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RUBBER RESEARCH INSTITUTE OF SRI LANKA

Annual Review 2023

Cover Story

The Rubber Research Institute of Sri Lanka (RRISL) successfully completed three Rubber Master Plan projects in 2023. These projects aimed to improve the rubber sector by addressing productivity improvement, labour shortage and sustainable harvesting techniques.

1. Commencement of tapping in untapped rubber lands - The Plant Science Department conducted a pilot project in the Kalutara district to identify abandoned rubber lands, determine the reasons and to recommencement of tapping. Nearly 100ha came to tapping and 64 Harvesters were trained for latex harvesting.

2. NVQ certification for Rubber Harvesting Assistants - RRISL introduced internationally recognized National Vocational Qualification (NVQ) Level 3 for Rubber Harvesters to enhance their social status, financial stability and attracting young workers to the industry. 169 candidates were awarded with NVQ certificates.

3. Rubber Farming Service Providers (RFSPs) - Key initiative from the Advisory Service Department of RRISL based on the para extension approach. This program was implemented to train non-skilled personnel on RF technologies/ practices as a solution to the shortage of qualified trained personnel into the rubber sector as entrepreneurs.

Rubber Research Institute of Sri Lanka

Annual Review - 2023

1st January 2023 to 31st December 2023

Editors
S P Withanage, PhD (Malaysia)
T H P S Fernando, PhD (Sri Lanka)
A P Attanayake, PhD (Sri Lanka)

Head Office & Laboratories
Dartonfield
Agalawatta

Board Office & Laboratories
Telewela Road
Ratmalana

CONTENTS

Board of Management, Committees & Staff Members

RUBBER RESEARCH BOARD OF SRI LANKA

BOARD OF MANAGEMENT

Members appointed by the Hon Minister of Plantation Industries

1. Mr Lakshman Abeysekera, Chairman, Rubber Research Board
2. Dr L M K Tillakeratne, Advisor (Rubber), United Nations Organization (up to 30.05.2023)
3. Mr Justin Senevirathne, Director, Lalan Rubbers (Pvt) Ltd
4. Mr Udara Premathilake, Director Plantations (Rubber), Kelani Valley Plantations PLC
5. Mr Prabath Wimal Kumara, Secretary/Director, Sri Lanka Council for Agricultural Research Policy (w.e.f. 16.05.2023)
6. Mr V Lokunarangoda, Chairman, Thurusaviya Fund
7. Mr Prins Gunasekara, Chief Executive Officer, Kegalle/Namunukula Plantations PLC
8. Mr Ajantha Galhena, Additional Director General (Acting), Ministry of Finance
9. Mr C C Muhandiramge, Additional Secretary, Ministry of Plantation Industries
10. Mr Manoj Udugampola, Chief Operating Officer (Rubber)- Pussellawa Plantations Ltd / Agalawatte Plantations PLC (w.e.f. 30.05.2023)

Ex-Officio Members

1. Mr Senaka Alawattegama, Chairman, Planters' Association of Ceylon
2. Mr Madhawa Warnakulasooriya, Director General, Rubber Development Department

In attendance

1. Dr Susantha Siriwardena, Director (Acting), Rubber Research Institute
2. Board Secretary, Ms. Akila Tharinduni, Administrative Officer, (Cover up Duties of the Secretary)

STANDING COMMITTEES

Estates Committee

1. Mr Lakshman Abeysekera, Chairman, Rubber Research Board
2. Dr Susantha Siriwardene, Actg. Director, RRISL
3. Mr Nishsanka Seneviratne, Deputy General Manager, Lalan Rubber Pvt Ltd
4. Mr Jagath Hettiarachchi, Senior Manager, Arrappolakanda Estate

5. Mr Manoj Udugampola, CEO, Pussellawa Plantations
6. Mr P.A.Lukshman, Senior Manager, Dartonfield Estate, RRISL
7. Mr B.S.S.Hewage, Senior Accountant, RRISL

Audit and Management Committee

1. Mr Ajantha Galhena, Additional Director General (Acting), Ministry of Finance
2. Mr Madhawa Warnakulasooriya, Director General, Rubber Development Department
3. Mr C C Muhandiramge, Additional Secretary, Ministry of Agriculture & Plantation Indudstries
4. Ms W A V D Perera, Audit Superintendent, National Audit Office
5. Mr K A C Shamantha, Chief Internal Auditor, Ministry of Agriculture & Plantation Indudstries

In attendance

1. Dr Susantha Siriwardena, Acting Director, Rubber Research Institute
2. Mr B S S Hewage, Senior Accountant, Rubber Research Institute
3. Ms M S I Senadheera, Internal Auditor, Rubber Research Board
4. Mr Susantha Dissanayake, Senior Administrative Officer, Rubber Research Institute
5. Ms Akila Tharinduni, Administrative Officer, Rubber Research Board

Scientific Committee

Members of RRISL

1. Mr Lakshman Abeysekara, Chairman, Rubber Research Board
2. Dr S Siriwardena, Actg. Director, RRI
3. Dr (Mrs) D G Edirisinghe, Actg. Additional Director, RRI
4. Dr (Mrs) S P Withanage, Deputy Director Research (Biology), RRI
5. Dr (Mrs) T H P S Fernando, Head, Plant Pathology & Microbiology Dept., RRI
6. Dr (Mrs) E S Munasinghe, Principal Research Officer, Adaptive Research Unit, RRI
7. Dr (Mrs) K V V S Kudaligama, Head, Biochemistry & Physiology Dept., RRI
8. Dr (Mrs) R P Hettiarachchi, Head, Soils & Plant Nutrition Dept., RRI
9. Dr (Mrs) A P Attanayake, Principal Research Officer, Raw Rubber & Chemical Analysis Dept., RRI
10. Dr K K Liyanage, Principal Research Officer, Genetics & Plant Breeding Dept., RRI
11. Dr T U K Silva, Principal Research Officer, Plant Science Dept., RRI
12. Mrs B M D C Balasooriya, Research Officer, Adaptive Research Unit, RRI
13. Dr (Mrs) D S A Nakandala, Senior Research Officer, Plant Science Dept., RRI

14. Dr (Mrs) M K R Silva, Research Officer, Plant Pathology & Microbiology Dept., RRI
15. Mr W D M Sampath, Senior Research Officer, Rubber Technology & Dept., RRI
16. Dr P K K S Gunarathne, Advisory Officer, Advisory Services Dept., RRI
17. Mr J K S Sankalpa, Senior Research Officer, Agricultural Economics Unit, RRI
18. Mr K Adikari, Research Officer, Raw Rubber Processing Development & Chemical Engineering Dept, RRI
19. Mrs. I H K Samarasinghe, Research Officer, Polymer Chemistry Dept., RRI
20. Dr W R N Alles, Senior Research Officer, Polymer Chemistry Dept., RRI
21. Mrs H A Ruwani Jayawardane, Research Officer, Soils & Plant Nutrition Dept., RRI
22. Mrs N P Surani Karunaratne, Research Officer, Biochemistry & Physiology Dept., RRI
23. Mrs P G N Ishani, Research Officer, Agricultural Economics Unit, RRI
24. Mrs Aloka Weerasinghe, Research Officer, Rubber Technology & Dept., RRI
25. Mr Manjula Alwis, Research Officer, Plant Science Dept, RRI
26. Mr Sangeeth Liyanaarachchi, Research Officer, Soils & Plant Nutrition Dept., RRI
27. Mr Dilhan Ratnayake, Research Officer, Biometry Section, RRI
28. Mr PA Lakshaman, Senior Manager (Estate), RRI

Members representing the Industry and other Institutions

1. Mr Nalaka Gunathilake, CEO, Agalawatte Plantations PLC, FLC Tower, No 19, Dudley Senanayake Mw, Colombo 8
2. Mr S Dissanayake, GM, Agalawatte Plantations PLC, Pambegama Estate, Parakaduwa
3. Mr K Fernando, AGM, Agalawatte Plantations PLC, Culloden Estate, Neboda
4. Mr Theekshana Bandara, Superintendent, Agalawatte Plantations PLC, Doloswella Estate, NIvithigala
5. Mr Lalinda Dhananjana, DM, Agalawatte Plantations PLC, Clyde Estate, Tebuwana
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7. Mr Asitha Thilakaratne, Superintendent, Balangoda Plantations PLC, Palmgarden Estate, Ratnapura
8. Mr D K Wijeratna, Superintendent, Balangoda Plantations PLC, Rambukkande Estate, Ratnapura
9. Mr Indusanka Ramanayake, Superintendent, Balangoda Plantations PLC, Mutwagalla Estate, Kiriella
10. Mr D L D S Kandegama, Superintendent, Balangoda Plantations PLC, Rye/Wikiliya Estate, Balangoda
11. Mr B Bulumulla, CEO, Elpitiya Plantations PLC, Level 09, Aitken Spence Tower 1, Vauxhall Street, Colombo 2

12. Mr A G Geeth Kumara, Senior General Manager, Elpitiya Plantations PLC, Level 09, Aitken Spence Tower 1, Vauxhall Street, Colombo 2
13. Mr B H U Bulugahapitiya, Senior Manager, Elpitiya Plantations PLC, Talgaswella Estate, Talgaswella
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23. Mr B P S M Cooray, Superintendent, Kegalle Plantations PLC
24. Mr S D Munasinghe, Superintendent, Kegalle Plantations PLC, Eadella Estate, Polgahawela
25. Mr B M J A Moonamalle, Superintendent, Kegalle Plantations PLC, Atale Estate, Atale
26. Mr Roshan Waidyakularatne, Superintendent, Kegalle Plantations PLC, Hathbewa Estate, Rambukkana
27. Mr M W Liyanasekara, Superintendent, Kegalle Plantations PLC, Parambe Estate, Undugoda
28. Mr Danushka Madiwaka. Superintendent, Kegalla Plantations PLC, Udapola Estate, Polgahawela
29. Mr Anusha Perera, CEO, Hapugastennda Plantations PLC, No 95A, NAmbapana, Ingiriya
30. Mr Ranil Kapugekiyana, DO, Hapugastenna Plantations PLC,
31. Mr Priya Gunawardena, DO, Hapugastenna Plantations PLC,
32. Mr B M Priris, Superintendent, Hapugastenna Plantations PLC, Bibile Estate, Bibile
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37. Mr Mr Sajith Gunawardane, Senior Manager, Horana Plantations PLC,Frocester Estate, Govinna
38. Mr Lakmal Kandegama, Senior Manager, Horana Plantations PLC, Neuchatel Estate
39. Mr Chathura Kumarasinghe, Deputy Manager, Horana Plantations PLC, Halwatura Estate
40. Mr Gayala Perera, Senior Manager, Horana Plantations PLC, Mirishena Estate
41. Mr Dan Seewaratnem, CEO, Kahawatte Plantations PLC, No 111, Negombo Rd, Peliyagoda
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43. Mr Tony Bertus, RGM, Kahawatte Plantations PLC, No 111, Negombo Rd, Peliyagoda
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45. Mr D Jayakody, Manager M & P, Kahawatte Plantations PLC, No 111, Negombo Rd, Peliyagoda
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48. Mr Jeewantha Senaratne, Senior Manager, Kahawatta Plantations PLC, Rilhena Estate, Pelmadulla
49. Mr Indrajith Rukmal, Manager, Kahawatta Plantations PLC, Akarella Estate, Openayake
50. Mr Suneth Hewagama, Senior Manager, Kahawatte Plantations PLC, Poranuwa Estate, Kahawatte
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53. Mr J N Hettiarachchi, Senior Manager, Kotagala Plantations PLC, Arapolakande Estate,Tebuwana
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55. Mr Deeshan Perera, Senior Manager, Kotagala Plantations PLC, Uskvalley Estate, Lathpandura
56. Mr R Thennakoon, Senior Manager, Kotagala Plantations PLC, Delkith Estate, Baduraliya

57. Mr Samantha Abeywardena, Manager, Kotagala Plantations PLC, Padukka Estate, Padukka
58. Mr N Wijeratne, Manager, Kotagala Plantations PLC, Eduragala Estate, Ingiriya
59. Mr Roshan Obeysekara, Manager, Kotagala Plantations PLC, Vogan Estate, Matugama
60. Mr Anura Weerakoon, CEO, Kelanivalley Plantations PLC, No 400, Deans Rd, Colombo 10
61. Mr Ranil Fenado, GM-Rubber Marketing & Ad;, Kelani Valley Plantations PLC, No 400, Deans Rd, Colombo 10
62. Mr Eranda Welikala, RGM, Kelanivalley Plantations PLC, Panawatte Estate, Yatiyantota
63. Mr S F Fernando, RGM, Kelanivalley Plantations PLC, Kiriporuwa Estate,
64. Mr R M U S Jayasundara, Manager, Kelanivalley Plantations PLC, Urumillewa Estate, Bulathkohupitiya
65. Mr D Samarasinghe, Senior Manager, Kelanivalley Plantations PLC, Edarapola Estate.
66. Mr P de S A Gunasekara, CEO, Namunukula Plantations PLC, No 310, High Level Rd, Nawinna, Maharagama
67. Mr J B Weerasekara, Superintendent, Namunukula Plantations PLC, Pallegoda Estate, Darga Town
68. Mr R Ranasinghe, Superintendent, Namunukula Plantations PLC, Eladuwa Estate, Matugama
69. Mr Kushan Karunathilake, Superintendent, Namunukula plantations PLC, Citrus Estate, Poddala
70. Mr N Kalugalle, Superintendent, Namunukula Plantations PLC, Miriswatte Estate, Welipenna
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72. Mr W W H P Fernando, Group Senior Manager, Lalan Rubbers (Pvt) Ltd, Udabage group, Deraniyagala
73. Mr C V Dias, Group Senior Manager, Lalan Rubbers (Pvt) Ltd, Miyanawita Estate.
74. Mr A Kuruppu, Actg. Senior Manager, Lalan Rubbers (Pvt) Ltd, Sapumalkande Group, Deraniyagala
75. Mr Tharindu Wickramasinghe, CEO, Maturata Plantations PLC, Colombo
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77. Mr L M A C Bandara, Superintendent, Maturata Plantations PLC, Wilpita estate, Akuressa
78. Mr M H P Gunarathna, Superintendent, Maturata Plantations Ltd, Diddenipota Estate, Matara
79. Mr Manoj Udugampola, Chief Operating Officer, Pussellawa Plantations PLC, Level 11, FLC Tower, No 19, Dudley Senanayake Mw, Colombo 8

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81. Mr Prasan Konara, Superintendent, Pussellawa Plantations PLC, Halpe Estate, Tummodara
82. Mr Shanaka Rupasinghe, Superintendent, Pussellawa Plantations PLC, Penrith Estate, Awissawella
83. Mr Anusha Weerakon, Superintendent, Pussellawa Plantations PLC, Elston Estate, Puwakpitiya
84. Mr Upul Siyambalagoda, DM, Pussellawa Plantations PLC, Elston Estate, Puwakpitiya
85. Mr L M Amarathunga Superintendent, Pussellawa Plantations PLC, Salawa Estate, Hanwella
86. Mr Chaminda Jayalath, Asst. General Manager, Pussellawa Plantations PLC, Aye Estae, Padukka
87. Mr Chrishan Hettiarachchi, Superintendent, Pussellawa Plantations PLC, Siriniwasa Estate, Waga
88. Mr Binesh Pananwala, CEO, Watawala Plantations PLC, No 754/5, Kandy Rd, Wedamulla, Kelaniya
89. Mr Sudeera Mananayake, Manager, Watawala Plantations PLC, Thalangaha Estate, Nakiyadeniya
90. Mr Nilantha Seneviratne, Manger, Watawala Plantations PLC, Nakiyadeniya Estate,
91. Mr Dimantha Samarasinghe, Senior Manager, Watawal Plantations PLC, Hemadola Estate, Udugama
92. Mr M I Gourdian, Executive Director – Admin & Rubber Estate, Malwatte Valley Plantations PLC No 280, Dam Street, Colombo 12
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94. Mr Gaya Nakandala, Consultant, 375/26, Ratnarama Rd, 4th Lane, Hokandara North
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96. Mr N M Amaraekara, Consultant, 37/9, Terrence Av, Mt. Lavinia
97. Mr Jayantha P Muthutantri, Consultant, No.4/4, Nelum Mw, Sirimal Uyana, Mt. Lavinia

Provident Fund Committee

01. Mr Lakshman Abeysekara, Chairman, Rubber Research Board
02. Dr Susantha Siriwardena, Acting Director, RRI, Member (w.e.f 01.01.2023)
03. Mr D M S Dissanayake, Senior Administrative Officer, Secretary
04. Mr B S S Hewage, Senior Accountant , Treasure

05. Dr (Mrs) K V V S Kudaligama, Head of Biochemistry Department, Elected Committee Member
06. Dr P K K S Gunarathna, Advisory Officer, Elected Committee Member
07. Mr J A S Chandrasiri, Rubber Extension Officer, Elected Committee Member

Chairman's Office & Board Secretariat

Chairman	-	Mr Lakshman Abeysekera
PA to Chairman	-	Ms Akila Tharinduni, Administrative Officer (Cover up Duties of the PA to Chairman)
Management Assistant	-	Ms S M D S R D A Wijerathne

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

Bankers
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Contact details:

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Deputy Director Research (Biology)	034 - 3346118
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Board Office and Rubber Chemistry & Technology Laboratories
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RUBBER RESEARCH INSTITUTE OR SRI LANKA
STAFF LIST

DIRECTORATE

Director	Vacant
Additional Director	Vacant
Deputy Director Research (Biology)	Vacant
Acting Director/ Deputy Director Research (Tech.)	S Siriwardena, BSc (SL), MSc (Australia), PhD (Malaysia)
Acting Additional Director	Mrs D G Edirisinghe, BSc (SL), MSc (SL), MPhil (UK), PhD (SL)
Acting Deputy Director Research (Biology)	Mrs S P Withanage, BSc Agric. (SL), MSc (India), PhD (Malaysia)

RESEARCH DEPARTMENTS

Agronomy Departments

Genetics & Plant Breeding	(*at Nivithigalakele Substation,Matugama)*
Head of Department	Mrs S P Withanage, BSc Agric. (SL), MSc (India), PhD (Malaysia**)**
Principal Research Officer	K K Liyanage, BSc Agri. MPhil (SL), PhD (China)
Experimental Officers	T M S K Gunasekera
	H P Peiris, Dip. Agric. (Kundasale)
	Mrs A K Gamage, BSc (SL)
Technical Officers	B W A N Baddewithana, BSc Agric. (SL), MPhil (SL)
(Research & Development)	Mrs N S Jayasinghe, BSc (SL)
Management Assistant (Clerical)	Mrs S D P K L Peiris
Plant Science	**(***at Dartonfield, Agalawatta***)**
Senior Research Officers	T U K Silava, BSc Agric. (SL), MPhil (SL), PhD (SL)
	Mrs D S A Nakandala, BSc Agric. (SL), PhD (SL)
Research Officer	W D M N de Alwis, BSc (SL)

Experimental Officers	D L N de Zoysa
	P D Pathirana, BSc (SL)
	P K W Karunathilaka, Dip. Agric. (Rathnapura)
Technical Officers	R Handapangoda, BSc Agric. (SL) (up to 31.05.2023)
(Research & Development)	Mrs U Dissanayake, HNDT, BSc (SL), MSc (SL)
	Miss H M Subasinghe, BSc (SL)
	R P D Priyadarshana, BSc (SL)
	Mrs U N Udayakumari, BSc (SL)
	Miss W M D Wickremakumari, BSc Agric. (SL)

Plant Pathology and Microbiology	**(***at Dartonfield, Agalawatta***)**
Head of Department	Mrs T H P S Fernando, BSc (SL), MPhil (SL), PhD (SL)
Research Officer	Mrs M K R Silva, BSc Agric. (SL), MSc (SL), PhD (SL)
Experimental Officers	Mrs E A D D Siriwardena, BSc (SL)
	S C P Wijerathne, NDT Agric. (Hardy)
	E A D N Nishantha, Dip. Agric. (Rathnapura), BIS Agric. (SL), M.AETM (SL)
Technical Officers	Mrs A H M N R Abeyrathne,BSc (SL), MSc (SL)
(Research & Development)	D A N Mallikaarchchi, BSc (SL)
Management Assistant	Mrs K A D Y Madushani Lanka, Dip. in (Comp.)

Soils and Plant Nutrition	**(***at Dartonfield, Agalawatta***)**
Head of Department	Mrs R P Hettiarachchi, BSc (SL), MPhil(SL), PhD (SL) (up to 08.12.2023)
Research Officers	Mrs H A R K Jayawardena, BSc Agric. (SL), MPhil (SL)
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	Miss A P Thewarapperuma
	P D T C Gunathilaka, NDT Agric.
Technical Officers	Mrs Eranga de Silva, NDT
(Research & Development)	G C Malawaraarchchi, HNDT (Hardy)

	Mrs M Kulathunga, BSc (SL) (up to 03.09.2023)
	Mrs R M Baddevidana, BSc (SL)
	H W Gayan, BSc (SL)
	B M K Rangana, BSc (SL)
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Research Officer	Mrs N P S N Karunaratne, BSc (SL)
Experimental Officers	M K Perera, BSc (SL)
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	L T B K Fernando, BSc (SL)
Management Assistant	Mrs H A Manoji Erandika
Advisory Services	(*at Telewela Road, Ratmalana***)**
Advisory Officer	P K K S Gunaratne, BSc Agric. (SL)
Assistant Training Officer	Mrs K G P Manahari, BSc (SL)
Rubber Extension Officers	D E P M Nananyakkara, Diploma in Agric. (Aquinas) (up to 01.06.2023)
	Nihal Gamage, Diploma in Agric. (Angunakolapelessa) (up to 28.04.2023)
	J A S Chandrasiri
	S M A Samarakoon, Diploma in Agric. (Kundasale)
	W P G D C P K Senanayake, NDT Agric. (Hardy)
	H G M B Jaysinghe, BSc (SL)
	K D K L Siriwardena, BSc (SL)
	Mrs K K I Jayasundena, BSc (SL) (up to 27.08.2023)
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	K D P Senaratne
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(Research & Development)	Mrs S G P Bhagayawedha, NDT
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	Miss A H D M N Gunawardena, BSc (SL)
	Mrs E N N Nanayakkara, BSc (SL) (up to 02.10.2023)
	K N D Tillekeratne, BSc (SL)

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Senior Research Officers	W P N Alles, Graduate Chamist, MSc (SL), MSc (UK), PhD (NZ) (up to 01.12.2023)
Research Officers	Mrs I H K Samarasinghe, BSc Agric.
	Y R Somaratne, BSc (SL), MSc (SL) (up to 10.04.2023)
Experimental Officers	Mrs N Jayawardana, Dip. Agric. (Bibile)
Technical Officers	Mrs H M H Danukamalee, BSc (SL)
(Research & Development)	Mrs S V Rupasinghe, BSc (SL)
	D V D Mallikarachchi, BSc (SL)
	Mrs H L T Tharaka, BSc (SL)
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Experimental Officer	Mrs C S Lokuge
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(Research & Development)	H D M S Wijewardena, BSc (SL)
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Technical Officers	R D Illeperuma, BSc (SL)
(Research & Development)	Miss P K N N Sadamali, BSc (SL)
	W A S Bandara, BSc (SL) (up to 05.01.2023)
Management Assistant	Mrs H A Janani Lakshika, BSc (SL)
	Mrs P D S Dilhani (up to 27.01.2023)

Section/Units

Biometry Section	(*at Dartonfield, Agalawatta*)
Research Officer	A M R W S D Rathnayake, BSc (SL)
Experimental Officer	O V Abeywardena, Dip. in Agric. (Kundasale)
Management Assistant (Clerical)	Mrs S N Munasinghe (up to 03.03.2023)

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 Officers	P M M Jayathilake, NDT (Agric.)
(Research & Development)	Mrs N M Piyasena, Dip. in Agric. (Kundasale)
Management Assistant (Clerical)	Mrs M A Randima Srimali

Agricultural Economics Unit	**(***at Dartonfield, Agalawatta***)**
Senior Research Officer	J K S Sankalpa, BSc (SL), MSc (SL), M.Econ. (SL)
Research Officer	Mrs P G N Ishani, BSc Agrric.
Library and Publications Unit	**(***at Dartonfield, Agalawatta***)**
Librarian	Mrs N C D Wijesekera, BA (SL), MSSc (SL)
Library Assistant & Assistant Publication Officer	Mrs R M Amaratunga, Intermediate; Lib. Sci. Doc. & Info. (SLLA) (up to 23.08.2023)
Experimental Officer	Mrs D M S Wijesekera, Dip.Rubber Tech. (PRI)
Library Assistant & Publication Assistant	Mrs D N C Amaratunga (up to 10.04.2023)
Audio Visual and Information Technology Unit	(*at Dartonfield Agalawatta*)
Network Administrative	S R D P C Peiris, BSc (SL)
Administration Department	*(Agalawatte)*
Senior Administrative Officer	D M S Dissanayake, BSc (Mgt.) (SL), MHRM (SL)
Management Assistant (Clerical)	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, Dip. in (HRM), Advanced Dip. in (CA & SP)
	Mrs B Chandralatha, BA (SL)
	Mrs M G L Niroshani, BA (SL)
Telephone Operator	Mrs J A D C Preethika
Administration Unit)	*(Rathmalana*
Administrative Officer	Mrs U K Akila Tharinduni, BSc (SL), PQHRM, MBM
Management Assistant (Clerical)	A T Senaratne
	Mrs A R M de Alwis

Internal Audit	**(***at Dartonfield, Agalawatta***)**
Internal Auditor	Mrs M S I Seenadeera, IFA, IPFA, IRCA, EPFA, PGDM
Management Assistant (Clerical)	A M W K Tillekeratne
Work Section	**(***at Dartonfield, Agalawatta***)**
Resident Engineer	K A D K Chathuranga, BSc (Eng.) Hons, CEng. MIE (SL)AMSSE (SL), GREEN ^{SL} AP
Engineering Assistant	Mrs W D D Prasadini, NDES
Technological Officer (Civil)	M A D K Jayasumana, NCT (up to 31.03.2023)
Transport Officer	U L D R LGunasinghe
Technological Officer (Mech.)	H J P Fernando, HNDE
Management Assistant (Clerical)	Mrs J A S Dharshani, (Dip. in Management) (up to 21.08.2023)
	Mrs K K D K P Ranaweera
	Mrs M H W H Kumari, BSc (SL)
Accounts Section	**(***at Dartonfield, Agalawatta***)**
Senior Accountant	B S S Hewage, CPFA (UK), CBA, APFA
Accountant	D S R M P Gunawardena, MBA (USJ), BSc (FM), FPFA, CBA, MAAT (from 01.12.2023)
Management Assistant (Accounting)	Mrs G P Kukulewitthana
Management Assistant (Clerical)	Mrs C Dissanayake (up to 14.02.2023)
	Mrs S I K Pathirage
	Mrs S A Niluka Harshani
	Mrs K K D Y L Ranaweera
	Miss K K T L Jayasekera
	J A J R Lakmal, B.com. (SL)
	Mrs R P Thilini
	K A Dilan Sampath
	Mrs Erandi Kanchana Jayasinghe, BA (SL) (up to 01.02.2023)
	Mrs S R Sinhabahu
	G N K Gunasena
	Mrs K D Piyumi Hasara

Cashier	Mrs G A D D Jayawardena
Kuruwita Sub-station	*at Kuruwita*
Management Assistant (Clerical)	D S Jayasinghe
Field Officer	D D A Jayathunga (up to 25.11.2023)
Polgahawela Sub-station	(*at Narampola Estate, Nungamuwa, Yatigaloluwa*)
Research Officer	Mrs B M D C Balasooriya, BSc (SL)
Management Assistant (Clerical)	D P N P Dissanayake
Monaragala Sub-station	(*at Kumbukkana, Moneragala*)
Field Officers	V G G Nishantha Gunaseela
	N V U S Vijitha Kumara
Management Assistant (Clerical)	Mrs D M P Sadun Kumari
	M M Chamath Kumara *
Dartonfield Group	
Senior Manager – Estate	P A Luckshman, BSc (SL)
Management Assistant (Clerical)	H D D Achinda
	M A N Sachith Pawinda
	T D Harsha
Field Officer	B M Siriwardena

***** Contractual basis

Awards – 2023

Dr. R.P. Hettiarachchi – Head of the Soils and Plant Nutrition Department, RRISL won the best presenter award for her article entitled "Effect of Slow-Release Fertilizer Techniques on Growth and Mineral Composition of Immature *Hevea* and Fertility of Rubber Growing Soils" at the National Institute of Plantation Management (NIPM) Symposium in August 2023.

Mr. W.D.M. Sampath received the Best Postgraduate Presenter Award for the presentation titled "Cure characteristics of polyethylene glycol grafted reduced graphene oxide (PEG-g-rGO) filled natural rubber composites" at the Wayamba University Research Congress (WURC) 2023.

RUBBER RESEARCH INSTITUTE OF SRI LANKA

DIRECTOR'S REVIEW

Susantha Siriwardena

This report, at the outset, presents an overview of the local and international rubber industry in the year 2023. It is followed by a summary of key research and development activities carried out by the institute to address the existing major issues in the rubber industry. The research activities carried out by each department and unit are briefed next. The performance of administrative and financial functions of the institute is also included in this report. Finally, the key obstacles being faced in carrying out R & D activities are also addressed.

Rubber Industry of Sri Lanka

Rubber production and consumption

Sri Lanka's rubber production in 2023 recorded 65,300 MT, falling short of the preceding year's production by 6,000 MT or 6%. In the above official figures, published by the Rubber Development Department, the quantity of Technically Specified Rubber (TSR) has not been disclosed, though there were 10 registered TSR manufacturers in the country. However, it was a challenging year for the local rubber industry where extremely high rainfall was registered in major rubber growing areas, reporting an over 3,000 to 5,000mm rainfall dramatically reducing the number of tapping days.

A part from the adverse rainfall, continued spread of the leaf disease known by the name *Pestalotiopsis* or Circular Leaf Spot Disease, particularly in these wet areas, contributed to a yield decrease of an estimated figure of about 10%. The above two factors suggest establishing new rubber plantations in non-traditional areas, where more dry weather conditions prevail to ensure economically viable natural rubber plantations. In addition, a sample survey carried out on the estimation of untapped lands in tappable lands revealed that approximately 10% of the tappable trees are not tapped daily due to a variety of reasons, and of them, high rainfall, tapper shortage, and unattractive rubber prices being the main causes.

A decline in the total rubber consumption in 2023 was shown amounting to 91,866 MT which includes 37,295 MT of imported NR. Approximately a 16% reduction in the NR demand for local rubber product manufacture has been reported.

NR exports and imports

As it has been done in the previous years, Sri Lanka exported NR in two forms, namely Crepe rubber and RSS. RSS and Crepe rubber contributed to 15% and 74% of the total exports respectively, while the balance was miscellaneous types, such as TSR and compounded rubber. The total exports of NR from the country were

recorded as 12,672 tons in 2023 against 15,138 tons of NR exports made in 2022 indicating a decline in exports.

Sri Lanka imported around 37,295 tons of NR in 2023, mainly in the forms of TSR (20%), RSS (51%), centrifuged NR latex & other latex (29%) and compounded rubber (0.3%). This shows a 42% decrease in imports in 2023 compared with the figure for the year 2022.

Rubber extent

The Rubber Development Department has revised the rubber extent in the country and it is 98,583 ha. According to their new statistics, the total mature and immature extents of the country are 84,998 ha and 13,585 ha, respectively. Of the total rubber extent, nearly 68% of rubber lands are occupied by the smallholder sector while the rest of the area is managed by large plantation companies and, just 1% is managed by the Government-owned agency, namely Janatha Estate Development Board. The Rubber smallholders continued to be dominant amongst producers by contributing over 67% of total national production. The country's average yield has also been adjusted in line with the revised rubber land extent showing a higher average productivity value of 838 kg per ha/year.

NR prices

Sri Lanka enjoyed a fairly reasonable price for both RSS and Crepe rubber during the second half of the year 2023. The average price of RSS category 3 was US $ 2.45 per kg in December 2023, while it was as low as US $ 1.5 per kg at the beginning of the year. The price of Latex Crepe rubber went up to US $ 2.78 per kg during December 2023 which was as low as US $ 1.70 at the beginning of the same year.

Export earnings from raw rubber and rubber products

The export earnings from raw rubber in 2023 totaled Rs.9.28 billion as against Rs.12.7 billion in the previous year. This is a decrease of Rs.3.42 billion or 26% compared with the previous year. As in the previous years, RSS and Crepe rubber were the two major types of Natural Rubber exported. Sri Lanka remains a key producer of superior-quality Crepe rubber in the global rubber market. Exports of 4,353 MT of Crepe rubber and 6,778 MT of RSS rubber earned Rs.2.2 billion and Rs.6.1 billion, respectively. The export earnings from the semi-processed rubber have been reported as Rs.9.3 billion in the year 2023, while it was Rs.9.5 billion in the year 2022.

The total export earnings from rubber products was Rs.327 billion (US$ 0.97bn). This was earned by exporting tyre products, rubber gloves and other rubber products for US$ 595 million, US$ 229 million and US$ 81 million, respectively. The prime destinations for local rubber products were the USA, followed by Germany, France, Pakistan, and China. Despite the decline being considered slight, it has been stagnating around US$ 1 billion for decades. However, it remains as the third largest export earner in the merchandise sector. These figures demand new investments for

manufacturing a new spectrum of export-oriented non-traditional rubber products and more avenues to expand our share in the global market.

Global Rubber Industry Review

NR supply

According to the statistics of the Association of Natural Rubber Producing Countries (ANRPC) total world NR production increased to 15,141 thousand tons in 2023 from 14,360 thousand tons in the previous year 2022 recording nearly a 9% annual increase. This is mainly due to the favourable NR price in the major markets in the Asia Pacific region during the second half of the year and tapping operations around the world becoming normal while overcoming the barriers imposed during the COVID-19 pandemic.

NR average yield

NR average yield (YPH) of the ANRPC countries varied between 624 to 1720 kg/ha/year. Vietnam has recorded the highest national average yield, while Philippines has recorded the lowest which was 624 kg/ha/year. As previously mentioned, the annual average yield of Sri Lanka was 838 kg/ha/yr in the year 2023.

Rubber extent

The total rubber extent in ANRPC countries is estimated at 12,890 thousand hectares in 2023 compared to the value of 12,882 thousand hectares in the previous year. Of the total extent of NR in ANRPC countries, about 75% fall under-tapped area.

Global NR demand

The total NR demand has increased to 15,501 MT thousand tons in 2023 showing a 3.2% decrease from the previous year 2022, which amounted to 15,540 thousand tons according to ANRPC. The world's largest NR consumer was China during the last five years and Chinese consumption is expected to reach 6,710 thousand tons in the year 2023, which was reported as 6,480 thousand tons in the year 2022.

World NR price movement

Despite the declining trend prevailing in most of the markets starting from the year 2011 up to 2018, prices experienced a gradual decline for the years 2021 and 2022. Global prices have shown a gradual recovery in the year 2023. Initially, the price of RSS3 was lower than Thailand's RSS3 prices until June of year 2023. However, starting in November, it saw an increase, reaching US$ 1.70, which surpassed the Bangkok price. The average RSS4 price of the Kottayam market, India has increased starting from March 2023 and decreased slightly up to US$ 1.83 per kg of RSS4 rubber at the end of December. The Indian rubber (RSS4) market behaves comparatively better than the other international markets.

Research and Development Focus

Rubber Research Institute of Sri Lanka recorded another landmark in its history by successfully completing a project in offering National Vocational Qualification-3 along with a beneficiary card - *Kiri Thuru Abhiman* - to 169 Rubber Harvest Assistants (RHAs) for the first time in the country, perhaps in the world, uplifting their social recognition and highlighting the professional tasks they are performing in the harvesting of latex in Rubber Plantations. This is another approach taken by the institute to find a pragmatic solution for the severe shortage of harvest assistants. Also, another project was successfully completed producing multi-skilled rubber farming service providers as an attempt to provide a solution for the shortage of technically competent service providers required for rubber farming activities. These service providers were given a comprehensive training on all aspects of rubber farming and were moulded to provide their services as entrepreneurs getting the contracts from the rubber plantation owners. In addition, a new concept of tapping of untapped rubber lands was initiated during the year as a way forward to arresting the declining NR production in the country.

The Circular Leaf Spot Disease (CLSD) continued to appear during the year 2023 as in the previous years. The disease survey conducted in 2023 showed that a decline in the crop is evident both in diseased and healthy plantations. The crop losses due to the disease and other factors were site-specific and hence recommendations are to be given after studying the individual sites. A national programme was formulated to combat the disease and the practical implementation is to be undertaken jointly with Rubber Development Department, Rubber Research Institute of Sri Lanka and stakeholders.

New genotypes were raised in the annual hand pollination programme at Nuechattle Estate using non-Wickham germplasm selections as the female parent to enrich the *Hevea* breeding pool. Clonal screening for new CLSD continued. Investigations on effectiveness of six different rain guard types were commenced during this year. Two nursery experiments were established in 2023 at the Dartonfield and Monaragala sub-stations representing Wet and Intermediate Zones, to study the clonal variation of stock-scion interaction according to morphological and physiological attributes under nursery conditions in different climatic zones in Sri Lanka. Modified perforated root trainer cones were tested with improved potting medium to raise more vigorous and healthy rubber plants in the nurseries. During the year, smallholder sector was supported by different types of advisory service programmes such as rehabilitation of rubber smallholdings and smoke houses, establishment of intercropping systems, advisory visits and workshops, participation at exhibitions, *etc.* Site specific latex stimulation protocols were proposed for specific low or unproductive rubber lands. Commercial scale testing of the new water-based ethephon formulation developed by RRISL was continued as a private-public partnership programme.

The trials commenced to assess nutrient management for CLSD in mature rubber plantations, alongside identifying management zones using geo-statistical techniques. Newly-developed fertilizer mixtures for nursery and immature rubber plantations were evaluated at Sapumalkanda Central Nursery and two other estates.

Farmer participatory adaptive research trials were conducted in Nuwaragampalata Central and Ipalogama Divisional Secretariats of the Anuradhapura District. Rubber-based farming models were conducted in Thalawa and Nachchaduwa Divisional Secretariats in the Anuradhapura district for demonstration purposes. The rate of adoption of the RRISL recommendations among rubber smallholder fields, medium-scale estates and Regional Plantation Companies of the Kalutara District was assessed and found to be approximately 55%, 60% and 73%, respectively.

Reduced graphene oxide nano sheets, polyethylene glycol (PEG) grafted reduced graphene oxide and copper (Cu) grafted reduced graphene oxide were synthesized and NR composites were produced incorporating the same. Electrical conductivity of 1 phr Cu grafted reduced graphene oxide incorporated NR composite was at a high level. Chemically treated Corn Husk Fibers (CHF), even at a low loading showed its potential to reinforce NR in its composites in the presence of a coupling agent. NR-based erasers were produced using the crepe rubber manufactured at the RRISL Crepe Rubber Factory, Dartonfield, Agalawatta. NR latex-based glue for a wool carpet manufacturing company in New Zealand, dry rubber-based cellular compound for a marine engineering application and deproteinized natural rubber (DPNR)-based reusable hygiene product were the other developments conducted during the year.

Experiments were conducted to find a potential coagulant derived from a naturally occurring acid source to find a replacement to formic acid used as a coagulant in the RSS manufacturing process. This was conducted to address the scarcity and high cost of formicacid prevailed during the past and manufacture RSS in a more sustainable manner. An experiment was conducted to utilize the rubber effluent water which has a considerable level of nitrogen as a liquid fertilizer for growing leafy plants. The plants showed an accelerated growth. However, further research is required to analyze the heavy metal contents in the waste water and these plants, before making a final recommendation.

New statistical methods were applied to socio-economic data in the rubber sector to improve the interpretability of research. Research work focusing on Machine Learning (ML) and Internet of Things (IoT) strategies was initiated in 2023 for the rubber sector. A collaborative research project titled “Use of GIS in rubber plantation management” was continued during the year.

Hindrance of Research Activities

All the administrative procedures were completed to recruit five Research Officers and five Rubber Extension Officers during the year 2023. Total research cadre is 79. Existing research staff is 25. Therefore, there are 54 vacancies when the approved cadre is considered. Among them there are 16 vacancies of Research

Officers at recruitment grade and 26 vacancies of senior grades (Senior Research Officers and Principal Research Officers) making 68.35 % of the research staff positions vacant. Out of 10 research departments only three departments are operated by the head of the department and other seven departments are operated by the junior research officers due to the lack of qualified scientists to appoint to those positions. Shortage of experienced and Senior Research Officers and inability to retain the research staff are crucial issues and adversely affect the guiding of the next generation and continuation of the research and development activities.

Administrative and Financial Functions

The Institute managed to continue R & D activities in prioritized areas with the available limited staff and continued to provide advisory and extension services to the small, medium and large scale rubber plantations and growers. New policies were adopted with the Rubber Research Board approval to streamline the deliveries to the stakeholders. Some of them are: Introduction of Intellectual Policy, Establishment of Clone Release Policy, Establishment of Dartonfield Estate Advisory Committee and RRISL Recommendations Release Policy. During the year under review, attention of the management was focused on to increase the income generation as per the directive given by the Minister of Finance, Economic Stabilization and National Policies in his observations on the Institute's Annual Report of 2021. This attempt yielded positive results with the increase of annual income from Rs.27.62 million in 2022 to Rs.53.2 million in 2023. An Income Generation and Disbursement Policy approved by the Rubber Research Board was submitted to the Ministry of Finance for their approval. Rs.442.25 Mn (CF) and Rs.94.10 Mn (via MPI) of the approved budget was received of which 87.9% was utilized. It was compelled to halt some other development projects scheduled for the year following the guidelines given by the Government due to the dire financial situation and restrictions imposed in the country.

Appreciation

The guidance, directions and financial support given by the Rubber Research Board and the Ministry of Agriculture and Plantation Industries are highly appreciated. Also, the guidance and funding assistance afforded to complete the few special projects during this year are highly admired. Other assistance rendered for conducting the R &D activities smoothly is gratefully recorded. All the categories of Research, Technical and non-Technical staff members of the Institute are also appreciated for their contribution towards the development of the economic situation of the entire country.

In conclusion, the contributions made by the Actg. Additional Director, Actg. Deputy Director - Research (Biology), and all the Heads of the Scientific and Non-scientific Departments/Units in compiling this Annual Review are also gratefully acknowledged. Special appreciations must be accorded to the Agricultural Economics Unit for furnishing required data for this report and to the staff of the Library and Publications Unit for compiling and producing the Annual Review 2023.

GENETICS AND PLANT BREEDING

S P Withanage

DETAILED REVIEW

Staff

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

Research students

M M S K Madigasekara, a student from the Faculty of Animal Science and Export Agriculture, Uwa Wellassa University of Sri Lanka, carried out her final year research project on "Precise selection of *Hevea* genotype(s) from 2014 hand pollinated progeny" under the supervision of Dr (Mrs) S P Withanage.

G M Kahawatta, a student from the Faculty of Animal Science and Export Agriculture, Uwa Wellassa University of Sri Lanka, carried out her final year research project on "Selection of promising genotypes from 2017 hand pollination progeny to reduce the breeding cycle in *Hevea*" under the supervision of Dr (Mrs) S P Withanage.

Meetings/Seminars and Workshops attended

Officer/s	Subject/Theme	Date	Organization
SP Withanage	Writing quality paper workshop	24th Mar.	Dartonfield
	Technology update Meeting	14th Sep.	Dartonfield
	Procurement procedures workshop	3-4th Nov.	Dartonfield
	Estate Committee Meeting	19th Dec.	RRB, Ratmalana
	Scientific Committee Meeting	11th Aug.	RRB, Ratmalana
	Plant Breeding workshop (Indonesia & Malaysia)	17 Sep -27 Sep.	IRRDB
K K Liyanage	Research Meeting	20th March	Dartonfield
	Scientific Committee Meeting	28th April	RRB, Ratmalana
	Taskforce meeting	02nd June	Dartonfield
	Workshop on official letter writing	06th July	Dartonfield
	Technology Update meeting	14th July	Dartonfield
	Scientific Committee Meeting	11th Aug.	RRB, Ratmalana
	Research meeting	01st Sep.	Dartonfield
	Workshop on Pesta disease	04th Sep.	Colombo
	Stakeholders consultative meeting	19th Sep.	NSF- Colombo

Research meeting	02nd Oct.	Dartonfield
Technology Update meeting	13th Oct.	Dartonfield
Technical Advisory Committee Meeting	14th Nov.	Dartonfield

Early detection of promising rubber genotypes (*Hevea brasiliensis*)-precisely to reduce the period of breeding cycle

In conventional breeding approaches, the long breeding cycle is one of the major limiting factors for the genetic improvement of rubber. Studies have been taken to select promising genotypes at the early stages of the breeding cycle using molecular strategies, morphological and physiological parameters. Four outstanding genotypes of 2017 HP selected from the mother plant nursery established at Nivitigalakele Substation were subjected to study *Ref* gene expression and yield performances.

