Alwis, M.N.** and D**e Zoysa, D.L.N.** (2018). Morphological and physiological responses of immature plants of *Hevea brasiliensis* to micro-irrigation. *Proceedings of International Rubber Conference and IRRDB Annual Meeting*, p.53. 2018, Abidjan, Côte D'Ivoire.

Nanayakkara, E.N.N., **Attanayake, A.P**., Wijesinghe, H.G.I.M. and Seneviratne, A.M.W.K. (2018). Effect of ethephon stimulation on physic-mechanical properties of carbon black filled natural rubber vulcanizate. p.395, *International Research Symposium***,** February 1-3rd, Uva Wellassa University, Badulla.

Nayanakantha, N.M.C., Panditharatne, B.M.S.S., Nakandala, S.A., Karunathilake, W. and **Seneviratne, P.** (2018). Exogenous nitric oxide donor sodium nitroprusside improves growth and physiological attributes of rubber (*Hevea brasiliensis*) under abiotic stress conditions. p.15. *Proceedings of the 5th International Conference on Agriculture*, 16-17th August 2018, Colombo.

Nayanakantha, **N.M.C.,** Madushani, K.A.U., **Seneviratne, P., Panditharathna, B.M.S.S., De Z. Dissanayaka, E.U.M.** and Karunarathna, B. (2018). Seed priming with nitric oxide enhances storage life, germination and seedling attributes of rubber (*Hevea brasiliensis*). pp.6-7. *Proceedings of the SLCARP International Agricultural Symposium*, 13-14 August, Colombo.

Nayanakantha, N.M.C., Panditharatne, B.M.S.S., Nakandala, S.A., Karunathilake, W. and **Seneviratne, P.** (2018). Exogenous *Moringa oleifera* leaf extract as a biostimulant improves growth and physiological attributes of rubber (*Hevea brasiliesnsis*) under sub-optimal climatic conditions. p.54. *Proceedings of the Symposium of RESCON 2018*, 9-10th November 2018, PGIS, Peradeniya.

Nayanakantha, **N.M.C.,** Madushani, U., Karunarathna, B., **Panditharathna, B.M.S.S.** and **Seneviratne, P.** (2018). Priming with nitric oxide donor sodium nitroprusside enhances germination and storage life of recalcitrant rubber (*Hevea brasiliensis*) seeds. p.4. *Proceedings of 2nd International Research Symposium*, Uva Wellassa University, February 1-3.

Nayanakantha, **N.M.C., Panditharathna, B.M.S.S**., **Seneviratne, P.** and **De Z. Dissanayaka, E.U.M.** (2018). Effect of selected clonal seedling rootstocks on

growth and budgrafting performance of rubber (*Hevea brasiliensis*). pp.22-26. *Proceedings of the National Symposium on Sustainable Plantation Management, 10th March*, National Institute of Plantation Management, Athurugiriya.

Rodrigo, Lakshman and **Munasinghe, Enoka** (2018). Sri Lankan experience in rubber cultivation in non-traditional areas. *Programme Book of the International Workshop on Statistical Applications in Socioeconomic Research and Forum on Current Socioeconomic Issues and their Impact on Rubber Production Sector Performance*. p.29. 1-5 October 2018, Rubber Research Institute of Sri Lanka.

Rodrigo, V.H.L. and **Munasinghe, E.S**. (2018). Carbon trading; rubber green to greener products! *The Journal of Plastic and Rubber Institute of Sri Lanka* **17**, 52-54.

Samaraweera, K.C., Wijesinghe, H.G.I.M., Etampawala, T.N.B., **Edirisinghe, D.G.** and Seneviratne, A.M.W.K. (2018). Silica extracted from rice husk ash as an effective reinforcing filler for natural rubber composites. *Proceedings of the IRSUWU*, p.394, 1-2nd February, 2018. Uva Wellassa University, Badulla, Sri Lanka.

Samindi, H.A.N.R., Attanayaka, D.P.S.T.G., Nagahawatta, D.P. and **Withanage, S.P.** (2018). Analysis of the promoter region of the rubber elongation factor gene (*ref*) of *Hevea brasiliensis* Muell. Arg. cv RRIC 121. *Proceedings of 17th Agricultural Research Symposium Part I,* pp.61-65, 28th-29th November 2018, Wayamba University of Sri Lanka, Makandura, Gonawila.

S**ilva, M.K.R., Fernando, T.H.P.S., Tennakoon, B.I.** and Umesha, B.V.A. (2018). Evaluation of the antagonistic effect of the diethyl ether extracts of local plant species on *Rigidoporus microporus:* the causal organism of white root disease of rubber. *Twenty third International Forestry & Environment Symposium 2018,* p.32. 23rd-24th November 2018, University of Sri Jayawardenapura.

Silva, M.K.R., **Fernando, T.H.P.S**., **Tennakoon, B.I.** and Umesha, B.V.A. (2018). Optimization of the protocol to assess the effectiveness of solvent extracts of prospective antagonistic plant species against White root disease of rubber. *Seventh Symposium of the Young Scientists Forum*, pp.140-145, National Science and Technology Commission, Sri Lanka.

Weerasinghe, P.K.P., Karunaratne, S.B., **Wijesuriya, W.** and Herath, H.M.L.K. (2018). Monitoring and forecasting of meteorological droughts in Sri Lanka: Spatio - temporal bayesian modelling approach. *Proceedings of 17th Agricultural*

Research Symposium Part II, pp.360-364, 28th-29th November 2018, Wayamba University of Sri Lanka, Makandura, Gonawila.

Wijesuriya, Wasana (2018). Statistical insight improves the interpretability of data generated through participatory approaches: experiences from the smallholder rubber sector of Sri Lanka. *IRRDB International Rubber Conference*, p.93. Ivory Coast.

Book Chapters/Modules Written

නයනකාන්ත, එන්.එම්.සී. වැවිලි බෝග නිෂ්පාදන තාක්ෂණය : 12 ශ්‍රේණිය, නව ව්‍යවහාරික විෂය සඳහා මොඩුලය සැකසීම (රබර් අංශය). අධ්‍යාපන පොදු සහතික පත්‍ර (උසස් පෙළ).

නයනකාන්ත, එන්.එම්.සී. වැවිලි බෝග නිෂ්පාදන තාක්ෂණය : 13 ශ්‍රේණිය, නව ව්‍යවහාරික විෂය සඳහා මොඩුලය සැකසීම (රබර් අංශය). අධ්‍යාපන පොදු සහතික පත්‍ර (උසස් පෙළ).

Newspaper articles

නයනකාන්ත, එන්.එම්.සී. (2018). රබර් වගාවට අලුත් ඉඩම්, සිළුමිණ. ජනවාරි 21, 2018.

Awards

Edirisinghe, D.G., Rathnawardhana, N.N., **Mahanama, M.K.** and Gunathilaka, Dayani (2018). Presidential Merit Award in the field of "Chemistry" for "Oreclaim" - A Mechano-chemical Reclaiming Process for Ground Rubber Tyre using Garlic.