Two genotypes *i.e.* 2017 HP-59 and 2017 HP-60 showing higher latex yields were tested taking the genotype 2017 HP-11 showing medium level yield capacity as the control using the *Ref* gene expression and the yield performances. The Livak method ($2^{-\Delta\Delta CT}$) was used to analyze quantitative gene expression and it was proven that *Ref* gene expression and yields were significantly higher than in the control clone 2017 HP-11. (S P Withanage and N S Jayasinghe).

Screening of drought/stress tolerant *Hevea* clones for sustainable rubber cultivation in marginal areas

This year's experiment was aimed to investigate the drought tolerance of six clones (RRIC 100, RRIC 102, RRISL Centennial 3, RRISL Centennial 4, RRISL 2003, PB 260) in comparison to the already identified drought-tolerant clone, RRIM 600. Six-month-old bud-grafted plants were utilized as both the control and treatment groups. Treatment plants underwent water withdrawal for approximately 10-14 days while physiological data (soil moisture, stomatal conductance, photosynthesis yield, and chlorophyll content) were collected from both control and treatment plants.

Upon observation of stress symptoms in the treated plants and consistent soil moisture readings, RNA was extracted from both the treatments and the control groups. Quantitative analysis/RT-PCR analysis was conducted using the Livak method with synthesized primers. The variation patterns of physiological parameters during the progression of water stress were more or less similar among all six genotypes. However, three clones, PB 260, RRISL Centennial 4, and RRISL Centennial 3, exhibited comparatively higher tolerance to drought conditions than the RRIM 600. Relative quantification of the expression of eight genes in water-stressed *Hevea* clones compared to the drought-tolerant clone, RRIM 600, was tested. The results indicated that PB 260, RRISL Centennial 4 and RRISL Centennial 3 showed significantly higher levels of difference compared to RRIM 600. When considering both physiological and molecular analysis data, PB 260 exhibited greater drought tolerance than the clones RRISL Centennial 4 and RRISL Centennial 3.

Assessment of genotypes from 2022 hand pollinated progeny of *Hevea brasiliensis*: using ref gene expression and genetic diversity

The primary objective of the research was to select high-yielding genotypes exhibiting significant genetic diversity at early stages of the breeding cycle in the 2022 hand-pollinated plant progeny. The study aimed to uncover genetic diversity among the selected genotypes utilizing molecular biological techniques. One specific objective was the identification of significantly divergent genotypes, while another was the determination of latex production based on the *REF* gene expression of the identified genotypes with high genetic variability. Through this investigation, it was possible to identify genotypes with the highest genetic diversity from the hand pollination progeny of 2022. This process will streamline the identification of superior clones with high genetic diversity enriching the *Hevea* genetic pool for future endeavors.

Hand pollination programme

The annual hand pollination programme was done at the Neuchatle estate, and seventeen new genotypes were raised. Two non-Wickham germplasm selections were successfully used as the female parent. Four clones were used as male parents to develop genetically diverse high-yielding vigorous genotypes. Details of new genotypes and crosses made are given in the Table 01.

Table 01. *Details of parentage and the number of genotypes obtained in 2023 hand pollination programme*

Cross	No. of genotypes obtained	Progeny numbers
MT 11-76 i x RRISL 2001	04	2022 HP 01 – 4
MT 11-76 i x RRISL 2006	08	2022 HP 05 - 12
MT 11-76 i x HP 2002-201	03	2022 HP 13 - 15
MT 11-76 ii x RRISL 2001	02	2022 HP 16 - 17
Total	**17**	

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

Multilateral clone exchange programme

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

Filling of vacancies at second adaptability trial established at Galewatta division at Dartonfield group was done. The average girth after the third year, in the

adaptability trial established at Neuchattle estate, is given in Table 02a and the first year girth in the trial established in Galewatta division is given in the Table 02b.

Table 02a. *Average girth of foreign clones established at Neuchatle estate*

Country of origin	Clone	Number of plants	Average girth (cm) 2021	2022	2023
Thailand	RRIT 251	24	10.9	16.3	24.5
	RRIT 3904	24	13.3	21.7	33.8
	RRIT 3604	24	6.0	8.1	10.5
	RRIT 226	24	9.4	17.0	26.8
	RRIT 408	24	9.7	14.0	21.4
India	RRII 414	24	11.6	16.7	22.2
	RRII 417	24	11.4	16.0	22.0
	RRII 422	23	12.5	18.7	28.2
	RRII 429	24	10.1	17.9	29.7
	RRII 430	23	8.1	16.1	23.7
Myanmar	ARCPC 2/4	20	13.3	22.2	34.4
	ARCPC 6/22	26	11.2	17.0	26.1

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

Table 02b. *Average girth of foreign clones established at Galewatta division, Dartonfield estate.*

Country of origin	Clone	Number of plants	Average girth (cm) 2023
Thailand	RRIT 251	62	8.0
	RRIT 3904	80	11.8
	RRIT 3604	80	7.22
	RRIT 226	80	11.83
	RRIT 408	80	6.2
India	RRII 414	100	8.7
	RRII 417	67	8.8
	RRII 422	80	10.5
	RRII 429	78	8.5
	RRII 430	80	8.2
Myanmar	ARCPC 2/4	80	4.9
	ARCPC 6/22	80	5.5

(S P Withanage, K K Liyanage, and N S Jayasinghe)

Evaluation of mother plant nursery

For the early selection of the best-performing genotypes, five-year-old 2017 hand-pollinated progeny was subjected to evaluation. Around forty-seven genotypes that

were in the tapping stage were subjected to evaluation and the progeny was characterized by yield parameters such as girth, latex yield, leaf area, bark thickness and latex physiology parameters such as sucrose content, inorganic phosphorous level, thiol content, and DRC %.

The girth was measured in individual genotypes at the height of 45 cm from the ground level and tapping was done at the same height. Best performing four genotypes were identified.

Table 3. *Girth (cm) at 45 cm, Average bark thickness (mm), and g/t/t of the best-performing genotypes from five year old 2017 hand-pollinated progeny (seedlings) established in mother plant nursery at Nivitigalakale in 2018*

Genotype number	Girth (cm)	Average bark thickness (mm)	Leaf area (mm^2)	g/t/t
2017 HP-59	24.0	5.0	8.06	9.3
2017 HP-60	26.0	5.0	111.43	17.8
2017 HP-63	24.0	4.7	54. 874	3.2
2017 HP-67	31.0	4.0	149.48	2.9

Evaluation of the previous hand-pollinated (HP) progenies

Small Scale Clone Trials

The summary of the small-scale clone trials that were maintained and monitored during the year under review is given in the Table 03.

Table 03. *Summary of the Small Scale Clone Trials*

HP year	Site	Planting season	Current status
2001	Kuruwita SS	Nov 2007	9th year of tapping
2002	Pallegoda I	July 2007	9th year of tapping
2002	Eladuwa II	May 2009	8th year of tapping
2004	Eladuwa Trial I	July 2009	8th year of tapping
2005	Monaragala	Nov 2014	Immature
2006	Payagala	Aug 2012	5th year of tapping
2007	Kuruwita SS (seedlings)	July 2009	7th year of tapping
2010	Eladuwa	Nov 2016	Immature
2011	Eladuwa	Oct 2018	Immature
2012	Eladuwa	Nov 2022	Immature
2013	Eladuwa	Nov 2022	Immature

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

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

Sixteenth-year girth measurements were taken, and the mean girth of clones was grouped using Duncan's multiple range tests, and the results are given in Table 05. Genotype 2002 HP-96 has performed better in comparison to the control clone RRISL 203. Collection of the yield data was disturbed due to the bad weather.

Table 05. *Mean girth of best performing HP entries selected from the 2002 HP progeny planted in 2007*

Clone	Mean girth (cm)
2002HP-96	82.6^{a}
RRISL 203	80.0^{ab}
2002HP-18	78.1^{abc}
2002HP-14	77.8^{abc}
2002HP-11	74.3^{bcd}
2002HP-17	74.2^{bcd}
2002HP-71	72.6^{bcde}
2002HP-69	72.3^{bcdef}
2002HP-24	71.5^{bcdef}
2002HP-77	71.1^{cdef}

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

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

Thirteen genotypes from 2002 hand pollination progeny were planted with two control clones, RRIC 121 and RRISL 203. Randomized Complete Block Design was used with four replicates per genotype. The replicate size was six. The height of the measuring point of the girth was changed from 150cm to 170 cm due to the height of the tapping panel. Fourteenth-year girth was taken, and mean girth values are shown in the Table 6a. Only a few test tappings were possible, and therefore, yield data was not analyzed.

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

Clone	**Mean girth (cm)**	**Clone**	**Mean girth (cm)**
2002 HP-138	78.7^{a}	RRIC 121	64.9^{cde}
2002 HP-93	77.1^{ab}	2002 HP-139	64.8^{cde}
2002 HP-30	72.9^{abc}	2002 HP-78	64.0^{cdef}
2002 HP-66	67.9^{bcd}	RRISL 203	59.6^{defg}
2002 HP-19	65.2^{cde}	2002 HP-62	57.8^{defg}
2002 HP-9	65.2^{cde}	2002 HP-52	56.9^{efg}

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

Evaluation of 2004 HP clones

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

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

The fourteenth-year girth was taken. The HP entries 2004HP-347 and 2004HP-107 showed significantly higher girth and two entries were ranked as similar as the clone RRIC 121 (Table 07).

Table 07. The mean *girth of 14th year of the best performing HP entries selected from the 2004 HP- progeny planted at Eladuwa estate. Mean values with the same letter are not significantly different.*

Clone	Mean girth (cm)
2004 HP-347	68.8^{a}
2004 HP-107	67.2^{ab}
RRIC 121	66.3^{abc}
2004 HP-48	66.1^{abcd}
2004 HP-456	66.1^{abcd}
2004 HP-164	64.8^{abcde}
2004 HP-50	64.8^{abcde}
2004 HP-178	64.5^{abcde}
2004 HP-228	64.0^{abcdef}
2004 HP-190	61.7^{bcdef}

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

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

Sixteen genotypes selected from 2010 HP progeny were planted in the Payagala estate in Completely Randomized Design with the control clones, RRISL Centennial 1 and RRISL 203. All agronomical practices were done according to RRISL recommendations. The eleventh-year girth was taken and the mean girth values of only the ten best-performing genotypes with the control clone are given in the Table 08.

Table 08. *Mean girth for the eleventh year for HP-entries of best performing genotypes with their control clones of the 2006 HP- progeny planted at Payagala estate.*

Clone	Girth (cm)
2006 HP-23	73.1^{a}
2006 HP-128	69.6^{ab}
2006 HP- 135	69.2^{ab}
2006 HP-119	66.5^{abc}

Clone	Girth (cm)
2006 HP-33	63.7^{bcd}
2006 HP-237	63.7^{bcd}
RRISL Cen. 1	62.7^{bcde}
RRISL 203	61.0^{cde}
2006 HP-85	60.9^{cde}
2006 HP-248	59.1^{cde}

(S P Withanage, K K Liyanage and N S Jayasinghe)

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

Fourteenth-year girth data were collected for the seedling progeny and family means are given in Table 09a. Family RRIC 130 x GP 21-163 recorded the highest girth. Sixth year tapping data were collected from the above progeny and family means are given in the Table 09b. Family RRIC 130 x GP 44-24 recorded the highest yield (g/t/t).

Table 09a. *Family mean girth of 2007 HP - progeny planted at the Kuruwita Substation in 2008*

Clone	Mean girth (cm)
RRIC 130 x GP21-163	73.6
RRIC 130 x 1-2	72.0
RRIC 130 x GP22-137	71.8
PB 260 x IAN 45-710	67.0
IAN 45-710 x PB 260	65.4
RRIC 130 x GP10-154	63.3
IAN 45-717 x PB 260	58.8
PB 260 x IAN 45-717	57.5

Table 09b. *Family mean yield of 2007 seedling HP progeny planted at the Kuruwita Substation in 2008*

Clone	Yield (g/t/t)
RRIC 130 x GP21-163	30.66^{a}
IAN 45-710 x PB260	30.42^{a}
PB 260 x IAN 45-710	26.82^{a}
RC 130 x GP10-154	21.41^{a}
RC 130 x GP22-137	19.51^{a}
IAN 45-717 x PB 260	12.76^{a}

(S P Withanage, K K Liyanage and H P Peiris)

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

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

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

Clone	Mean girth (cm)	Clone	Mean girth (cm)
PB 86	52.5^{a}	RRIC 52	47.0^{abcd}
RRIC 103	52.5^{a}	2005 HP-45	47.0^{abcd}
2005 HP-27	52.0^{a}	2005 HP-58	44.6^{abcd}
RRISL 201	50.5^{ab}	2005 HP-06	44.1^{abcd}
2005 HP-02	49.5^{abc}	RRIC 100	43.6^{abcd}
2005 HP-07	48.0^{abcd}	2005 HP-48	43.5^{abcd}

(S P Withanage, K K Liyanage and N S Jayasinghe)

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

Sixteen genotypes selected from 2010 HP progeny were planted in the Eladuwa estate in Completely Randomized Design with control clones, RRIC 121 and RRISL 2001. All agronomical practices were done according to RRISL recommendations. The seventh-year girth was taken and the mean girth values of the ten best-performing genotypes are given in Table 11.

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

Clone	Girth (cm)
2010 HP-38	51.0^{a}
2010 HP-4	50.3^{ab}
2010 HP- 9	48.5^{abc}
2010 HP-41	47.5^{abcd}
2010 HP-11	46.8^{abcd}
RRISL 121	46.6^{abcde}

Clone	Girth (cm)
2010 HP-35	46.4^{abcde}
2010 HP-44	45.6^{abcdef}
2010 HP-22	45.0^{bcdef}
2010 HP-19	44.4^{cdefg}

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

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

Sixteen genotypes selected from 2011 HP progeny were planted in the Eladuwa estate in Completely Randomized Block Design with the control clones, RRIC 121 and RRISL 2001. All agronomical practices were done according to RRISL recommendations. The fifth-year girth was taken (Table 12) and five HP entries showed significantly higher girth and four entries were ranked as similar as the control clone RRIC 121.

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

Clone	Girth (cm)
2011 HP-236	40.4^{a}
2011 HP-75	39.5^{ab}
2011 HP-71	39.3^{ab}
2011 HP-302	39.0^{abc}
2011 HP-300	38.7^{abc}
RRIC 121	37.7^{abcd}
2011 HP-276	37.6^{abcd}
2011 HP-334	37.4^{abcd}
2011 HP-196	37.3^{abcd}
2011 HP-297	37.0^{abcd}

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

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

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

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

Clone	Site	Year of planting	Mean girth (cm)		
			2021	2022	2023
RRISL 201	Dammeria B	2010	51. 9	54.0	55.0
	Eladuwa	2009	61.7	62.2	63.0
RRISL 203	Eladuwa	2009	62.3	62.6	64.0
	Wewassa	2011	61.5	64.5	-
	Lagos	2011	59.7	60.5	61.7
	Lagos	2013	57.3	58.2	59.4
	Muwankanda	2010	56.5	57.0	57.9
	Dammeria B	2010	41.8	42.7	43.3
	Kamburupitiya	2011	68.0	68.6	71.3
RRISL 208	Lagos	2013	56.5	57.3	58.0
	Moralioya	2010	62.6	63.4	65.1
	Eladuwa	2009	58.8	59.5	60.4
RRISL 219	Kuruwita	2008	56.4	56.6	57.0
RRISL 2000	Kuruwita	2005	75.8	76.4	78.7
RRISL 2001	Dammeria B	2010	60.2	62.6	63.8
	Muwankanda	2010	65.2	66.1	67.8
	Wewassa	2011	56.9	58.8	-
	Lagos	2013	56.4	57.5	58.5
RRISL 2003	Lagos	2013	58.4	59.3	60.7
RRISL 2006	Lagos	2013	53.6	55.0	56.4
	Eladuwa	2009	63.5	64.1	65.3
	Moralioya	2010	65.9	66.7	68.6
	Notinghill	2021	-	7.5	12.4
RRISL 2100	Edalla	2010	61.2	62.5	63.5
	Kuruwita	2011	54.9	56.1	57.1
	Notinghill	2021	-	6.0	9.8
RRISL Centennial 2	Eladuwa	2009	68.7	69.2	69.6
RRISL Centennial 3	Kuruwita	2009	62.3	63,3	64.9
	Eladuwa	2009	69.0	69.5	71.3
	We-oya	2010	63.6	65.2	65.9
	Edalla	2010	69.0	70.7	73.2
	Kuruwita	2011	61.6	62.4	63.1
	Siriniwasa	2011	62.1	63.0	63.3
	Lagos	2013	58.9	59.7	60.8
	Notinghill	2021	-	8.6	14.2
RRISL Centennial 4	Kuruwita	2007	60.3	60.6	61.4
	Eladuwa	2009	60.0	60.4	61.0
	Lagos	2011	63.1	64.8	65.7
RRISL Centennial 5	Eladuwa	2009	62.2	62.8	63.8
	Kuruwita	2007	66. 4	67.0	67.9

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

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

Clone	Site	Year of planting	Girth in cm		
			2021	2022	2023
GPS II	Kuruwita	2005	58.7	59.5	60.4
HP 86-10	Kuruwita	2009	53.1	54.1	54.4
HP 86-87	Kuruwita	2009	56.6	57.5	58.9
HP 87-235	Kuruwita	2008	58.7	60.0	61.0
HP 92-129	Kuruwita	2007	83.5	63.9	64.6
HP 95-55	Lagos	2013	61.1	62.6	63.2
RRIC 100 seedlings	Kuruwita	2005	75.4	76.3	77.3
HP 2000-201	Nivitigalakele	2020	8.2	13.6	21.5
MT 11-76i	We-oya	2021	-	5.5	7.6
MT 11-76ii	We-oya	2021	-	5.2	8.5
HP 98-132	Eladuwa	2022	-	-	NT
HP 2000-201	Elasuwa	2022	-	-	NT

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

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

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

Clone	Tapping system	Site	Year of planting	Average yield (g/t/t)	Year of tapping
RRIC 100 (Seedling trial)	S2 d3	Kuruwita	2005	15.05	12th
RRISL 201	S2 d2	Eladuwa	2009	29.63	7th
RRISL 203	S2 d2	Dammaria B	2010	36.95	5th
	S2 d2	Lagos	2011	24.88	7th
	S2 d2	Eladuwa	2009	25.86	7th
RRISL 208	S2 d2	Eladuwa	2009	29.20	7th
	S2 d3	Moralioya	2010	NT	6th
RRISL 219	S2d3	Kuruwita	2008	26.81	9th
RRISL 2001	S2 d2	Dammaria B	2010	50.63	5th
Centennial 2	S2 d2	Eladuwa	2009	17.38	7th
Centennial 4	S2 d2	Kuruwita	2007	16.94	8th
	S2 d2	Lagos	2011	22.73	7th
	S2 d2	Eladuwa	2009	26.37	7th

Clone	Tapping system	Site	Year of planting	Average yield (g/t/t)	Year of tapping
Centennial 3	S2 d2	We-Oya	2010	26.55	7th
	S2 d4	Siriniwasa	2011	34.93	5th
	S2 d2	Eladuwa	2009	20.91	7th
	S2d3	Kuruwita	2011	15.82	6th
	S2d2	Kuruwita	2009	13.22	7th
RRISL 2006	S2 d3	Moralioya	2010	NT	5th
	S2d2	Eladuwa	2009	42.91	7th
Centennial 5	S2 d2	Eladuwa	2009	19.41	7th
	S2 d2	Kuruwita	2007	20.82	8th
RRISL 2000	S2 d3	Kuruwita	2005	12.13	12th
RRISL 2100	S2d3	Kuruwita	2011	16.96	6th

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

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

Clone	Tapping system	Site	Year of planting	Average yield (g/t/t)	Year of tapping
GPS II	S2d3	Kuruwita	2005	34.77	11th
HP 86-10	S2d3	Kuruwita	2009	22.27	6th
HP 86-87	S2d3	Kuruwita	2009	14.09	7th
HP 87-235	S2d3	Kuruwita	2008	11.32	8th
HP 92-129	S2d2	Kuruwita	2007	29.69	8th
HP 95-55	S2d2	Lagos	2013	-	-

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

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

Multiplication, establishment, and scientific evaluation of the *Hevea* germplasm collection continued to enhance productivity through genetic improvement and management of the genetic resources of *Hevea*. Girth data of the newly established germplasm selections at Polgahawela substation and Nivitigalakele substation were collected (S P Withanage, K K Liyanage and B W A N Baddewithana).

Testing of promising clones for sub-optimal conditions

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

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

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

Table 16. *Details of smallholder/RRI collaborative trials at Eastern Province and the nineth 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 12/1	SM Wirawardana Marawa Padiyathalawa	IL2	> 1600	RRISL 2001 RRISL 203 RRISL 2005 RRISL 2006	NT NT NT NT
SRT-EP 12/2	Indrani Kusumalatha Marawa Padiyathalawa	IL2	>1600	RRISL 203 RRIC 121 RRISL 2001 RRISL 2006	NT NT NT NT
SRT-EP 12/3	AM Sumanawathi Helakomana Padiyathalawa	IL2	> 1600	RRISL 203 RRIC 100 RRISL 2005 RRISL 208	NT NT NT NT
SRT- EP12/4	HM Wimalasena Kudaharasgala Mahaoya	IL2	> 1600	RRISL 208 RRISL 2005 RRIC 100 RRISL 203	NT NT NT NT
SRT-WP 12/8	Ranjith Thambawita Bandaragama Panadura (Kalutara district - Control Trial)	WL 1a	>3300	RRISL 208 RRISL CEN 3 RRISL 2001 95HP - 55 RRISL 203 RRIC 100 RRISL 211 RRISL 2005	66.8 66.9 68.3 72.5 64.6 70.3 63.8 68.4

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

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

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

Nineth-year mean girth of three experimental plots established in Ampara area in the Eastern Province was in the table 17. Tapping and processing of latex were practiced but yield data was not collected.

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

Trial	Smallholder & Location	Agro-climatic Region	75% expectancy-value of Annual Rainfall (mm)	Clones planted (No. of trees)	Mean girth (cm)
SRT-EP 13/1	HM Jayarathna 17-1 C, Lathugala Warankatagoda	DL2a	> 1300	RRIC 121(210)	59.3
SRT-EP 13/4	HM Saman Kumara 17/1 B, Lathugala Warankatagoda	DL2a	> 1300	RRISL 203(210)	62.2
SRT-EP 13/5	M Chandrani Ranasingha 51 B - 2, Lathugala Warankatagoda	DL2a	> 1300	RRISL 203 (210)	57.2

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

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

Four experimental sites were established in Bibile area with the collaboration of the World Vision Organization. Seventh year girth data were not taken due to the constraints in travelling. One trial was established in Katharagama and the seventh-year girth data were taken and details are given in the table 20.

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

Trial	Smallholder & Location	Agro-climatic	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)	NT
SRT-UP 15/2-WV	AM Karunawathie Ilukpathana	IL1c	>1300	RRISL 2001 (215)	NT
SRT-UP 15/3-WV	HMW Wijekumara Kudumirisketiya	IL1c	>1300	RRISL 2001 (430)	NT

	Ilukpathana				
Trial	**Smallholder and Location**	**Agro-climatic Region**	**75% expectancy-value of Annual Rainfall (mm)**	**Clones & the number of plants**	**Mean girth (cm)**
Katharagama					
SRT-UP 15/5	GK Chaminda Diyawaragmmana Junction, Sella Rd Kataragama	DL 5	>650	RRISL2001 RRISL 203 (215)	39.5 42.2

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

PLANT SCIENCE

T U K Silva

DETAILED REVIEW

Staff

Dr T U K Silva, Principal Research Officer, Dr (Mrs) D S A Nakandala, Senior Research Officer, Mr W D M N de Alwis, Research Officer, Mr D L N de Zoysa, Mr P D Pathirana and Mr P K W Karunatilaka, Experimental Officers, Mr R Handapangoda, Mrs E U M D Z Dissanayake, Miss H Subasinghe, Mr D Priyadarshana, Mrs U N Udayakumari and Miss W M D Wickramakumari, Technical Officers and Mrs P D A H M A de Almeida, Management Assistant were on duty throughout the year. Mr R Handapangoda, Technical Officer who joined the Department on 2009, resigned from RRISL with effect from 31.05.2023 after 14 years of remarkable service.

Mr R S Kalugalaarachchi, Ananada Sasthralaya, Mathugama completed a research project under NSF school project programme, titled "Increase the Productivity of Plants in Outer Space and Under Adverse Conditions" under the supervision of Dr (Mrs) D S A Nakandala.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Subject/Theme	Number of programmes	Beneficiary/Client	Officers involved
Rubber nursery management, bud grafting and immature upkeep	07	Rubber Development Officers Nursery Managers and related workers	WDMN de Alwis L Zoysa
Nursery management, bud grafting and field establishment, Tapping	03	NIPM students Agricultural Diploma students	TUK Silva DSA Nakandala WDMN de Alwis L Zoysa PKW Karunatilaka
Rubber Nursery Management and Immature Upkeep	05	Rubber Development Department Officers	WDMN de Alwis, L Zoysa, EUM Disanayaka
Rubber Harvesting Assistants-NVQ-RPL Level 3 under Rubber Master Plan Projects	24	Rubber Harvesting Assistants in Regional Plantation companies in Kalutara District	Plant Science Department and Advisory Services Department

Training unskilled Rubber Harvesters in abandoned rubber lands under Rubber Master Plan Project	10	Smallholder sector in Agalawatta region (64 participants trained)	TUK Silva PKW Karunatilaka H Subasinghe D Priyadarshana
Training sustainable harvesting through bark auditing	10	Smallholders RPCs Managers, Field Officers and tappers	TUK Silva PKW Karunatilaka H Subasinghe

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject	Organization
TUK Silva	Fellowship of International Rubber Research and Development Board	Jointly organized by the IRRDB and Malaysian Rubber Board, Kuala Lumpur, Malaysia
TUK Silva DSA Nakandala WDMN de Alwis	Scientific Committee Meeting	Rubber Research Institute
TUK Silva DSA Nakandala WDMN de Alwis	IRRDB workshop on New Circular Leaf Spot Disease	Jointly organized by RRISL and International Rubber Research and Development Board (IRRDB)
TUK Silva WDMN de Alwis	Nursery meeting	Ministry of Plantation Industries and Rubber Development Department
TUK Silva DSA Nakandala	Project Progress Review on Rubber Master Plan Projects	Ministry of Plantation Industries
DSA Nakandala	International Conference on Building Resilience in Tropical Eco-systems	ICBRITAE, Galle Face Hotel, Colombo
	International Symposium on "Sustainable Plantation Management"	NIPM, Queens Berry Hotel, Colombo
WDMN de Alwis	Root trainer progress	Ministry of Plantation Industries, Ministry of Industries and Rubber Development Department
	Rubber, Plastic & fiber based industry related, Research presentation & networking forum 2023	Ministry of Industries
	Initial discussion on developing root trainer cones with DSI international	RRISL

Services

Testing the quality of polythene

Polybag samples for government rubber nurseries and polythene samples for rain guards were checked for quality and specifications made by the RRISL (TUK Silva and H Subasinghe).

Supplying of marking plates

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

Issuing authentic budwood

The distribution of budwood was stopped temporarily during the year 2022 and issued budded plants in order to establish their own budwood nurseries in the commercial nurseries (TUK Silva WDMN de Alwis DLN De Zoysa).

Issuing authentic budded plants

A total of 6,277 rubber plants were distributed to enhance the clonal composition of 11 plantation companies (Table 1) and the clonal composition (Table 2) and smallholder nurseries (Table 3). Specifically 5,862 plants were supplied to the plantation companies, while 415 plants were allocated to smallholders. The distribution was carried out under the supervision of the Plant Science Department, utilizing plants from the Sapumalkanda Estate, which is managed by the Lalan Group, along with the Gurugoda and Egaloya nurseries of the Rubber Development Department. Distribution of bud-wood plants is given in the Table 4.

Table 1. *The authentic budded plants supplied to plantation companies*

Plantation Company	**Total Plants Supplied**
Agalawatte Plantation	785
Kotagala Plantation	1040
Kegalle Plantation	1180
Kellani Valley Plantation	975
Elpitiya Plantation	225
Pussellawa Plantation	542
Hapugasthenna Plantation	270
Lalan Plantation	135
Plantation Company	**Total Plants Supplied**
Malwatta Valley Plantation	190
Dartonfield Plantation	405
Balangoda Plantation	115
Total number of plants	5,862

Table 2. *Distribution of clones by the number of plants supplied*

Clone	Number of Plants Supplied
RRIC 102	280
RRIC 100	300
RRIC 130	510
RRIC 133	140
PB 260	1,624
PB 28/59	50
PB 217	20
PB 86	135
Centennial 3	41
Centennial 4	935
Centennial 5	350
RRISL 2100	240
RRISL 2000	767
RRISL 2001	405
RRISL 2004	270
RRISL 2006	230
RRISL 201	385

Table 3. *Total Plants Supplied to private nurseries*

Smallholder Nursery	Total Plants Supplied
Mr S Senevirathne	90
Mr Jayarathne	60
Mr S Ananda	65
Mr Ranawaka	75
Mr Witharana	50
Mr Wijerathne	55
Mr A Isadeen	20
Total Plants Supplied to All Smallholders	415

Table 4. *Distribution of Budwood Nursery Plants by Clone*

Clone	Number of Plants Supplied
RRIC 102	35
RRIC 100	50
PB 86	30
Centennial 4	115
Centennial 5	60
RRISL 2001	20
RRISL 2006	140

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

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

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

New clones established in RDD bud wood nurseries

Budded plants were issued to RDD nurseries and the details of the established plants are given in the Table 6.

Table 6. *Establishment of new clones in RDD bud wood nurseries during the year 2023*

RDD Nursery	Clone	Year of planting	No of plants
Egaloya	RRIC 102	2023	250
	RRIC 100	2023	500
	RRIC 121	2023	400
Gurugoda	RRISL 2006	2023	50
Moneragala	RRIC 102	2023	100
	Centennial 3	2023	60
Welikadamulla	RRISL 2006	2023	93
Meerigama	RRISL 2006	2023	104

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

Nursery Inspection

Government, RPC, and private nurseries were inspected and details are given in Tables 7, 8 & 9. The inspection reports have been issued timely.

Table 7. *Details of government nurseries established in Jan 2022, August 2022, January 2023, and August 2023*

Nursery	Season	No. of plants established	No. of plants Certified
Egaloya	2022 Jan	100,000	18,240
	2022 Aug	155,178	17,709
	2023 Jan	53,622	
	2023 Aug	70,000	
Gurugoda	2022 Jan	171,391	18,068
	2022 Aug	165,000	
	2023 Jan	35,000	
	2023 Aug	50,000	

Nursery	Season	No. of plants established	No. of plants Certified
Karapincha	2022 Jan	90,000	14,800
	2022 Aug	90,000	29,147
	2023 Jan	33,946	
	2023 Aug	47,400	
Meerigama	2022 Jan	100,000	49,060
	2022 Aug	200,000	66,005
	2023 Jan	Not established	
	2023 Aug	130,548	
Welikadamulla	2022 Jan	280,000	76,805
	2022 Aug	220,000	67,000
	2023 Jan	Not established	
	2023 Aug	160,000	
Middeniya	2022 Jan	72,550	14,312
	2022 Aug	94,254	14,878
	2023 Jan	52,000	
	2023 Aug	50,000	
Moneragala	2022 Jan	186,898	
	2022 Aug	213,852	
	2023 Jan	76,000	
	2023 Aug	284,650	
Padiyathalawa	2022 Jan	50,000	3,500
	2022 Aug	71,000	28,744
	2023 Jan	10,534	1,223
	2023 Aug	120,000	
Total		**3,303,289**	**419,491**

Table 8. *Details of RPC nurseries established in 2023 January*

Regional Plantation Company	No. of estates with nurseries	No. of nurseries for the RPCs	No. of plants established in 2023	No of plants certified
Agalawatte	5	5	303,450	13,500
Kegalle	8	11	133,390	45,912
Kelanivally	4	4	80,843	8,000
Kotagala	5	6	37,250	
Lalan	1	1	65,000	
Pussellawa	5	6	207,850	91,800
Elpitiya	1	1	14,000	6,000
Namunukula	1	1	40,180	
Total	**30**	**35**	**881,963**	**165,212**

Table 9. *Details of private nurseries established in 2023 January*

Region	No. of nurseries	No. of plants established	No. of plants certified
Kegalle	10	159,388	56,708
Rathnapura	3	95,500	57,194
Moneragala	4	155,600	?
Kalutara	1	145,000	33,000
Total	**18**	**555,488**	**146,902**

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

Inspection of bud-wood nurseries

All bud-wood nurseries belonging to the Rubber Development Department, RPCs, and Private nurseries were inspected (T U K Silva, W D M N de Alwis, D L N de Zoysa, and R Handapangoda)

Discarding weak plants in rubber nurseries

Discarding weak young budded plants and unsuccessful seedling plants in RDD nurseries was done in the presence of officials from both RRISL and RDD. This program was started in the year 2022 to avoid issuing poor-quality plants to the field. Details are given in Table 10.

Table 10. *Number of weak plants discarded from 2022 January and 2022 August nurseries*

Description	No. of established plants	No. of plants discarded
RDD nurseries	3,229,814	106,663
RPC nurseries	739,533	151,090
Private nurseries	399,888	85,353

The number of plants issued to the fields by the RDD, RPCs, and private nurseries without the RRISL certification is given in Table 11. It is shown that approximately 731,605 plants were issued to the farmers without undergoing the certification process and should be controlled in the future.

Table 11. *The number of budded plants issued without certification - weak plants discarding*

Nursery		No. of budded plants issued without adhering the discarding of weak plants	Total
RPC	Agalawatta	119.230	
	Kegalle	14,354	
	Hapugasthenna	1,890	
	Pussellawa	40,655	176,129
RDD	Egaloya	38,164	
	Karapincha	16,187	
	Gurugoda	60,730	
	Meerigama	61,113	
	Padiyathalawa	49,200	
	Moneragala	180,453	
	Welikadamulla	117,432	523,279
Private	Kegalle	73,930	
	Rathnapura	6,000	
	Monaragala	22,879	102,809

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

Visits

Advisory	-	25
Experimental	-	83
Nursery inspection	-	236
Total	-	**344**

LABORATORY INVESTIGATIONS

Tissue culture

Renovation of the tissue culture laboratory was almost completed, Installation of some equipment was done and arrangements of the interior of the laboratory have been completed. Tissue culture work will be done next year onwards (T U K Silva and H Subasinghe).

FIELD EXPERIMENTS

Nursery Techniques

Development of rapid bud grafting technique

This experiment was started in the Meerigama and Padiyathalawa RDD nurseries in the year 2022 to provide a practical solution for the shortage of skilled bud

grafters. Details of the experiment on the new technique and the success rate of the bud grafting were reported in Annual Review 2022. After successive bud grafting, the phenology of bud break and sprouting under each bud grafting technique was observed in 2023. Table 12 and 13 show the days taken for bud breaking and sprouting of plants in the experiments carried out at Meerigama and Padiyathalawa RDD nurseries.

Table 12. *Duration taken for bud break and sprouting of budded plants at Meerigama nursery*

Bud-grafting technique	Average days to bud break after the cutback	Days for optimal bud sprouting after the bud break
Traditional	5	10
Rapid	5	10

Table 13. *Duration taken for bud break and sprouting of budded plants at Padiyathalawa RDD nursery*

Bud-grafting technique	Average days to bud break after the cutback	Days for optimal bud sprouting after the bud break
Traditional	12	7
Rapid	12	7

These results explained that both bud grafting techniques are considered to be effective in bud grafting at large-scale rubber nurseries.

Juvenile Bud-grafting Method

The experiment was started in 2022 at Meerigama and Padiyathalawa RDD nurseries with one and half months old seedling plants. The objective is to produce two whorled budded plants at a stipulated time, *i.e.* with the onset of the planting season in order to increase the establishment and survival rate at the field.

Treatments were;

T1- Juvenile bud grafting method

T2- Traditional bud grafting method (control)

Once the plants were bud-grafted using the above methods, they were kept in the nursery for about 9 months before transplanting them to the field. Tables 14 &15 showed the growth attributes of three-month and nine-month-old budded plants before transplanting.

Table 14. *Growth attributes of the budded plant after 3 months*

Treatment	Stem Diameter (mm)	Plant Height (cm)	No of leaves	Leaf chlorophyll content (SPAD Unit)
T1	8.2 ±0.1	48.2±0.9	17.9±0.4	50.9±0.90
T2	8.2±0.3	49.9±2.2	16.5±0.7	41.0±0.7

Table 15. *Growth attributes of the budded plants after 9 months*

Treatment (Bud grafting techniques)	Stem height cm per plant	Stem diameter mm per plant	Average no of leaf whorls per plant
T1	100.8±45.07	10.96±4.90	3.46
T2	56.52±25.27	8.26±3.69	2.41

Results revealed that the juvenile bud-grafted plants showed higher growth performance of scion than the traditional bud grafting methods (M N De Alwis, U N Udayakumari, L Soyza and W M D Wickramakumari)

New porous root trainer experiment

A new experiment on modified root trainers for rubber nurseries was commenced at the central rubber nursery in Sapumalkanda Estate (Managed by the Lalan Group) to investigate the effect of different types of root trainers and potting media on the growth of young budding plants. The study was conducted in August 2023 and employed a Randomized Complete Block Design (RCBD) with 16 treatments. Young budding plants in 15.24 cm x 38.1 cm (6.95dm^3) black polythene bags that are filled with top soil medium was taken as the control. Treatment combinations are shown in Table 16. The data collected from 640 plants were analyzed to evaluate the performance of different types of root trainers and potting media.

Table 16. *Treatment combinations of Root Trainer experiment*

Treatment	Type of container and potting medium
C1M1	Non Perforated+100% coir pith
C1M2	Non Perforated+75% coir pith + 25% compost
C1M3	Non Perforated+50% coir pith + 50% compost
C1M4	Non Perforated+25% coir pith+ 75% compost
C1M5	Non Perforated+100% compost
C2M1	Scattered Perforated+100% coir pith
C2M2	Scattered Perforated+75% coir pith +25% compost
C2M3	Scattered Perforated+50% coir pith+50% compost
C2M4	Scattered Perforated+25% coir pith+75% compost
C2M5	Scattered Perforated+100% compost
C3M1	Perforated on edges+100% coir pith
Treatment	**Type of container and potting medium**
C3M2	Perforated on edges+ 75% coir pith +25% compost
C3M3	Perforated on edges+ 50%coir pith +50% compost
C3M4	Perforated on edges+ 25%coir pith + 75% compost
C3M5	Perforated on edges+ 100% compost pith
Control (YB)	Polybag plant + top soil medium

Plant growth parameters, including height, girth, root length, number of leaf whorls, chlorophyll content, dry matter content, root shoot ratio, bud-grafting success, and shoot sprouting time were measured at regular intervals to assess the effects of treatments on plant development. The temperature of the medium of each treatment was also taken during the daytime.

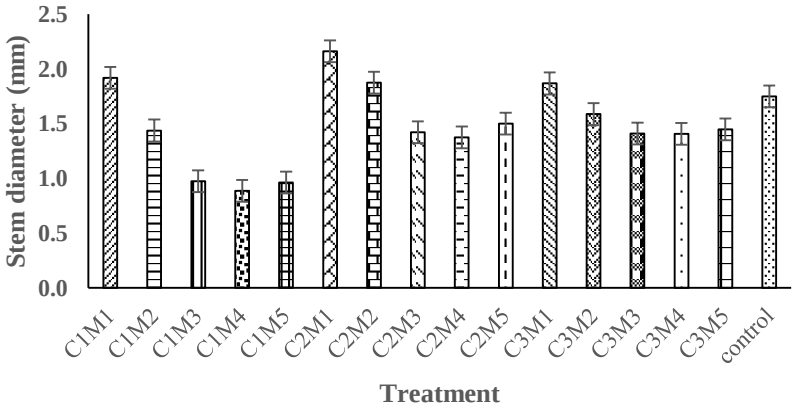


Fig. 1. Mean stem diameter of a plants across different treatments at 1 month after planting

The growth of plants in terms of diameter (mm), one month after planting is shown in figure 1 and C2M1 recorded the highest growth performance.

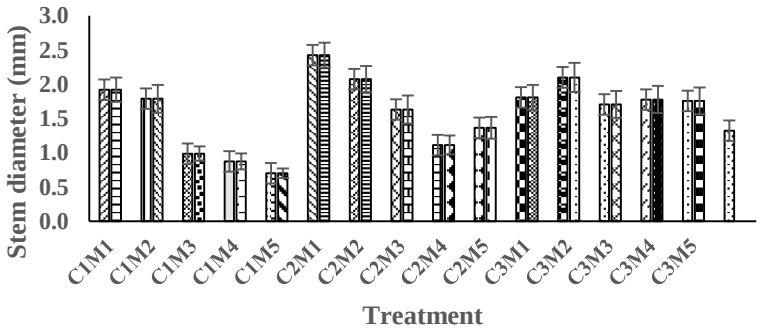


Fig. 2. Mean stem diameter of plants across different treatments, 3 months after planting

According to the Figure 2, the girth increment gained in one month that C2M1 and C2M2 have obtained a better girth increments (mm).

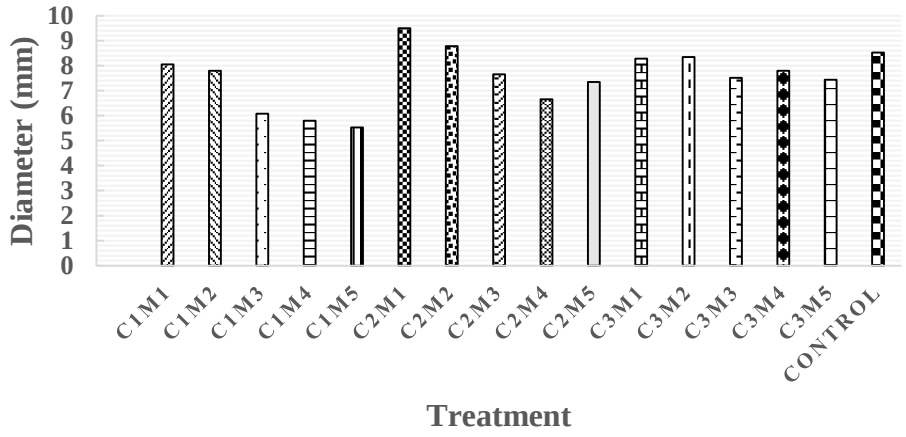


Fig. 3. Mean stem diameter of plants across different treatments at 4 months after planting

According to Figure 3, the girth gained after four months, C2M1 and C2M2 have obtained comparatively better diameters of stock plants compared to other treatments. Growth of young budding plants in poly bags under control treatment showed comparable results with the root trainers.

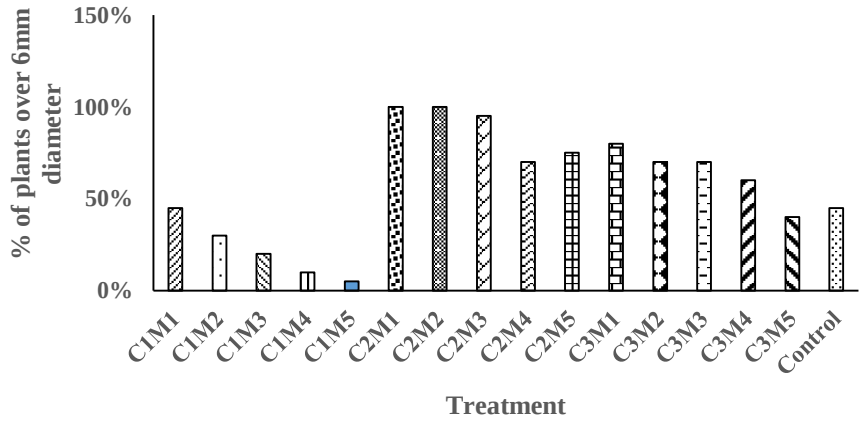


Fig. 4. Percentage of plants over 6mm diameter, in different treatments after 3 months of planting

According to Figure 4, the treatments C2M1 and C2M2, showed the highest number of plants with a stem girth of 6 mm or greater after a period of 3 months.

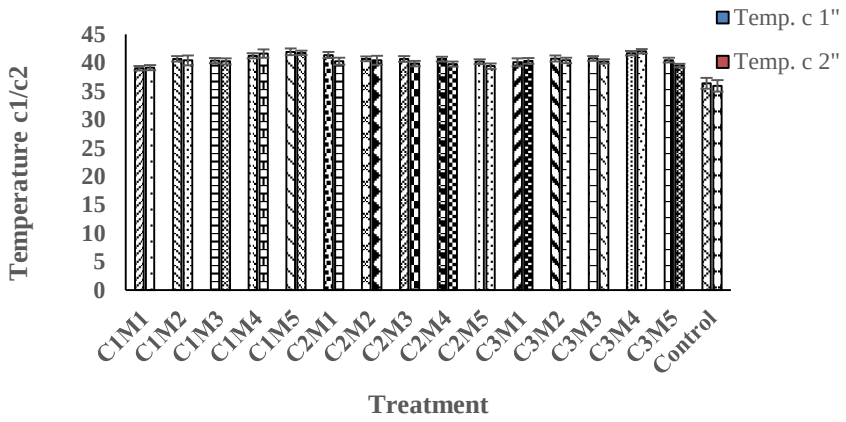


Fig. 5. Temperature variation of the soils in different media at the depths of 1 inch and 2 inches

There were no significant variations of soil temperature in all treatments tested. (W D M N de Alwis and L Zoysa).

Impact of Stock - Scion Interaction on the growth and Rubber yield of *Hevea brasiliensis*

To study the impact of stock-scion interaction on the growth performance of young rubber nursery plants under wet and dry climates, two nursery experiments were established at the Dartonfield and Moneragala Sub Station in January, 2023. The clonal variation of stock-scion interaction according to morphological and physiological attributes under nursery conditions in different climatic zones was assessed during the nursery period. Rubber seeds from isolated fields of four clones *i.e;* RRIC 121, RRIC 100, PB 86 and RRISL 2001 were collected with the onset of December-January seed fall and two rootstock nurseries were established with 1000 plants at each nursery in the Dartonfield estate and Moneragala substration. The seedling nurseries were established according to Randomized Complete Block Design with three replications for each treatment having 60 seedlings. Unselected mixed clone seedlings were kept as the control. Once the seedlings reached the bud-grafting stage, plants were bud-grafted with each clone as depicted in Table 17. However, the plants in the nursery established in Moneragala Substation were bud grafted only with the clone, RRIC 100 to observe the clonal compatibility on one clone (Table 18). Percentage bud grafting success was recorded one month after grafting (Table 17 and 18).

Table 17. *The treatment combination and success rate (%) of stock-scion plants after bud grafting at Dartonfield Nursery*

Stock	Scion			
	RRIC 121	**RRIC 100**	**PB 86**	**RRISL 2001**
RRIC 121	100	94.4	82.6	73.1
RRIC 100	91.1	100	75	83.3
RRISL 2001	96	93.1	79.2	80
Unselected	100	89.3	76.7	81.6

Results of the study revealed that bud grafting success was more than 90% with all the rootstocks when grafting was practiced with the clone RRIC 121 and 100. All rootstocks including unselected stocks were performed well in grafting of RRIC clones than PB 86 and RRISL 2001. Further higher compatibility was shown selecting stock and scion from same clone especially in RRIC 121 and RRIC 100.

The seedlings of different clones established at the Moneragala nursery and bud-grafted using the clone RRIC 100 to observe the compatibility for one clone and the success rate of each seedling raised from particular clone was recorded in Table 18.

Table 18. *The treatment combination and success rate (%) of stock-scion interactions after bud grafting at Moneragala Sub Station nursery*

Stock	Scion
	RRIC 100
RRIC 121	94%
RRIC 100	99%
PB 86	92%
RRISL 2001	91%
Unselected	94%

(D S A Nakandala and U N Udayakumari)

Direction of row planting systems for rubber nursery plants

The growth of the scion of the nursery plants on the directions of plants placing *i.e.,* T1- East-West oriented (Control) and T2- North-South oriented was observed to investigate the effect of row direction arranged in the nursery on scion growth. Experiment design and data on plant growth before bud grafting were recorded in the Annual Review 2022. Table 19 shows the growth attributes of scion after bud grafting under two directions.

Table 19. *Effect of row orientation on scion growth parameters in rubber nursery six months after cut-back*

Treatment	Diameter of shoot(mm)	Height of shoot (cm)	No of leaf whorls	Internodal length (cm)	Chlorophyll content
1	8.6 ±0.7	65.1±4.4	2.0±0	27.2±3.5	48.2±3.8
2	9.8±0.9	71.4±4.4	2.0±0	32.7±5.5	46.6±2.2

A difference of growth parameters was observed for the scion according to the directions and results were comparable for both directions (W D M N de Alwis, U N Udayakumari and E U M D Z Dissanayake).

Irrigation systems for rubber nurseries

A new irrigation experiment was commenced under sprinkler irrigation systems in two RDD rubber nurseries at Gurugoda and Egal-oya in January, 2023 in order to study different potting media and trenching techniques for increasing moisture retention ability in soils while enhancing plant growth and improving irrigation water use efficiencies. The trial was commenced as two-factor design with different potting mixtures and trenching techniques with or without the application of coir pith. Two seedling nurseries consisting of 5000 plants of each nursery were established according to Randomized Complete Block Design (RCBD) with five replicates each containing 100 plants in double row system. Treatments were as follows;

Factor 1: Different potting media

1. Top soil mixture (control)
2. Top soil mixture : Coir pith=1:1
3. Top soil mixture : Burnt Rice Husk= 1:1
4. Top soil mixture : Coir pith: Burnt Rice Husk=2:1:1
5. Top soil mixture : Coir pith: Compost=2:1:1

Factor 2: Trenching techniques

1. Trench with coir pith.
2. Trench without coir pith

Further, poly bags were filled with the above potting mixtures in two different techniques separately for two nurseries as the sandwich method and full mixture method for Egal-oya and Gurugda rubber nurseries respectively. These experiments were managed as two experiments and data were recorded separately in collaborated with the Soils and Plant Nutrient Department. Plants were irrigated with sprinkler system during dry periods with the irrigation frequency of once in two days for 30 days. Growth data in the two respective experiments on plant stem diameter and chlorophyll content were recorded in Table 20 and 21.

Table 20. *Growth performance of seedling plants of different treatments at Gurugoda RDD Nursery under sprinkler irrigation*

Factor 1 Potting mixtures (Full mixture method)	Factor 2 Trench with /without coir pith	Diameter (mm)	leaf Chlorophyll content (SPAD unit)
Top soil (control)	with coir pith	10.5	52.8
Top soil (control)	without coir pith	10.0	52.6
Top soil : Coir pith=1:1	with coir pith	11.2	53.4
Top soil : Coir pith=1:1	without coir pith	10.6	52.0
Top soil : Burnt Rice Husk= 1:1	with coir pith	10.6	51.5
Top soil : Burnt Rice Husk= 1:1	without coir pith	10.0	51.2
Top soil : Coir pith: Burnt Rice Husk=2:1:1	with coir pith	10.3	52.7
Top soil : Coir pith: Burnt Rice Husk=2:1:1	without coir pith	10.0	51.0
Top soil : Coir pith: Compost=2:1:1	with coir pith	10.8	51.3
Top soil : Coir pith: Compost=2:1:1	without coir pith	10.2	50.9

Table 21. *Growth performance of seedling plants of different treatments at Egal-oya RDD Nursery under sprinkler irrigation*

Potting mixtures (Sandwich method)	Trench with/without coir pith	Diameter (mm)	leaf Chlorophyll content (SPAD unit)
Top soil (control)	with coir pith	10.0	57.9
Top soil (control)	without coir pith	9.9	58.1
Top soil : Coir pith=1:1	with coir pith	10.2	54.6
Top soil : Coir pith=1:1	without coir pith	10.2	54.4
Top soil : Burnt Rice Husk= 1:1	with coir pith	9.0	55.6
Top soil : Burnt Rice Husk= 1:1	without coir pith	8.5	56.7
Top soil : Coir pith: Burnt Rice Husk=2:1:1	with coir pith	9.8	56.3
Top soil : Coir pith: Burnt Rice Husk=2:1:1	without coir pith	8.3	54.4
Top soil : Coir pith: Compost=2:1:1	with coir pith	10.4	53.4
Top soil : Coir pith: Compost=2:1:1	without coir pith	8.5	49.1

Results showed that the seedling plants kept in trenches where coir pith put in to it, recorded a higher growth irrespective of different potting media and method of

filling. Considering the potting media and method of filling, soil mixtures with top soil:coir pith=1:1 and top soil:coir pith: compost=2:1:1 ratios have shown better performance under coir pith trenches for full mixture and sandwich method respectively (D S A Nakandala, R Jayawardhana, and U N Udayakumari).

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

Young budding plants raised in polybags of different sizes were established in 2020 at Dapiligoda, Dartonfield Estate. Regular maintenance was carried out by the estate throughout the year, and the data collected during the experimental period are currently being analyzed (D S A Nakandala and U N Udayakumari).

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

Young budding plants established in two different colour of polybags (Black and transparent) in the standard size (6"x15") were planted in 2020 at Dapiligoda of Dartonfield Estate and regular maintenance was done by the estate throughout the year. Data gathered during the experimental period are being analyzed (D S A Nakandala and E U M D Z Dissanayaka).

Morphological and physiological evaluation of rubber clones for climate-specific adaptation in Sri Lanka (CLADSR Metric)

The study was conducted in January and August 2022 in Moneragala (intermediate climate) and Gurugoda (wet climate) regions in Sri Lanka. Various rubber clones were evaluated for morphological traits and bud grafting success in nursery conditions. Data collection included measurements of leaf color, internode lengths, angle of the scion, girth of the scion, and axillary bud morphology.

Data gathered were recorded in the Table 11. The results demonstrates that clones exhibited distinct morphological traits across different regions, aiding in the identification of high-quality planting materials specific to each clone and region.

Table 22. *Morphological growth characteristics of rubber clones in the intermediate zone*

Clone	Length of the 1st internode (cm)	Length of the 2nd internode (cm)	Angle of scion shoot	Girth of the scion shoot at 1 cm from the bud union (cm)	Bud grafting success (%)	Leaf colour	Axillary bud
Centennial 4	14.67±0.42	8.30±0.44	27.14±0.69	9.29±0.19	94	7.5GY 3/4	Protruded
RRISL 2006	20.97±044	10.92±0.27	38.98±0.70	8.99±0.28	96	7.5GY3/2	More or less protruded
RRISL 211	14.12±0.56	9.36±0.84	35.71±1.14	8.81±0.16	87	7.5GY3/4	More or less protruded
RRISL 208	16.30±1.02	8.14±0.55	35.46±1.34	8.71±0.28	91	7.5GY 3/4	More or less protruded
Centennial 5	12.55±0.44	7.66±0.61	33.61±1.01	8.58±0.17	91	7.5GY 3/4	Normal
RRIC 121	19.37±0.38	10.54±0.33	42.00±1.12	8.49±0.30	95	7.5GY 3/4	Normal
RRISL 201	18.33±0.54	10.22±0.35	39.57±0.98	8.33±0.34	92	7,5GY4/6	More or less protruded
RRISL 130	13.30±0.38	6.01±0.32	42.46±1.23	8.30±0.36	87	7.5GY3/4	Normal
Centennial 3	13.81±0.52	10.47±1.04	41.00±0.80	8.30±0.16	90	7.5GY3/4	More or less protruded
RRISL 2001	16.66±0.51	7.90±0.41	39.07±1.31	8.03±0.22	95	7.5GY3/4	Normal
RRISL 219	17.67±0.51	11.17±0.43	40.90±1.07	7.58±0.25	90	7.5GY3/4	Normal
PB 86	16.07±0.66 8.42±0.56	6.93±0.25	46.35±0.70	6.93±0.25	85	7.5GY3/4	Normal
RRISL 203	15.91±0.49	8.37±0.46	37.56±1.58	6.67±0.16	91	7.5GY3/4	Normal
RRIC 100	15.22±0.47	9.70±0.49	19.35±1.37	6.41±0.18	88	7.5GY4/6	Normal
RRIC 102	20.88±0.84	10.85±0.67	44.14±2.61	6.37±0.14	92	7.5GY4/6	More or less protruded
RRISL 217	14.55±0.66	9.34±0.78	38.61±1.04	6.36±0.26	87	7.5GY4/6	More or less protruded

Table 23. *Morphological growth characteristics of rubber clones in the wet zone*

Clone	Shoot length (cm)	Inter whorl Length	Diameter (mm)	Angle (between stock and scion)	Chlorophyll (SPAD)
Centennial 4	51.36	28.5	8.675	24.33	47.82
RRIC 102	63.46	35.43	8.86	28.66	36.84
Centennial 3	43.23	17.63	8.03	25	42.77
RRISL 2001	55.16	28.6	9.1	33.2	45.52
PB260	58.7	32.66	8.36	27.66	43.81
RRIC 133	62.47	36.43	8.9	27.05	36.7
RRISL2004	48.86	23.76	9.63	25.33	40.08
PB217	51.16	22.01	7.48	29.72	50.74
PB86	52.53	25.13	8.16	27.05	48.56
RRIC100	52.71	27	9.47	26.83	45.14
PB28/59	51.36	36.73	9.47	30	45.94
C5	55.4	24.56	9.47	22	35.83

(W D M N de Alwis, L Zoysa, R Handapangoda and E U M D Z Dissanayaka)

Planting techniques

Stumped budding experiment (SB/2016/Moneragala)

A stumped budding experiment was established at the Moneragala Substation in November 2016. Regular maintenance, including manuring and circle weeding, was done throughout the year. The annual girth of the treatment plants *i.e.*, normal budded stumps (control) and whole plants with root balled was recorded in Table 24. According to the data, 65% of the total stand has reached the girth above 45 cm and tapping will be commenced in the year 2024.

Table 24: *Mean annual girth of stumped budded plants and root balled plants*

Treatment	Girth (cm)
Whole plant root balled	45.5±0.6
Stumped budded plants	40.6±0.9

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

Evaluation of the air pruning mechanism and root ball longevity in nursery plants: A case study from Madeniya estate (August 2023)

This study investigates the effectiveness of the air pruning mechanism in promoting root ball development and evaluates the duration for which root ball plants can be sustained in a nursery environment. The experiment was conducted at the nursery of Madeniya Estate in August 2023, focusing on the growth performance and root system integrity of plants subjected to air pruning (W D M N de Alwis, D L N de Zoysa and W M D Wickramakumari).

Optimizing canopy development and yield in rubber plantations: enhanced contour planting strategies across diverse slope gradients

To evaluate the impact of contour distance on canopy development and rubber yield using an improved planting system. Rubber plantations in Pussellawa, Kegalle and Lalans, focusing on lower, middle, and higher slope conditions.

Data on *Hevea* clones was collected by measuring contour distance, girth, planting year, SPH, elevation, slope degree, and shape using altimeters and clinometers. The study compared conventional and improved contour planting methods to assess their effects on canopy growth and yield (W D M N de Alwis, L Zoysa and W M D Wickramakumari).

Mechanization of planting holing (PT/HE/2020/Moneragala*)*

An experiment was set up to introduce a new tractor-mounted auger (a digger machine) to the farmer fields in the Moneragala District. The experiment was established at three fields of Kumarawatta Estate in Moneragala with the onset of North-East monsoon rains in 2020. General maintenance was done by the estate. Data gathered during the experimental period are being analyzed. (D S A Nakandala and P K W Karunathilaka)

Cultural practices during the immature phase

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

This experiment was established in 1992 and yield data was not recorded from 2020, considering the age of the plantation. Total assessments of timber, fuel and biomass are to be conducted when uprooting in the next year (T U K Silva and H Subasinghe)

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

This experiment was established at the Galewatta Division of the Dartonfield Group in July 2020 and a smallholder field in the Moneragala District was established in the year 2022 with four promising clones: RRISL 201, RRISL 2006, Centennial 4, and RRIC 121. The objective of this study was to evaluate the growth, physiological, and molecular biological variations of different rubber clones under different climatic conditions. Data recorded on plant girth at the field established at Galewatta were tabulated in Table 25. According to data gathered so far, RRISL 2006 and Centennial 4 recorded comparatively higher girth after three years of planting in the wet zone.

Table 25. *Variation in plant girth of different clones under wet climatic conditions*

Clone	Stem girth at 120 cm height (cm)
RRISL 201	19.8 ±0.9
RRISL 2006	21.5 ±0.8
Centennial 4	21.0 ±0.9
RRIC 121	18.8 ±0.8

Data recorded on girth of the plants six months after the establishment in Moneragala field trial were tabulated in Table 26. The RRIC 121 recorded a comparatively a higher girth and the clone Centennial 4 followed the higher girth when compared the clone RRISL 201 and 2006 under dry climates with sub-optimal conditions in the intermediate zone.

Table 26. *Variation of plant girth of different clones under dry climatic conditions*

Clone	Basal stem girth (cm)
RRISL 201	3.4 ±0.5
RRISL 2006	3.5 ±0.3
Centennial 4	3.7 ±0.6
RRIC 121	4.0 ±0.5

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

Exploitation

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

The objective of this experiment was to investigate the possibilities to increase the productivity of rubber plantations through the management of bark consumption rates. A rubber field established in 2006 with RRIC 121 clone at Sirikandura estate was selected for the study. Six tapping systems were employed as treatments (Table 27). The experiment was designed according to a Randomized Complete Block Design (RCBD) with three replications of each treatment. Growth and yield data were recorded (Table 28). Out of the six treatments T6 and T5 were recorded with higher g/t/t values than the other treatments due to the lower tapping intensity. Treatment 1 recorded moderate value. The T2 and T3 recorded the lowest values due to the effects of both higher frequency.

Table 27. *Description of tapping systems employed as treatments*

Treatment	Tapping system
T1	S/2 d2 + Recommended number of recovery tappings per month (control)
T2	S/2 d1 + Without rain guards or recovery tapping (smallholder Practice)
T3	S/4 d1 + With rain guards (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 d6 5% ET (monthly)

Table 28. *Mean girth, bark thickness and yield (g) per tree per tapping (g/t/t) under different tapping systems*

Treatment	Mean girth (cm)	Mean bark thickness (mm)	Yield (g/t/t)
T1	74.2	8.6	29.7
T2	76.8	8.8	25.2
T3	77.2	8.5	24.2
T4	73.7	8.3	28.4 20.2*
T5	72.6	7.9	35.6
T6	73.8	8.2	36.5

* g/t/t recorded from supplementary holiday tapping (T U K Silva, H Subasinghe and D Priyadarshana)

Intercropping

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

This intercropping field was established as a demonstration plot at the RRISL substation in Moneragala. The growth of rubber trees in terms of girth under different planting systems is given in the Table 29. At present, cinnamon, guava and mango plants can be seen as perennials in this area. After maturity of rubber, short term crops like pineapple and banana have been replaced by cocoa.

Table 29. *The girth of rubber trees under different intercropping systems and spacing arrangements*

Intercropping system	Spacing of rubber (m)	Girth of rubber (cm)
Rubber x Pineapple	Single row system	66.8
Rubber x Banana	2.5 m x 7.75 m	66.3
Rubber x pomegranate/Guava	Single row system	59.6
Rubber* x pomegranate*/Guava*	2.5 m x 12 m	52.3
Rubber x Cinnamon	Paired row system	65.5
Rubber x Mango/Rambutan	(3 m x 3 m) – 18 m	61.6

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

Rubber x **Intercropping trials in Moneragala and Ampara districts**

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

Four fruit crops *i.e.* orange, soursop (Anoda), Guava and Papaya were planted under rubber with 2.5 m x 7.75 m and 2.5 m x 12.0 m spatial arrangements. Planting of both rubber and fruit crops were done as per the recommendations given by RRISL and the Department of Agriculture. The growth of rubber in terms of girth at 4 feet height five years after planting is shown in Table 30. Growth of intercrops after five years is shown in Table 31. There were no significant growth differences in between two spatial arrangements of rubber. Basal girth of soursop and orange was comparable under two spatial arrangements of rubber. Basal girth of guava was poor under narrow spacing of rubber, *i.e.* 2.5m x 7.75m.

Table 30. *Mean girth at four feet height (cm) of rubber trees under different treatments and under different spatial arrangements*

Main treatment (spatial arrangement of rubber)	Sub treatment (intercrop)	Girth of rubber (cm)
2.5 m x12.0 m	Soursop	33.4
	Orange	31.8
	Guava	29.5
2.5 m x 7.75 m	Soursop	33.7
	Orange	33.9
	Guava	29.9

Table 31. *Mean basal girth (cm) of intercrops under different spatial arrangements of rubber*

Main treatment	Sub treatment (intercrop)	Basal girth (cm)
2.5 m x 12.0 m	Soursop	42.7
	Orange	29.9
	Guava	19.0
2.5 m x 7.75 m	Soursop	58.0
	Orange	44.3
	Guava	39.6

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

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

Two hectares of land were selected from a farmer at Hingurana in the Ampara district in 2018. Four fruit crops *i.e.* orange, soursop, guava and papaya were planted under rubber with the spacing of 2.5 m x 7.75 m. However, establishment rates of fruit crops and rubber were not satisfactory due to the long dry spells that prevailed at the

time of establishment. Therefore, this trial has been terminated from 2021 (T U K Silva, H Subasinghe and D Priyadarshana).

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

Two hectares of land were selected from each farmer's field at Hingurana and Mahaoya in the Ampara district to establish intercropping trials with short-term crops. At the beginning, three short-term crops, *i.e.* thibbatu, thumbakaravila and maize were established under rubber with a 2.5 m x 7.75 m spacing system. Only, Mahaoya field has been continued and the girth values are shown in Table 36. However, short-term crops were not established from 2021 onwards (T U K Silva, H Subasinghe and D Priyadarshana).

Table 32. *Mean girth (cm) of rubber at 120 cm height in Mahaoya field*

Area	Tree girth (cm)
Replicate 1	30.2
Replicate 2	30.2
Replicate 3	29.9
Control	32.4

Testing of new spacing of Pineapple as an intercrop of Rubber in Salawa Estate (IC/PA/2021/1)

Two paired rows of pineapple with a gap of 1.5 m in the center of two rubber rows were the previously recommended method to grow pineapple with rubber. Based on the request of planters and the pineapple growers to increase the land use efficiency whilst minimizing the weed growth with lesser number of pineapple in the area, this study was planned to test three paired rows of pineapple with 1.25m gap in between paired rows. Within the paired rows, suckers are spaced 30-45 cm within and 60 cm between rows as shown in the sketch diagram (Fig. 33). The distance between rubber rows should be 7.75 m and rubber trees should be 2.5 m distance. The distance from a rubber tree to the first row of pineapple should be 1.725 m.

An area of 11.0 ha. field was selected in the Kanampella Division of Salawa estate with financial support of the Pussellawa Plantation Company in year 2021. The rubber planting was done following the above distance and pineapple planting was done using both two and three paired row systems following the Randomized Complete Block statistical design. Mean girth of rubber in both areas are given in the Table 33 and nearly 10 cm girth increment of rubber can be achieved with pineapple intercropping.

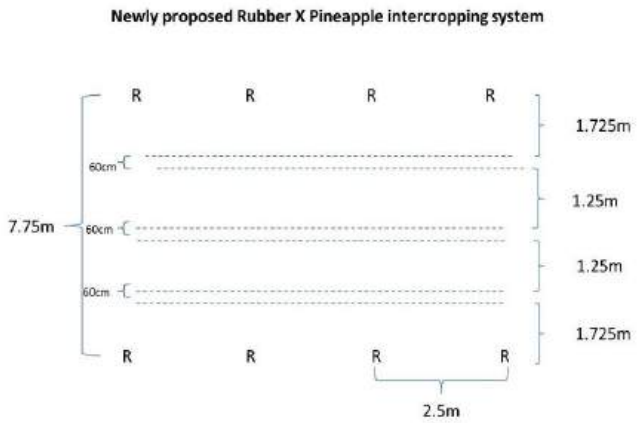


Fig. 33. Schematic diagram of (R) rubber and three paired rows of pineapple representing as dotted lines

Table 33. *Mean girth (cm) of rubber plants in the control plot and in the pineapple intercropped area*

Treatments	Average Girth of Rubber (cm)		Girth Increment (cm)
	2023 January	2023 December	
Control	7.35	13.20	5.85
Pineapple intercropped area	10.80	20.63	9.82

(T U K Silva, P D Pathirana and H subasinghe)

Rubber Master Plan Development Projects

Introduction of NVQ-qualified socially recognized Harvesting Assistants in the rubber sector

RRISL has taken an initial foot step on the way forward to offer the internationally recognized National Vocational Qualification (NVQ) to the Rubber Harvesting Assistants as Level 3 under Rubber Master Plan projects with the National Apprentice and Industrial Training Authority (NAITA) for the first time in the Sri Lankan rubber history. The project was completed in collaboration with the Advisory Service Department, Rubber Development Department, and four Regional Plantation Companies in Kalutara District namely; Agalawatta, Horana, Kotagala and Namunukula. RRISL has chosen 213 Harvest Assistants currently employed in the profession in different sectors, i.e. Rubber Plantation Companies and small & medium scaled rubber holding sector, and they were assessed according to the criteria stipulated by the Tertiary Vocational and Education Commission (TVEC) for Recognized Prior Learning protocol. 169 candidates were successful in their assessments registering 80%

success rate. This project was funded by the Ministry of Plantation Industries through the Rubber Master Plan as a pilot project targeting the Kalutara District. In addition to that, RRISL empowered them by introducing a '***Kiri Thuru Abiman*'** privilege card with multiple benefits, subjected to an annual performance review which will be offered to all qualified harvesters. Further to that, they will also be entitled to a Life Insurance which has been newly introduced as ***'Jeewana Shakthi'*** from Sri Lanka Insurance Corporation for full coverage of field-level accidents to protect their lives and provide strength for unforeseen incidents, at a special rate. (S Siriwardhana, D S A Nakandala, T U K Silva, P K K S Gunaratne, U N Udayakumari, P K W Karunathilaka, H Subasinghe, and D Priyadarshana).

The recommencement of tapping for untapped rubber lands - A pilot project in Kalutara District

The project mainly aimed to find out reasons for the existence of lands abandoned and to provide possible solutions to make them productive. Identification of abandoned rubber lands, pinpointing major causes, and re-commencing tapping were the major objectives of this project. Total extent covered was 102 hectares.

In this project, dynamic new entrepreneur groups including 62 villagers have been trained and introduced to tap untapped lands for sustainable rubber production and land owners can get their service on a contract basis (S Siriwardhana, T U K Silva, D S A Nakandala, P K W Karunathilaka, H Subasinghe, and D Priyadarshana).

PLANT PATHOLOGY AND MICROBIOLOGY

T H P S Fernando

DETAILED REVIEW

Staff

Dr (Mrs) T H P S Fernando, Head, Department of Plant Pathology and Microbiology and Dr (Mrs) M K R Silva, Research Officer were on duty throughout the year. Experimental Officers, Mrs E A D D Siriwardene and Mr S C P Wijayaratne worked throughout the year. Mr E A D N Nishantha was in Japan on no-pay leave. Technical Officer, Mr D A N Mallikarachchi was on duty throughout the year and Mrs A H M N R Aberathne, Technical Officer was on maternity leave with effect from 17th November 2023. Mrs K A D Y Madushani Lanka, Management Assistant, worked throughout the year. Mr G K S Madhusanka and Miss H R G N Peiris, Temporary Technical Assistants worked under the Pestalotiopsis Project resigned from duties with effect from May 2023 & November 2023 respectively. Mr L Vidushika assumed duties as a Temporary Technical Assistant with effect from 14th August 2023 under the Pestalotiopsis Project.

Research Grants received

Source and Grant	Duration	Title of the Project	Allocation (Rs. Mn.)	Status
Ministry of Plantation Industries	2021-2025	Studies on the biology and epidemiology of the Pestalotiopsis Leaf fall disease and to develop effective management strategies.	49.46	In progress

Research students

Dr (Mrs) T H P S Fernando and Dr (Mrs) M K R Silva supervised the final year research projects of the following undergraduate students and postgraduate students. Thirteen number of students from Universities and Technical Colleges were trained at the department on basic and applied plant protection and microbiological activities.

Name	Study Programme	Duration	University	Project Title
Thusitha	MPhil	2018 - 2023	University of Ruhuna	Formulation of ethephon based low cost yield stimulants for commercial rubber plantations in Sri Lanka.
Mr. P.W. Balasooriya	MPhil	2020-2023	University of Colombo	Application of indigenous soil micro flora as biological control measures for white root disease of rubber growing lands in Sri Lanka
MNN Zainab	Research Project	2022-2023 (6 months)	Sabaragamuwa University	Isolation of endophytic fungi from rubber (*Hevea*) leaves and to test their pathogenicity
KGA Maduhansika	Research project	2023-2024 (6 months)	Open University of Sri Lanka	Isolation of potential microorganisms to be used for coagulation of latex
HRGN Peiris	Research Project	2023-2024 (6 months)	Open University of Sri Lanka	Isolation and preparation of microbial consortium to accelerate composting of plant material
HAYU Hettiarachchi	Research project	2023 (2 months)	University of Ruhuna	Antifungal activity of *Padina minor* and *Sargassum ilisifolium* from Sri Lankan Southern coastal waters against rubber pathogenic fungi
KP Sathsarani	Research project	2023-2024 (4 months)	Sabaragamuwa University of Sri Lanka	The effect of *Hevea brasiliensis* leaf extracts on the growth of circular leaf spot disease pathogens
JMM Ishana	Research Project	2023-2024 (4 months)	Sabaragamuwa University of Sri Lanka	Detection of the causative agents of circular leaf spot disease pathogens in soil
JMK Madhushani	Research Project	2023-2024 (4 months)	Sabaragamuwa University of Sri Lanka	The effect of leaf stages on establishment of circular leaf spot disease pathogen

Name	Study Programme	Duration	University	Project Title
ACSS De Silva	Research Project	2023-2024 (4 months)	Sabaragamuwa University of Sri Lanka	Evaluation of molecular level variability of Pestalotiopsis isolated from circular leaf spot disease of *Hevea brasiliensis*
PU Kariyawasam	Research Project	2023-2024 (3 months)	Sabaragamuwa University of Sri Lanka	Isolation of endophytic bacteria an antoganistic to the pathogens associated with the circular leaf spot disease of rubber *Hevea brasiliensis* plantations
IMI Abayarathna	Research project	2023-2024 (3 months)	Sabaragamuwa University of Sri Lanka	Identification of alternative hosts for the circular leaf spot associated pathogens of *Hevea brasiliensis*
SLKK Silva	Research project	2023-2024 (3 months)	Sabaragamuwa University of Sri Lanka	Effect of copper-based fungicides on the conidial germination of *Colletotrichum* spp. Causing circular leaf spot disease of rubber
HDD Sandamali	Research Project	2023-2024 (3 months)	University of Ruhuna	Identification of alternative hosts for the circular leaf spot disease of *Hevea brasiliensis*
JMMI Udayakanthi	Research project	2023-2024 (4 months)	Sabaragamuwa University of Sri Lanka	Detection of the causative agents of the Circular leaf spot disease pathogens in the soil
M.H.N.C Weerasinghe	Research Project	2023/2024 (6 months)	University of Peradeniya	Determining the temporal variation of culturable endophytic microbial population in the leaves of healthy and circular leaf spot disease infected rubber plants

Commettes attended

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

Consultancies

Officers	Subject	Organization
THPS Fernando	Providing consultancy inputs to help control an epidemic of rubber leaf fall disease in the Phillipines	Food & Agriculture Organization of the United Nations

Training programmes conducted

Dr (Mrs) T H P S Fernando and Dr (Mrs) M K R Silva served as the resource personnel in training Rubber Development Officers, Rubber Extension Officers, Estate Managers, Assistant Superintendents and Field Officers. Mrs E A D D Siriwardene, Mr S C P Wijayaratne, Mrs Nadeeshani Aberathne and Mr Akila Mallikaarachchi covered the practical aspects of the above programmes while all the staff members extended their fullest cooperation in educating about 15 students from Universities and Technical Colleges on departmental activities.

Experimental/Advisory visits

Purpose	No of visits
Experimental	31
Advisory	**437**
Other	17
Total	**485**

LABORATORY AND FIELD INVESTIGATIONS

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

White Root Disease Management – Trials undertaken as demonstration plots

Demonstration plots to test the efficacy of chemical controlling of white root disease established in different rubber growing areas during the year 2022 were monitored. (T H P S Fernando, S C P Wijayaratne and E A D D Siriwardena).

Rehabilitation of White root disease patches - Demonstration plots

The white root disease patches rehabilitated at Galewatta, Nivithigalakale, Dartonfield Estate, Kuruwita Substation and Galatura Estate were successfully completed. Sulphur sprinkling was carried out to make conditions unfavorable for the growth of the fungus *Rigidoporus microporus.* Later, indicator plants were established (*Gliricidia and Croterlaria*) to trace out any remaining inocula. Use of other economical crops as indicators will fascilitate disease identification while providing an additional income. A new trial was initiated in Dartonfield Estate, RRI to try Cassava as an indicator plant for the identification of the white root disease.
(T H P S Fernando and S C P Wijayaratne).

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

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

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

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

Chemical management of Circular Leaf Spot Disease

a) Screening of the potential fungicidal systems against the CLSD under field conditions

A series of field experiments on the chemical controlling of CLSD were carried out during the refoliation stage of 2023. Each treatment was applied at 2 replicates in

one site and a replicate consisted of a set of mature/ immature rubber trees in a land area of approximately 1ha. Three fungicides were tested (Table 2) and based on the basic fungicides used in the treatment, the treatments were divided into three sets and were handled by three officers (Table 3).

Table 2. *Fungicides used in the field study*

Fungicide	Product details	Mode of action
carbendazim 50% w/w	Billet carbendazim, Plantchem	Systemic
hexaconazole 50g/l EC	Hayleys hexaconazole, Hayleys	Systemic
copper hydroxide 57.6% w/w	Champ, Hayleys	Contact

Table 3. *Details of the field experiments on the chemical management of CLSD*

Fungicide	Location	Responsible Officer
carbendazim - Treatment set 1	Halwathura estate Yatadola estate Finzeen estate	E.A.D.D. Siriwardena
hexaconazole - Treatment set 2	Newchattle estate Pallegoda estate Miriswatta estate	D.A.N. Mallikarachchi
copper hydroxide -Treatment set 3	Thalgaswala estate Galatura estate Halpe estate	S.C.P. Wijayaratne

The treatments adopted in the field experimentation under each set of trials are summarized below (Tables 4, 5 & 6).

Table 4. *Treatments adopted in the field experiments on the chemical management of CLSD – Treatment: Trial set 1*

Treatment No	Copper brown & Apple green			Semi – mature	Mature 1	Mature 2	Mature 3
1.	Soluble S - 10g/l+ carbendazim-30g/l	Soluble S – 10g/l + carbendazim-30g/l	Soluble S – 10g/l + carbendazim -30g/l	carbendazim -30g/l	carbendazim -30g/l	Soluble S - 10g/l + carbendazim-30g/l	
2.			Soluble S - 10g/l + carbendazim - 30g/l	Soluble S - 10g/l + carbendazim - 30g/l	carbendazim - 30g/l	carbendazim - 30g/l	carbendazim - 30g/l
3.	Soluble S - 10g/l + carbendazim-30g/l	Soluble S - 10g/l + hexaconazole – 30ml/l	Soluble S - 10g/l + carbendazim -30g/l	hexaconazole – 30ml/l	carbendazim -30g/l		

Treatment No	Copper brown & Apple green	Semi – mature	Mature 1	Mature 2	Mature 3	Treatment No	Copper brown & Apple green
4.	carbendazim - 30g/l + Soluble S- 10g/l	carbendazim - 30g/l + Soluble S - 10g/l +	carbendazim - 30g/l + mancozeb - 10g/l	carbendazim - 30g/l + mancozeb - 10g/l	carbendazim - 30g/l + mancozeb - 10g/l		
5.	carbendazim - 30g/l + copper - 20g/l	carbendazim - 30g/l + copper - 20g/l	carbendazim - 30g/l + copper -20g/l	carbendazim - 30g/l + copper -20g/l	carbendazim - 30g/l + copper -20g/l		
6.		carbendazim-50g/l + hexaconazole – 50ml/l			carbendazim -50g/l + hexaconazole – 50ml/l		
7.	Soluble S - 10g/l + hexaconazole-30ml/l	Soluble S - 10g/l + hexaconazole-30ml/l	Soluble S - 10g/l + hexaconazole-30ml/l	hexaconazole-30ml/l	hexaconazole-30ml/l		
8.	Soluble S - 10g/l	Soluble S - 10g/l			carbendazim -50g/l + hexaconazole – 50ml/l		
9.	High Volume (10 Tanks/ ha)- carbendazim-30g/l	High Volume (10 Tanks/ha)- carbendazim-30g/l	High Volume(10 Tanks/ha)- carbendazim -30g/l	High Volume(10 Tanks/ha)- carbendazim -30g/l	High Volume(10 Tanks/ha)- carbendazim -30g/l		
10.		High Volume (10 Tanks/ha)- carbendazim-30g/l		High Volume (10 Tanks/ha)- carbendazim -50g/l + hexaconazole – 50ml/l			

Table 5. *Treatments adopted in the field experiments on the chemical management of CLSD – Treatment: Trial set 2*

Treatment No	Copper Brown & Apple Green			Semi Mature	Mature 1	Mature 2	Mature 3
1	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	hexaconazole – 30ml/l	hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	

Treatment No	Copper Brown & Apple Green	Semi Mature	Mature 1	Mature 2	Mature 3	Treatment No	Copper Brown & Apple Green
2			Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	hexaconazole – 30ml/l	hexaconazole – 30ml/l	hexaconazole – 30ml/l
3	Soluble S – 10g/l carbendazim- 30g/l	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l carbendazim- 30g/l	hexaconazole – 30ml/l	carbendazim - 30g/l		
4	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	hexaconazole – 30ml/l mancozeb - 10g/l	hexaconazole – 30ml/l mancozeb - 10g/l	hexaconazole – 30ml/l mancozeb - 10g/l		
5	hexaconazole – 30ml/l copper – 20g/l	hexaconazole – 30ml/l copper – 20g/l	hexaconazole – 30ml/l copper – 20g/l	hexaconazole – 30ml/l copper – 20g/l	hexaconazole – 30ml/l copper – 20g/l		
6		hexaconazole – 50ml/l carbendazim- 50g/l			hexaconazole – 50ml/l carbendazim - 50g/l		
7	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	Soluble S – 10g/l hexaconazole – 30ml/l	hexaconazole – 30ml/l	hexaconazole – 30ml/l		
8	Soluble S – 10g/l	Soluble S – 10g/l			hexaconazole – 50ml/l carbendazim - 50g/l		
9	High Volume (10 tanks/hec) hexaconazole – 30ml/l	High Volume (10 tanks/hec) hexaconazole – 30ml/l	High Volume (10 tanks/hec) hexaconazole – 30ml/l	High Volume (10 tanks/hec) hexaconazole – 30ml/l	High Volume (10 tanks/hec) hexaconazole – 30ml/l		
10		High Volume (10 tanks/hec) hexaconazole – 30ml/l		High Volume (10 tanks/hec) hexaconazole – 50ml/l carbendazim- 50g/l			

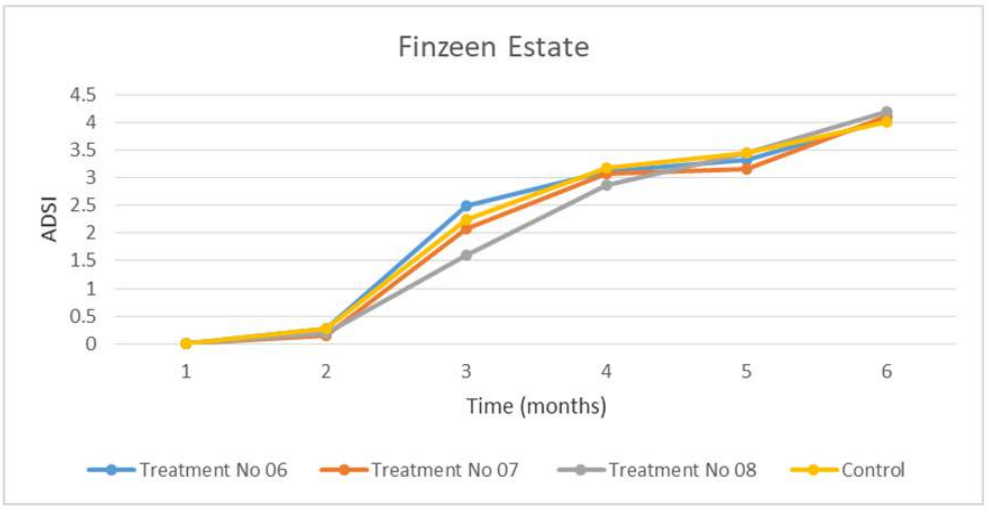
Table 6. *Treatments adopted in the field experiments on the chemical management of CLSD – Treatment: Trial set 3*

Treatment No	Copper Brown & Apple Green			Semi mature	Mature 1	Mature 2	Mature 3
1.				Soluble S - 10g/l + carbendazim - 30g/l	Soluble S - 10g/l + carbendazim - 30g/l	copper 50g/l	copper 50g/l
2.				Soluble S - 10g/l + carbendazim - 30g/l	Soluble S - 10g/l + carbendazim - 30g/l	copper 100g/l	copper 100g/l
3	Soluble S - 10g/l + carbendazim -30g/l	Soluble S - 10g/l + carbendazim – 30g/l	Soluble S - 10g/l + carbendazim-30g/l			copper 100g/l	copper 100g/l
4.						copper 100g/l	copper 100g/l
5.	carbendazim - 30g/l + copper -20g/l	carbendazim - 30g/l + copper - 20g/l	carbendazim - 30g/l + copper - 20g/l			copper 100g/l	copper 100g /l
6.	Soluble S - 10g/l + carbendazim -30g/l	Soluble S - 10g/l + carbendazim-30g/l	Soluble S - 10g/l + carbendazim-30g/l			copper 100g/l Oil-based	copper 100g /l oil-based
7.						copper 100g /l Oil-based	copper 100g /l Oil-based
8.							copper 100g /l oil-based

As per the planned treatment protocol, the fungicide applications were carried out during different leaf maturity stages and before the appearance of the symptoms. However, the application time was different at locations as the refoliation was not synchronized during the year. In order to manage the Powdery mildew, an application of a sulphur based fungicide was also done where applicable.

The CLSD severity of each plot (Average Disease Severity Index-ADSI) was evaluated at monthly intervals based on the leaf fall status of a random set of trees. The disease progression pattern (variation of the ADSI versus time in months) under treatment set 1 is shown in Figure 1 (the fungicide application points are denoted on the time axis as arrows).


Halwathura Estate
ADSI
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
7
Time (months)
Trt No 01
Trt No 02
Trt No 03
Trt No 04
Trt 05
Control


Finzeen Estate
ADSI
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
1
2
3
4
5
6
Time (months)
Treatment No 06
Treatment No 07
Treatment No 08
Control

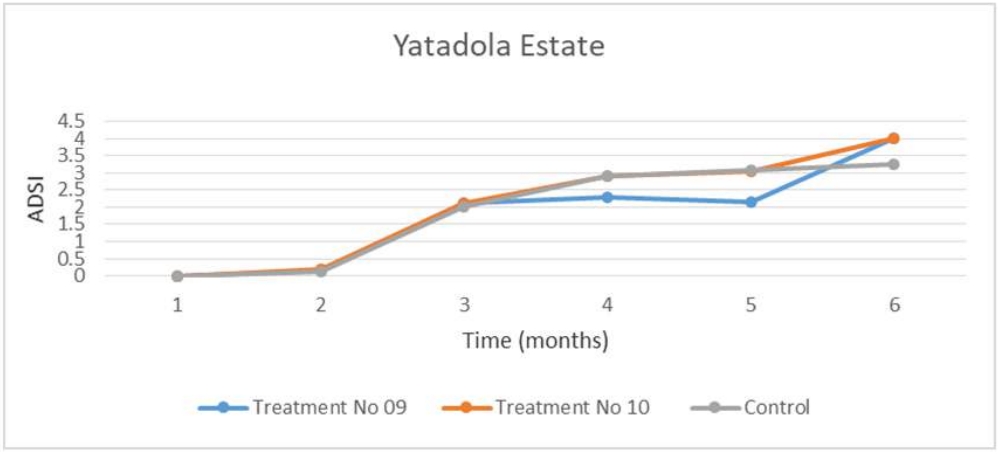
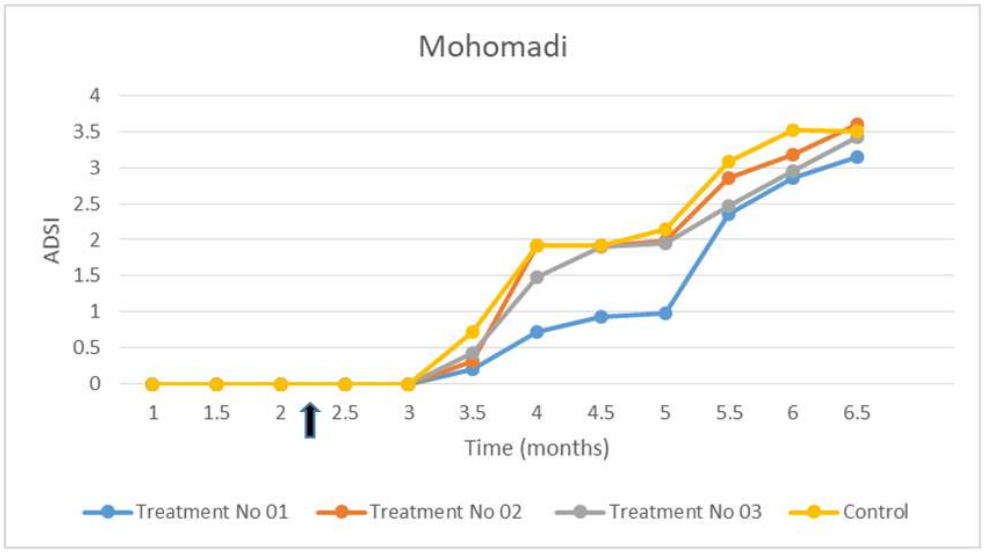


Fig. 1. Disease progression in the experimental plots under the treatment set number 1

The disease progression pattern (varation of the ADSI versus the time in months) under treatment set 2 is shown in the Figure 2 (the fungicide application points are denoted on the time axis as arrows).



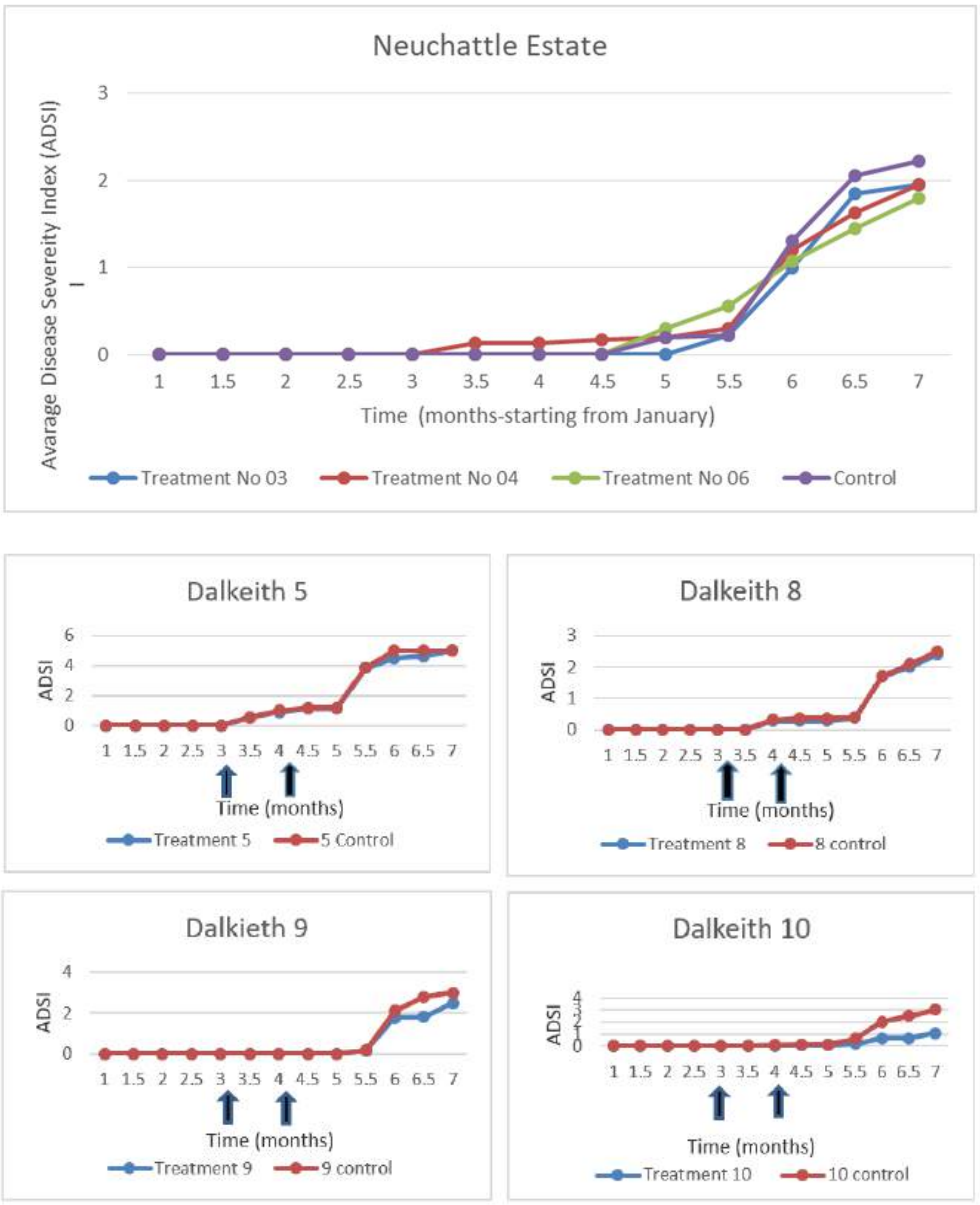
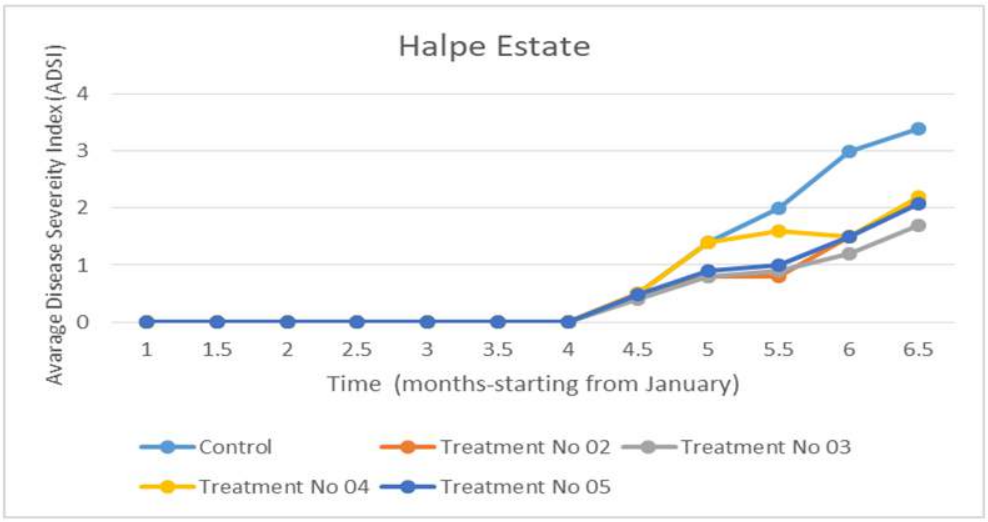
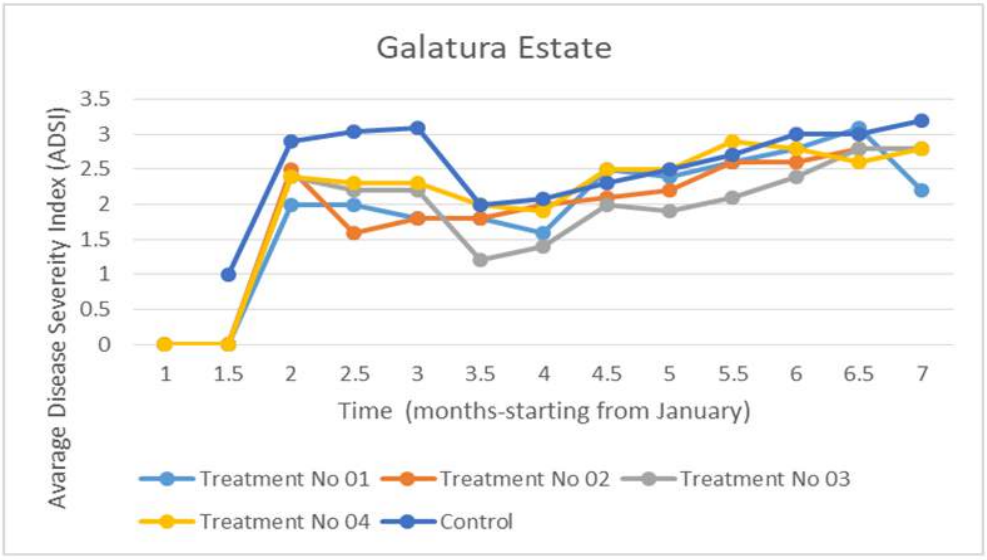


Fig. 2. Disease progression in the experimental plots under the treatment set number 2

The disease progression pattern (the varation of the Average Disease Severity Index – ADSI versus the time in months) under treatment set 3 is shown in the Figure3 (the fungicide application points are denoted on the time axis as arrows).





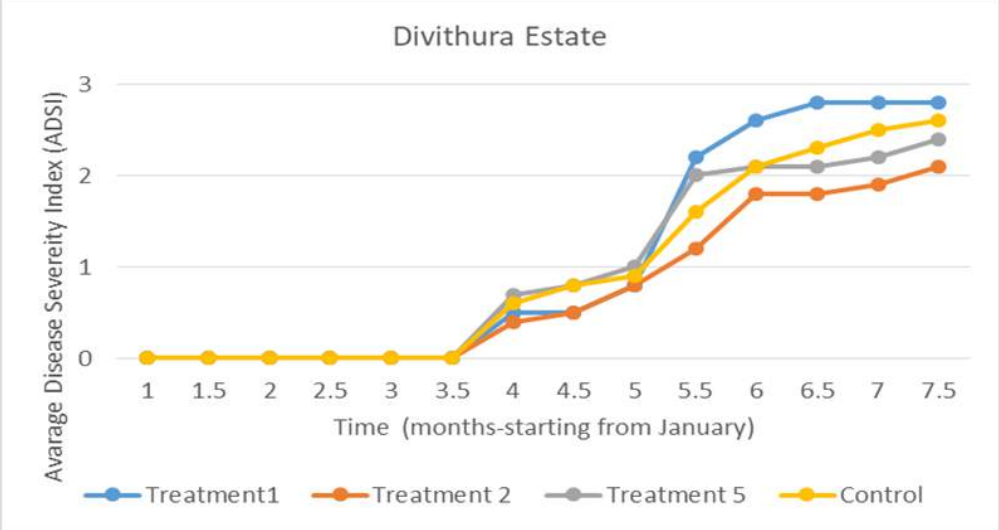


Fig. 3. Disease progression in the experimental plots under the treatment set number 3

Though the disease progression curves show a slight delay of the establishment of the symptoms at different fungicide applications, it was observed that the reduction of the ADSI was not persistent throughout the disease active period (M K R Silva, T H P S Fernando, E A D D Siriwardena, S C P Wijayaratne, D A N Mallikarachchi)

b) Testing of the fungicide package recommended by RRII on CLSD

To assess the feasibility of using the fungicidal package recommended by the Rubber Research Institute of India (08kg Copper oxychloride in 40 litres of water applied in one hectare of rubber plantations), a sample of the specific fungicide was imported from India with the permission of the Registrar of pesticide, as the specific formulation was not available in the country. Moreover, the oil product (named as agricultural oil) was purchased from the Indian Oil Company, in Sri Lanka. The fungicidal recommendation was tested for the followings.

i. Phytotoxicity

The fungicide in the agriculture oil was evaluated for phytotoxicity under the budwood nursery conditions. The fungicide at the RRII recommended rate (8kg in 40 litre) showed phytotoxicity on immature leaves of copper brown and apple green stages (Fig. 4a). However, no phytotoxicity was observed on semi-mature and older leaves on which the fungicide is recommended (Figure 4b).

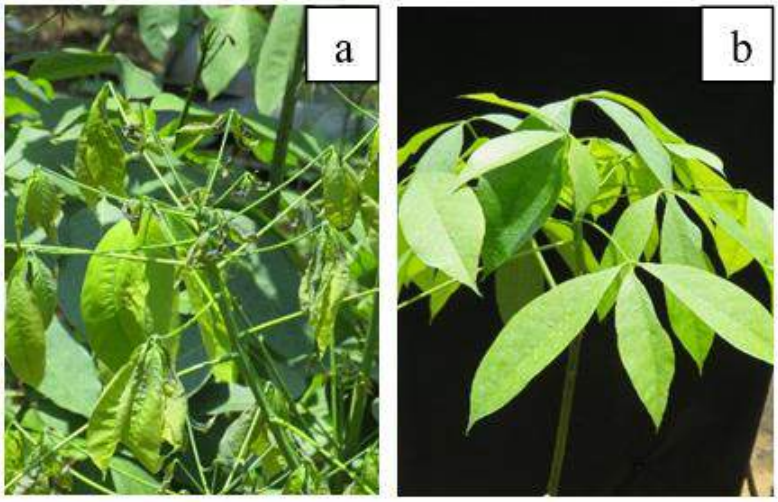


Fig. 4. Phytotoxicity test of Copper Oxycloride on a) copper brown & apple green leaves b) semi-mature leaves

ii. The solubility of the fungicides in different solvents

The solubility of the imported fungicide along with the locally available Copper-based fungicides was tested in water, agriculture oil, and other prospective oils. The time taken to produce a visible precipitate was reported in 10-minute intervals (table 7).

Table 7. *Solubility of the fungicides in different solvents in various time intervals*

Solvent	Fungicide	10 min.	20 min.	30 min.	40 min.	50 min.	60 min.	24 h
Water	**COC-I**	UND	UND	UND	UND	UND	UND	UND
	COC-SL	PD	PD	PD	PPT	PPT	PPT	PPT
	Champ	DIS	DIS	PA PPT	PPT	PPT	PPT	PPT
Paraffin oil	**COC-I**	DIS	PA PPT	PPT	PPT	PPT	PPT	PPT
	COC-SL	UND	UND	UND	UND	UND	UND	UND
	Champ	UND	UND	UND	UND	UND	UND	UND
Diesel	**COC-I**	DIS	PA PPT	PPT	PPT	PPT	PPT	PPT
	COC-SL	PPT	PPT	PPT	PPT	PPT	PPT	PPT
	Champ	UND	UND	UND	UND	UND	UND	UND
Agricultural oil	**COC-I**	DIS	PA PPT	PPT	PPT	PPT	PPT	PPT
	COC-SL	PPT	PPT	PPT	PPT	PPT	PPT	PPT
	Champ	UND	UND	UND	UND	UND	UND	UND

Undissolved – UND Partially dissolved - PD, Precipitated – PPT , Partially Precipitated - PA PPT, Dissolved - DIS

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

iii. Comparison of the efficacy - *in vitro*

The efficacy of three copper-based fungicides was compared using *in vitro* techniques: Poison Food Technique (PFT) and Conidial Germination Inhibition Test (CGIT) (table 8).

Table 8. *Fungicides and the concentrations used for the study*

Fungicide	Formulation	Mode of action
Copper oxy chloide (Indian)	56% w/w	Contact
Copper oxy chloide (Sri Lankan)	50g/l w/w	Contact
Copper Hydroxide (Champ)	57.6% w/w	Contact

The fungicides were tested under a series of concentrations: 100, 250, 500, 750, 1000 and 1500ppm in PDA. The fungicides were tested against three *Colletotrichum* isolates: C6, C8, C10 and C24 (table 9).

Poison Food Technique (PFT)

In the PFT, a completely randomized design with four replicates was adopted. The analysis of the variance of the reduction in diameter over the control at different concentrations of the fungicides and the pathogen isolates was carried out using the statistical software SAS and subsequently, mean separation was done with Duncan's Multiple Range Test (DMRT). The variation in the diameter reduction of the fungus values (DR) at different concentrations of the fungicides is shown in tables 9,10,11 & 12.

Table 9. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, C6

Fungicides	% inhibition of growth at different concentrations of fungicides (ppm)				
	100	**250**	**500**	**750**	**1500**
COC-I	54.230^{a}	74.243^{a}	74.168^{a}	54.063^{a}	70.172^{a}
$Cu(OH)_2$	10.741^{b}	13.041^{b}	11.756^{b}	7.591^{b}	12.273^{b}
COC-SL	-2.462^{c}	1.242^{c}	8.930^{b}	1.059^{b}	7.195^{b}

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

Table 10. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, C8

Fungicides	% inhibition of growth at different concentrations of fungicides (ppm)				
	100	**250**	**500**	**750**	**1500**
COC-I	55.082[a]	61.637[a]	68.606[a]	55.810[a]	49.14[a]
$Cu(OH)_2$	10.418[b]	14.765[b]	10.675[b]	26.300[b]	13.157[b]
COC-SL	9.893[b]	10.280[b]	11.515[b]	12.143[c]	11.773[b]

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

Table 11. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, C10

Fungicides	% inhibition of growth at different concentrations of fungicides (ppm)				
	100	**250**	**500**	**750**	**1500**
COC-I	36.094[a]	54.300[a]	38.047[a]	23.597[a]	27.634[a]
$Cu(OH)_2$	0.703[b]	-0.101[b]	-5.072[b]	2.155[b]	15.818[a]
COC-SL	-17.123[c]	-11.624[b]	-16.752[c]	-17.270[b]	-16.572[b]

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

Table 12. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, C 24

Fungicides	Percent inhibition of growth at different concentrations of fungicides (ppm)				
	100	**250**	**500**	**750**	**1500**
COC-I	54.929[a]	47.938[a]	36.915[a]	52.042[a]	70.756[a]
$Cu(OH)_2$	18.957[b]	19.704[b]	19.700[b]	15.477[b]	10.777[c]
COC-SL	14.257[b]	13.510[b]	10.656[c]	10.778[b]	15.489[b]

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

According to the results, fungicides showed a significant variation in the DR value for all the pathogen isolates used. Moreover, the CuOCl of Indian origin has shown a significant inhibition against all the *Colletotrichum* isolates at all the tested concentrations.

Conidial Germination Inhibition Test (CGIT)

The CGIT was performed and the percentage inhibition of conidial germination against the control was calculated under each treatment. The analysis of the variance of the diameter reduction values over the control at different concentrations of the fungicides and the pathogen isolates was carried out using the statistical software SAS and subsequently, mean separation was done with Duncan's Multiple Range Test (DMRT). The percent inhibition in germination over the controls at different concentrations of fungicides is shown in Tables 13 & 14.

Table 13. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, (C 6)

Fungicides	**% inhibition in germination over control at different concentrations of fungicides (ppm)**				
	100	**250**	**500**	**750**	**1500**
COC-I	0.278^{a}	-14.480^{c}	-11.150^{b}	-12.015^{c}	-8.55^{b}
$Cu(OH)_2$	11.986^{a}	40.77^{a}	38.11^{a}	93.75^{a}	68.96^{a}
COC-SL	16.413^{a}	7.880^{b}	$7.010^{a,b}$	11.878^{b}	66.22^{a}

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

Table 14. *In vitro* effect of fungicides and their concentration on the growth of the *Colletotrichum* isolate, (C 8)

Fungicides	**% inhibition in germination over control at different concentrations of fungicides (ppm)**				
	100	**250**	**500**	**750**	**1500**
COC-I	-19.909^{b}	-13.339^{c}	-16.938^{c}	-20.620^{c}	-10.300^{c}
$Cu(OH)_2$	59.074^{a}	95.889^{a}	98.889^{a}	100.00^{a}	98.61^{a}
COC-SL	47.933^{a}	53.95^{b}	50.989^{b}	53.288^{b}	46.66^{b}

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

According to the results, the CuOCl of Indian origin has shown a negative effect on the inhibition of conidial germination (though it showed a significant inhibition against all the *Colletotrichum* isolates at all the tested concentrations under PFT), the test will be repeated and further studies will be carried out.

iv. Efficacy testing – field level

As the fungicide and the oil were received after the onset of the disease in CLSD-vulnerable locations in the wet zone, testing of the fungicide package in the wet

zone field conditions during the year could not be conducted. However, the fungicidal package was tested for efficacy at an 08-year-old rubber field in Moneragala. Carbendazim at the rate of 10g/l was used as the control.

However, the disease progression pattern of the treatment plot did not show any difference from that of the control plot. The monitoring of the trial is in progress and the testing will be repeated (M K R Silva, T H P S Fernando, S C P Wijayaratne).

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

Data recording of the polybag nursery-level experiment carried out at the Dartonfield estate to evaluate the effectiveness of higher concentrations of fungicides on the management of CLSD. The treatments are summarized in Table 15.

Table 15. *Treatments of the nursery-level experiment on the effectiveness of higher concentrations of fungicides on the management of CLSD*

Treatment No	Fungicide	Conc	Base	Sprayed foliar stage	No of applications
01	carbendazim (50% w/w)	50g/l	Water	Copper brown	2
02	carbendazim (-50% w/w)	50g/l	Water	All stages	14
03	carbendazim (50% w/w)	50g/l	Water	Apple green	2
04	carbendazim (50% w/w)	50g/l	Water	Semi mature	4
05	carbendazim (50% w/w)	50g/l	Water	Mature	7
06	hexaconazole (50g/l EC)	50ml/l	Water	Apple green	2
07	CuOCl	50g/l	Paraffin oil	Apple green	2
08	copper hydroxide (57.6 % w/w)	50g/l	Water	Apple green	2
09	Control				

(MKR Silva, THPS Fernando, DAN Mallikarachchi)

The disease assessment was initiated at the onset of the disease in the experimental plot. The monthly assessment of the disease development is shown in figure 5.

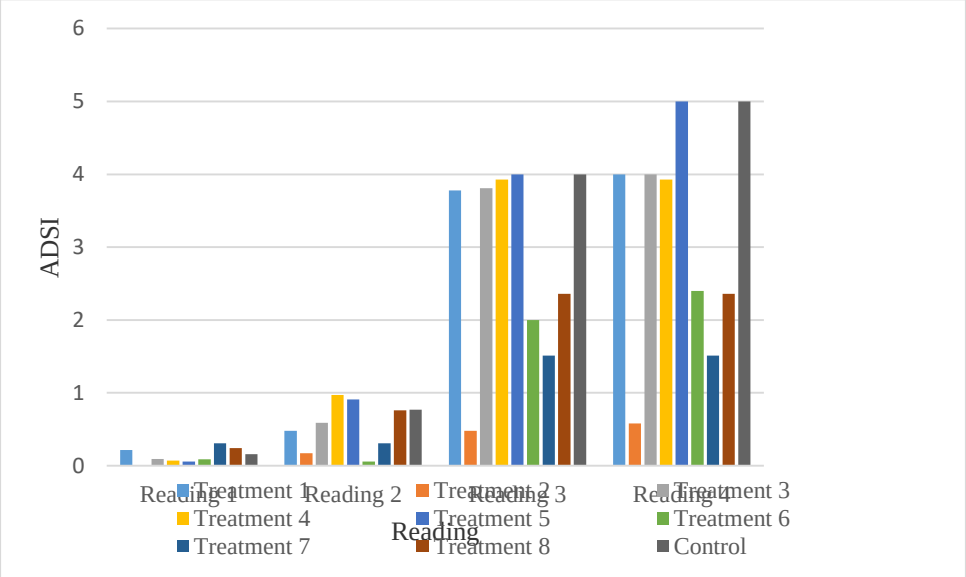


Fig. 5. The disease progression pattern of the experiment at four readings

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

While seeking the avenues of using different oils as a base of fungicide application (oil-based fungicide application), based on the price and the market availability, diesel was tested on mature leaves of rubber. Diesel-based Carbendazim was tested, as it was the only fungicide found to be soluble in diesel among the effective fungicides.

The effectiveness of spraying Carbendazim (30g/l) using diesel as a spray base for spraying was tested at Nivithigala Kele, Mathugama. The disease progression pattern of the treatment plot showed no any difference from that of the plot with carbendazim in water (M K R Silva, T H P S Fernando, D A N Mallikarachchi)

e) Fogging

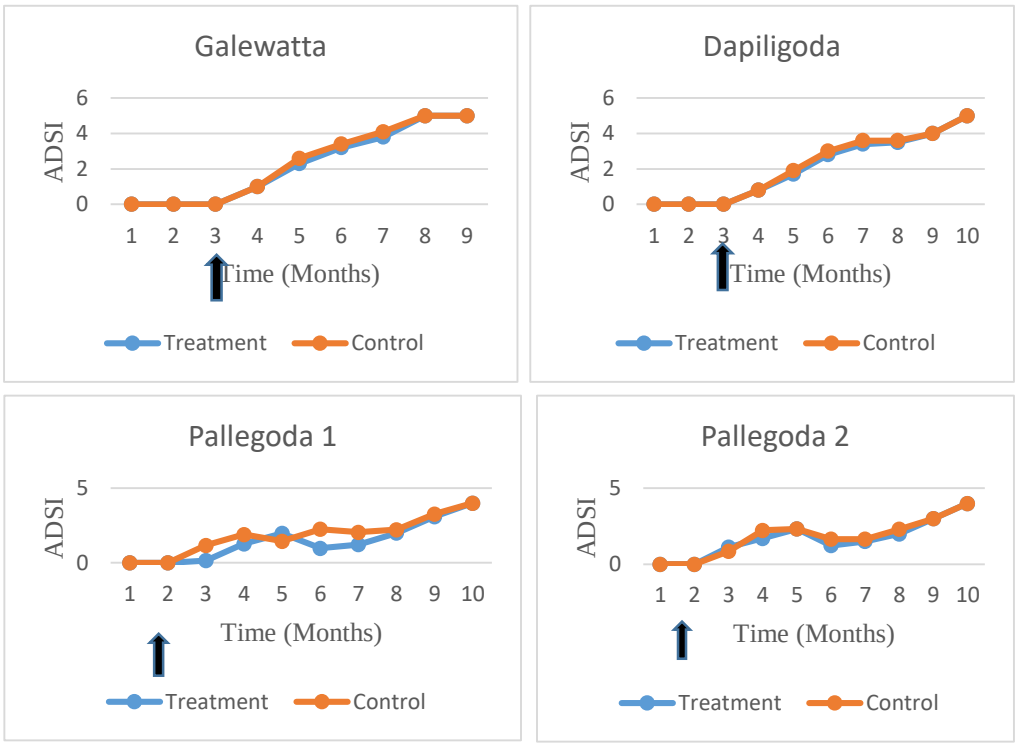
The application of the fungicides onto mature rubber plantations using the thermal fogging technique was assessed at different carbendazim concentrations. The time of application of fogging at each site was determined based on the leaf maturity level. Diesel was used as the solvent and three concentrations: 30g/l, 80g/l and 100g/l were tested (Table 16). Each treatment was replicated in two blocks at the same location. However, the rate of application could not be unified among the treatments

based on the nature of the application (as the discharge is produced in the form of a fog, the wind effect was very prominent in determining the rate of application).

Table 16. *Details of the experiments on fogging*

Location	Fungicide Concentration	Approximate no of trees	Solvent Volume
Galewatta	30g/l	130	3l
Dapiligoda	30g/l	250	4l
Pallegoda 1	30g/l	200 (0.5ha)	4l
Pallegoda 2	80g/l	210 (0.5ha)	4l
N'kele	100g/l	100	4l

The disease progression pattern (the varation of the ADSI versus the time in months) is shown in the Figure 6 (the fungicide application points are denoted on the time axis as arrows).



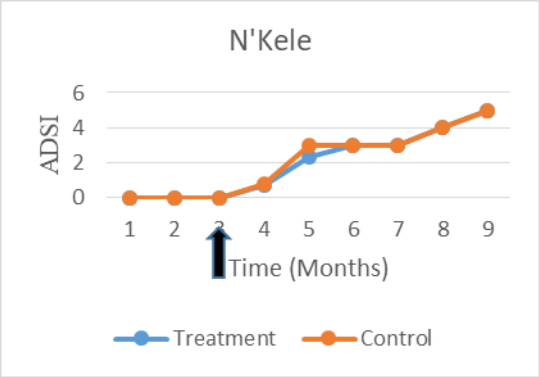


Fig. 6. The disease progression pattern of the fogging experiments

Though the disease progression pattern of some of the treatments show a slight changes from that of the control, it was observed that the reduction of the ADSI was not persistent (Fig. 6). (M K R Silva, T H P S Fernando, E A D D Siriwardena, S C P Wijayaratne, D A N Mallikarachchi).

f) Application of different cocktails to manage CLSD

Different cocktails were tested under field conditions to manage CLSD. Three experiments were carried out at the Yatadola and Elston estates. The disease progression pattern is shown in Figure 7 (the cocktail application points are denoted in the time axis as arrows).

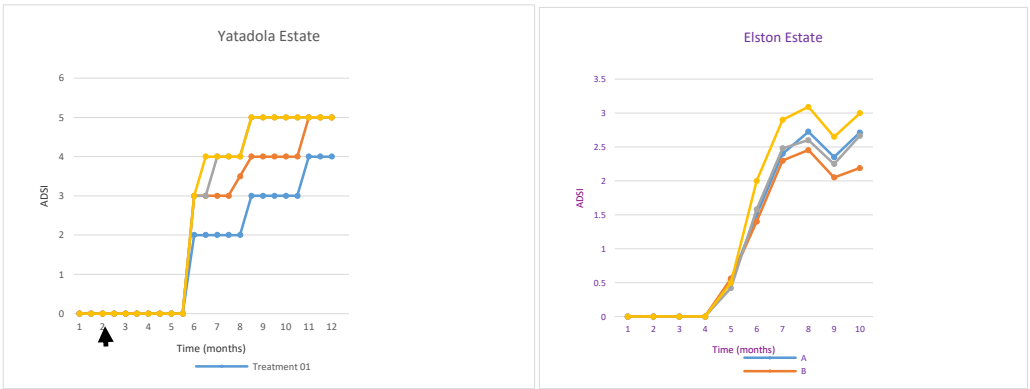


Fig. 7. The disease progression pattern of the cocktail experiments

In both locations, the treatment showed a significant lowering of the ADSI towards the end of the year. In the Elston experiment, it was observed that ADSI values of all the treatments have gone down at the ninth month reading due to the occurrence of a refoliation spell of a certain percentage. However, in the experimental field at the Miyanawita estate, where the same treatments were applied at a later phase i.e. after the appearance of the symptoms of the disease, no significant difference in the ADSI was observed compared to the control (M K R Silva, T H P S Fernando, E A D D Siriwardena, S C P Wijayaratne).

g) Chemical management of CLSD using drone technology

In the management of CLSD, experiments to find out the prospects of using drone technology in spraying fungicides was assessed with the outsourcing of the drone service. The fungicide application was carried out at following locations:

Location	Fungicides	Solvent
Galewtta	hexaconazole 30ml/l sulphur 10g/l	Water
	carbendazim 20g/l mancozeb 30g/l sulphur 10g /l	
	carbendazim 20g/l mancozeb 30g/l-1 hexaconazole 30ml/l	
	carbendazim 30g/l + sulphur 10g/l	
	copper 30g/l + sulphur 10/l	
Moneragala	carbendazim 30g/l + sulphur 10g/ l	Water
	copper 50g/l + sulphur 10g/ l	
	copper 50g/l + sulphur 10g/ l	
Kuruwita	mancozeb 30g/l + carbendazim 20g/l sulphur 10g/l	Water
	carbendazim 30g /l + sulphur 10g/l	
	hexaconazole 30ml/l + mancozeb 30g/l sulphur 10g/l	
Peenkanda	hexaconazole 50ml/l + sulfur 20g/l	Water
	carbendazim 20g/l + mancozeb 30g/l sulfur 10g/l	
	mancozeb 100g/l	Diesel
Halpe	carbendazim 30g / l + sulphur 10g / l-1	Diesel
	hexaconazole 30ml/ l + sulphur 10g/l	
	carbendazim 30g / l + sulphur 10g / l	
	hexaconazole 50ml/ l + sulphur 10g/l	
	carbendazim 30g/l + sulphur 10g/ l	

(T.H.P.S. Fernando, M.K.R. Silva, S.C.P. Wijayaratne)

Screening of Clones against Leaf and Panel Diseases (23/PP/02)

Screening of Clones against Corynespora Leaf fall disease (CLFD)

The incidence of Corynespora leaf fall disease was mild during the year 2023. The pathogen isolates were obtained from non traditional areas – Padiyathalawa, Ampara, RDD nursery. The pure cultures were purified and kept for further research work (T H P S. Fernando, M K R Silva and E A D D Siriwardena).

Maintenance of nurseries for screening purposes – Ratnapura District

Fifty *Hevea* clones are maintained at the Kuruwita substation Ratnapura for clonal evaluation economically important leaf fall diseases (T H P S Fernando, M K R Silva, E A D N Nishantha and A Mallikarachchi).

Establishment of a nursery for screening purposes - Moneragala

Fifty *Hevea* clones are maintained at the Moneragala substation, Moneragala for clonal evaluation economically important leaf fall diseases (T H P S Fernando, M K R Silva and S C P Wijayaratne).

Establishment of a nursery for screening purposes – Padiyathalawa

Fifty *Hevea* clones are maintained at the Moneragala substation, Moneragala for clonal evaluation economically important leaf fall diseases. (T H P S Fernando, M K R Silva, E A D D Siriwardena).

Establishment of a nursery for screening purposes - Dartonfield

Fifty *Hevea* clones are maintained at the Moneragala substation, Moneragala for clonal evaluation economically important leaf fall diseases (T H P S Fernando, M K R Silva, E A D D Siriwardena).

Establishment of a nursery for screening purposes – Sapumalkanda Estate

Fourty eight *Hevea* clones have been established at the Dartonfield Estate, RRISL for clonal evaluation against Corynespora leaf fall disease (T H P S Fernando, M K R Silva and A Mallikarachchi).

Screening of clones against Circular Leaf Spot Disease (CLSD)

The incidence of ***Circular Leaf Spot Disease*** was less severe during the year 2023 compared to the year 2022. The disease severity was comparatively low for the clones RRIC 100, RRISL 2006 and CEN 4. All the other clones are being monitored against the disease and also in different rubber growing agro-climatic areas. The sites where several clones had been planted also showed a comparatively low disease severity (T H P S Fernando, M K R Silva and E A D D Siriwardena).

Screening of clones against Circular Leaf Spot Disease (CLSD) using conidia

Conidia suspensions were prepared using the pathogen isolates and the different clones were artificially inoculated to see the variability in the susceptibility. Both the isolates, *Colletotrichum* spp and Pestalotiodes were used for the experiment. The experiment is in progress (T H P S Fernando, E A D N Nishantha, A H M N R Aberathne and G K S Madhusanka).

Screening of clones against Circular Leaf Spot Disease (CLSD) using toxic metabolites

The toxic metabolites produced by the pathogen isolates were prepared in the Czepek dox broth medium. The toxin were filtered after an incubation period of eight days. This toxin will be used in the clonal screening programme in the future work (T H P S Fernando, A H M N R Aberathne, G K S Madhusanka and G Peiris).

Table 5. *Results of the Survey on Corynespora leaf fall disease conducted in 2023*

Clone	ADSI *	Clone	ADSI *
RRIC 121	0	RRISL221	0
RRIC 102	0	RRISL222	0
RRIC 130	0	RRISL2000	0
RRISL 203	0	RRISL2002	0
PB 260	0	RRISL2004	0
RRIC 133	1.0	RRISL2005	0
RRISL 201	1.0	RRISL2006	0
RRISL 205	0	GPS 1	0
RRISL206	0	PB 255	1.0
RRISL210	0	PR 255	0
RRISL211	0	PR 305	0
RRISL215	0	RRII 105	1.0
RRISL216	0	PB235	0
RRISL217	1.0	BPM 24	0
RRISL219	0	RRISL 200	N/A
RRISL2001	0	Centennial 2	0
RRISL2003	0	Centennial 3	1.1
RRISL 218	1.0	Centennial 4	0
RRISL 204	0	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

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

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

Screening of* Hevea *Germ plasm collection against Circular Leaf Spot Disease (CLSD)– Neuchatal estate

The screening programme was started during the year 2022. The visual ratings to be made first to detect the variability on disease susceptibility. In vitro and in vivo testings will be initiated (T H P S Fernando, S. Withanage, K Liyanage, E A D D Siriwardena and A Baddewithana, Collaboratively with the Genetics and Plant Breeding department).

Biology of Pests (23/PP/03)

Identification of causative organisms associated with the Circular Leaf Spot Disease

Circular Leaf Pot Disease severity was lower compared to the year 2022 and Majority of the isolates obtained were Pestalotioides. The other main pathogen was *Colletotrichum*. Among the isolates nearly 70% represented Pestalotioides pathogens– three genera, Neopestalotiopsis, Pestalotiopsis and Psuedopestalotiopsis. Although the *Colletotrichum* were low in number, they were more pathogenic. Some of the Pestalotioides showed a very mild pathogenicity assayed by detached rubber leaf method using the conidial suspensions. Cultural and reproductive characteristics showed significant variability among the isolates. Based on morphological characters, 13 pathogen isolates were selected for further studies. Sequencing revealed that there were three main species such as; *Colletotrichum siamense, C. fructicola* and *C. gigasporum*. Koch's postulates were proven with the three *Colletotrichum* species on rubber seedlings. This is the first report of *C. siamense, C. fructicola* and *C. gigasporum* associated with the newly spreading leaf fall disease of rubber plantations. *C. gigasporum* was identified as a poor sporulator compared with the other two species. According to the pathogenicity studies, *C. gigasporum* showed the highest Disease Index value (T H P S Fernando, M K R Silva, A H M N R Aberathne, E A D N Nishantha and E A D D Siriwardena).

a) Effect of soil nutrition on the development of CLSD

Field experiments initiated at Sirikandura estate and a medium-level rubber plantation at Maggona to evaluate the effect of soil nutrition on the development of CLSD were continued. Fertilizer application and the recording of the ADSI of the

experimental plots were carried out at specific intervals (M K R Silva, T H P S Fernando, D A N Mallikarachchi – collaboratively with the Department of S & PN).

b) Survival of the CLSD-causing pathogens in soil

To evaluate the inoculum potential of the circular leaf spot disease in the soil, the soil samples of five rubber plantations in the Kaluthara district were collected and assessed. The serial dilution method followed by the microscopic observation was used to identify the causative pathogens of circular leaf spot disease. *Pestalotioides* sp. was successfully isolated and identified from all five rubber plantations. The detached leaf assay was used to confirm the pathogenicity of the isolated fungi. According to the observations, the pH range of the soils from where conidia of *Pestalotioides* sp. were detected ranged from 4.25 and 5.69. Further studies on the isolated fungi are being carried out (M K R Silva, T H P S Fernando and A Mallikarachchi).

a) Survival of CLSD pathogens in plant debris

The experiments to reveal the pathogen survival on the plant debris is in progress (T H P S Fernando, M K R Silva, A H M N R Aberathne and A Mallikarachchi).

Surveillance of potential pests and disease outbreaks (PP / 04)

a) Evaluation of the CLSD development on the yield parameters

A collaborative field investigation was initiated with the Departments of Plant Science, Biochemistry & Physiology, Soil & Plant Nutrition & Genetics & Plant Breeding at the Halpe estate to determine the effect of CLSD on the performance of the trees. Four fields were selected for the study as two fields with very severe CLSD and two with no/mild CLSD level. In order to minimize the effect of other variability on the performance of the trees, it was managed to select all four fields were with RRIC 121 and approximately similar age. An initial assessment of the disease and other conditions were assessed were carried out (T H P S Fernando, M K R Silva, E A D D Siriwardena, S C P Wijayaratne, D A N Mallikarachchi - collaboratively with the Departments of PS, BC & P, S & PN and G & PB).

Biology of Pests (23/P/02)

Determination of the diversity of culturable endophytic microbial population in the leaves of healthy and circular leaf spot disease (CLSD) Infected rubber plants

Circular leaf spot disease (CLSD) is a newly-reported devastating disease of rubber cultivation in Sri Lanka. Previous investigations have reported the possible involvement of *Colletotrichum* and *Pestalotiopsis* spp. as fungal pathogens of CLSD. However, aetiology and management of the CLSD are not fully understood. Eventhough endophytic microbial populations are beneficial for plant health, their structural and functional imbalances promote disease development. The present study

was aimed to determine the variation of endophytic microbial diversity of the leaves of healthy and CLSD-infected rubber plants and to screen biological control agents of pathogenic fungi among the endophytic microbes in healthy and early CLSD-developmental stages. Healthy and symptomatic leaves of the four stages of CLSD development (i.e. S1, S2, S3 and S4) were collected from two fields. Culturable endophytic fungi, bacteria and actinomycetes were isolated using specific media and morpho-species were recorded. As ecological parameters, species richness (SR), species evenness (SE), relative abundance of the species (RA) and Shannon-Weiner diversity index (SWDI) were quantified. A total of 41 fungal and 25 bacterial morpho-species were isolated from healthy and different stages of CLSD from location 1 and it was 32 and 13, respectively for location 2. RA of bacteria and fungi significantly differed among the stages of disease progression (P=0.05) though SR, SWDI and SE of bacteria and fungi showed no significant difference with the disease progression stages. No endophytic actinomycetes were isolated. Two morphologically different *Colletotrichum* isolates and a Pestalotiopsis sp. were isolated from symptomatic rubber leaves and antagonistic effect against them by seven fungal and bacterial morpho-species residing in healthy and S1-stage leaves was assayed. Six of them inhibited the colony growth of the *Colletotrichum* and *Pestalotiopsis* isolates by a range of 20-100%, confirming the promise of endophytic fungi and bacteria in healthy and S1 stage leaves as biological control agents of CLSD (T H P S Fernando, Devika M De Costa and M H N C Weerasinghe - collaboratively with the University of Peradeniya).

Evaluation of Survivability of the Causative Agents of the Circular Leaf Spot Disease in Leaf Litter of Rubber Plantations in the Kalutara District

Rubber (*Hevea brasiliensis*) is a deciduous plant and a major industrial crop in the economic world. And it is facing diseases like circular leaf spot disease, which reduces latex quality and causes significant losses. The disease is spreading among Sri Lankan rubber plants, causing leaf fall and affecting latex yield. The Rubber Research Institute of Sri Lanka reports that *Collectricum* species and Pestalotioides are playing a synergistic role in causing this new leaf fall disease. As per the method, leaf litter samples were collected from the five rubber plantations in Kalutara district, then dilution series were prepared and cultures were initiated to isolate pathogens. Their morphology was observed and identified according to their colony and conidial characteristics, such as colony morphology, colony color, spore size, and spore shape. A pathogenicity test was performed using the above-isolated *Colletotrichum* species with non-wound and wounded rubber leaves inoculated in suspension and a control sample inoculated with distilled water. Different colony morphology characteristics and colony colors were shown on theupper and lower surfaces of isolated *Colletotrichum* species from five rubberplantations. And their conidial morphology of conidial size (μm) data of *Colletotrichum* species isolates were subjected to a turkey

pair-wise comparison test at the P< 0.05 probability level for mean comparisons among conidial length and width. All the isolated *Colletottrichum* species caused lesions on detached rubber leaves after the pathogenicity test. Based on the results of this study, it can be concluded that *Colletotrichum* species survive in all rubber plantation leaf litter and have been found to affect circular leaf spot disease through pathogenicity tests (T H P S Fernando, K D M Nayanahari Colaboratively with the, Sabaragamuwa University of Sri Lanka).

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

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

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

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

Isolation of bacteria with a potential for the coagulation of latex from Hevea brasiliensis

Rubber industry plays a significant role in Sri Lanka's economy. Rubber (*Hevea brasiliensis*) which belongs to the family Euphorbiaceae is the most economically important member of the genus *Hevea*. Rubber is the third largest plantation crop grown in Sri Lanka and the economic product of the tree is latex. Coagulation of latex is a crucial step in the rubber processing chain, as it significantly influences the properties of the final rubber product. Traditionally, coagulation was achieved naturally, aided by acidic by-products from microorganisms, allowing the latex to coagulate in collection cups over several days. However, commercial production frequently incorporates acids such as formic acid, acetic acid, and sulfuric acid, each impacting the rubber differently. The rubber industry has a severe economic and environmental issue as a result of its excessive reliance on expensive imported

chemical coagulants, especially formic acids, for the coagulation of latex. This study intends to address this problem through exploring the possibility of using bacteria isolated from rubber cup lumps as a cost and environmentally-friendly replacement for latex coagulation. The main objective of this study isolation and identification of microorganism to coagulate latex under field condition. The experiment was conducted in the Rubber Research Institute of Sri Lanka, Dartonfield Agalawatta. Five treatments (Bacteria samples) were isolated and used in this experiment and the five treatments were tested separately for the coagulation of rubber latex, the time taken for coagulation, serum pH and the dry weight was measured. Formic acid was used as the control and according to the data obtained 5 treatments were compared with formic acid. Considering the above facts, it was concluded that treatment 3 (Bacteria sample) shows similar activity to formic acid (Control).

Characteristic	**Culture A**	**Culture B**	**Culture C**	**Culture D**	**Culture E**	**Culture F**
Surface appearance	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Color	White	White	Transparent	White	White	Transparent
Shape						
Form	Irregular	Irregular	Irregular	Irregular	Irregular	Irregular
Margin	Undulate	Entire	Lobate	Entire	Entire	Lobate
Elavation	Flat	Flat	Flat	Flat	Flat	Flat
Gram's Test	Pink Gram negative	Violet Gram positive	Violet Gram positive	Violet Gram positive	Pink Gram negative	Violet Gram positive

(T H P S Fernando, S Siriwardena, A Attanayaka, M K R Silva, A H M N R Aberathne and K A L Vidushika)

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

Disease Survey for the year 2023

A disease survey was called by the TASK FORCE – Ministry of Plantation Industries. Based on the survey the total extent under the disease was approx. 25,000 ha. (T H P S Fernando, M K R Silva collaboratively with the Advisory Services Department and the Rubber Development Department).

Studies on Alternative hosts Alternative hosts study for CLSD associated pathogens

The CLSD pathogens were isolated from the tea plants, cinnamon plants and many other host plants grown in and around the rubber plantations. The pathogenicity studies are in progress. (T H P S Fernando, D P Kariyawasam and E A D N Nishantha).

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

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

Developing a national level fungal culture collection – WDCM registered

A collection of fungal cultures is maintained at the Plant Pathology & Microbiology Department in view of using them for research and development purposes. These pure cultures of beneficial and pathogenic are provided for nationally and internationally important research and development purposes (T H P S Fernando, M K R Silva and A H M N R Aberathne).

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

Rubber latex coagulation bacteria

Six bacteria and six fungi were isolated from coagulated rubber latex in the field. Pure cultures of them were obtained. They were grown in malt extract broth medium and the pH changes of each media were measured. The experiment is still continuing. The most effective bacteria was grown in potato dextrose broth and tested for latex coagulation (T H P S Fernando, S Siriwardena, A Attanayaka, M K R Silva, N Aberathne and K A L Vidushika).

Development of latex – based coco peat media to grow *Trichoderma harzianum* as a biofungicide

- Population density of *T. harzianum* on high compost-coco peat media with lowest (T7) and medium (T8) rubber amounts respectively were comparable and those values (7.3×10^4 colonies per gram) were significantly higher than the others at the 30th of incubation period (Fig. 27).
- The water holding porosity was higher (59.99%) in high compost-coco peat media which has medium rubber amount (T8) and the pH of media was 6.5.
- All media showed viable population density of *T. harzianum* and high compost-coco peat media which has medium rubber amount substrate (T8) showed better growth at the end of one month as laboratory experiment.
- Cost of a block prepared with 15g of T8 medium was LKR 6.54.

(T.H.P.S. Fernando, K.V.V.S. Kudaligama and C.A.E. Gayesha, Department of Natural Resources, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka)

Isolation of endophytic fungi from Rubber (*Hevea*) leaves and to test their pathogenicity

The experiment was aimed to isolate endophytic fungi from different rubber clones and to test their pathogenicity against rubber plants. The objectives were to isolate the endophytic fungi from non-symptomatic leaves, to assess their pathogenicity levels, isolate of endophytic fungi from rubber leaves, purify the cultures and do the pathogenicity test. Three main rubber clones were subjected to the study: RRIC 121, RRISL 203 and RRIC 100. Four leaf stages were used in the isolation of the microorganisms; Copper brown, Apple green, Semi mature, and Mature stage. Samples were collected from Rubber Research Institute, Dartonfield Estate. Twenty different fungal endophytes were isolated from healthy symptomless plant leaves. When a mycelium appeared round the edge of the sample on the PDA plate, the hyphal tips were transferred on to a fresh PDA plate. Among them 12 isolates were proven as non-pathogenic. Eight isolates were reported as leaf pathogens. The endophytes were isolated using potato dextrose agar (PDA). 203SM 2, 203M 3, 203 1, 203 M2, 121 M 1, 100 M 1, 100 M 2 and 203 SM 3 were reported as leaf pathogens and other 18 were reported as nonpathogens. Pathogens reported by observing spots on leaves. The severity of leaf disease was determined by the size of lesions or spots on the leaves (THPS Fernando, A H M N R Aberathne and G K S Madhusanka M.N.N. Zainab Sabaragamuwa University of Sri Lanka)

Isolation of endophytic fungi from *Hevea brasiliensis* and investigation of their antagonism against circular leaf spot disease pathogens of rubber

In Sri Lanka, the latex yield losses from rubber plantations are largely due to the foliar diseases of rubber plants. Regular application of chemical fungicides to eradicate pathogens causes pollutes to the environment and creates health hazards. And they may also create new pathogen strains that are resistant to the chemicals. Cultural practices, biological control, and chemical control are all used as integrated management techniques for the management of diseases. “Circular Leaf Spot Disease” or “New Leaf Fall Disease” has been observed in Sri Lankan rubber cultivations since July 2019. Interim fungicide recommendations have been made to manage the disease. Three rubber clones; RRIC 121, RRIC 100, and RRISL 203 were used to isolate endophytic fungi and they were investigated for their antagonism against the pathogens using the dual culture method. From the isolated endophytic fungi, the most effective nine antagonistic agents were selected (three from each clone) by calculating the Percentage Growth Inhibition (PGI) value. The causative agents; six *Colletotrichum* spp. and three Pestalotioides species that had been identified by the RRISL as the primary and secondary causative agents of the disease were used to investigate the antagonism of isolated endophytic fungi. The cultural and morphological characters of the selected endophytic fungi which were found as the most effective antagonistic agents were observed and recorded. All selected endophytic

fungi were preserved under short-term and long-term storage methods for future studies. From dual culture method; entophytic fungi who were isolated from RRISL 203 clone showed the highest percentage of antagonism among all the isolated fungi from three clones. Entophytic fungi isolated from RRIC 121 and RRIC 100 showed similar percentages of antagonism for the pathogens of the disease. Two selected endophytic fungi were identified using CMI Index up to the genus level as *Aspergillus niger* and *Aspergillus ustus.* The cultural and morphological characters of the selected fungi have shown that all the isolated endophytic fungi were different from each other (T H P S Fernando, A H M N R Aberathne G K S Madhusanka and S A C Sandamali, Uva Wellassa University)

Advisory visits and training programmes (PP– 08)

The staff of the department made 90 advisory visits mainly to handle complicated disease problems. The majority of these visits were for the estate sector while the others were directed to the department by the Extension staff. The department conducted ten training programmes on disease identification, prevention and management to educate the Extension staff and the stakeholders of the new findings.

The staff of the department served as the resource personnel in training Estate Managers, Assistant Superintendents and Field Officers. Students from Universities and Technical Colleges were also trained in departmental activities. Mr. Priyantha Peiris covered all audio visual aspects with regard to the training programmes organized by the institution.

International Workshop on the "Circular Leaf Spot Disease Pestalotiopsis) and other economically important diseases of rubber plantations" Funded by the International Rubber Research and Development Board (IRRDB)

Delegates from Malaysia, Indonesia, India, USA participated. A publication was also produced on the new directions and strategies for sustainable disease management (T H P S Fernando & the staff of Plant Pathology & Microbiology Dept.)

SOILS AND PLANT NUTRITION

L A T S Liyanaarachchi

DETAILED REVIEW

Staff

Dr (Mrs) R P Hettiarachchi, Head of the Department, after 32 years of service retired on 15th December 2023. Mrs H A R K Jayawardana, and Mr L A T S Liyanaarachchi Research Officers were on duty throughout the year. Experimental Officers Miss V Edirimanna, Miss A Thevarapperuma and Mr T Gunathileke, Technical Officers, Mrs K E de Silva, Mr G C Malawaraarachchi, Mrs R M Baddevidana, Mr M W H Gayan, and Mr B N K Rangana were also on duty throughout the year and Mrs K M M E K Kulatunga resigned from duties on the 15th of March 2023.

Research Students

The following students have completed their Research studies under the supervision of Mr. L A T S Liyanaarachchi.

- U K A Indumini, a student from the Faculty of Agriculture, University of Rajarata Sri Lanka, conducted a part of her final year research project on "Impact of slope positions on soil fertility in immature rubber plantations".
- H A V R Praboda, a student from the Faculty of Agriculture, the University of Rajarata Sri Lanka, conducted a part of her final year research project on "Identification of the spatial variability of soil properties with different cover crop management in immature rubber plantations".

Seminars/ Trainings/ workshops/Conferences/ Meetings conducted

Officer	Subject	Organization
RP Hettiarachchi	Effect of Slow-Release Fertilizer Techniques on Growth and Mineral Composition of Immature *Hevea* and Fertility of Rubber Growing Soils	National Institute of Plantation Management (NIPM) Symposium
Mrs H A R K Jayawardana	Preliminary Investigation to Determine the Potential of Using Rubber Processing Factory Effluent as Nutrient Source for Food Crops	National Institute of Plantation Management (NIPM) Symposium
Dr (Mrs) R P Hettiarachchi	Effect of Slow-Release Fertilizer Techniques on Growth and Mineral Composition of Immature *Hevea* and Fertility of Rubber Growing Soils	Scientific Committee Meeting

Officer	Subject	Organization
Mr L A T S Liyanaarachchi	Presentation on Reach Smart Plantation Status with GIS, GPS and Remote Sensing	Scientific Committee Meeting
Mr L A T S Liyanaarachchi	Presentation on Reach Smart Plantation Status with GIS, GPS and Remote Sensing	Rubber Research Board
All the staff	Training on Soil Sampling and Laboratory Analysis	Industrial Technology Institute (ITI)
All the Staff	A Workshop on Slow-Release Fertilizer Application	Devalakanda Estate staff of Kelani Vally Plantation PLC

Seminars/ Trainings/Workshops/Conferences/ Meetings Attended

Officer	Subject	Organization
RP Hettiarachchi	Fertility management for rubber plantations	Rubber Research Board
HARK Jayawardana	Bio-efficacy Reports of weedicide samples	Office of Registrar of Pesticide
LATS Liyanaarachchi	Roundtable Event on 'Evaluating Policy Options in Fertilizer: Sri Lanka's Experience and Lessons from Other Countries	Ministry of Agriculture
LATS Liyanaarachchi	Awareness Program on German Supply Chain & Due Diligence Act	Sri Lanka Export Development Board
Mrs Eranga De Silva, Mr Gayan Malawalaarachchi, Mr Helaru Gayan and Mr. Kasun Rangana	Training on Laboratory Management and Performance Improvement	Association of Testing Laboratories

Visits

Advisory	04
Experimental	70
Others	55

LABORATORY AND FIELD INVESTIGATIONS

Soil Fertility Management

Slow-release fertilizer applications

Effect of Different Slow-Release Fertilizer Applications on the Growth of Immature Rubber Cultivations

Different slow-release fertilizer application techniques were compared with conventional estate management fertilizer applications at three sites namely Sapumalkanda, Mahaoya and Pitiyakanda estates, Lalan Rubber Plantation Company. The following treatments were applied at each site.

Treatment 1 – Conventional Fertilizer Application
Treatment 2 – Fertilizer Encapsulated Coir Brick (R/U 12:14:14)
Treatment 3 – Polythene Fertilizer Bag (R/U 12:14:14)
Treatment 4 – Reusable Porous Tube (R/U 12:14:14)
Treatment 5 - Fertilizer Encapsulated Coir Brick (R/U 20:07:20)

After eight months, girth data were obtained at the 4 feet height of the plants and the mean girth of each treatment was observed. Experiments are continued and the second data set will be collected in the year 2024 for each site.

Table 1. *Mean girth of each treatment at Mahaoya, sapumalkanda and Pitiyakanda experimental sites*

Treatment	Mean girth (cm) Mahaoya	Mean girth (cm) Sapumalkanda	Mean girth (cm) Pitiyakanda
Conventional Fertilizer Application	5.10	4.35	6.51
Fertilizer Encapsulated Coir Brick (R/U 12:14:14)	5.80	5.45	7.52
Polythene Fertilizer Bag (R/U 12:14:14)	6.60	8.14	8.15
Reusable Porous Tube (R/U 12:14:14)	6.13	5.91	7.85
Fertilizer Encapsulated Coir Brick (R/U 20:07:20)	6.00	5.73	7.15

Evaluation of Integrated Organic and Inorganic Fertilizer Application Techniques on the Plant Growth of Immature Rubber

The field trial was initiated in February 2023 at Salawa Estate, Hanwella, to evaluate the impact of different fertilizer treatments on immature rubber plants.The experimental design used is a Randomized Complete Block Design (RCBD). The experiment consists of five treatments with 25 plants per treatment, replicated four times, totalling 500 plants. The treatments are as follows: T1 (Estate practice), T2 (Compost + inorganic Fertilizer applied twice a year, 300g inorganic fertilizer and 4kg compost per year), T3 (Coconut husk + Inorganic fertilizer, applied once a year), T4 (Paddy Husk + Inorganic Fertilizer, applied twice a year, 300g inorganic fertilizer and

4kg paddy husk per year), and T5 (Fertilizer bag + compost, applied once a year, 300g fertilizer and 1kg compost per year).

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

Growth performances were measured by obtaining girth data for each treatment of immature rubber at the Kuruwita study area under the treatment plan described in the table 2. Statistical comparison of each treatment was done using the SAS statistical software by comparing means. Treatments: T5 and T4 showed promising results comparatively to other treatments while conventional fertilizer recommendation under the T1 showed the lowest girth performance. Details of the mean comparison are included in the Table 2.

Table 2. *Details of the treatments*

Treatment	Description	Average plant girth (cm)
T1	100% recommended fertilizer Control	15.90^{a}
T2	100% recommended fertilizer + compost and other amendments	15.60^{ab}
T3	100% recommended fertilizer + EM + compost and other amendments	14.16^{bc}
T4	50% recommended fertilizer + compost and other amendments	14.05^{bc}
T5	50% recommended fertilizer + EM + compost and other amendments	12.66^{c}

Effect of nutrient management on the severity of the Circular Leaf Spot Disease

Circular Leaf Spot Disease is a significant threat to rubber plantations in Sri Lanka and many other countries. The Soils and Plant Nutrition Department is investigating the impact of different fertilizer treatments on the severity of the disease with the collaboration of the Plant Pathology and Microbiology Department.

The first leaf nutrient data set of total Nitrogen (TN), available Phosphorous (AP), exchangeable Potassium (EK), and exchangeable Magnesium (EMg) were obtained after one year of application below treatments for the immature rubber plantations in Sirikandura and Maggona areas. The data were analysed for the mean comparison in SAS 9.0 statistical software and details of the mean comparison are included in the Table 3.

Table 3. *Mean comparison of the nutrient levels of treatments*

Treatments	Average nutrient levels (%)			
	TN	AP	EK	EMg
T1	1.78^{ab}	0.14^{a}	0.96^{ab}	0.19^{b}
T2	1.68^{b}	0.10^{b}	0.94^{ab}	0.21^{a}
T3	1.71^{ab}	0.12^{ab}	0.79^{b}	0.19^{ab}
T4	1.83^{ab}	0.14^{a}	0.89^{b}	0.21^{ab}
T5	1.91^{a}	0.15^{a}	1.06^{a}	0.22^{a}

The results revealed that treatment 5 had comparable positive results while control treatment and no fertilizer treatment showed comparatively low performaces except in the available phosphorous level. The experiment is in progress. the next field experiment was initiated at the Waga division of the Halpe estate to study the impact of the disease severity with effective nutrient management.

Identification of Management Zones under Mature Rubber Lands in Sri Lanka Using Geospatial and Geostatistical Techniques

Delineation of Management Zones in Mature Rubber Plantations Using Soil Organic Carbon, Total Nitrogen, and C/N Ratio

Key soil chemical properties such as Soil Organic Carbon (SOC), pH, Total Nitrogen (TN), and Carbon Nitrogen ratio (C/N Ratio) are critical properties which fundamentally influence soil health and quality. The cumulative impact of these properties determines the nutrient availability, microbial activities, soil fertility and overall soil health which are essential to sustainable cultivation. SOC plays a vital role by improving soil physical structure and contributing to the nutrient reservoir in the soil. Hence, the C/N ratio is also a very critical property which explains the soil nitrogen and carbon behaviours. pH also determines the plant nutrient availability and solubility in soils that are either too alkaline or acidic conditions. Hence, TN plays a crucial role in plant nutrition by contributing significantly to photosynthesis and plant vigor. The delineation of management zones under mature rubber plantations in the Kuruwita substation, mature rubber land was done by employing the Geographic Information System (GIS) based approach to assess the cumulative impact of SOC, TN, pH and C/N ratio on the soil quality. Most ideal geostatistical techniques from Inverse Distance Weighted (IDW), Kringing and Spline were identified to develop the spatial distribution of the above-mentioned soil chemical properties for the total number of 22 soil samples collected from a 12 ha mature rubber growing land using different error estimations known as Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE), Mean Square Error (MSE), and Root Mean Square Error (RMSE). The detailed comparison of error metrics is included in Table 4-7.

Table 4. *Error Comparison of Geostatistical Techniques for Total Nitrogen*

	MAE	MAPE	MSE	RMSE
IDW	0.03	30.80	0.002	0.04
Spline	0.04	31.19	0.002	0.04
Kringing	0.04	31.45	0.002	0.04

Table 5. *Error Comparison of Geostatistical Techniques for Soil Organic Carbon*

	MAE	MAPE	MSE	RMSE
IDW	0.24	14.97	0.07	0.28
Spline	0.25	15.97	0.09	0.30
Kringing	0.16	10.28	0.03	0.18

Table 6. *Error Comparison of Geostatistical Techniques for Ph*

	MAE	MAPE	MSE	RMSE
IDW	0.16	3.10	0.04	0.19
Spline	0.38	7.22	0.23	0.48
Kringing	0.18	3.61	0.04	0.20

Table 7. *Error Comparison of Geostatistical Techniques for C:N ratio*

	MAE	MAPE	MSE	RMSE
IDW	3.03	23.34	12.53	3.54
Spline	3.55	29.09	13.79	3.71
Kringing	3.49	26.69	16.16	4.02

Services

Land selection and suitability for rubber cultivation

No land selection reports were issued in 2023 as there were no requests for land suitability assessments from rubber growers.

Site-specific fertilizer recommendation by soil and foliar survey programme

Under this program, 4136.30 hectares of mature rubber lands were surveyed and 28 reports were issued for the site-specific fertilizer recommendations for the next three years of 2024-2027. Details of the survey are shown in Table 9.

Workshops, Training and Efficacy Testing programmes

Under this programme, one workshop, and one training programme were conducted for the Kelani Valley Plantation PLC and Industrial Technology Institute (ITI) respectively and details are given in Table 8.

Efficacy testing of Yara Mila fertilizers which are known as highly efficient and 4th generation fertilizers, were evaluated under immature rubber plantations at

traditional and non-traditional rubber growing areas in Sri Lanka as a Private Public Partnership (PPP) programme with CIC Agribusiness (Pvt) Limited. Trials are continuing at four immature rubber plantation sites in Moneragala and Padiyathalawa, and Salawa, Halpe estates of traditional rubber growing areas in the country.

Table 8. Details of the workshops, training programmes and efficacy testing programmes

Program	Target group	Income (Rs.)
Awareness workshop	Kelanivalley Plantation PLC	25,000.00
Training Program	Industrial Technology Institute (ITI)	
Yara Mila Efficacy Testing Program	CIC Agribusiness (Pvt) Ltd	500,000.00

Analytical services

Various samples received from estates, smallholders, universities, private organizations, other government institutes, and different stakeholders were analyzed at the Soils and Plant Nutrition Laboratory (SPNL) under this program. The laboratory issued 60 outside analytical reports for 578 samples. Among the samples, 241 soil samples, 165 fertilizer samples, 4 compost samples, 165 leaf samples, and 3 samples belong to the other category. Details of the analytical service are included in Table 9.

Table 9. *Details of the analytical services and site-specific fertilizer recommendation program*

No	Name of the company/estate	Analytical Service		Site-specific fertilizer recommendation programme		Income	
		No. of reports	No of samples	No. of reports	Survey extent (ha)	Outside analytical service (Rs.)	Site-specific fertilizer recommendation programme (Rs.)
1	Eladuwa Estate	1	2			5600.00	
2	Unknown					7900.00	
3	Cuileagh Estate	1	10			1000.00	
4	University of Peradeniya	1	30			156000.00	
5	CECB	2	30			78,000.00	

6	Ayr Estate	1	2			20800.00	
7	Pallegama	2				14,000.00	
8	Miyanavita	2	6	1	233.75	16,800.00	70,125.00
9	Nishantha	1	2			5600.00	
10	Miyanavita	1	1			2800.00	
11	Mr. Dhanuka Sampath	2	2			800.00	
12	Miriswatta	1	2			5,600.00	
13	Udabage	1	6	1		16800.00	
14	Pitiyakanda	1	3	1	550.03	8,400.00	165,009.00
15	Damro	3	14			39,200.00	
16	Sapumalkanda	1	4	1	547.97	12600.00	164,391.00
17	Ketandola	2	20	1	27.04	57,400.00	8,112.00
18	Parambe	4	11	1	230.86	30,800.00	69,258.00
19	Citrus	1	1			2800.00	
20	Atale	1	5			14000.00	
21	Etana	1	8			22400.00	
22	Madeniya	1	5			14000.00	
23	Weniwella	1	8			22400.00	
24	Hathbewa	1	7			19600.00	
25	Padukka	1	2			5600.00	
26	Mahaoya	1	4			39200.00	
27	Ambedeniya	1	7			19600.00	
28	Eladuwa Estate	1	6			16800.00	
29	Yatederiya	1	3			8400.00	
30	Thalgaswela	1	96			268800.00	
31	Elpitiya	1	20	1	91.73	56000.00	27,519.00
32	Uva Wellasa uni.	1	105			745000.00	
33	Palmadulla	1	1			2800.00	
34	Udabage	1	6			16800.00	
35	Udabage	1	2			5600.00	
36	Bibila Estate	1	1			2800.00	
37	Pitiyakanda	1	3			8400.00	
38	Divithura	1	31			86800.00	
39	Higgoda	1	4			7825.00	
40	Udapola	1	12	1	154.27	33600.00	46,281.00
41	RDD	1	12			33600.00	
42	Miyanavita	1	3			8400.00	
43	Ruhunu University	1	48			4800.00	
44	Miriswatta	1	5			14000.00	
45	Kapuwella Watta	1	3			34800.00	
46	Mahaoya	1	6			62400.00	
47	Rambukkanda	1	1			2800.00	
48	Techno biZ	2	7			12800.00	
49	Edella	1	1			14000.00	

50	Lalan Rubber	1	1		8400.00	
51	Giragama					
52	Mohommadi					
53	Kotagala Plantation PLC			11	1532.21	459,663.00
54	Culloden			1	83.05	24915
55	Ambatenna			1	34.69	10407
56	Clyde			1	181.45	54435
57	Kiriwanaketiya			1	65	19500
58	Sanqahare			1	38.4	11520
	Total					

BIOCHEMISTRY AND PHYSIOLOGY

K V V S Kudaligama

DETAILED REVIEW

Staff

Dr (Ms) KVVS Kudaligama, continued duties as the Head of the Biochemistry & Physiology department. Ms NPSN Karunarathne, Research Officer, Mr MKP Perera, Experimental Officer, Mr LTBK Fernando and Ms NN Abewardhana, Technical Officers and Ms HAME Hettiarachchi, Management Assistant were on duty throughout the year. Ms PDTL Madushani, Technical Officer reported to duty on 09.01.2023 after maternity leave.

Research students

Student name	Research Topic	University
K. P. Sathsarani C. S. Sandaruwani B. H. Weerasingha	Industrial training programme of Bachelor's degree	Sabaragamuwa University of Sri Lanka
H. A. N. R. Samindi G. M. Kahawatte M. M. S. Madigasekera H. P. K. M. M. de Alwis	Industrial training programme of Bachelor's degree	Uva Wellassa University
K. P.N.M. Jayawardhana	Industrial training programme of Bachelor's degree	South Eastern University
G. H. T. Ginasena	Induction training programme of Higher National Diploma in Agriculture	Technical College, Kuliyapitiya

Seminars/Conferences/Workshops/Exhibitions attended

Officer/s	Subject/Theme	Organization
KVVS Kudaligama	Workshop on Intellectual Property	MPI
KVVS Kudaligama	International Plantation Summit	Hayleys PLC
KVVS Kudaligama	Innovation Forum	MPI
KVVS Kudaligama NPSN Karunarathne	International Symposium on Sustainable Plantation Management	NIPM
KVVS Kudaligama NPSN Karunarathne	International Workshop on Circular Leaf Spot Disease of Rubber	RRISL/ / IRRDB
NPSN Karunarathne	Sustainable Finance	MPI and UNDP Sri Lanka

Training programmes conducted

Officer/s	Subject/Theme	Remarks
KVVS Kudaligama	Effective introduction of new LIH systems to address current issues in the rubber plantation industry	Elston estate Padukka estate Halpe estate Miriswatte estate 07 smallholdings
KVVS Kudaligama NPSN Karunarathne	Low intensity harvesting to cope with current issues- tapper shortage in rubber plantations	Rubber growers, Field Officers
KVVS Kudaligama	Low intensity harvesting systems of rubber latex.	REO RDO

Field visits

Advisory - 20
Experimental - 342
Miscellaneous - 11

Sample testing

Commercial Ethephon mixtures - 04 samples

LABORATORY AND FIELD INVESTIGATIONS

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

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

Research and development on low-intensity harvesting strategies

Elston estate – S/2 d4 system

Monitoring and data collection of the pilot project to investigate the commercial scale performance of S/2 d4 harvesting system at Elston estate has been continued during the year 2023. Fields have been planted with the clone RRIC 121 and rain-guarded to minimize rain interferences. Growth, latex flow parameters, yield parameters, latex physiology, and raw rubber properties were monitored according to the plan. Monthly application of 0.6g of 2.5% ethephon was practiced as per the RRISL recommendation for the S/2 d4 system. However, four planned stimulation rounds had to be suspended with the occurrence of a heavy leaf fall due to circular leaf spot disease. Average dry rubber content of latex did not fell below 35% at any month. During January, February April and September months number of tapping days has been considerably reduced due to rain interferences. Lowest yields were recorded from the

February to May period as a result of the wintering of trees and also due to suspending the application of stimulation rounds in particular months as per the recommendation. The highest yields were recorded from the month of June – December period (Table 1). The average intake per harvester was 11.33 kg and with the total number of 70 tapping the recorded yield per ha was 1097kg (400 tree/ha stand). Reduction of tapping days together with suspended stimulation rounds have been identified as the main reason for the reduction of yield.

Table 1. *Yield and related figures of the field harvested with S/2 d4 system at Elston estate*

Month	Dry rubber content (%)	Daily dry rubber yield of a tree (g)	Intake per harvester (kg/ 300 trees)	Number of tapping days	Stimulation
Jan	35.86	35.90	10.77	4	no
Feb	35.52	27.08	8.13	4	no
Mar	36.97	24.06	7.22	6	no
Apr	35.03	22.81	6.84	4	no
May	35.36	31.35	9.41	6	yes
Jun	37.36	43.65	13.10	7	yes
Jul	36.91	46.25	13.88	8	yes
Aug	37.49	51.49	15.45	8	yes
Sep	36.75	44.36	13.30	5	no
Oct	37.13	35.03	10.51	6	no
Nov	37.30	42.85	12.86	6	yes
Dec	37.52	48.46	14.54	6	yes

Table 2. *Latex physiological parameters of the field harvested with S/2 d4 system at Elston estate*

Latex physiological properties	
Sucrose (mM)	5.69
Thiol (mM)	0.75
Inorganic phosphorous content (mM)	10.84
Polyphenol (mM)	7.23
Total solids content (%)	47.96

Average Sucrose content of the field in Elston estate was 5.69mM and inorganic phosphorous content was 10.84 mM. The higher thiol (0.75 mM) content observed is in favour of the defence system pocesses in trees against reactive oxygen species that evolve during rubber biosynthesis. The average total solids content which was 47.96% denotes a better latex regeneration capacity in trees (Table 2).

Table 3. *Raw rubber properties of the field harvested with S/2 d4 system at Elston estate*

Raw rubber properties	
Initial plasticity	49.98
Plasticity Retention Index	84.88
Mooney viscosity (ML (1+4)@100 ºC)	83.34
Ash content (%)	0.23
Nitrogen content (%)	0.32
Lovibond colour index	3.00

Observed raw rubber properties of the unfractioned unbleached crepe processed with latex of experimental field in Elston estate are given in the Table 3.

Table 4. *Growth performance of trees of the field harvested with S/2 d4 system at Elston estate*

Growth performances	
Girth (cm)	62.82
Bark thickness (mm)	7.39

The average girth of trees in the experimental field was 62.82cm whilst the average bark thickness observed was 7.39mm (Table 4) (K V V S Kudaligama, N P S N Karunarathne, M K P Perera, L T B K Fernando, P D T L Madushani and N N Abewardhana).

Dartonfield estate - S/2 d4 system

Testing of S/2 d4 in commercial scale has also been continued in a 5.17 ha mature rubber field replanted in 2010 at Nivithigalakele division of Dartonfield estate. It is a mixed plantation with RRIC 121 and RRISL 203 clones. The total number of tapping days under d4 frequency was 69 and 14% reduction from the accepted level due to rain interferences and tapper absenteeism. DRC% of the latex varied between 39 – 40 % during the year. The field was with 8 tapping blocks and the average intake per harvester was 9.33 kg. The average productivity of a tree was around 2.18 kg whilst the field had an average of 873 kg/ha/yr productivity (Table 5). Out of 10 planned stimulation rounds, only 02 have been applied poor canopy condition occured due to CLSD and this has been identified as the main reason for low yield levels in the field.

Table 5. *Monthly variation of yield parameters of field harvested with S/2 d4 system at Nivithigalakele division of Dartonfield estate*

Month	Tapping days	Dry rubber content (%)	Daily dry rubber yield of a tree (g)	Intake per harvester (kg)	Stimulation
JAN	6	39.81	34.46	10.34	No
FEB	5	39.63	36.70	11.01	No
MAR	7	39.97	43.07	12.92	No
APR	6	40.00	33.41	10.02	No
MAY	5	40.00	27.28	8.18	No
JUNE	5	39.29	26.36	7.91	No
JULY	7	39.51	33.06	9.92	Yes
AUG	6	40.00	37.27	11.18	Yes
SEPT	4	40.00	24.94	7.48	No
OCT	6	38.70	28.03	8.41	No
NOV	6	39.73	26.06	7.82	No
DEC	4	40.00	22.51	6.75	No

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

Popularization of low-intensity harvesting systems

Activities were conducted to provide an evidence-based approach through demonstrations, to popularize new low-intensity harvesting systems in both smallholder and plantation sectors to address current issues and thereby to obtain associated benefits. To improve the knowledge of S/2 d4 adaptation, awareness programmes were conducted for 52 Officers and workers in the Elston, Halpe, and Miriswatta estates. Sixteen on-site programmes were conducted to improve the theoretical and practical knowledge of low-intensity harvesting systems for 23 interested smallholder growers. A training programme was conducted in collaboration with RRI Academy for 25 participants from different RPCs to enhance the knowledge on low-intensity harvesting to cope with current issues in rubber plantations. Two awareness programmes were conducted for REOs and RDOs to improve their knowledge on low-intensity harvesting and stimulation. Total number of trainees was 45. Under the task force activities, three training programmes were conducted for the rubber smallholders in Moneragala District to improve their knowledge of harvesting strategies. Total number of participants were 110.

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

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

Kandakaduwa (Dry zone)

Experimental field established at Kandakaduwa Army farm in 2015 with RRIC 100, RRIC 121, RRISL 203, RRISL 2001 and PB 260 clones to evaluate their performances in the Dry Zone. Up to the year 2022, chlorophyll content, epicuticular wax content, relative water content (RWC), leaf area and stomatal conductance were assessed as physiological parameters. As the trees were grown to a reasonable height, assessing physiological properties was stopped and girth of the trees together with merchantable timber height were measured during the year 2023.

Table 6. *Growth performances of rubber trees planted in Kandakaduwa experimental site*

Clone	Girth at 4ft (cm)	Merchantable timber height (cm)
RRIC 100	32.30	655.83
RRIC 121	31.82	693.44
RRISL 203	34.48	642.60
RRISL 2001	27.81	551.11
PB 260	22.34	486.40

At Kandakaduwa experimental site RRIC 121 together with RRIC 100 and RRISL 203 showed a better performance in the growth of trees and growth of the trees of RRISL 2001 and PB 260 clones were not substantial. Best growth performances were observed in RRIC 121 trees whilst PB 260 trees showed the least rate of growth (Table 6).

Padiyathalawa (Intermediate zone)

Performances of nine clones developed by RRISL established in the experimental field at Padiyathalawa in 2017 were evaluated with plant physiological data during 2023. Chlorophyll content, epicuticular wax content, relative water content, leaf area, and stomatal conductance were assessed as physiological parameters of the clones planted together with soil moisture level in the morning. Wind speed, air temperature and relative humidity were recorded as environmental parameters at the time of measuring. Growth performance of the trees were evaluated as girth and merchantable timber height. The level of the soil moisture content and relative humidity varied between 7.46 – 15.81% and 74.8 – 85.3%, respectively in the studied field at the

time of data collection. The lowest and highest air temperatures recorded were 29.5 and 33.0 ^{o}C, respectively (Table 7).

Table 7. *Average environmental conditions in Padiyathalawa field at the time of collection of plant physiological data*

clone	wind speed (km/hr)	Air temperature (^{o}C)	Relative humidity (%)	Soil moisture content (%)
RRIC100	1.8	30.7	84.8	15.81
RRIC102	1.8	30.0	79.5	8.47
RRIC121	1.2	30.2	85.3	10.97
RRISL201	3.6	33.0	77.1	13.44
RRISL203	4.6	31.3	81.3	13.77
RRISL2001	4.1	32.2	76.2	7.46
RRISL2100	2.1	32.4	75.4	13.72
Centennial 3	1.8	32.3	74.8	13.24
Centennial 4	1.1	29.5	84.6	9.94

Table 8. *Growth performances of rubber trees planted in Padiyathalawa experimental site*

Genotype	Girth at 4ft (cm)	Merchantable timber height (cm)
RRIC100	35.70	381.09
RRIC102	35.66	318.84
RRIC121	34.19	418.05
RRISL201	44.55	389.48
RRISL203	35.61	404.45
RRISL2001	39.21	351.13
RRISL2100	30.29	314.74
Centennial 3	45.21	439.23
Centennial 4	34.07	349.94

Out of nine genotypes in the field, Centennial 3 showed the best growth performance with 439.23cm merchantable timber height and 45.21cm girth. Growth of RRISL 201 was also promising. The lowest growth performances were shown by RRISL 2100 genotype. Though the merchantable timber height of RRIC 121 and RRISL 203 clones were substantial, their girth was poor (Table 8).

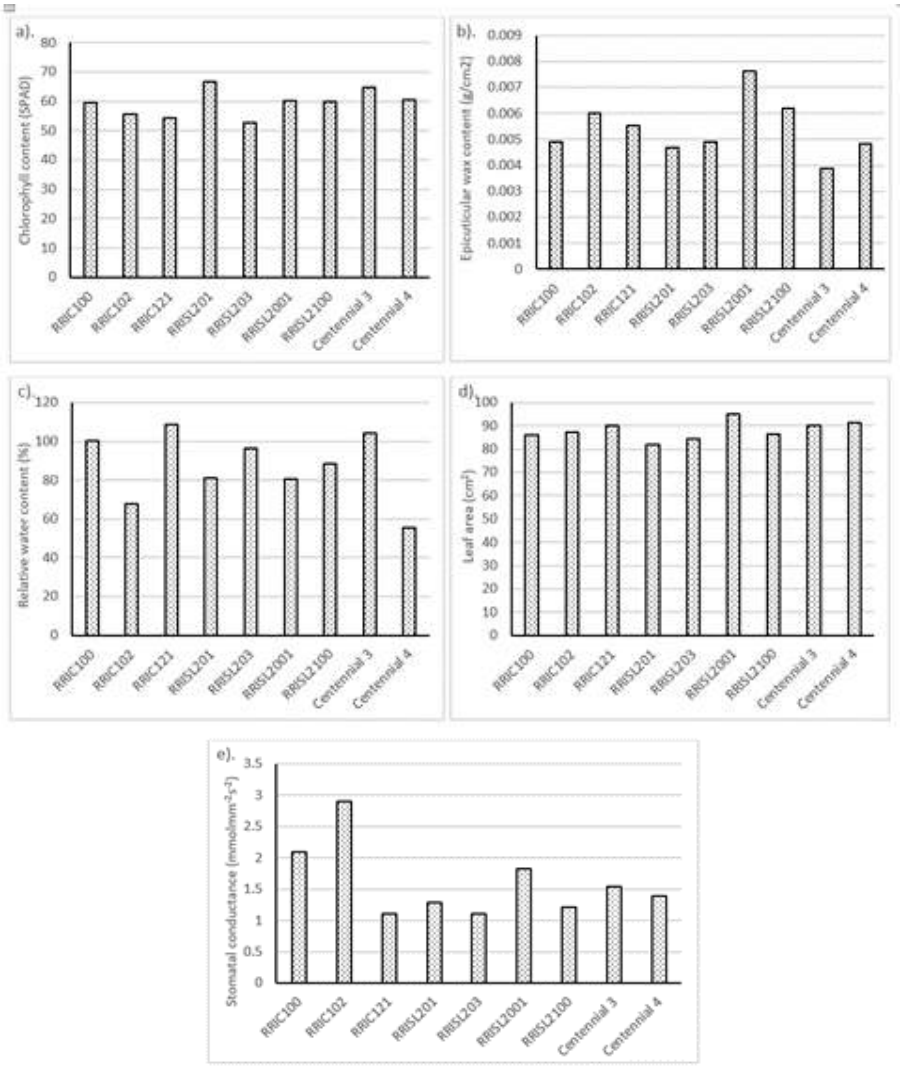


Fig. 1. (a). Chlorophyll content, (b). epicuticular wax content, (c). relative water content, (d). leaf area and (e). stomatal conductance of different *Hevea* genotypes planted at the Padiyathalawa experimental site.

Out of the nine clones tested in the Padiyathalawa site, the highest leaf chlorophyll content was observed in RRISL 201 followed by the clone Centennial 3. The clones, RRIC 100, RRISL 2001, RRISL 2100 and Centennial 4 clones showed more or less similar leaf chlorophyll contents. RRIC 102, RRIC 121 and RRISL 203 had comparatively lower leaf chlorophyll contents (Fig.1a). Epicuticular wax content

was highest in the clone RRISL 2001 followed by two clones RRISL 2100 and RRIC 102 clone. The lowest wax content was observed in the Centennial 3 clone (Fig.1b). Relative water content was maximum in the RRIC 121 and minimum in the Centennial 3 clones whilst RRIC 102 and Centennial 4 clones showed the minimum values (Fig.1c). The highest and lowest leaf area were observed with RRISL 2100 and RRISL 201, respectively (Fig.1d). Stomatal conductance varied between 1.11 $mmolm^{-2}s^{-1}$ and 2.91 $mmolm^{-2}s^{-1}$ among the clones where RRIC 121 and RRISL 203 showed the lowest value (1.11 $mmolm^{-2}s^{-1}$) whilst RRIC 102 attributed the highest stomatal conductance (2.91 $mmolm^{-2}s^{-1}$) (Fig. 1e).

Hambegamuwa (Dry Zone)

Table 9. *Growth performances of rubber trees planted in Hambegamuwa experimental site*

Clone	girth at 4ft (cm)	Height of the tree (cm)
RRIC 100	35.39	807.61
RRIC 102	34.89	754.79
RRISL 201	31.95	791.04
RRISL 203	38.21	910.80
RRISL 2001	30.61	828.13
RRISL 2100	30.95	717.95
Centennial 3	32.85	682.50
Centennial 4	33.38	893.44

RRISL 203 clone followed by RRIC 100 and RRIC 102 clones showed a better girthing of trees whilst RRISL 2001 and RRISL 2100 clones showed the least girthing. Height of RRISL 203 was the highest and Centennial 3 clone showed the least height of the trees. Height of the trees of Centennial 4, RRISL 2001 and RRIC 100 clones were also higher (Table 9).

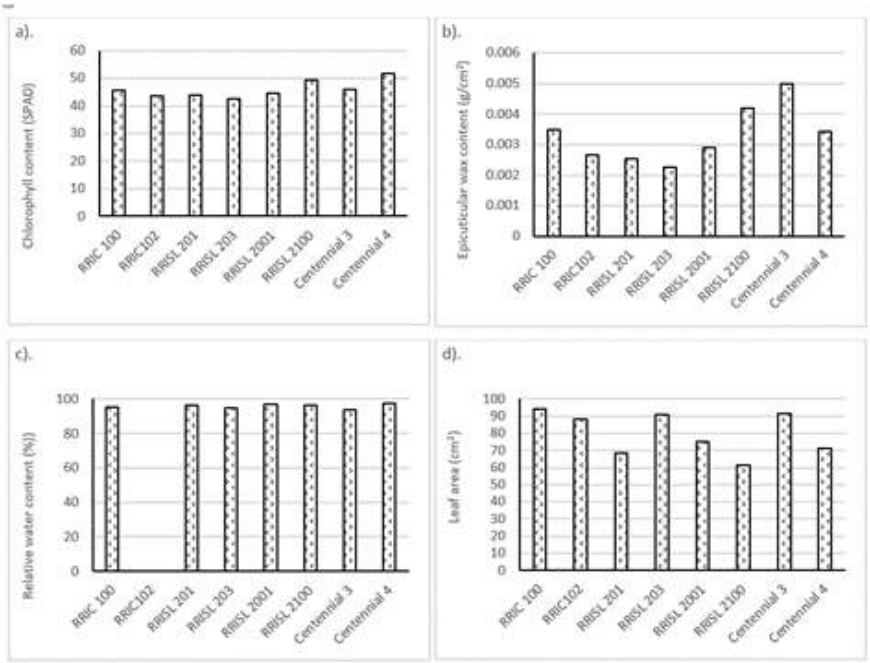


Fig. 2. (a). Chlorophyl content (b). Epicuticular wax content, (c). Relative water content and (d). Leaf area of different *Hevea* genotypes planted in Padiyathalawa experimental site.

Leaf chlorophyll content of clones planted in Hambegamuwa experimental site varied between 42.48 - 42.66 SPAD unit. Highest chlorophyll contents were observed in the Centennial 4 clone whilst RRISL 203 showed the least leaf chlorophyll content (Fig. 2a). The highest epicuticular wax content was shown by the clone Centennial 3 attributing an average value of 0.005 g/cm^2. RRISL 203 showed the lowest epicuticular wax content in leaves and it was also considerably lower in the clones RRIC 102 and RRISL 201 (Fig. 2b). All the clones tested showed more or less similar relative water contents in leaves (Fig. 2c). The clones, RRIC 100, RRIC 102, RRIC 203 and Centennial 3 had broader leaves with an average leaf area of above 88 cm^2. However, the leaf area of the clones, RRISL 201 and RRISL 2001, RRISL 2100 and Centennial 4 were considerably low (Fig. 2d). (K V V S Kudaligama, N P S N Karunarathne and M K P Perera)

Research & development to support the clonal screening activities through physiological and biochemical testings

Biochemical and physiological screening of HP progenies

Biochemical and physiological assessments of latex of twenty selected genotypes of the 2014 HP progeny was continued for the year 2023 at the field established in Nivithigalakele Sub-station on request of the Department of Genetics & Plant Breeding. The contents of sucrose, inorganic phosphorus, thiol polyphenols, dry rubber content, total solids content and daily dry rubber yield in terms of gram per tree per tap (g/t/t) were also analysed (Table 10).

Table 10. *Latex physiological parameters of Hevea HP progeny developed by 2014 hand pollination programme (under micro tapping condition)*

Genotype No:	Sucrose (mM)	Inorganic phosphorus (mM)	Thiol (mM)	Poly-phenols (mM)	Dry Rubber Content (%)	Total Solid Content (%)	Non rubber content (%)	Total volume (ml)	g/t/t (g)
2	1.18	0.41	0.16	1.42	55.35	56.21	0.86	12.00	6.64
11	3.30	2.59	0.34	1.66	46.32	49.82	3.50	64.00	29.64
13	4.59	0.52	0.25	1.46	47.40	50.83	3.43	42.00	19.91
15	4.40	0.54	0.28	1.14	49.73	52.96	3.22	13.00	6.47
21	4.17	2.15	0.30	1.55	42.63	49.39	6.76	62.33	26.57
33	10.31	0.40	0.27	1.74	42.88	54.28	11.40	13.67	5.86
35	4.19	1.95	0.33	1.55	40.31	43.74	3.43	30.00	12.09
39	4.73	1.23	0.30	1.62	49.16	52.68	3.52	51.67	25.40
42	1.91	5.06	0.25	1.23	46.55	49.56	3.01	99.33	46.24
58	3.96	0.51	0.24	1.41	47.81	50.92	3.11	26.33	12.59
62	4.11	0.80	0.37	1.34	50.47	53.10	2.63	19.00	9.59
65	3.83	1.33	0.32	1.55	47.09	50.44	3.35	29.00	13.66
78	3.87	2.21	0.29	1.64	44.76	48.14	3.38	52.83	23.65
79	7.02	2.50	0.27	1.29	45.51	48.51	3.00	6.00	2.73
83	5.44	1.63	0.26	1.29	38.66	41.90	3.24	23.33	9.02
102	5.08	2.62	0.29	1.19	48.01	51.37	3.37	30.33	14.56
106	3.97	1.33	0.27	1.17	40.17	43.26	3.09	40.67	16.34
114	2.43	1.21	0.26	1.11	49.34	51.16	1.82	10.00	4.93
164	6.52	2.25	0.43	1.31	37.63	41.06	3.42	49.83	18.75
167	2.49	2.12	0.46	1.39	42.85	45.61	2.76	32.50	13.93

According to the results, *Hevea* genotype No. 42 had the highest g/t/t whilst No: 11, 21, 39, and 78 showed a comparatively medium g/t/t values. All the other genotypes showed lower g/t/t level revealing deficient latex regeneration capacities.

Though the latex sucrose content of the genotype 42 is lower, a considerably higher inorganic phosphorus and g/t/t levels indicated that this genotype has a possibility to perform well with a higher metabolic activity among the genotypes tested. Genotypes No: 11, 21, 39, and 78 had low levels of sucrose and inorganic phosphorous which reveals the need of further assessments under small scale trials.

Biochemical and physiological screening of clones

An experiment was conducted to evaluate the physiological performance of established clones with an aim to develop a physiological index to support the clonal screening. Seven *Hevea* clones (RRISL 208, RRISL 203, RRISL 2006, RRISL 201, Centennial 3, Centennial 4 and Centennial 5) planted in the year 2009 at Eladuwa estate were assessed during 2023 for their latex physiology, latex flow and yield parameters (Table 11). Rubber fields were tapped on virgin panel with S/2 d3 (half spiral, once in three days) tapping system without stimulation.

Table 11. *Latex physiological parameters of different Hevea clones planted in Eladuwa Estate experimental field*

***Hevea* clone**	**Latex physiological parameters**					
	Sucrose content (mM)	**Inorganic phosphorus content (mM)**	**Thiol content (mM)**	**Polyphenol content (mM)**	**Total solids content (%)**	**pH**
RRISL 201	7.59	9.45	0.25	1.25	44.86	6.64
RRISL 203	8.93	10.59	0.29	1.94	48.01	6.65
RRISL 208	20.52	12.11	0.39	4.32	44.21	6.73
RRISL 2006	15.82	31.17	0.30	4.95	49.38	6.70
Centennial 3	7.58	7.37	0.52	1.84	37.83	6.73
Centennial 4	8.10	15.35	0.33	1.16	42.62	6.71
Centennial 5	9.25	7.45	0.37	1.72	34.04	6.68

Among the tested clones in Eladuwa estate, the highest sucrose content in latex was shown by the clone RRISL 208 (20.52mM) followed by RRISL 2006 (15.82mM) clone. The lowest sucrose content was observed in Centennial 3 and RRISL 201. The highest inorganic phosphorus content was observed in the clone RRISL 2006 with an average value of 31.17 mM whereas all the other clones showed values lower than 15.50mM during the study period. The lowest inorganic phosphorous content was observed in the clone Centennial 3 (7.37 mM) and Centennial 5 (7.45 mM) clones. The clone, Centennial 3 had the highest content of thiol (0.52 mM) in latex (Table 11) amongst the clones tested reflecting a lower level of reactive oxygen species (ROS) due to insufficient latex regeneration. The clones RRISL 208 (4.32 mM) and RRISL 2006 (4.95 mM) reported the highest polyphenol content in latex which may result in

a higher degree of discoloration. Total solids content was also found at the highest level in RRISL 2006 (49.38 %) and RRISL 203 (48.01 %) and the lowest level in Centennial 5 (34.04 %) (Table 11).

Table 12. *Yield and flow parameters of different Hevea clones planted in Eladuwa Estate experimental field*

Hevea clone	Yield and flow parameters				
	Initial flow rate	**Plugging index**	**Latex volume per tree (ml)**	**Dry rubber content (%)**	**Daily dry rubber yield per tree (g)**
RRISL 201	3.51	4.91	87.36	42.11	35.30
RRISL 203	3.73	11.99	35.42	45.30	15.11
RRISL 208	6.92	8.01	88.36	40.59	35.50
RRISL 2006	4.16	2.95	108.20	46.70	50.27
Centennial 3	3.73	3.97	104.27	34.60	34.85
Centennial 4	3.78	3.81	115.39	39.32	46.09
Centennial 5	3.31	5.30	68.47	31.01	21.37

The lowest plugging index and a moderate initial flow rate was observed in the clone RRISL 2006, resulting in a considerably higher tree productivity level. Though the plugging index of RRISL 208 clone was at a higher level, the plants have given a considerable yield. Quite higher plugging index observed in the clone RRISL 203 was one of the reasons to the lower per day yield of a tree. Considering yield-related parameters, RRISL 2006 and RRISL 203 reported the highest dry rubber contents in latex respectively with averages of 46.70 and 45.30 whereas Centennial 5 showed the lowest. However, there was a considerable variation in latex yields of both particular clones resulting in lower per day yield from a tree. Dry rubber yield per tree per tapping (g/t/t) showed some variations among the tested clones. The highest g/t/t values were obtained from RRISL 2006 and Centennial 4 with an average of 50.27 g and 46.09 g during the study period. The lowest was recorded in RRISL 203 which had an average value of 15.11g. RRISL 208, RRISL 201, and Centennial 3 clones have already resulted in substantial yield reflecting their metabolic and yielding capacities daily dry rubber yield of a tree resulting from the Centennial 5 clone was considerably lower compared to the other clones in the field (Table 12).

Considering yield and latex physiological data together, RRISL 2006 clone held a high metabolic activity, sugar loading capacity, total solids, dry rubber and lower antioxidant levels revealing its high yielding capacity and high vulnerability to tapping panel dryness. RRISL 208 exhibited high sugar loading capacity with an average level of metabolic activity which shows the possibility of adopting low intensity harvesting with stimulation. When it comes to Centennial 4, higher yield with low sucrose content and average metabolic activity reflects the ability of a reasonable latex regeneration capacity within laticifers. Having low g/t/t value, sugar content, inorganic phosphorus level and dry rubber content, RRISL 203, Centennial 3 and Centennial 5 indicate the

unsatisfactory performance in the wet region. Further studies are being carried out to test their long-term yielding capacity and sustainability.

Latex diagnosis of RRISL 2001 clone

Assessment of latex physiology, latex flow and yield parameters of RRISL 2001 has been together with RRIC 100 as the reference clone in a field opened for tapping at the beginning of 2023 in the Dartonfield estate. Trees were rain-guarded and tapped with S/2 d3 system without ethephon stimulation.

Table 13. *Yield and latex physiological parameters of RRISL 2001 and RRIC 100 clones planted in Dartonfield estate experimental field*

***Hevea* clone**	**Yield and latex physiological parameters**					
	Sucrose content (mM)	**Inorganic phosphorus content (mM)**	**Thiol content (mM)**	**Polyphenol content (mM)**	**Total solids content (%)**	**pH**
RRISL 2001	9.19	11.47	0.38	1.44	37.29	6.50
RRISL 100	7.39	5.58	0.34	1.42	40.48	6.74

Comparatively to RRIC 100, average sucrose, inorganic phosphorus, thiol and polyphenol contents were higher in the clone RRISL 2001. However, the total solids content observed in RRISL 2001 reflected the inadequate rubber regeneration in laticifers (Table 13).

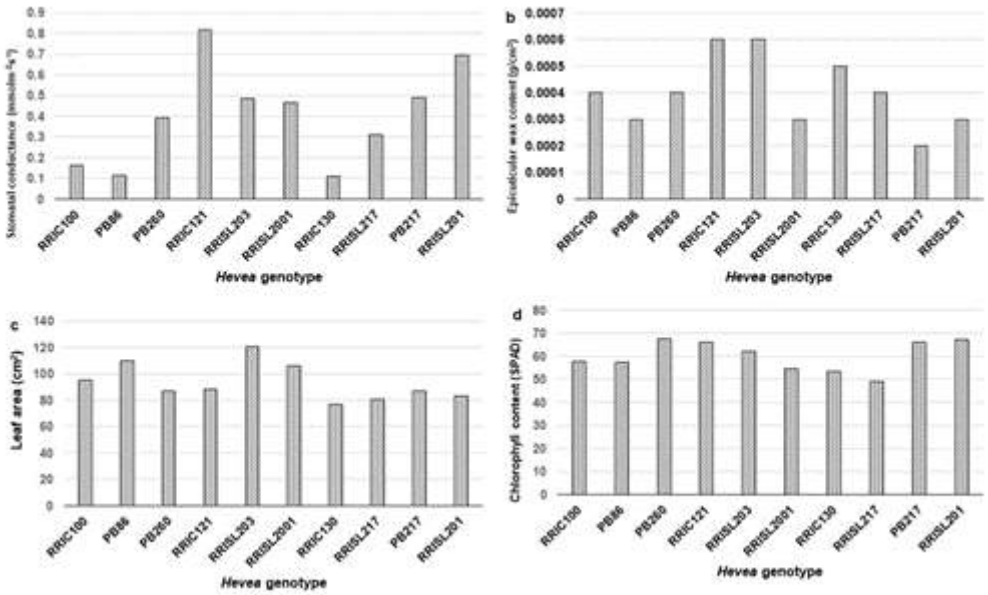
Table 14. *Yield and flow parameters of RRISL 2001 and RRIC 100 clones planted in Dartonfield estate experimental field*

***Hevea* clone**	**Yield and flow parameters**				
	Initial flow rate	**Plugging index**	**Latex volume per tree (ml)**	**Dry rubber content (%)**	**Daily dry rubber yield per tree (g)**
RRISL 2001	4.62	9.76	53.90	34.02	18.41
RRISL 100	3.19	6.86	59.86	37.71	21.88

Plugging index of RRISL 2001 was higher resulting a lower average latex volume than the clone RRIC 100. There was a reduction in the dry rubber content of latex in the clone RRISL 2001. Thereby, average daily dry rubber yield per tree of RRISL 2001 was lower than the RRIC 100 (Table 14). This further indicates the inadequate regeneration of rubber in RRISL 2001 clone. Further investigations are being carried out to study the performance of the clones (N P S N Karunarathne, K V V S Kudaligama N N Abewardhana and P D T L Madushani).

Study on biochemical and physiological parameters of plants of different Hevea genotypes

An experiment has been conducted to evaluate the biochemical and physiological performance of different *Hevea* genotypes to identify better clones that can mitigate abiotic and biotic stresses. Ten clones, established at Bud Wood Nursery in the Dartonfield estate were evaluated for their physiological and biochemical performances. Chlorophyll content, epicuticular wax content, relative water content (RWC), leaf area and stomatal conductance were assessed as physiological parameters. The activity of superoxide dismutase (SOD) enzyme which acts as an antioxidant to mitigate oxidative stress under abiotic and biotic stressful environments in *Hevea* was also studied during this study. Wind speed, air temperature, relative humidity, and soil moisture level were recorded as environmental parameters.



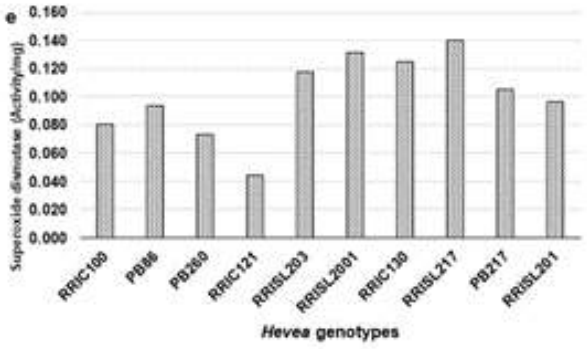


Fig. 3. (a). Stomatal conductance, (**b)**. epicuticular wax content, (**c)**. leaf area, (**d).** chlorophyll content and **e)**. superoxide dismutase activity of different Hevea genotypes grown in bud wood nurseries.

The highest stomatal conductance was reported in the clone RRIC 121 (0.82 $mmolm^{-2}s^{-1}$) followed by RRISL 201 (0.70 $mmolm^{-2}s^{-1}$) whereas all the other clones tested had stomatal conductance values lower than 0.50 $mmolm^{-2}s^{-1}$(Fig.3a). Higher epicuticular wax content was observed in RRIC 121 (0.0006 g/cm^2), RRISL 203 (0.0006 g/cm^2) and RRIC 130 (0.0005 g/cm^2) clones, whilst PB 217 (0.0002 g/cm^2) had the lowest (Fig. 3b). Out of the ten clones tested, RRISL 203, PB 86, RRISL 2001 and RRIC 100 reported a comparatively higher leaf area and other six clones showed more or less similar leaf areas (Fig. 3c). Chlorophyll contents observed in PB 260, RRISL 201, PB 217, RRIC 121 and RRISL 203 clones were above 60 SPAD units. In the clones, RRIC 100, PB 86, RRISL 2001 and RRIC 130, the chlorophyll contents varied among 50 – 60 SPAD units. However, the clone RRISL 217 the chlorophyll content of leaves were below 50 SPAD units (Fig. 3d). The highest SOD activity was observed in RRISL 217 (0.140 units/mg) followed by RRISL 2001 (0.131 units/mg) > RRIC 130 (0.125 units/mg) > RRISL 203 (0.118 units/mg) indicating comparatively higher level of defence activity at nursery level out of the clones tested. The lowest antioxidant activity by SOD was reported in the clone RRIC 121 (0.044 units/mg) (Fig. 3e) (N P S N Karunarathne, K V V S Kudaligama N N Abewardhana and P D T L Madushani)

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

Experiment established at Elston estate, Puwakpitiya has been continued to investigate the effectiveness of new water based (NWB) formulation together with two commercially available water based (EWB) and oil based (EOB) ethephon mixtures. Tapping system used was S/2 d4 and according to the RRISL recommendation 0.6g of 2.5% ethephon were applied per tree in monthly basis avoiding the wintering period. Latex physiology and raw rubber properties of unfractioned unbleached crepe were

assessed under the application of three types of ethephon mixtures. Yield performance was analysed with the daily records maintained by the estate.

Average latex sucrose content of both water based mixtures were more or less similar and oil based mixture have shown slightly higher latex sucrose content. Average inorganic phosphorous content was increased in test trees NWB ethephon. Similar thiol contents were observed in both water based mixtures whilst oil based mixture showed a slightly higher thiol content. New water based ethephon showed a higher total solids contents when compared to both the existing ethephon formulations. More or less similar pH values were observed under three types of stimulants. Sucrose and inorganic phosphorus levels were comparatively higher in latex of the trees treated with NWB ethephon (Table 15).

Table 15. *Latex physiological parameters of trees treated with new water based (NWB), existing water based (EWB) and existing oil based (EOB) ethephon.*

Parameter	NWB	EWB	EOB
Sucrose content (mM)	5.24	5.15	6.69
Inorganic phosphorus content (mM)	13.62	8.67	10.22
Thiol content (mM)	0.71	0.71	0.83
Polyphenol content (mM)	6.63	7.33	7.71
Total solid content (%)	47.97	46.03	49.89
pH value	6.8	6.8	6.7

Plasticity retention index under NWB ethephon was slightly lower than the commercial ethephon mixtures. Out of the three types of mixtures Mooney viscosity of unfractioned unbleached crepe rubber with the application of NWB ethephon was slightly higher. Nitrogen content was also slightly higher in the trees applied with EOB formulation. Ash contents under three types of mixtures did not show a considerable variation. Average Lovibond colour index of raw rubber under three different types of stimulants was similar (Table 16).

Table 16. *Properties of unfractioned unbleached crepe rubber harvested from trees treated with new water based (NWB), existing water based (EWB) and existing oil based (EOB) ethephon.*

Parameter	NWB	EWB	EOB
Plasticity retention index	82.61	85.89	87.01
Mooney viscosity ML (1+4)@100 ºC	85.34	82.73	83.61
Nitrogen (%)	0.31	0.32	0.35
Ash (%)	0.22	0.24	0.21
Lovibond colour index	3	3	3

Due to the high rainfall in year 2023, actual tapping days were lower than the expected level. Four ethephon applications had to be suspended in the year with the poor canopy condition occurred due to the circular leaf spot disease. Average dry rubber content of latex in tapping blocks applied three formulations were above 36%. Average intake per harvester in tapping blocks applied new water based ethephon was 11.17 kg leading to 1168 kg/ha/yr productivity level. However, with the commercial mixtures observed the intake per harvester was slightly higher and the average productivity levels observed with the existing water based and oil based ethephon were 1224 and 1232 kg/ha/yr (assuming 400 trees/ha), respectively (Table 17).

Table 17. *Average yield of tapping blocks (300 trees) and productivity (400trees/ha) harvested with S/2 d4 system using different types of ethephon formulations in Elston estate*

Tapping system	Actual tapping days	DRC %	GTT (g)	IPH (kg)	YPT (kg)	YPH (kg)
New water based ethephon	68	36.59	36.55	11.17	2.92	1168
Existing water based ethephon	69	36.34	38.30	12.18	3.06	1224
Existing oil based ethephon	70	36.85	38.47	13.64	3.08	1232

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

ADVISORY SERVICES

P K K S Gunarathne

DETAILED REVIEW

Staff

Dr P K K S Gunarathne (Head – Cover up duties, Advisory Officer) was on duty throughout the year. Mr D E P M Nanayakkara (Rubber Extension Officer) retired from the service with effect from the 31st of May 2023. Mr K Karunarathna (Office Assistant) retired from the service with effect from the12th of May 2023. Mrs K K I Jayasundara (Rubber Extension Officer) resigned from the service with effect from the 16th of August 2023. Mr D E P M Nanayakkara (Polgahawela), Mr S M A Samarakoon (Kandy/Matale), Mr W P G D C P K Senanayake (Galle), Mr H G M B Jayasinghe (Kegalle), Mr D S Dissanayake (Colombo/Gampaha), Mrs G R Tennakoon (Bulathsinhala), Mr P V S Madhubhashana (Kuruwita), Mr E W S R Kumara (Pelmadulla), Mr J A S Chandrasiri (Matugama) and Mr M N P De Silva (Matara) worked as a rubber extension officer in each REO range respectively.

Conferences/Meetings/Seminars/Workshops attended

Officer/s	Subject/s	Organization/s
P.K.K.S Gunaratna, All REOs	Technology update programmes, Research Extension Dialogue Rubber harvesting assistant – NVQ 3 pre and final assessments. Rubber extension with adult education – NIPM Dip. In	RRISL
P.K.K.S Gunaratna	Plantation management – Rubber sector training program. Institutional re-structure discussion	RRISL
P.K.K.S Gunaratna	Rubber industry development and regulation committee discussion	MPI
P.K.K.S Gunaratna	Discussion on social media and other media sources usage in institutions	MPI
P.K.K.S Gunaratna	2024 annual extension plan committee meeting	MPI
P.K.K.S Gunaratna	Stratergic technology transfer approaches to improve productivity of the smallholder sector	RRISL
P.K.K.S Gunaratna	Discussion on payment based advisory services in MPI institutions	RRISL

Officer/s	Subject/s	Organization/s
P.K.K.S Gunaratna	Extension committee member meetings	RRISL
P.K.K.S Gunaratna	Establishment of a technical advisory committee for the Dartonfield	RRISL
P.K.K.S Gunaratna	Advisory committee to the RRB on scientific affairs and research and development	RRISL
P.K.K.S Gunaratna	Business development committee meetings	RRISL
P.K.K.S Gunaratna	Team leader – development of mobile App. For smallholder rubber product manufacture	RRISL
P.K.K.S Gunaratna	Team leader – Govimithuru sewaya	RRISL
P.K.K.S Gunaratna	Providing leadership to Dartonfield Academy	RRISL
P.K.K.S Gunaratna	District agriculture development committee – Kandy, Mathale districts	District Secretariats
P.K.K.S Gunaratna	Invigorating the Natural rubber, attracting youth participation – IRRDB online participation	Online
P.K.K.S Gunaratna	Participation in the development of the syllabus of NVQ levels 4 and 5	TVEC
P.K.K.S Gunaratna	The PGIA Annual Congress, presented a paper titled “Identification of the factors affecting adoption of rubber farming in Moneragala District of Sri Lanka”	Postgraduate Institute of Agriculture, University of Peradeniya
P.K.K.S Gunaratna	Fourth International Conference on Intangible Cultural Heritage and presented a paper titled “The socio-economic condition of hired female latex harvesters of the smallholder rubber sector in Kegalle District in Sri Lanka”	University of Sri Jayewardenepura and UNESCO Sri Lanka National Commission
P.K.K.S Gunaratna	International symposium on sustainable plantation management and presented a paper titled “Rubber harvesters’ turnover intention in medium scale rubber holdings in Kalutara District”	National Institute of Plantation Management, Sri Lanka
P.K.K.S Gunaratna	First research symposium and presented a paper titled “A case study in Ratnapura District”	Gem and Jewellery Research and Training Institute of Sri Lanka
P.K.K.S Gunaratna	Third international conference on science and technology and presented “ Utilization of information on rubber farming by rubber smallholders: a case study in Monaragala District”	South-Eastern University of Sri Lanka

PROGRESS OF PROJECTS AND SERVICES

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

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

Project 1 (ASD/01/A) Participatory developed rubber holdings

To increase the land-use efficiency and improve the adaptability of RRISL recommendations, selected sub-standard rubber smallholdings were developed as "Participatory developed rubber holdings" (Table 1). Fourty-five immature and 57 mature holdings were fully developed (Fig.1 and 2).

Table 1. *Details of participatory development done for selected sub-standard smallholder rubber holdings*

Range	**No. of developed holdings**	
	Mature	**Immature**
Colombo/Gampaha	07	02
Polgahawela	07	05
Kandy/ Matale	04	04
Kegalle	10	04
Bulathsinhala	01	00
Matugama	07	10
Pelmadulla	09	05
Kuruwita	03	03
Galle	06	06
Matara	03	06
Total	**57**	**45**

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Fig. 1. Developed immature holding - Mr. W. Gunasiri (Matugama REO range)

Fig. 2. Developed mature holding – Mr.H. M. Jayathissa (Colombo/ Gampaha REO range)

Project 2 (ASD/01/B) Promotion of usage of rain guards

To popularize the rain guard technology as a short-term strategy to increase the productivity of rubber smallholdings, 10 demonstration plots were established under the supervision of REOs (Table 2).

Table 2. *Details of rain guard demonstration holdings*

Range	No. of rain guard demonstration holdings established
Colombo/Gampaha	1
Polgahawela	3
Kandy/ Matale	3
Kuruwita	1
Pelmadulla	2
Total	**10**

Fig. 3. Demonstration of rain guarded rubber holding –Mr. Padmalal Udayasiri (*Pelmadulla* REO range)

Project 3 (ASD/01/C) Promotion of area specific intercropping systems

To popularize area specific intercropping systems to increase the income during the immature period of rubber smallholdings, 6 intercropping demonstration plots were established (Table 4).

Table 3. *Area-specific intercropping and mixed cropping demonstration plots*

Range	No. of demonstrations
Colombo/Gampaha	1
Matugama	2
Polgahawela	2
Kuruwita	1
Total	**6**

Fig. 4. Intercropping plots with pineapple – Mr P V Wickramathunga (*Matugama* REO range)

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

Advisory and extension services were provided for the construction of six new RSS production centers and rehabilitation of 15 substandard processing centers, to maintain them as cost-effective units as per the requests of owners (Table 4), (Fig. 5).

Table 4. *Construction, rehabilitation and modification of new and sub-standard rubber processing centers*

Range	**No. of RSS production centers**	
	New centers	**Rehabilitated centers**
Colombo/Gampaha	0	1
Polgahawela	2	4
Kandy/ Matale	2	2
Bulathdinhala	0	1
Pelmadulla	0	4
Kuruwita	1	2
Galle	1	1
Total	**6**	**15**

Fig. 5. Constructed new rubber processing center – Mr. H. M. Jayathissa (*Bulathsinhala* REO range)

Project 5 (ASD/01/E) Projectsrelated to advisory visits in traditional rubber growing areas

Seven hundred and sixteen pre-planned technical advisory visits were conducted by REOs to solve the technology adoption problems in the rubber holdings, introduction of intercropping systems, rainguarding, construction of new RSS centers and rehabilitation of substandard RSS centers (Table 5).

Table 5. *Details of projects related advisory visits*

Range	Nature of technical advisory visit					
	Establishment of rehabilitation rubber holdings	**Introduction of Intercropping systems**	**Introduction of rain guard technology**	**Construction of new RSS centers**	**Rehabilitation of substandard RSS centers**	**Total**
Colombo/Gampaha	31	3	2	0	5	**41**
Polgahawela	33	3	12	5	12	**65**
Kandy/ Matale	119	0	33	0	18	**170**
Kegalle	98	0	0	0	0	**98**
Matugama	29	10	0	1	2	**42**
Bulathsinhala	9	0	0	0	3	**12**
Pelmadulla	61	0	7	0	16	**84**
Kuruwita	13	3	0	2	4	**22**
Galle	78	0	0	8	4	**90**
Matara	70	0	0	9	13	**92**
Total	**541**	**19**	**54**	**25**	**77**	**716**

Thrust Area 02 :Technical advisory programmes to solve technology adoption problems of stakeholders of the rubber sector

Project 6 (ASD/02/A) Technical advisory visits on requests of rubber smallholders

Two hundred and ninety two technical advisory visits were made by REOs to solve technology adoption problems of rubber smallholders in relation to all agronomic and processing aspects. A separate report was prepared by REOs on each visit and follow-up actions were attended where necessary (Table 6).

Table 6.*Technical advisory visits conducted on requests of rubber smallholders*

Range	No. of technical advisory visits made by REOs				
	Immature	**Mature**	**Processing**	**Special**	**Total**
Colombo/Gampaha	5	10	0	5	**20**
Polgahawela	6	31	13	0	**50**
Kandy/ Matale	7	50	0	0	**57**
Kegalle	3	21	5	0	**29**
Matugama	3	4	2	9	**18**
Bulathsinhala	1	15	1	0	**17**
Pelmadulla	5	12	2	0	**19**
Kuruwita	4	16	4	3	**27**
Galle	3	39	0	0	**42**
Matara	4	24	1	0	**29**
Total	**41**	**222**	**28**	**17**	**308**

The above technical advisory visits were categorized as follows (Fig. 6,7 and 8).

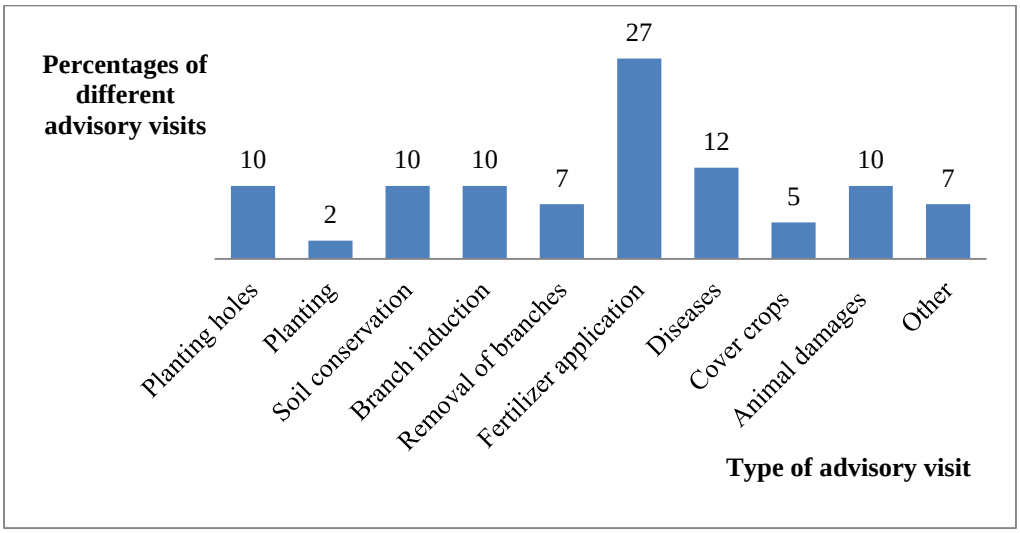


Fig. 6. Types of technical advisory visits conducted in immature holdings

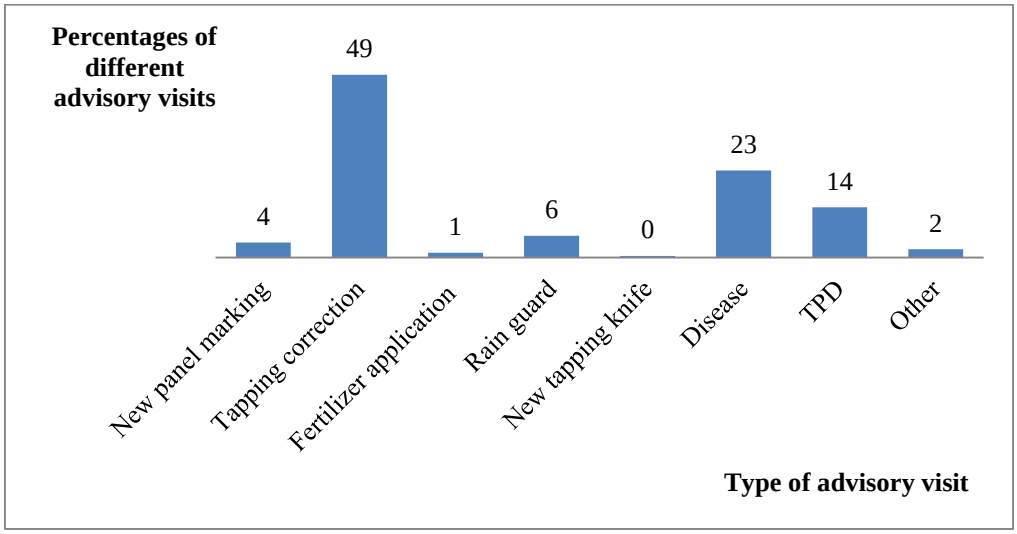


Fig. 7. Types of technical advisory visits conducted in mature holdings

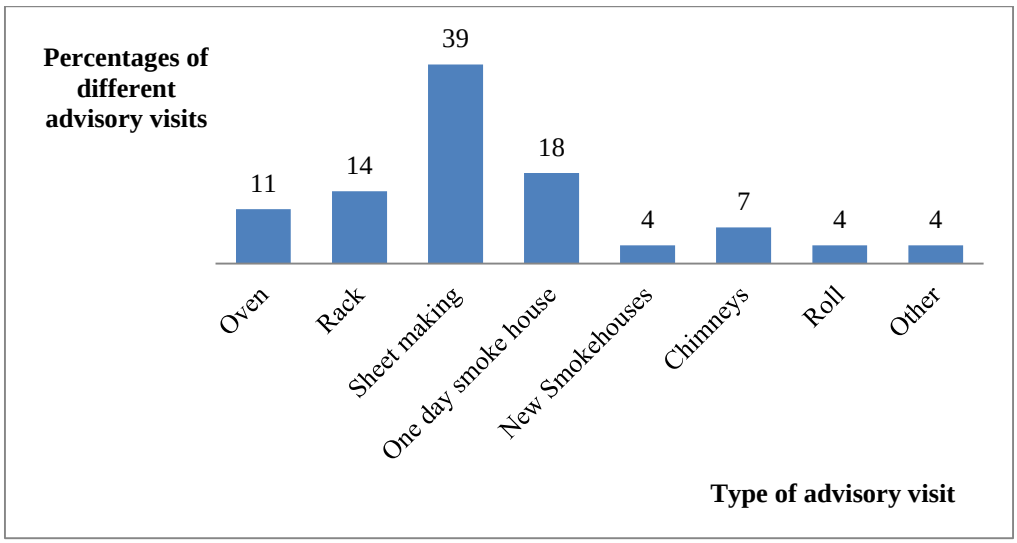


Fig. 8. Types of technical advisory visits conducted in RSS production centers

Thrust Area 3 : Human resource development of stakeholders in the rubber sector

Project 7 (ASD/03/A) Awareness programmes

Eight awareness programmes on general cultivation aspects of rubber were conducted to educate 108 field staff in the estate sector. Eighteen awareness programmes on general cultivation aspects of rubber were conducted to educate 313 small and medium scale farmers. Participation from each range for the programmes are summarized in the Tables 8 and 9.

Table 8. *Participation at the awareness programmes on general cultivation aspects of rubber in the estate sector*

Range	No. of programs	No. of participants
Colombo/ Gampaha	1	7
Plogahawela	2	49
Matugama	1	20
Pelmadulla	2	23
Kuruwita	2	9
Total	**8**	**108**

Table 9. *Details of small and medium scale grower participation to the awareness raising programmes on general cultivation aspects of rubber*

Range	No. of programmes	No. of farmers trained
Colombo/ Gampaha	1	7
Pelmadulla	1	9
Kuruwita	1	10
Matugama	7	177
Galle	4	59
Matara	4	51
Total	**18**	**313**

Fig. 9. Awareness and training programme conducted at *Ratiyala* estate – *Bulathsinhala* range

Fig. 10. Online awareness programme conducted for field officers of estate sector

Project 8 (ASD/3/B) Skill development of Rubber Harvesting Assistants (RHAs)

Both tapping skill development programs were conducted to educate 359 and 89 semi-skilled RHAs of the estate sector and smallholders, respectively. Participation from each range for the programmes is summarized in the Tables 10 and 11 (Figure 10).

Table 10. *Details of RHAs participation in tapping skill development programs in the estate sector*

Name	No. of participants
Halwatura estate	20
Pusella estate	43
Alupolaestate	27
Eheliyagoda estate	46
Sundarland estate	37
Alapalawala estate	17
Ayr estate	58
Penrith estate	44
Salawa estate	48
Andigama estate - NLDB	19
Total	359

Table 11. *Details of small and medium scale grower participation in tapping skill development programs*

Range	No. of programmes	No. of farmers trained
Colombo/ Gampaha	1	11
Plogahawela	1	17
Kandy/ Matale	1	6
Kegalle	1	17
Bulathsinhala	1	8
Matugama	3	19
Matara	1	11
Total	**9**	**89**

Fig. 10. Tapping skill development programme conducted at *Halwatura*estate – *Horana* Plantation

Project 9 (ASD/3/C) Quality improvement of RSS

To improve the product quality of RSS produced by rubber smallholders, 01 training programmes was conducted for the benefit of 19 selected RSS producers in Polgahawela REO range.

Project 10 (ASD/3/D) Involvement of REOs as resource personnel for other organizations

The following programmes were attended by REOs as resource personnel on requests made by different organizations.

Tapper Tanning School – Seven days

Table 12. *Details of the services provided by REOs for tapper training school*

Organization	Number of programmes	Resource personnel
Thurusaviya Fund	02	Dr P K K S Gunarathne, D E P M Nanayakkara, S M A Samarakoon, H G M BJayasinghe, D S Dissanayake, G R Tennakoon, P V S Madhubhashana, E W S R Kumara, J A S Chandrasiri, K K I Jayasundara

Human resource development programs under rubber task force in non-traditional areas

Table 13. *Training programs under the rubber task force in non-traditional areas.*

Organization	Name of the programme	Number of programmes	Resource personnel
STaRR project	Tapping skill development	6	J A S Chandrasiri D S Dissanayake
STaRR project	Quality improvements of RSS	2	E W S R Kumara P V S Madhubhashana
STaRR project	Tapper Tanning School (one day)	3	H G M B Jayasinghe

Table 14. *Involvement for the other programs as resource personnel.*

Name of the programme	Organization	Number of programmes	Resource personnel
Awareness programme (One day)	Thurusaviya Fund	11 1	J A S Chandrasiri D S Dissanayake
University undergraduates' field visits	Colombo university	4	E W S R Kumara P V S. Madhubhashana
Awareness programme (One day)	NIPM		H G M B Jayasinghe

Fig. 11. Tapper Tanning School conducted in *Galigamuwa, Kegalle* with the collaboration of Thurusaviya fund

Project – 11 (ASD/3/E) NVQ level 3 certification of Rubber Harvesting Assistants

With the guidelines of Tertiary and Vocational Education Commission (TVEC), the following qualified officers were selected and trained as registered contingency based assessors of TVEC. Dr P K K S Gunarathne, C P K Senanayake, H G M B Jayasinghe, D S Dissanayake, G R Tennakoon, P V S Madhubhashana, E W S Kumara, J A S Chandrasiri and M N P De. Silva. Under the rubber master plan of Ministry of plantation industries, a special pilot project was conducted to award NVQ level 3 for qualified tappers in Kalutara district was successfully completed with plant sciences department, RRISL.One hundred sixty nine of qualified tappers were awarded as NVQ level 3 rubber harvesting assistants by this project.

Fig. 13. Assessments of NVQ level 3 rubber harvesting assistants

Project – 12 (ASD/3/F) Practical workshop on contour lining and planting

To improve the contur lining knowledge and skills of field practitioners, practical workshop was conducted to estate sector field officers and managers. Twenty nine participants were trained respectively.

Fig.16. Contour lining practical workshop for estate sector officers

Project – 13 (ASD/3/G) Conducted income generated programs

The following physical and online programs were conducted with the collaboration of RRISL departments to all stakeholders and SLR 1,750,594.00 of income generated additionally.

Table 15. *Conducted income generated programmes*

Name of the programme	Type of the programme	Income (SLR)
Graphene Applications in natural rubber technologies	International Webinar	128,393.00
Practical Workshop on Contour Lining and Planting	Practical workshop	160,453.00
In-service training on RDD	Practical Workshop	342,785.00
In-service training on RDD	Practical Workshop	451,493.00
Low Intensity Harvesting to cope up with current issues	Practical workshop	120,000.00
Cashew cooperation – Practical workshop and Training	Practical workshop	24,600.00
UvaWellassa University – Practical Workshop and Training	Practical workshop	61,100.00
STaRR – Training programmes	8 Practical workshops	445,770.00
University of Colombo undergraduates' training program	Practical workshop	16,000.00
Total		1,750,594.00

Thrust area – 04 Introduction of Auntroprenuership Oppertunities

Project 14 (ASD/4/A) Value added rubber products manufacturing training progams

With the collaboration of Rubber Technology and Development Department of RRISL, 02 successful traning programs were conducted to enhance knowledge and skills of 40 rubber growers at Ratmalana RRISL and laboratory. G R Tennakoon and J A S Chandrasiri played the key roles during the organizing programs.

Fig. 12. Rubber based value addition product development training programme at Auditorium, Ratmalana RRISL and laboratory of Rubber Technology and Development Department

Project – 15 (ASD/4/B) Introducing the Rubber Farming Service Providers (RFSP) into the rubber sector

Rubber Farming Service Providers (RFSPs) programme is one of a key initiative from Advisory Service Department of Rubber Research Institute of Sri Lanka based on para extension approach. This programme was implemented in 2023 in order to train non-skilled village youth on Rubber Farming (RF) technologies or practices as a solution to the shortage of qualified trained personnel in village level to practice and introduce RF technologies into the rubber sector. And also RFSPs established as entrepreneurs with the aiming of enhancing the socio-economic status of them. Under the rubber master plan of Ministry of plantation industries, a special pilot project was conducted to introduce special work groups to facilitate rubber industry. The main objective to train village youth on rubber farming technologies/practices as a solution to the shortage of qualified trained personnel in village level to practice and introduce RF technologies/practices into the rubber sector.Specific objectives were to introduce the skilled rubber farming professional practitioners to the rubber sector, to improve the adoption rate of the rubber farming practices and to enhance the socio-economic status of the rubber smallholders and RFSP. Forty nine RFSP were introduced to the sector by this project.

As the first step, a preliminary discussion was done with relevant officials and stakeholders from Rubber Plantation Companies (RPCs), medium scale estates and small holders. Following this, several awareness programmes, pocket meetings and group discussions were done for calling applications from interested stakeholder group. Finally, 49 trainees (6 – females and 43 – males) were selected through the interview and divided into 7 groups (49 RFSPs) to continue the vocational training workshop.

Fig. 13. Selection of 50 trainees

During 8 full days of practical workshop, 10 land sites (1/4 ac. per group) were allocated to each groups. According to the National Competency System (NCS) for TEVC standards (Level 3), following practices were up-skilled to RFSPs,

- Land clearing
- Contour lining
- Fencing
- Disease identification and management
- Up-keeping (Immature and mature)
- Tapping panel marking
- Rain-guard fixing
- Compost preparation

Furthermore, the evaluation of this vocational training workshop were completed by the REO of the ASD. Besides a motivational programme and exposure visit to Rubber Research Institute of Sri Lanka were done. RFSPs were equipped with knives (ketta), slash knife (vesi ketta), crowbar (alawangu), normal fork and mammoty, panel marking stencils and rain guard fixing equipment after the successfully completion of the vocational training course. And safety kit, rain coats, boots, hand gloves, t-shirts and hats were provided. Further an attendance allowance was also allocated for trainees.

Fig. 15. Conducting the vocational training on Rubber farming service providers

Fig. 16. Rubber farming service providers

Their profiles are published as registered RFSPs in RRISL website, mass media, social media (You tube and Facebook page of RRISL and MPI) to introduce them to respective service takers. Finally, those trained RFSPs were introduced as multi-skilled labor into the rubber sector who known as registered and certified RFSPs in Rubber Research Institute of Sri Lanka. Job tasks of RFSPs are monitored under the supervision of Rubber Extension Officers from Advisory Service Department, Rubber Research Institute of Sri Lanka. Annually, RFSPs will be certified by RRISL. Currently those RFSPs are working at RPCs, medium scale estates and smallholder sector.

Fig. 17. Rubber farming service providers equipped tools and safty kits

Thrust area – 05 Development of an effective extension network in the smallholder rubber sector

Pestalotiopsis leaf disease impact survey

To identify the impact of *Pestalotiopsis* leaf diseaseto the estate sector, collaborative suryey series was conducted in each rubber growing regions with the participation of all RRISL scientific departments staff and estate staff.

Plantation sector adoptability survey

To identify the adopatability of RRISL recommended technology, collaborative suryey series was conducted in each rubber growing regions with the participation of adaptive research unit, RRISL.

Contribution to exhibitions

As a part of extension service, to transfer the rubber related technology to the general public, contributed to following exhibitions islandwide.

Table 15. *Contribution to exhibitions*

Institution	Location	Title	Contribution
National botanic garden	Gampaha Henarathgoda	Anniversary exhibition	D E P M Nanayakkara, S M A Samarakoon, H G M B Jayasinghe, D S Dissanayake, K K I Jayasundara, Amila Nuwan
Industrial Development Board	BMICH	Industry 2023 exhibition	D S Dissanayake, P V S Madhubhashana, Amila Nuwan
Labuduwa agriculture center	Galle	Agriculture exhibition	C P K Senanayake, M N P De Silva, Amila Nuwan
Piliyandala Dharmaraja vidyalaya	Piliyandala	Anniversary exhibition	D S Dissanayake, G R Tennakoon, Amila Nuwan
Industrial Development Board	Samanala ground	Galle trade fare 2023	C P K Senanayake, M N P De Silva, S I Pothuwila, Amila Nuwan, M H M Madusha

Fig. 18. Contribution to exhibitions

Dissemination of slow release fertilizer technology among rubber smallholders

Under the collaboration with the soil and plant nutrition departments, slow release fertilizer technology was distributed among the 14 rubber smallholders in Kalutara and Kegalle Districts.

RUBBER TECHNOLOGY AND DEVELOPMENT

Dilhara Edirisinghe

DETAILED REVIEW

Staff

Dr (Mrs.) Dilhara G Edirisinghe, Head of the Department was on duty throughout the year. In addition, she served the institute as the Actg. Additional Director during the year. Mrs. U Aloka Weerasinghe, Research Officer commenced her Ph.D. studies in January 2023 at Nanyang Technological University, Singapore and was on full-time study leave throughout the year. Mr W D M Sampath, Senior Research Officer, completed his Ph.D. research work and resumed duties at the department on 1st November 2023.

Mrs Priyanthi Perera, Experimental Officer served the department until 1st June, 2023. Mr Mahesh Abhayawardena, Mrs Gayathri Bhagyawedha, Mrs Ishani Jayaratne, Mr Nadun Tillekeratne and Mrs Madushani Gunawardena, Technical Officers were on duty throughout the year. Mrs Nushara Nanayakkara Technical Officer resigned from the institute on 2nd October, 2023.

Mr Chaminda Peiris, Development Officer assumed duties on 1st January, 2023.

Research students

Postgraduate students

Mr. W D M Sampath (Research Officer, Rubber Technology & Development Dept.), Ph.D. student, Wayamba University of Sri Lanka completed his research project on "Synthesis of nanographene and characterization of its composites based on natural rubber" under the supervision of Dr (Mrs) D G Edirisinghe.

Undergraduate students

Mr W Y S De Silva, B.Sc. (Palm & Latex Technology and Value Addition) undergraduate student, Uva Wellassa University of Sri Lanka conducted his research on "Determination of cure, physico-mechanical, and thermal aging properties of natural rubber based green composite developed by incorporation of corn husk leaf powder and corn husk fiber" under the supervision of Dr (Mrs) D G Edirisinghe.

Miss L H Hashini Irangika, B.Sc. (Honours) (Polymer Science) undergraduate student, University of Sri Jayewardenepura initiated her research on "Enhancement of properties of natural rubber composites using innovative pineapple leaf short-fiber modifications: A green composite approach" under the supervision of Dr (Mrs) D G Edirisinghe and Mr W D M Sampath.

Webinars / Training / Conferences/ Workshops / Meetings attended

Officer/ s	Subject/ Theme	Organization
D G Edirisinghe	Working group meeting on drafting SLS Standard for Passenger Car Tyres	Sri Lanka Standards Institution (SLSI) – Engineering Division
D G Edirisinghe	Inauguration of the "River Project"	Ministry of Plantation Industries (MPI)
D G Edirisinghe	Research-Extension Dialogue	Rubber Research Institute of Sri Lanka (RRISL)
D G Edirisinghe	Workshop – Formulation of a Plantation Policy	MPI in collaboration with National Institute of Plantation Management (NIPM)
D G Edirisinghe	Awareness program conducted by resource persons from the National Innovation Agency (NIA)	MPI
D G Edirisinghe	Awareness program conducted by resource persons from French Agricultural Research Centre for International Development (CIRAD)	RRISL
D G Edirisinghe	Meeting – Rubber, Plastic & Boat Building sectors	Ministry of Industries (MoI)
D G Edirisinghe	Brain storming session and way forward	RRISL
D G Edirisinghe	Meeting – Formulation of a "Road Map" for the development of policy framework to modernize the agriculture sector.	MPI
D G Edirisinghe	Government stakeholder meeting on UAE-Sri Lanka Business Forum & Trade Fair	Presidential Secretariat
D G Edirisinghe	Advisory Committee Meeting – Rubber, Rubber based Products and Plastics Product Sector	Export Development Board (EDB)
D G Edirisinghe, Mahesh Abhayawardena, Gayathri Bhagyawedha, Nadun Thilakarathne, Madushani Gunawardena and Nushara Nanayakkara	General awareness program on the "Circular Leaf Spot Disease and its Management" Lecture on entrepreneurship skills by Prof. Rani Joseph of India and training program on professional development by Mr. J.A.A.S. Ranasinghe	RRISL

Officer/ s	Subject/ Theme	Organization
D G Edirisinghe	Committee Meeting – Evaluation of applications of the "Rubber, Plastic and Fibre based Industry related Research Presentation and Networking Forum 2023"	MoI
D G Edirisinghe	Advisory Committee Meeting – Organizing a collaborative workshop for MSMEs to enhance productivity targeting export market	EDB
D G Edirisinghe	Meeting – Thailand-Sri Lanka Free Trade Agreement	MPI
D G Edirisinghe	Awareness Program on Re-engineering	MPI
D G Edirisinghe, W D M Sampath, Mahesh Abhayawardhana	Symposium on "Rubber, Plastic and Fibre based Industry related Research Presentation and Networking Forum 2023" at Waters Edge, Battaramulla	MoI
D G Edirisinghe	International Symposium on Sustainable Plantation Management at Hotel Queensbury, Malabe	NIPM
D G Edirisinghe	Techno Tour to RRISL, Dartonfield, Agalawatta	TechnoBiz Lanka
D G Edirisinghe and Mahesh Abhayawardena	Trouble shooting in regard to manufacture of balloons	Janrich (Pvt.) Ltd.
D G Edirisinghe	Scientific Committee Meeting	RRISL
D G Edirisinghe	Awareness program on "Rubber Board Act" conducted by the Legal Officer of MPI	RRISL
D G Edirisinghe and Nadun Thilakarathne	Inauguration of the International Workshop on "Circular Leaf Spot Disease"at Marino Beach Hotel, Colombo	International Rubber Research & Development Board (IRRDB) joinly with RRISL
D G Edirisinghe	Meeting – Progress on implementation of recommendations given in the "Draft Report of Performance Review of RRISL 2017-2019" prepared by NASTEC at Isurupaya, Battaramulla	National Science and Technology Commission (NASTEC)
D G Edirisinghe	Meeting – Manufacturing of the new porous root trainer cone for rubber plants in collaboration with Samson International PLC, Galle	MoI
D G Edirisinghe	Meetings – Formulation of a policy framework to modernize the agriculture sector (rubber sector)	Presidential Secretariat and MPI

Officer/ s	Subject/ Theme	Organization
D G Edirisinghe and Madushani Gunawardena	Meeting – Development of a medical product in collaboration with Ceyflex Rubber at E.B. Creasy & Co.	Kotalawala Defence University (KDU)
D G Edirisinghe	Advisory Committee Meeting – Rubber, Plastic and Allied Industries Sector	MoI and Plastics & Rubber Institute of Sri Lanka (PRISL)
D G Edirisinghe	Meetings – Editorial Sub-committee	PRISL
D G Edirisinghe	Meeting – Action Plan 2024	MPI
Ishani Jayaratne	Visited Earth Foam, Horana to conduct trials on preparation of natural rubber latex foam using geosilica	Product Accelerator, University of Auckland, New Zealand
Gayathri Bhagyawedha and Nadun Thilakarathne	Technology update at Dartonfield, Agalawatta	RRISL
Madhushani Gunawardena	Training on "Statistical Analysis for Chemical Laboratories	Association of Testing Laboratories
Mahesh Abhayawardhana and Nadun Thilakarathne	Seminar on "Polymer Characterization"	EDB
Chaminda Peiris	Tamil Language Course	MPI

Lectures / Webinars / Conferences / Training / Workshops conducted

Officer/ s	Subject /Theme	Beneficiary / Client
Staff of the department	Training on "Rubber Product Manufacture" at RRISL, Ratmalana	74 entrepreneurs / rubber small holders from different districts of the country
Staff of the department	Workshop on "Manufacture of rubber products at cottage level" in collaboration with the Adaptive Research Unit (ARU) and Advisory Services Department (ASD) of RRISL at RRISL, Ratmalana	A group of 10 young entrepreneurs / rubber small holders from Padiyatalawa
Staff of the department	Workshop on "Manufacture of rubber products at cottage level" at RRISL, Ratmalana	26 rubber small holders from Kegalle district
Staff of the department	Training program on "Rubber product manufacture" at RRISL, Ratmalana	17 Rubber Development Officers of the Rubber Development Department (RDD)

Officer/ s	Subject /Theme	Beneficiary / Client
W D M Sampath	Lecture - Compounding ingredients used in dry rubber industry	Students of the Certificate Course in Rubber Technology – PRISL
W D M Sampath	Lecture - Rubber coated textiles	Students of the Certificate Course in Rubber Technology – PRISL
W D M Sampath	Lecture - Overview the rubber industry and future challenges with emphasis on quality improvement & Productivity Enhancement/ Collection, Preservation and transportation of latex	Professional Programme in Rubber Manufacture & Factory Practices - NIPM
Staff of the department	Practical demonstration on "Latex based and dry rubber based products manufacture" at RRISL, Ratmalana	B.Sc. (Agri. Sp.) undergraduates of the Department of Plantation Management, Wayamba University of Sri Lanka
Staff of the department	Field training on "Rubber Technology"	Undergraduate students of Palm & Latex Technology and Value Addition – Uva Wellassa University
Staff of the department	Field training on "Rubber Technology"	Undergraduate students of Dept. of Agricultural Technology, Faculty of Technology, University of Colombo
Mahesh Abhayawardhana and Nadun Thilakarathne	Participated in the MPI stall of the National Industry Exhibition, "Industry 2023" held at BMICH, Colombo.	Industrial Development Board (IDB)
D G Edirisinghe, Mahesh Abhayawardhana and Nadun Thilakarathne	Participated in the RRISL stall and attended the inauguration ceremony of COMPLAST 2023 & RUBEXPO 2023	PRISL in collaboration with SMART Expos India Pvt. Ltd.
Gayathri Bhagyawedha and Nadun Thilakarathne	Participated in the RRISL stall at the Exhibition held at the Labuduwa Farm, Galle	Agriculture Department, Southern Province
Mahesh Abhayawardena, Gayathri Bhagyawedha, Ishani Jayaratne, Nadun Thilakarathne and Madushani Gunawardena	Participated in the RRISL stall of the educational exhibition, "DMV DIORAMA 2023" held at the Dharmaraja Maha Vidyalaya, Piliyandala.	Dharmaraja MahaVidyalaya Piliyandala

LABORATORY INVESTIGATIONS

Dry Rubber Technology

1. Development of Rubber Composites with Green Materials

(a) Development of natural rubber based composites with corn husk leaf powder and corn husk fiber

Two types of fillers, corn husk fiber (CHF) and corn husk powder (CHP) were prepared using corn husk leaves, which are abundant agricultural waste. CHF filler, a cellulosic fiber was extracted using sodium hydroxide and thereafter alkali treatment, sodium chlorite bleaching, and oxalic acid hydrolysis were carried out to remove residual impurities and reduce the fiber size. CHP is the desiccated and ground corn husk leaf. Extracted CHF was characterized using FTIR and TGA. Two separate NR-composite series were prepared with varying amounts of CHF and CHP and compared the cure and physico-mechanical properties of the composites with those of carbon black (N 660-FEF) filled NR composites. The CHP series consisted of 5 levels from 20 to 40 phr at 5 phr intervals, while the CHF series consisted of 4 levels from 1.5 - 3 phr at 0.5 phr intervals in the presence of silane-69 coupling agent. All the blends showed acceptable scorch and cure times, while the CHF series showed an increased state of cross-linking. CHP series was not the perfect match to the control prepared without CHP, but its hardness ranged from 40 to 47 IRHD, and the control showed 41.41 ± 0.743 IRHD. Tensile strength, modulus at 100% elongation, and elongation at break of the CHF series showed no significant difference compared to its controls prepared with FEF and $CaCO_3$. Hardness ranged from 41 to 43 IRHD and showed an increasing pattern with CHF loading, while its two controls ranged in 40.3 ± 0.496 IRHD. Abrasion volume loss of the CHF series was lower than the two controls. Overall, the CHF series showed its potential for reinforcing NR in the presence of a coupling agent, while its 2.5 phr level was the best-performing treatment level.

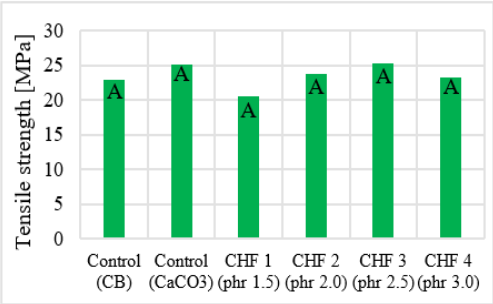


Fig. 1. Variation of tensile strength of the CHF series

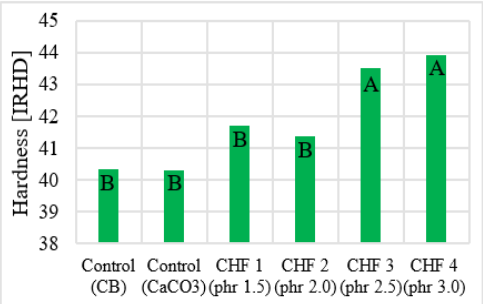


Fig. 2. Variation of hardness of the CHF series

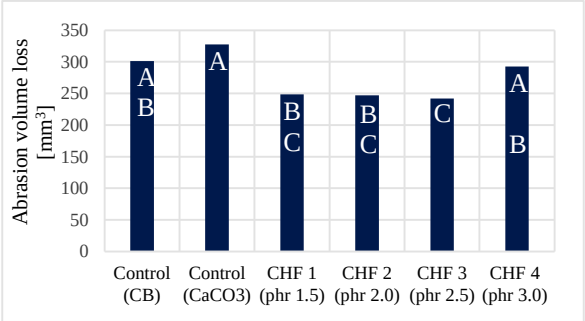


Fig. 3. Variation of abrasion volume loss of the CHF series

(D G Edirisinghe, W Y S De Silva, B.Sc. (Palm & Latex Technology and Value Addition) undergraduate student, Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Madhushani Gunawardena, Prof. Wasantha Seneviratne and M.P. Charithangi of Uva Wellassa University, Badulla)

(b) Development of natural rubber composites with pineapple leaf fiber

The pressing need for sustainable materials across industries motivates this research, which explores the potential of pineapple leaf fibres (PALF) as reinforcement in natural rubber (NR) composites. The goal is to develop eco-friendly alternatives to conventional materials, contributing to advancing green composites and promoting environmentally responsible practices. The study begins by determining the critical fibre length of PALF for NR composites. Considering PALF's hydrophilic nature and NR's hydrophobicity, surface modifications, including NaOH treatment, Salicylic acid treatment, PEG, and Si 69 treatments, are selected and characterized using FTIR analysis. Critical lengths are determined for each treatment: untreated= 5.96mm, NaOH treated=4.48mm, salicylic acid treated=4.76mm, PEG treated=5.08mm, and Si 69 treated= 2.44mm. A qualitative phase involves preparing NR composites with untreated and treated PALF to find the most effective treatment. Evaluation includes cure characteristics, physico-mechanical properties, aging properties, swelling, and water absorption. Results indicate that the Si 69 treatment is the most effective, showing 58% of tensile strength and 13.4% improvement in hardness compared to the control composite, along with better aging properties. Optimization of fibre loading with the best treatment is pursued, varying PALF loading from 5phr to 25phr. Rheological properties, physico-mechanical characteristics, and aging properties are studied, focusing on the application of a solid tyre middle layer. The optimum loading identified is 15phr of PALF.

Fig. 4. Manually Extracted PALF

Fig. 5. Treated PALF with its Critical

Table 1. *Diameter, tensile strength, the maximum load, interfacial shear strength (IFSS), and critical length of PALF for different treatments*

Treatment	Diameter (mm)	Tensile strength (MPa)	Maximum load to debond the fiber (MPa)	IFSS (MPa)	Critical Length (µm)
Untreated	0.36	129.74	3.70	2.83	5959.8
NaOH treated	0.24	150.79	4.96	4.04	4483.0
Salicylic treated	0.21	141.31	3.29	3.12	4762.4
PEG treated	0.26	126.86	3.98	3.25	5078.9
Si 69 treated	0.21	165.34	6.10	7.11	2441.9

The variations in tensile strength among the composites are significant and can be attributed to the treatment methods and filler materials used. For instance, the tensile strength of PALF-filled composites is notably lower than that of control composites. The untreated PALF composite (B) exhibits the lowest tensile strength, indicating that the untreated fibers have limited adhesion to the matrix. Hardness values show that all PALF-filled composites, except E, show higher hardness values than unfilled composites. This can be further explained by studying the elasticity of composites. Incorporating fibers into the rubber matrix may reduce the elasticity and increase the stiffness of the composites. Among fiber-filled NR composites (F) , Si 69 treatment shows higher hardness, and it may be due to the better adhesion of fibers with the rubber matrix.

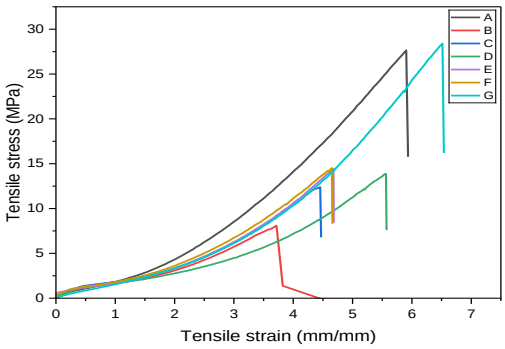


Fig. 6. Stress-strain curves of treated and untreated PALF filled NR

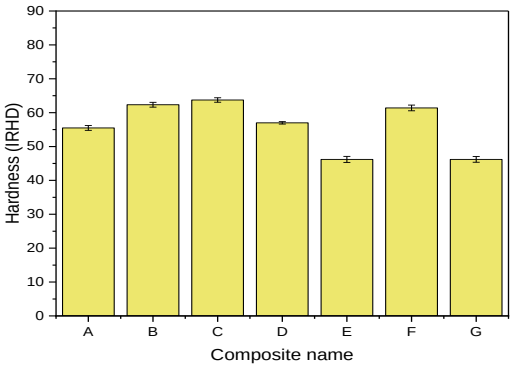


Fig. 7. Hardness of treated and untreated PALF filled NR composites

(D G Edirisinghe, W D M Sampath, L H H Erangika, B.Sc., undergraduate student, Department of Polymer Science, Faculty of Applied Sciences, University of Sri Jayewardenepura, Madhushani Gunawardena and Dr S Gunathilake, University of Sri Jayewardenepura)

2. Development of Natural Rubber Composites with Polyethylene glycol (PEG) grafted as well as copper (Cu) grafted reduced graphene oxide

Polyethylene glycol (PEG) is nontoxic, biocompatible, and heat resistant and further, it can be used as a dispersant agent. The molecular chains of PEG on the surface of the grafted rGO provide good compatibility with the polymer matrix. In addition, different types of conductive metals are used as fillers to incorporate polymer matrices such as copper (Cu), aluminum (Al), nickel (Ni), etc. Copper is a reddish metal with a face-centered cubic crystalline structure and further, Cu is malleable, ductile, and an extremely good conductor of both heat and electricity. Hence, in this study, two series of PEG-g-rGO/NR and Cu-g-rGO/NR nanocomposites were fabricated based on the melt mixing technique, which produced nanocomposites with homogeneously dispersed PEG-g-rGO and Cu-g-rGO in the NR matrix. The 0.8 phr PEG-g-rGO filled NR composite showed better tensile strength in comparison with the other PEG-g-rGO composites and the NR composite prepared without PEG-g-rGO (control). Also, the former composite showed better tear strength and resilience value. Furthermore, the PEG-g-rGO filled NR composites indicated a remarkable improvement in 100% and 300% modulus properties compared to that of the control. Elongation at break percentage of the PEG-g-rGO / NR composites prepared with less than 0.6 phr loading of PEG-g-rGO was at a high level. However, the hardness of PEG-g-rGO filled NR composites could not be seen significant variation. In addition, composites prepared with 0.8 and 1.0 phr loadings of PEG-g-rGO showed fine surface morphology as it homogenously disperses in the NR matrix and this has led to an improvement in

properties. Moreover, the performance of NR composite prepared with 0.8 phr loading of PEG-g-rGO in overall showed a considerable level of applicability for high physico-mechanical polymeric applications.

The Cu-g-rGO-filled NR composites indicated a remarkable improvement in modulus at 100% and 300% elongation. Not only that, the NR composite prepared with Cu-g-rGO significantly improved electrical conductivity. Further, 1 phr loading of Cu-g-rGO illustrated a higher conductivity performance than the composites prepared with PEG-g-rGO.

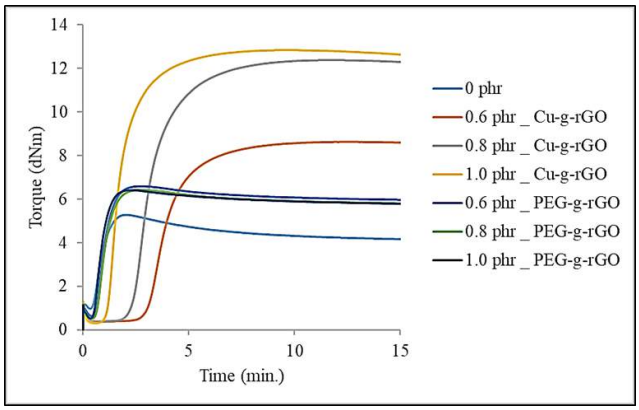


Fig. 8. Rheographs of PEG-g-rGO/NR and Cu-g-rGO/NR composites

Figure 8 shows the rheographs of PEG-g-rGO/NR and Cu-g-rGO/NR composites with different loadings. Hence, NR composites prepared with Cu-g-rGO represent significant variation compared with PEG-g-rGO. The stress-strain behavior of NR composites with and without PEG-g-rGO. Stress-strain curves of PEG-g-rGO composites exhibit a highly elastic shape or amorphous nature. The composite prepared with 0.8 phr loading of PEG-g-rGO shows higher stress-strain properties than the other PEG-g-rGO-filled composites and the control.

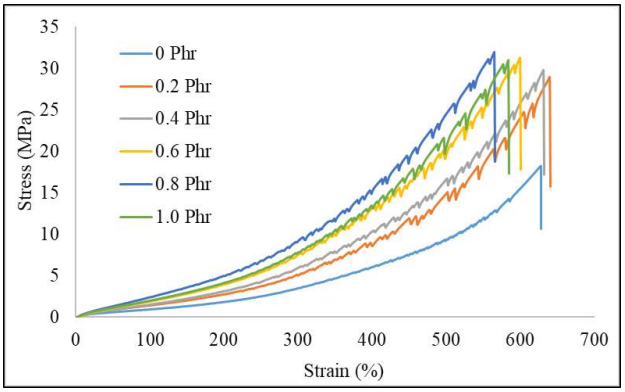


Fig. 9. Stress-strain properties of PEG-g-rGO/NR composites

The fracture surface of the control (without PEG-g-rGO) is smooth and plane, as observed in Figure 10 (a). The NR composite prepared with 0.4 phr loading of PEG-g-rGO shows a weak interface of the fracture surface, indicating poor surface adhesion (Figure 10 (b)). However, the composite prepared with 0.8 phr loading of PEG-g-rGO has better surface adhesion (Figure 10 (c)) as it homogenously disperses in the NR matrix, which led to improved physico-machanical properties.

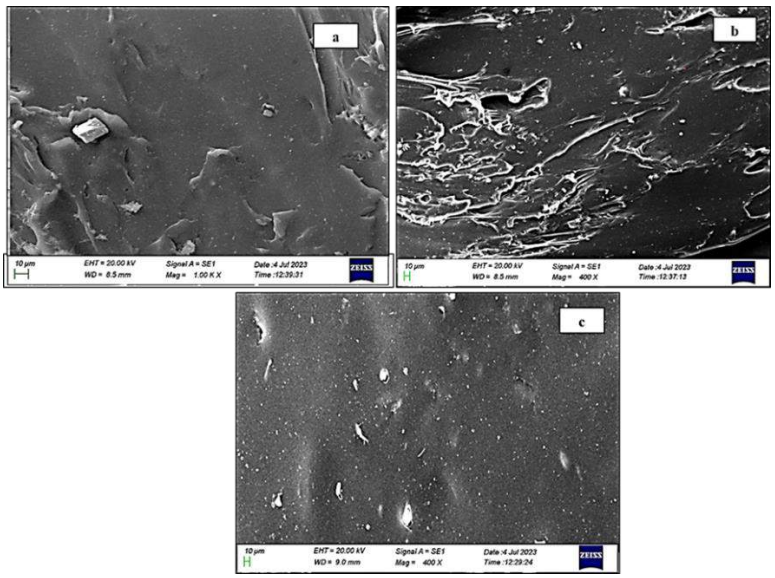


Fig. 10. SEM images of tensile fracture surfaces of composites prepared with different PEG-g-rGO loadings: (a) 0 phr (b) 0.4 phr (c) 0.8 phr

As shown in Figure 11, the electrical conductivity of Cu-g-graphite and PEG-g-rGO-filled NR composites varies from 0.0002 to 8.52 mS/m. Figure 11 clearly illustrates that the electrical conductivity increases with increased Cu-g-rGO content. Conductive networks gradually form and penetrate the insulating polymeric matrix with increased metallic filler loading. The electrical conductivity of the 1 phr loaded Cu-g-rGO/NR and PEG-g-rGO/NR composites is 8.52 and 0.0002 mS/m, respectively. Cu-g-rGO has improved the electrical conductivity of the composites by four orders of magnitude, owing to the uniform dispersion of Cu-g-rGO in the NR matrix.

Figure 12 shows the resistivity of PEG-g-rGO/NR and Cu-g-rGO/NR composites. As shown in Figure 12, the control composite indicates higher electrical resistivity since NR is a high-insulating material. As expected, the variation of electrical resistivity of NR composites presents an opposite trend to that of electrical conductivity (Fig. 11). In addition, the composites prepared with Cu-g-rGO present low electrical resistivity compared with PEG-g-rGO-filled NR composites.

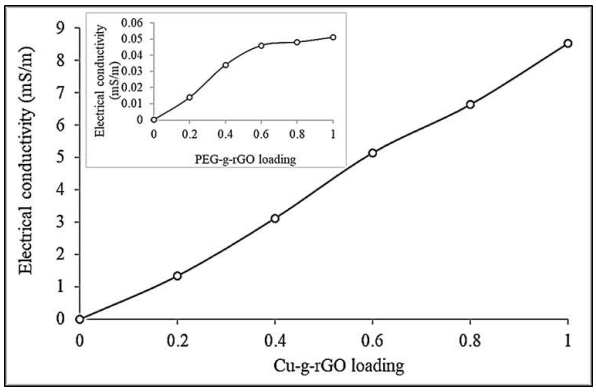


Fig. 11. Electrical conductivity of PEG-g-rGO/NR and Cu-g-graphite/NR composites

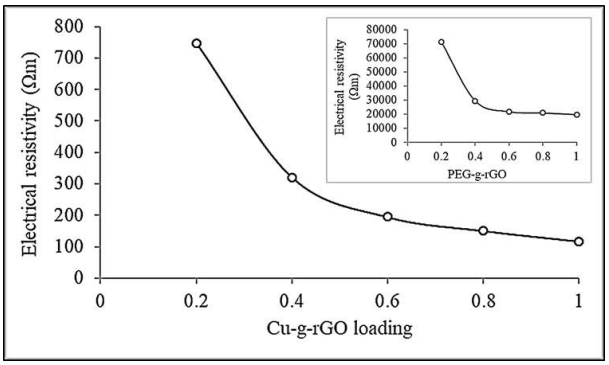


Fig. 12. Resistivity of PEG-g-rGO/NR and Cu-g-graphite/NR composites

(W D M Sampath, D G Edirisinghe and Prof C A N Fernando- Head/Department of Nano Science Technology)

Industrial Extension

The following properties of polymer materials/compounds/products were tested and test reports were issued to the respective companies/government organizations on their request.

Sole Crepe Hardness	**Rubber Compound Physico-mechanical properties**	**Rubber Product Physico-mechanical properties**	**Polythene Tensile and ageing properties**
Atale Estate, Kegalle Plantations.	Ceytra (Pvt.) Ltd.	Lakjeewa Industries (Pvt.) Ltd.	Lalan Rubbers (Pvt.) Ltd.
Elston Estate, Pussellawa Plantations Ltd.	University of Ruhuna	ExGlobe (Pvt.) Ltd.	
Panawatte Estate, Kelani Valley Plantations Plc.	Microcells Pvt. Ltd.	Quality Latex Products (Pvt.) Ltd.	
Dewalakanda Estate, Kelani Valley Plantations Plc.	Ceyflex Rubber Ltd.	Nava Lanka Chemical Industries (Pvt.) Ltd.	
Elpitiya Plantations Plc.	University of Sri Jayewardenepura	Dharmasiri Tyre House (Pvt.) Ltd.	
Kotagala Plantations Ltd.	DTH Superdag (Pvt.) Ltd.	Atlas Axillia (Pvt.) Ltd.	
Peenkande Estate	Samson Rubber Industries (Pvt.) Ltd.	Lak Methodic Co. (Pvt.) Ltd.	
	Dharmasiri Tyre House (Pvt.) Ltd.		
	ExGlobe (Pvt.) Ltd.		
	Samson Reclaim Rubbers Ltd.		
	Road Runner Industries Pvt. Ltd.		
	Uva Wellassa University		
	Bhagya Industries (Pvt.) Ltd.		
	Jafferjee Brothers Exports (Pvt.) Ltd.		
	John Keels Research		

Development of Rubber Compounds / Products

The following rubber compound / product developments were conducted on requests made by the respective clients.

Development	Client
Dry rubber based cellular compound for a marine engineering application	Tantri Trailers (Pvt.) Ltd.
Deproteinized natural rubber (DPNR) based reusable hygiene product	Ceylon Natural Rubber (Pvt.) Ltd.
Crepe rubber based compound suitable to produce a medical item	Neuro Surgeon – Kotalawala Defence University (KDU)
NR latex based glue to bond recycled carpet waste material	Auckland University, New Zealand
Mechano-chemical reclaiming process for NBR glove waste	Lalan Rubbers (Pvt.) Ltd.
Glove out of butyl rubber	Lalan Rubbers (Pvt.) Ltd.

POLYMER CHEMISTRY

I H K Samarasinghe

DETAILED REVIEW

Staff

Mrs I H K Samarasinghe, Research Officer was assigned to cover up the duties of the Head of Department of Polymer Chemistry with effect from 2nd January 2023 and was on maternity leave from 30th June 2023.Mr Y R Somaratne, Research Officer and Dr Ravindra Alles, Senior Research Officer resigned from the institute on 10th April 2023 and 26th September 2023 respectively.

Mrs Nirmala Jayawardena, Experimental Officer was on duty throughout the year. Mrs H M H Dhanukamalee, Mrs P S V Rupasinghe, Mr D V D Mallikaarachchi, and Mrs H L T Tharaka Technical Officers were on duty throughout the year. Mr N W E Chanu Maduranga, Management Assistant, resigned on 13th March 2023.

Research Students

W M T M Wickramasinghe, an undergraduate student from the Department of Export Agriculture, Uva Wellassa University conducted his research project titled "preparation and characterization of savinase treated deproteinized skim crepe rubber " under the supervision of Mrs I H K Samarasinghe.

Chamod Gunatilake an undergraduate student from the Department of Environmental and industrial Sciences , Faculty of Science ,University of Peradeniya conducted his industrial project titled" Preparation of Epoxidized Natural Rubber and Characterization" under the supervision of Mrs I H K Samarasinghe.

E P Manishi Pradeepani an undergraduate student from the Department of Polymer Science, University of Sri Jayawardenapura conducted her industrial project titled "Preparation and Characterization of Cyclized natural rubber" under the supervision of Mrs I H K Samarasinghe.

L H H Erangika an undergraduate student from the Department of Polymer Science, University of Sri Jayawardenapura conducted her industrial project titled "Analysis of the new test method for Sodium Salt of Thiol Mercaptan - Bleaching Agent used in Crepe Rubber Industry" under the supervision of Dr Ravindra Alles.

Lectures/Seminars/Webinars/Training/Workshops/Conferences conducted

Officer/s	Subject/ Theme	Beneficiary/ Client
I.H.K Samarasinghe	Project report evaluating and viva-voce examiner for the project titled "Development of Field Latex Preservative System to Substitute Existing TMTD/ZnO System"	A student of Diploma in Polymer Technology Course, Plastics & Rubber Institute, Sri Lanka
W.R.N. Alles	Value-added natural rubber grades	Students of Advance Certificate Course in Plantation Management, National Institute of Plantation Management
Staff of the department	Field training program on "Familiarization to advanced polymer material Characterization"	Undergraduate students of Palm & Latex Technology and Value Addition, Uva Wellassa University

Lectures/Seminars/Webinars/Training/Workshops/Conferences/Meetings attended

Officer/s	Subject/Theme	Organization
I.H.K Samarasinghe, Y. R. Somarathna and W.R.N Alles	Scientific Committee Meeting	Rubber Research Institute of Sri Lanka
	Graphene Applications in Natural Rubber Technologies	Rubber Research Institute of Sri Lanka and The Plastic and Rubber Institute of Sri Lanka
I.H.K Samarasinghe, and W.R.N Alles	Progress Review Meeting/Research Meeting	Rubber Research Institute of Sri Lanka
	Brainstorming session to way forward	Rubber Research Institute of Sri Lanka
W.R.N Alles and Y. R. Somarathna	Young Researchers' Forum	Rubber Research Institute of Sri Lanka
W.R.N Alles	Research Extension Dialog	Rubber Research Institute of Sri Lanka
	How to be a value-added researcher. /technical person" - by Emirate Prof. Rani Joseph- Horizon University and "General responsibilities and expectations"	Dartonfied Academy

Officer/s	Subject/Theme	Organization
Mrs Nirmala Jayawardena	International Workshop on leaf Spot Disease of Rubber Plantations	International Rubber Research & Development Board
H.M.H. Dhanukamalee	Training on statistical analysis for chemical laboratory	Plastic and Rubber Institute
D.V.D. Mallikaarachchi	Advanced Polymeric materials characterization for dry rubber, latex and plastic industry	Technobiz, SLAMERP and EDB

LABORATORY INVESTIGATIONS

Development of modified natural rubber grades

Preparation and Characterization of epoxidized natural rubber (ENR)

The major disadvantage of rubber is its sensitivity towards heat, oxygen and ozone due to the presence of an unsaturated double-bond structure, which consists of cis-1,4-polyisoprene. To maintain its position as the material of choice in various product applications, natural rubber is subjected to modification processes to overcome its drawbacks. Modifications to the NR can be done either by using physical or chemical methods. These modifications not only reintroduce natural rubber to adapt to specific application needs but will also minimize the dependency on synthetic rubber while aligning with increased awareness of sustainable material.

Epoxidation of natural rubber is a chemical process that involves the introduction of epoxide groups into the polymer chains of natural rubber.NR characteristics are enhanced through epoxidation, which makes it suitable for product applications such as resistance to oil and solvents, air permeability resistance, wet skid resistance and bonding to various mediums such as metal, ceramics and textiles. The epoxidation of natural rubber is a complex process that requires careful control of reaction conditions, including the concentration of reactants, the reaction time, and the temperature.

The effect of reactant concentrations (H_2O_2) on the epoxy content of ENR was studied and the samples were characterized using FTIR. Epoxidation reaction was conducted by in situ generation of performic acid in the latex stage. The concentration of H2O2 was varied and drop-wise addition was performed.

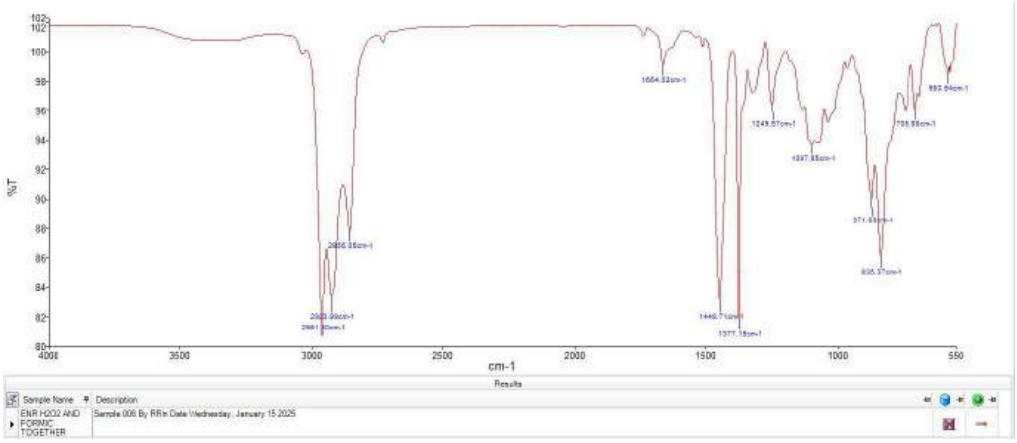


Fig. 1. FTIR spectrum of ENR

Laboratory trials on the above experiment were able to synthesize ENR with 30 mol% epoxidation. Figure 1 illustrates the FTIR spectrum of one of the samples synthesized and observed characteristics peaks at wave numbers, 870 cm^{-1} and 1240 cm^{-1} which attributed to the symmetric stretching and asymmetric stretching of epoxide ring, respectively (I H K Samarasinghe, D V D Mallikarachchi, Nirmala Jayawardena, and H M H Dhanukamalee).

Preparation and Characterization of Savinase-Treated Deproteinized Skim Crepe Rubber

The main objective of this study is to use Savinase enzyme produced by *Bacillus licheniformis*, for the treatment of skim latex to mitigate its nitrogen content by breaking down proteins and hence to be used as a value-added product. However, this protein breakdown process may have adverse effects on the raw rubber properties of skim crepe rubber as well as physico-mechanical properties of vulcanizates prepared with that of the rubber. Therefore, an experiment was set up to evaluate the effect of Savinase enzyme on deprotenizing skim crepe rubber. In that context, a series of Savinase treated skim crepe rubber samples was prepared by varying the amounts of Savinase as 0, 1, 2, 3, and 4 mL on 1L of skim latex. Skim crepe laces were prepared after coagulation and the raw rubber properties such as nitrogen, dirt, ash, and the volatile matter content of Savinace treated skim crepe rubber were measured according to ISO standards. Physico-mechanical properties of vulcanizates prepared with Savinase treated skim crepe rubber were also determined. Initially the Savinase enzyme was characterized using FTIR. When adding 2 mL of Savinase to 1 L of skim rubber, the percentage nitrogen content of the skim crepe is decreased by about 90% compared to the untreated skim crepe rubber ($P < 0.05$). It was observed that vulcanizate prepared with skim crepe rubber (the control sample) exhibited the highest physico-mechanical

properties such as tensile strength, elongation at break, tear strength, and hardness ($P < 0.05$) compared to those of the vulcanizates prepared with Savinase treated skim crepe rubber. However, tensile strength and hardness of the vulcanizate prepared with Savinace treated (2 mL of Savinase on 1L skim latex) skim latex demonstrates improved tensile strength and hardness compared to other treated samples ($P < 0.05$). It was observed that tear strength of vulcanizate prepared with Savinase treated latex increases proportionately with increasing Savinase concentration up to 3 mL/L of skim latex. In conclusion, the physico-mechanical properties of skim rubber latex can be enhanced by utilizing a savinase concentration between 2.0–3.0 mL/L of skim latex, and concentration of 2 mL/L was identified as the most effective for preparing skim crepe rubber vulcanizates with improved tensile strength and hardness (I H K Samarasinghe, P S V Rupasinghe and W M T M Wickramasinghe (Undergraduate Student of Uva Wellassa University of Sri Lanka).

Carbon Black/processed mica hybrid filler system for Natural Rubber based tyre compounds

To develop a hybrid filler system for tyre tread compounds, mica and carbon black were combined in this study. The primary objective is to minimize the use of carbon black and its detrimental effects on the environment and human health. By adjusting the ratios of carbon black and mica while keeping the same filler amount overall, the study aims to create a range of rubber composites. This study aims on the cure characteristics, and the physical and mechanical properties of natural rubber-filled mica composites. Seven compounds were made by varying the mica and Carbon Black ratios. A composite with 50 phr of carbon black (with no mica) is considered as the control sample. Compounds were prepared according to a standard rubber compounding formula.

The highest optimum cure time (T_{90}) and the scorch time (ts2) is observed in the control sample. The highest curing rate is shown in the CB25WM25 sample. It is interesting to note the reduction of scorch time and cure time with increasing mica loading. Addition of either mica or combination of both does not affect both M_H (maximum torque) and M_L(minimum torque) values.

Test results showed non-linear fluctuations in tensile strength (Fig. 2). However, CB25WM25 achieved the similar tensile strength of control sample.

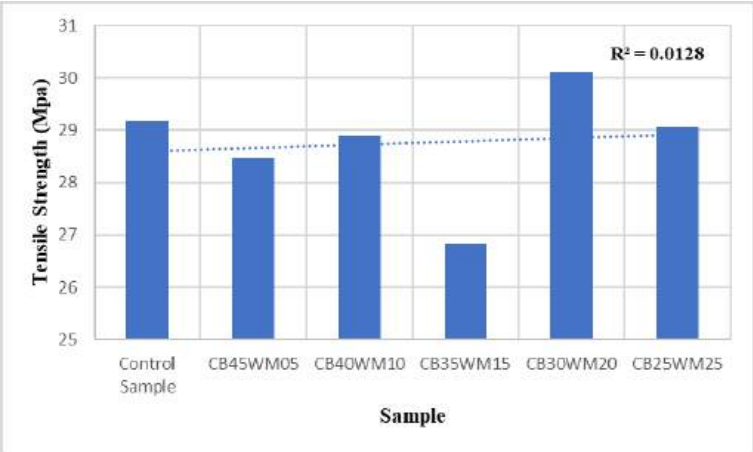


Fig. 2. Variation of tensile strength with mica loading

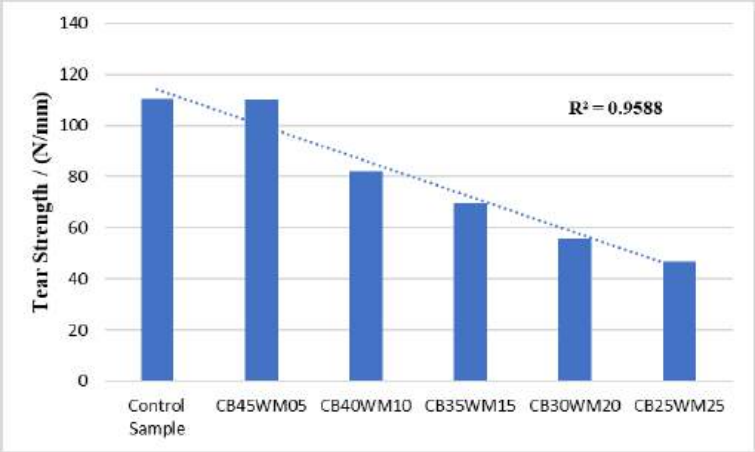


Fig. 3. Variation of tear strength with mica loading

Tear strength refers to a material's ability to prevent cuts or rips from spreading and this parameter is crucial for tyres due to harsh working conditions like collisions, punctures, and frictional forces, ensuring durability and structural integrity. According to test results (Figure 3), the tear strength of the rubber compound series decreases, as the mica percentage increases. This may be owing to the reduction of rubber-filler interactions with increasing waste mica content.

Figure 4, the hardness of the compounds prepared using carbon black/processed mica hybrid filler system decreases with increasing the mica loading and it may be due to the difference in reinforcement effect between carbon black and mica. Carbon black enhances mechanical properties, while mica's plate-like structure may not provide the same level of support.

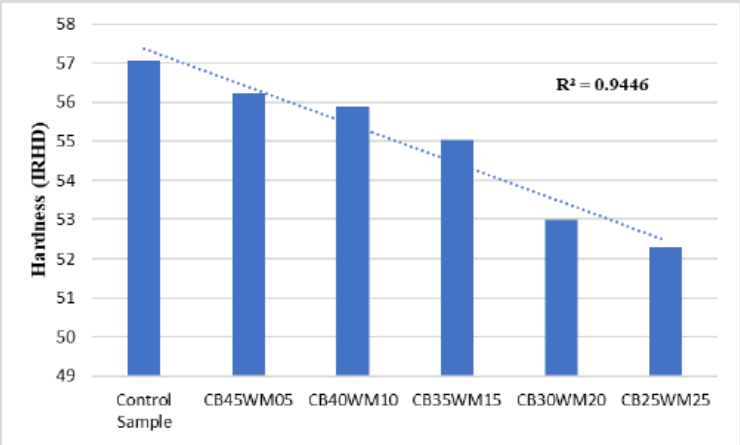


Fig. 4. Variation of Hardness with mica loading

A material's resistance to abrasion is its capacity to sustain mechanical procedures such as erosion, rubbing, and scraping while maintaining its form and structural integrity. This characteristic makes precision-engineered components durable and reliably functioning by enabling them to withstand repeated wear and friction during operation.

The study discovered that abrasion volume loss increases (Fig. 5) with larger mica content in rubber compounds prepared with carbon black/processed mica hybrid filler system (Figure 5), with the largest loss occurring at a ratio of 30:20 carbon black to mica. It was also indicated that there was less abrasion volume loss in the compound prepared with 50:50 combination of carbon black to mica compared to the former compound. (Y R Somarathna, D V D Mallikarachchi, Sithmini Prathiba (Undergraduate Student of Sri Jayewardenepura University of Sri Lanka).

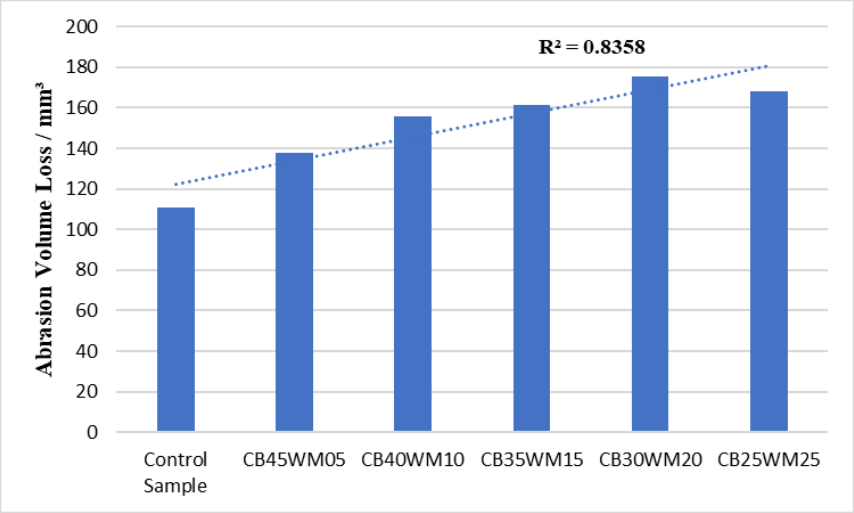


Fig. 5. Variation of Abrasion Resistant with mica loading

A new test method for determination of sodium salt of thiol mercaptan bleaching agent use in the crepe rubber industry.

Crepe rubber, essential for various industries, necessitates high purity to meet market quality standards, with discolouration often caused by carotenoid pigments posing a significant challenge. Bleaching agents, like sodium para toluene thiophene, are commonly employed to address this issue. However, the presence of silver salt precipitate in the bleaching agent poses challenges to typical back titration procedures for measuring bleaching agent strength, especially in endpoint determination. This work presents a unique gravimetric analysis approach verified by FTIR to determine the active component level precisely. The process involves precipitating the sodium salt of tolyl mercaptan with a calibrated silver nitrate solution and then drying the mixture to a constant weight. The gravimetric approach yielded an estimated active component concentration of 46% w/w in the experimental data, which is higher than the validated value of 36% w/w obtained using back titration. Eight crepe rubber samples, prepared with varying bleaching agent quantities, are evaluated using PRI and Lovibond colour tests. According to the comparative study, the gravimetric methodology is effective and yields findings comparable to those of conventional approaches. Additionally, because the gravimetric approach is unscented, it improves accessibility and worker safety. This primarily benefits users with less analytical experience and on-site applications in manufacturing environments. To facilitate wider use and improved manufacturing processes, this study advances quality control procedures by establishing the appropriateness of the gravimetric approach as a user-friendly substitute for determining bleaching chemical levels to be used in crepe rubber

(W R N Alles and L H H Erangika (Undergraduate Student of Sri Jayewardenepura University of Sri Lanka).

Industrial Extension

The following clients obtained both technical and consultancy services from the department throughout the year.

- National Water Supply & Drainage Board
- Dipped Products PLC
- Samson Rubber Industries (Pvt) Ltd
- Textrip (Pvt) Ltd
- Polymer Products Impex (Private) Limited
- Samson International PLC
- Samson Rubber Products (Pvt) Ltd
- Samson Compounds (Pvt) Ltd
- Jafferjee Brothers Exports (Pvt) Ltd
- Lakjeewa Industries (Pvt) Ltd
- Microcells (Pvt) Ltd
- Stellana LK
- Lalan Eco Latex (Pvt) Ltd
- University of Ruhuna
- University of Sri Jayewardenepura

RAW RUBBER AND CHEMICAL ANALYSIS

Anusha Attanayake

DETAILED REVIEW

Staff

Dr (Mrs) A P Attanayake, the Principal Research Officer, was in charge of the department's overall activities throughout the year. Mrs C S Lokuge, the Experimental Officer was on duty throughout the year, Ms M U D S Weerasinghe, Mr H D M S Wijewardana, and Mr K A S T Koswatta, Technical Officers were on duty throughout the year. Management Assistant Ms Janani Lakshika was on duty throughout the year.

Research students

Postgraduate students

M.Phill student from the University of Ruhuna had conducted her research on "Purification & Commercialization of pyrolytic carbon char generated from waste tire pyrolysis plants in Sri Lanka under the supervision of Dr Anusha Attanayake. The project was conducted under the financial support from the AHEAD grant.

Undergraduate students

Miss W K Amarasekera, B.Sc. (Palm & Latex Technology and Value Addition) student from Uva Wellassa University of Sri Lanka conducted her research on "Impact of varied Zinc Concentration Levels on Natural Rubber Latex Film Properties" under the supervision of Dr (Mrs) A P Attanayake.

Mr R M V S Ratnayake, B.Sc. (Palm & Latex Technology and Value Addition) student from Uva Wellassa University of Sri Lanka conducted his research on "Identification of Alternative Bleaching Agent for the Chemical Used in Crepe Rubber Manufacturing" under the supervision of Dr (Mrs) A.P Attanayake.

Ms K P M P Gunathilaka, B.Sc. student from Department of Chemistry, Faculty of Applied Sciences, University of Sri Jayewardenepura conducted her research on "Evaluation of curing characteristics and reinforcing behavior of cinnamon wood biochar filled natural rubber composites" under the supervision of Dr (Mrs) A P Attanayake.

Seminars/Training Programmes/Workshops/Exhibitions conducted

Officer/s	Subject	Beneficiary/Client
A.P Attanayake	TSR Manufacturing	Diploma students from the National Institute of Plantation Management
A.P Attanayake	TSR Manufacturing	Diploma students from the National Institute of Plantation Management
Staff of the Department	Latex & raw rubber testing	Group of students from Uva Wellassa University
Staff of the Department	Latex Testing	Students from Wayamba University
Staff of the Department	Dry rubber testing	TSR and tyre manufacturers
Staff of the Department	Latex & raw rubber testing	Students from Sabaragamuwa University

Lectures / Seminars / Workshops / Meetings attended

Officer/s	Subject	Organization
A.P Attanayake	TSR steering committee	Ministry of Plantation Industries
A.P Attanayake	Web base services	Ministry of Plantation Industries
A.P Attanayake	ISO 17043 awareness program	SLAB
A.P Attanayake	ISO 17025 laboratory accreditation audit	Industrial Technology Institute
A.P Attanayake	HS code meeting	Ministry of Finance
A.P Attanayake	International Sustainability Summit	Ministry of Plantation Industries
A.P Attanayake	A Path for commercialization of Research Findings & Innovations	Ministry of Industries
A.P Attanayake	Sri Lanka Sustainable Financial Tools	Ministry of Plantation Industries
A.P Attanayake	IRRDB-RRISL Conference	International Rubber Research & Development Board
A.P Attanayake	Business Process Re-engineering workshop	Ministry of Plantation Industries
A.P Attanayake	Advance Polymer Material Characterization workshop	Technobiz Lanka Pvt Ltd.
A.P Attanayake	Orientation Session for contact points	National Science Foundation
A.P Attanayake	Meeting – Rubber, Plastic & Boat Building sectors	Ministry of Industries (MOI)

Officer/s	Subject	Organization
A.P Attanayake	Brainstorming session and way forward	RRISL
A.P Attanayake	Techno Tour to Dartonfield, Agalawatta	Technobiz Lanka Pvt Ltd
A.P Attanayake C.Lokuge. M.U.D.S.Weerasinghe, H.D.M.S.Wijewardana, Mr. K.A.S.T. Koswatta	Workshop on 5S concept application to the organization	Guest: Eng (Ms) Sakunthala; conducted by RRISL, Rathmalana
A.P Attanayake C.Lokuge. M.U.D.S.Weerasinghe, H.D.M.S.Wijewardana, Mr. K.A.S.T. Koswatta	ISO 17025:2017 requirements	Ms. Subadra Jayesinghe
A.P Attanayake C.Lokuge. M.U.D.S.Weerasinghe, H.D.M.S.Wijewardana, Mr. K.A.S.T. Koswatta	Testing Laboratory Accreditation	Ms Subadra jayesinghe
A.P Attanayake C.Lokuge	International Symposium on CLSD of Rubber	Conducted by the Plant Pathology & Microbiology Department, RRISL

LABORATORY INVESTIGATIONS

Effect of heavy metal ions on latex quality parameters- Effect of different Zinc concentration levels on latex film properties

The introduction of Zinc Oxide (ZnO) into natural rubber latex can enhance the concentration of zinc ions (Zn^{2+}) within the latex colloid, leading to the reinforcement of the latex system. However, it is imperative to exercise caution concerning the quantity of ZnO employed, as excessive usage has been observed to potentially compromise the physico-chemical and physico-mechanical properties inherent to natural rubber latex. This study was carried out to investigate the effect of added Zn^{2+} on the physico-mechanical properties of natural rubber latex concerning

glove formulation. Initial latex properties were investigated before treating with Zn^{2+} (Table 1).

Table 1. *Initial latex properties of the centrifuge latex sample*

Latex Property	Initial Level
Alkalinity	0.54 ± 0.01
TSC (%)	61.71 ± 0.03
DRC (%)	60.22 ± 0.02
MST	190.45 ± 0.00
VFA	0.0315 ± 0.00
pH	10.43 ± 0.00
Phosphate	199.3 ± 0.81

Values in each column represent the means of three replicates ± SE (standard error).

Concentrated latex samples were treated with varying amounts of Zn^{2+} levels and kept for 21 days of maturation. Weekly evaluations were carried out throughout the storage duration to analyze the fluctuation in latex properties, encompassing Mechanical Stability Time (MST), Volatile Fatty Acid Number (VFA), pH and Phosphate levels.

Variations of latex properties over added zinc concentrations with storage time

Mechanical Stability Time

MST was recorded over storage time in order to check the stability of latex changes with time (Figure 1). According to the graph MST in each week has been decreased with increasing zinc level. Zinc forms zinc ammonia complex ions ($[Zn(NH4)_n]^{2+}$) which will combine with fatty acid soaps adsorbed on rubber particles to create insoluble zinc soaps, which causes latex to gel or to coagulate. And also, with the addition of higher concentrations of zinc to high ammonia, NRL caused latex coagulation. It was due to the binding of zinc ions and carboxylate anions on the surface of rubber particles. These could be the reasons behind the reduction of MST with increasing zinc level. The MST over time does not have a significant change, but there is a little decrement with time. Therefore, the decrement with time could be due to the destabilization of latex due to several reasons mentioned above.

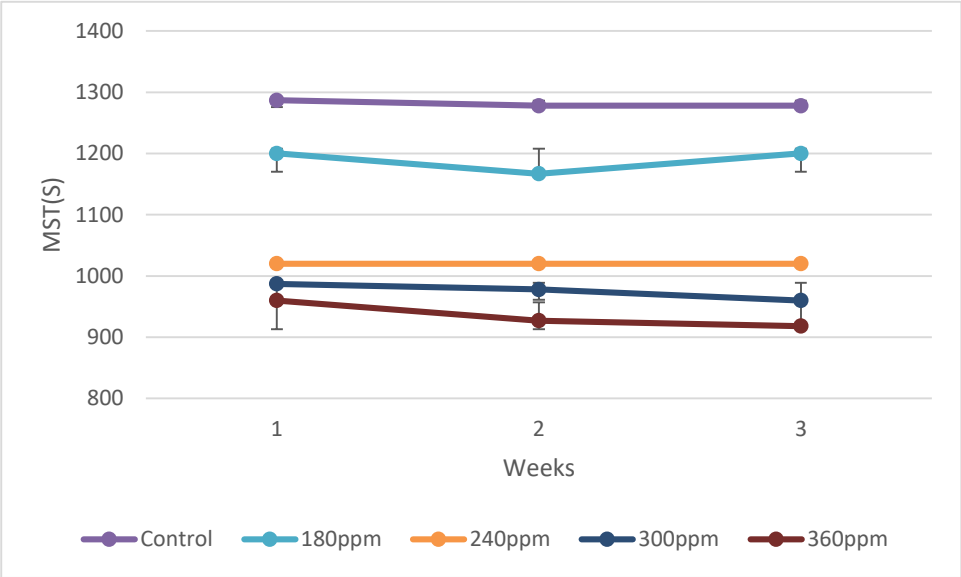


Fig. 1. Variation of Mechanical Stability Time (MST) over storage time of latex

VFA Number

An increasing pattern of VFA number with storage time was observed in all four treatments except the 360ppm level (Figure 2). An increasing pattern of VFA was observed with the increasing zinc level except the 1st week of 180ppm treatment. Divalent metal ions like zinc have been shown to promote bacterial growth. These microbial metabolic pathways can produce volatile acids as byproducts increasing VFA. This could be the reason behind the increasing VFA, which is increasing zinc level and storage time. Also, with time, oxidation of latex components like proteins can occur leading to form volatile acids. Transition metal ions like zinc can act as catalysts for these oxidation reactions. activity as explained above. With time, the colloid gets saturated with VFAs including free fatty acids and glycerol increasing the surface area/ volume ratio in the colloid. High surface area/volume is responsible for the increment of antimicrobial properties in colloids. The increment of antimicrobial properties of the CL is the main reason for the VFA reduction. short chain fatty acids have ability of decrease the VFA number while increasing pH value. This can be the reason behind the decrement of VFA number in 360ppm level.

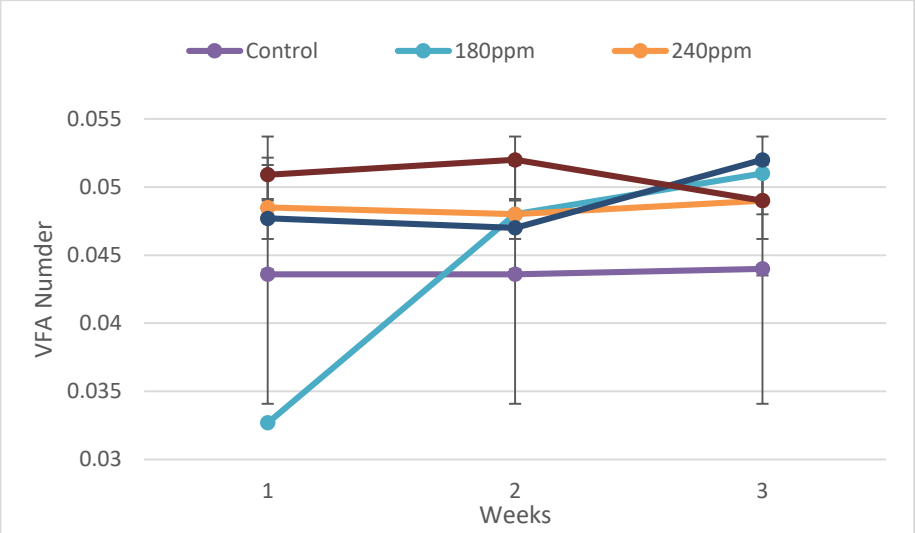


Fig. 2. Variation of Volatile Fatty acid Number over storage time of latex

pH Value

A significant increment in pH can be seen in all four treatments except 180ppm with storage time (Figure 3). Some metal ions can undergo hydrolysis when coming into contact with water forming hydroxide ions. These hydroxide ions are responsible for the increment in pH in the latex system with time. The rate of pH has been decreased after the second week. The formation of fatty acids due to microbial activity with time could be the reason. There exists a discernible variation at the 180ppm concentration level. When considering in between treatments a clear pattern cannot be identified. Variation could be due to the evaporation of ammonia while handling. Handling was done while making sure to evaporate a minimum amount of ammonia but still, there can be a slight variation. Since the variation deviates between 10.34-and 10.53, this slight variation could be due to that reason.

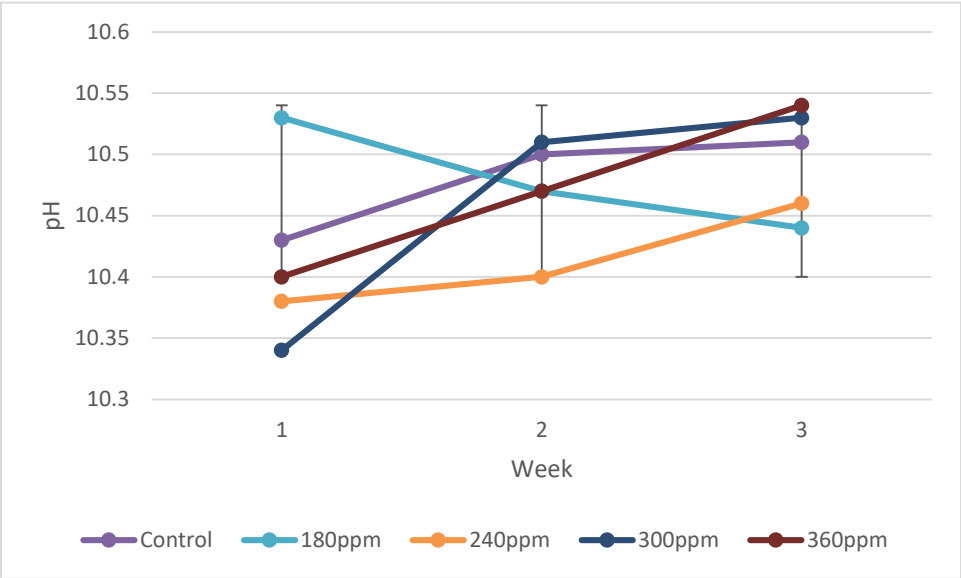
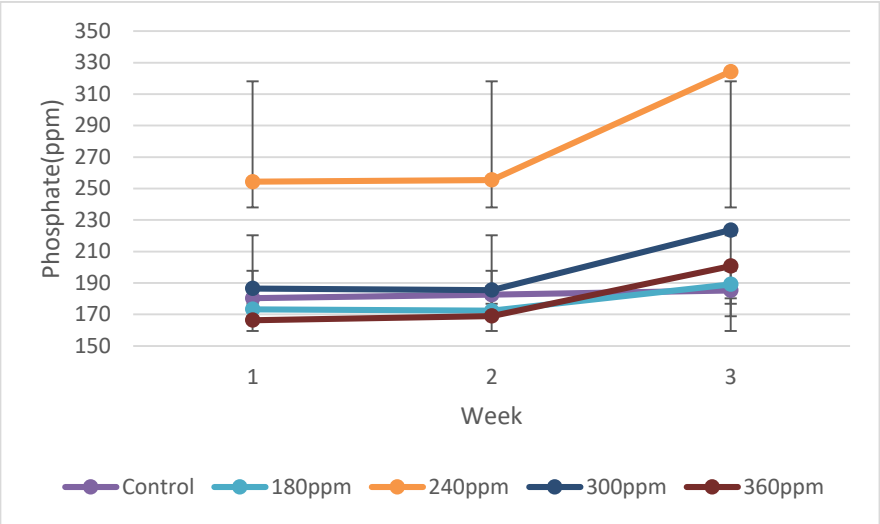


Fig. 3. Variation of pH over storage time of latex

Phosphate Content

Total phosphate content was recorded over the storage time and is illustrated in Figure 4. The amount of total phosphate in all five treatments is steadily rising to the 3rd week, which can be attributable to the continuous lipid hydrolysis. When considering about the phosphate change between the treatments with altered zinc level, there is a pattern of increasing the phosphate content up to 240ppm and then decreasing. Zinc ions can form complexes with phosphate ions in the medium resulting continuous sludge formation. This could be the reason to decrease the amount of phosphate ions in the medium and for low phosphate content in 360ppm level. However, there is a deviation in 240ppm level where it has a significant higher level of phosphate than other treatments.



Variation of compounded latex MST over added zinc concentrations with storage time

MST of compounded latex was recorded over the storage time up to 32hours maturation period is illustrated in Figure 5. A clear pattern of decreasing MST up to 24 hours and then increasing can be noticed. The reason could be the maturation of latex after compounding.

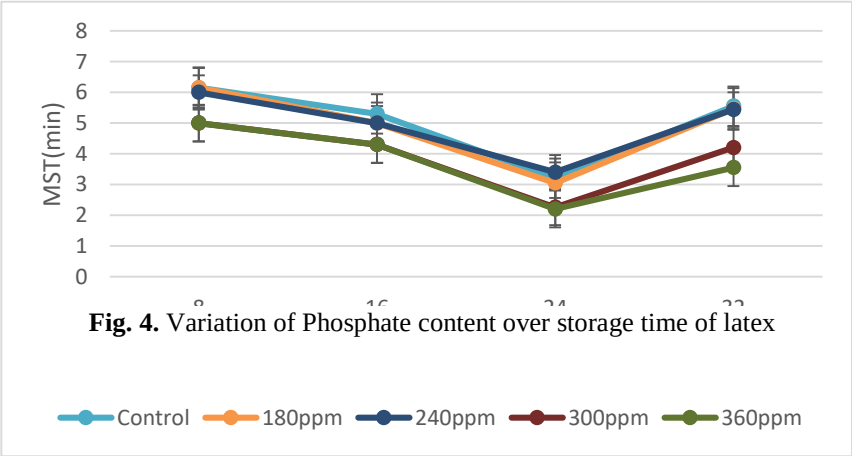


Fig. 4. Variation of Phosphate content over storage time of latex

Fig. 5. Variation of compound MST over storage time

The MST value between treatments with the increment of zinc level has been reduced comparatively. With the addition of higher concentrations of zinc to high ammonia NRL caused latex coagulation. It was due to binding of zinc ions carboxylate anions on the surface of rubber particles. This could be a reason behind the reduction of MST with increasing zinc level. However, a significant difference between treatments could not be seen due to the lower concentration gap between treatments.

Determination of latex film properties

These investigations were conducted in adherence to the applicable ISO procedures. After 21 days samples were compounded, and MST was estimated for three days. Changes in film properties such as tensile strength and tear strength were investigated after the preparation of latex films. The mechanical properties of latex films were not statistically significant ($p > 0.05$). Maximum tensile strength was observed at the zinc concentration of 125.58ppm which was used as the control without adding zinc. The sample with the highest zinc concentration (360ppm) showed a maximum tear strength of 44.37MPa. Hence this study concludes that higher zinc levels impair an effect on physicochemical properties by reducing the stability of natural rubber latex, and there is no significant effect on physico-mechanical properties like tensile and tear strength of latex. Furthermore, variations in zinc concentration can impact the stability of compounded latex by inducing a decrease in MST with an increase in zinc levels. However, it is important to note that the influence of zinc levels on properties such as tensile and tear strength did not exhibit statistical significance, based on the conducted statistical analysis. This absence of significant disparity could be attributed to the relatively minor discrepancies among the zinc concentration treatments.

The outcomes of this investigation reveal a noteworthy relation between the concentration of zinc ions in latex and the inherent properties of natural rubber latex, including MST, VFA content, and Phosphate levels, as evidenced by the calculated p values. The escalating zinc content in latex demonstrates a tangible influence on latex stability, characterized by a reduction in MST and an elevation in VFA count (A P Attanayake, C Lokuge, M U D S Weerasinghe, RRISL) (W K Amarasekera, Prof Wasantha Seneviratne, and T A N T Perera of Uva Wellassa University, Badulla) and P H Sarath Kumara, Lalan Rubber Pvt Ltd)

Identification of an alternative natural product to replace the bleaching agent used in the crepe rubber industry

The supply of raw rubber is essential to continue the rubber product manufacturing process. Crepe rubber, produced through the coagulation of field latex, is widely regarded as the purest form of natural rubber in the market. Crepe rubber is widely used in producing pharmaceuticals and surgical products that come into touch with the human body because of its high purity level. Indeed, Sri Lanka is recognized

as the world's leading producer of high-quality latex crepe rubber. Color is the main factor affecting the quality of crepe rubber. Enzymatic and yellow discoloration are the predominant types of discoloration during the process. Enzymatic discoloration is caused by melanin formation through phenol and amino phenol, while yellow discoloration is attributed to carotenoid pigments present in the lutoid phase. To avoid enzymatic discoloration and yellow discoloration sodium bisulphite or sodium metabisulphite, and sodium para toluene thiophanate (SPTT) are commonly used. However, SPTT is toxic and it has a monopoly market. In this study natural alternative has tested as a bleaching agent. Comparatively, AVL shows high reducing power. AVL contains peroxidase and aloesin which will help to form active radicals and inhibit melanogenesis. Based on the chemical composition of VCB it was suspected to have bleaching ability.

AVL extract was prepared using water at 90°C for 2 hours. VCB extract was prepared using ethanol at room temperature for 1h using a magnetic stirrer. The filtrate of the extractions was obtained and tested as bleaching agents. These alternatives were added before coagulation in the process of making crepe rubber. Prepared crepe rubber sheets were subjected to raw rubber tests, including the Lovibond color index test, Po/ PRI, Mooney viscosity, volatile matter content, nitrogen content, and ash content. VCB and AVL did not significantly improve the color of crepe rubber sheets, although they met the average specification for crepe rubber.

The ineffectiveness of VCB and AVL in enhancing the color of crepe rubber and breaking down carotene compounds in the white fraction of latex may be attributed to insufficient concentrations of suspected compounds with bleaching potential, as well as the presence of multiple chemical compounds in both VCB and AVL, which could potentially interfere with the intended breakdown of carotene by the active ingredients of the bleaching agents, challenging the achievement of the presumed mechanism in the bleaching process for carotene compounds.

However, the natural color of VCB disrupted the color of the crepe rubber, even after the activated charcoal treatment. Studying the bleaching effect of VCB poses a challenge. Isolating a presumptive compound from VCB would be a good approach for further research (A P Attanayake, H D M SWijewardana, and K A S T Koswatta, RRISL) (M V S Ratnayake, Prof Wasantha Seneviratne and G R V S Gamlath of Uva Wellassa University, Badulla)

Identification of an alternative carbon black source from waste wood ash

The study was conducted for the determination of the suitability of using cinnamon wood biochar (CWB) as an alternative filler material for natural rubber instead of the use of carbon black N330 (CB-N330) due to its non-renewability and high cost. Material characterization was performed for CWB material using Fourier transform infrared spectroscopy (FTIR), Thermo-gravimetric analysis (TGA), particle size analysis, X-ray diffraction analysis (XRD) and scanning electron microscopy with energy dispersive X-ray analysis (SEM-EDX). Rubber compounding, Vulcanization,

cure characteristics and testing of mechanical properties were done according to the ISO standard procedures. Two compounds were prepared with about 20 phr filler loading using CWB and CB-N330.

Rubber compounding was done using an internal mixer (KAIYAN, KY-3220A-1L) and a two-roll mill (Well Shyang Machinery Co., Ltd). Compounding was done in two cycles as; the first cycle in the internal mixer and the second cycle in the two-roll mill. The compounding formula for the rubber compounding process is given in Table 2**.**

Table 2. *Rubber compounding formula*

Ingredients	**phr (parts per hundred parts of rubber)**	
	Control sample with carbon black N330 (S_{CB})	**Experimental sample with CWB (S_E)**
RSS (Ribbed Smoked Sheets)	100	100
Carbon black (N330)	20	-
Cinnamon wood bio char (CWB)	-	20
Zinc oxide	5	5
Stearic acid	2	2
IPPD (N-Isopropyl-N'-phenyl-1,4-phenylenediamine)	1	1
Processing oil (white oil)	2	2
Sulfur	2.5	2.5
MBTS (2-2'-Dithiobis(benzothiazole))	1.5	1.5
TMTD (Tetramethylthiuram disulfide)	0.3	0.3

Results of FTIR shows the available functional groups on the surface of the cinnamon wood biochar (CWB) in Figure 6. According to the spectrum, a peak around 3426.11cm^{-1} could be observed and it can be considered as due to the presence of OH groups in alcoholic or phenolic groups. Another two peaks around 2922.67cm^{-1} and 2852.51cm^{-1} were observed and they could be considered as due to the presence of C-H bonds of aliphatic groups. And also, a peak around 1581.15cm^{-1} indicated the presence of aliphatic –C=C- bonds. The peak around 1030.28cm^{-1} could be due to the presence of –C-O- bond containing groups. A peak around 1745.14cm^{-1}, showed the presence of carbonyl groups on the surface of the CWB.

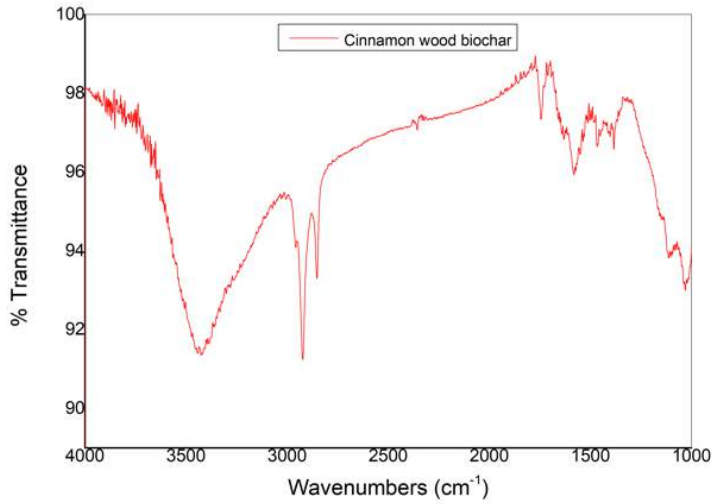


Fig. 6. FTIR spectrum of cinnamon wood biochar

The average particle size of the filler material was obtained as about less than 3.14 (± 0.30) µm (Fig. 7).

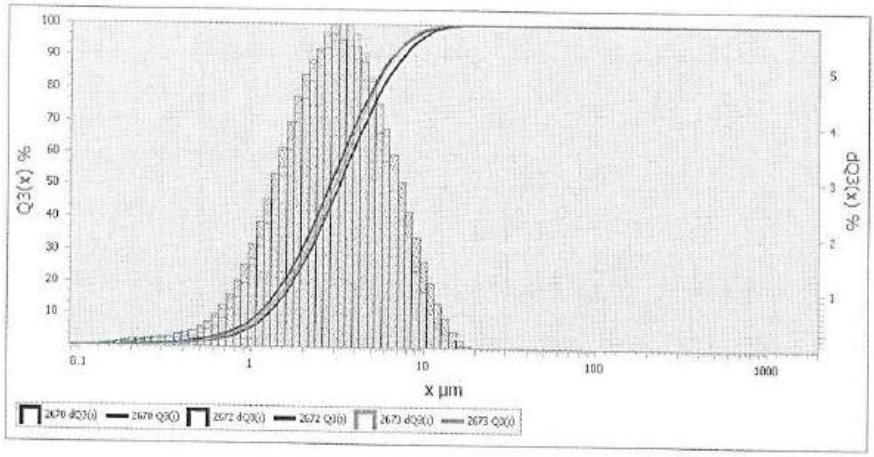


Fig. 7. Particle size distribution of CWB sample

The tensile strength and tear strengths were lower in the filled compound than in the CB-N330 filler compound. Slightly reduced cure characteristics, 300% modulus, elongation at break, hardness, and specific gravity were obtained with the CWB-filled compound compared to the CB-N330-filled compound.

Even though the CB-N330-filled rubber compound had superior properties to the CWB-filled compound, significant results of the curing and mechanical properties of the studied CWB-filled compound showed a more cost-effective, renewable filler source for the use of natural rubber compounds.

Quality analysis of latex, raw rubber and rubber processing chemicals

Testing and certification services were provided to all the sectors in the rubber industry as given below:

Services	No. of samples
Miscellaneous Analysis	
Dry rubber	1356
Latex samples	542
Chemical samples	49
Number of tested samples	789
Testing certificates	364

Achievements

Successfully completed the MPI funded special project for laboratory accreditation and laboratory procedures were established as per ISO 17025 Laboratory accreditation status.

Participated for the proficiency testing programme conducted by Malaysian Rubber Board and showed outstanding performance among 15 international latex testing laboratories.

The application submitted for the Rubber Plastic and Fiber Based Research Presentation and Networking Forum-2023 was selected for the poster presentation at the Rubber Plastic and Fiber Based Research Presentation and Networking Forum-2023 Grand Ballroom, Waters Edge, Battaramulla.

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Kasun Adhikari

DETAILED REVIEW

Staff

The duties of the head of the department were covered by the Research Officer Mr K Adhikari throughout the year. Experimental Officers Mrs U M S Priyanka, Mrs V C Rohanadeepa, and Mr. A K D Warnajith, Technical Officers Mrs P K N N Sandamali, Mr R D Illeperuma, Management Assistant Mrs H A J Lakshika, and Development Officer Mrs. W H C Nuwanthika were on duty throughout the year. Mr A S Bandara a Technical Officer resigned from his duties with effect from the 05th January 2023.

Research Assistants

Miss N L A Prabodani, Research Assistant, conducted a research "Application of wood ash for neutralization of crepe rubber effluent and utilization of it as a source of fertilizer" under the supervision of Dr S Siriwardena.

Undergraduate Students

Mr G M Pushpakumara, a B.Sc. student from the University of Wayamba, Sri Lanka completed a research project on "An investigation of the cure characteristics, mechanical and thermal properties of the solid tire middle compound generated by the sludge of purification plants" under the supervision of Dr. Susantha Siriwardena.

Mr E H D Prasanga, a B.Sc. student from the University of Uva Wellassa, Sri Lanka completed a research project under the supervision of Dr Susantha Siriwardena. Ms D M S Iresha, a B.Sc. student at the University of Sabaragamuwa, Sri Lanka completed a research project titled " A comparative study of raw rubber properties of natural rubber manufactured from latex coagulated using pineapple peel extract" under the supervision of Dr S Siriwardena (06 months research project). Ms I M U K Bandara, a BSc student at the University of Sabaragamuwa, Sri Lanka completed a research project titled _" Coconut shell extract as an alternative coagulating agent for natural rubber latex" under the supervision of Dr S Siriwardana / Dartonfield (06 months research project).

Seminars/training programs/workshops/conferences/meetings attended

Officer/s	Subject	Organization
K Adhikari	Analytical skills development course	Indian Institute of Chemical Technology, Hyderabad

Officer/s	Subject	Organization
UMS Priyanka RD Illeperuma	Training on statistical analysis in chemical Laboratories	Plastic & Rubber Institute
UMS. Priyanka RD Illeperuma	Awareness training for CEA registered Laboratories	Central Environment Authority
KSP Adhikari UMS Priyanka RD Illeperuma WHC Nuwanthika	Workshop on 5 S concept application to the organization	Guest: Eng(Ms) Sakunthala; conducted by RRISL, Rathmalana
UMS Priyanka	International Symposium on CLSD of Rubber	Conducted by the Plant Pathology & Microbiology Department, RRISL
KSP Adhikari UMS Priyanka RD Illeperuma WHC Nuwanthika	Workshop on ISO Laboratory Accreditation	Mrs. Subadra Jayasinghe
UMS Priyanka RD Illeperuma WHC Nuwanthika	Workshop on ISO Laboratory Accreditation	Mrs. Subadra Jayasinghe
KSP Adhikari UMS Priyanka AKD Warnajith RD Illeperuma PKNN Sandamali WHC Nuwanthika	Participation in lectures on the Future of the Rubber Industry	Prof. Rani Joseph; conducted by RRISL

Seminars/training programs/workshops/conferences/meetings conducted

Officer/s	Subject	Organization
PKNN Sandamali	Demonstration on Nestler regent and alternative application to latex inspection	Factory in RRISL, Dronfield
AKD Warnajith VC Rohanadeepa	Training program on raw rubber processing and practices for higher diploma students. Training program on raw rubber processing and practices for diploma students.	NIPM

AKDWarnajith	Training program on RSS Manufacturing for smallholders in Ampara(03 days)	Ampara (03 days)
	Demonstration on RSS drying and Milling for smallholders in Ampara.	Ampara.
	Demonstration of RSS manufacturing for Smallholders in Ampara & Monaragala (2 days)	Ampara & Monaragala (2days)
	Practical workshop on Rubber Farming	Dartonfield
	Training program on Raw rubber processing and practices for undergraduate students.	Faculty of Applied Sciences University of Sri Jayewardenepura
	Field Training program for undergraduate students	University of Rajarata
	Training on Raw rubber processing and practices	DPL, Kurunegala
	Field Training program in S&C Latex (Pvt) Ltd for undergraduate students	Faculty of Animal Science and Export Agriculture, University of Uwa Wellassa
UMS Priyanka WHC Nuwanthika	Demonstration in Exhibition	Industrial Development Board-Ministry of Industries
K Adhikari UMS Priyanka AKD Warnajith RD Illeperuma PKNN Sandamali WHC Nuwanthika	Training program on Raw rubber processing & wastewater testing for undergraduates	Faculty of Animal Science and Export Agriculture, University of Uwa Wellassa

Advisory Visits

Services provided	No. of Factories/visits
Waste water sample collection for testing	29
Factory inspection	02
ETP inspection	02
SS unit inspection	03
RSS manufacturing inspection	03
Tank Calibration	04
Troubleshooting	02
Smokehouse construction advisory	01

Industrial Sample Testing Service

Collection of wastewater samples from raw rubber processing and allied

Sample tested	No of the samples tested	No certificates issued
Waste water-Rubber Related	44	41
Waste water Rubber Related	17	12
Processing Water	10	04
Miscellanies sample (Metal ions, Nitrogen)	06	02
Analysis of Extractable proteins	36	18
Epidemic prevention certificates	78	78

industries and analysis of wastewater for water quality parameters were carried out throughout the year.

Laboratory Investigations

Manufacture of low Nitrogen RSS using pineapple extract

RSS were produced by the conventional manufacturing process, by varying the volume of pineapple extract added into natural rubber latex (NRL) as the coagulant. Five types of RSS were prepared by varying volumes of pineapple extract from 5 ml to 30 ml at 5 ml intervals. A control RSS sample was prepared by adding 1% formic acid into the NRL as the coagulant agent. Then visual observations of the serum after the complete coagulation and the color of the prepared sheets are initialized. After that, prepared RSS were compounded and vulcanized respectively for testing cure characteristics and physico-mechanical properties. It was found that pineapple extract is effective to reduce the nitrogen content without retarding the tested raw rubber properties of prepared RSS excluding the dirt content of RSS compared to the control. Cure characteristics of compounds and physico-mechanical properties of vulcanizates also varied according to the amount of pineapple extract added to prepare RSS.

The visual observations of the serum after the complete coagulation and the color of the prepared sheets are presented in Table 01.NRL samples, which contained 5 mL, 10 mL, and 15 mL pineapple extract were coagulated with milky serum and the other three samples with 20 mL, 25 mL, and 30 mL did not obtain a milky serum. Bubbles that were visible on the RSS were almost equal in size and texture. Those were in a convex shape and could be popped by touching. Also, bubbles were evenly distributed on the sheets. The number of bubbles was varied as S-1 ≈ S-2 > S-3 > S-4 > S-5 > S-6 respectively. Hence, it was recognized that 20 mL of the pineapple extract was the minimum optimum amount required for the coagulation process to prepare 500 g of RSS. The dry rubber weight of the samples is shown in Table 02. Considering the absence of the milky serum, color development, less bubble formation, and relative hardness 20 mL, 25 mL, and 30 mL were selected for further experiments as the minimum amounts for the coagulation. S-1, S-2, and S-3 RSS which were prepared with formerly selected amounts, and control RSS sheets were used for further testing.

Table 01. *Visual observations of the serum and RSS sheets*

Sample volume (mL)	Sample No	Presence of milky serum	pH of the serum	Color
30	S-1	No	5.45	The upper surface is yellow
25	S-2	No	5.50	The upper surface is yellow
20	S-3	No	5.57	The upper surface is yellow
15	S-4	Yes	5.63	The upper surface is pale yellow
10	S-5	Yes	5.62	The upper surface is pale yellow
05	S-6	Yes	5.64	The upper surface is pale yellow
Control	C	No	4.73	White

Table 02. *Dry rubber weight of the samples*

Sample No	Dry weight (g)
S-1	478.15
S-2	483.17
S-3	479.66
C	495.73

The results obtained for raw rubber properties of tested RSS sheets are presented in Table 03. Comparable values for raw rubber properties can be observed for pineapple extract added RSS (PRSS) with the control excluding nitrogen content and dirt content. Each PRSS has shown a lower nitrogen content than the control. However, PRSS samples have shown comparable nitrogen content with each other. In contrast, the dirt content of PRSS has given higher values than the control. PRSS samples have shown comparable dirt content with each other. Therefore, it is implied that pineapple extract is effective to reduce the nitrogen content without retarding tested raw rubber properties excluding the dirt content of RSS.

Table 03. *Raw rubber properties*

Sample No	Wallace Plasticity		Mooney viscosity	Nitrogen content	Volatile matter	Dirt content	Ash content
	P_o	PRI	ML(1+4)@100°C	%(w/w)	%(w/w)	%(w/w)	%(w/w)
S-1	50	76.84	91.85	0.08	0.34	0.019	0.22
S-2	46	79.43	92.75	0.12	0.31	0.023	0.19
S-3	50	73.76	95.32	0.10	0.34	0.025	0.23
C	45	77.73	90.16	0.37	0.41	0.011	0.19

The prepared PRSS and the control were compounded according to a basic formula to test for cure characteristics and physico-mechanical properties, which are given in Tables 04, 05, and 06. According to table 04, compounds prepared from S-2 and S-3 PRSS has shown better cure characteristics than the control. However, S-1 PRSS has displayed some comparable cure characteristics with the control.

Lower hardness, tear strength, and rebound resilience can be observed for each PRSS than the control, which may have occurred due to the removal of nitrogen in PRSS than the control. According to Table 06, S-1 PRSS has shown better tensile properties compared to the control. S-2 and S-3 PRSS have shown comparable tensile properties with each other with some better tensile properties compared to the control. These observations could have occurred due to the combined effect of the nitrogen content and the dirt content of the RSS.

Table 04. *Curing characteristics*

Sample No	S` max (dNm)	S` min (dNm)	TS 2 (min)	TC 90 (min)	Cure rate index
S-1	5.41	1.17	3.71	12.40	23.57
S-2	4.22	0.89	2.58	12.11	29.94
S-3	4.45	1.02	2.48	9.92	29.10
C	5.49	1.29	3.61	12.98	23.76

S` max – Maximum torque
S` min – Minimum torque
TS 2 – Scorch time
TC 90 – Cure time

Table 05. *Physico-mechanical properties of the vulcanizates 1*

Sample No	Tear strength	Hardness	Rebound resilience
S-1	22.46	24	69
S-2	23.00	25.33	63
S-3	22.86	25.33	65.5
C	26.11	27	72

Table 01. *physico-mechanical properties of the vulcanizates 2*

Sample No	Tensile strength (MPa)	Elongation at break (%)	Modulus at 100% elongation (MPa)	Modulus at 300% elongation (MPa)
S-1	18.71	917.03	1.12	1.63
S-2	14.13	2026.45	0.51	0.85
S-3	16.21	2198.95	0.59	0.94
C	17.43	817.62	0.64	0.31

Table 07 gives the properties of the serum obtained after the coagulation of NRL. Increment of values for each tested property can be seen for each serum obtained after coagulating NRL using pineapple extract compared to the control. The values of all serum properties increased with the subsequent addition of pineapple extract.

Table 02. *Serum properties*

Sample No	pH	COD (mg/L)	TSC (mg/L)
S-1	5.45	6936	10,760
S-2	5.50	7548	10,988
S-3	5.57	7956	10,696
C	4.73	6732	10,830
Tolerance limits	6.5 – 8.5	400	1500*/1000

*CEA standards Centrifuged latex processing effluent

(S Siriwardena, U M S Priyanka, V C Rohanadeepa, A K D Warnajith, and R D Illeperuma)

Study on the use of fermented waste cooked rice extract as an eco-friendly coagulant for latex coagulation

The rubber sector, particularly among smallholders, faces growing challenges due to rising environmental concerns and economic pressures. Traditional chemical coagulants used in the coagulation of rubber latex are known to contribute to environmental pollution, making the need for eco-friendly alternatives increasingly urgent. This study explores the potential of natural coagulants, focusing on the use of waste-cooked rice extract as an environmentally sustainable and cost-effective solution for latex coagulation. The flow diagram of the research project is listed in the Fig 1.

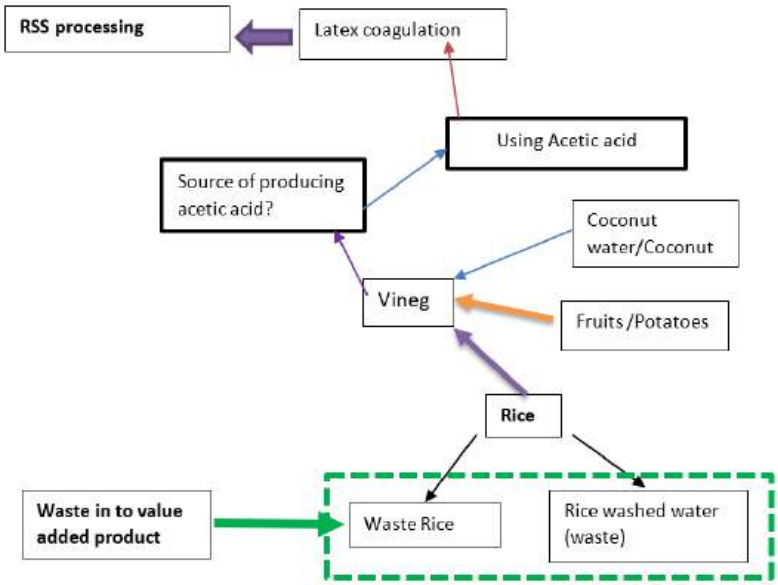


Fig 1. Flow diagram of producing RSS with acid extracts using different acid sources and fermented rice waste

Firstly, the optimal waste rice-to-water ratio and pH for effective coagulation were investigated. Four waste rice-to-water ratios were used 1:1, 3:4, 1:2, and 1:4. The prepared samples were kept for 08 days, and the pH value of each sample was measured daily within 24-hour time intervals. The sample showing the lowest pH was selected for further experimentation. After that, Ribbed Smoked Sheets (RSS) were prepared by adding the filtered waste cooked rice extract solution as a coagulant varying coagulant amounts from 150ml to 250ml at 25ml intervals. The control RSS sample was prepared using formic acid as a coagulant. All sheets were prepared according to the conventional manufacturing method excluding the coagulation step. Coagulation time, the milky nature of the serum, and serum condition were evaluated after 18 hours prior to milling of coagula. The serum properties include COD (Chemical Oxygen Demand), TSS (Total Suspended Solids), pH and total nitrogen content were tested. Finally, the raw rubber properties of the RSS were evaluated after smoke drying for five days. While investigating the optimum optimal waste rice-to-water ratio, all samples showed pH values in the range of 4.5–5.5, with a subsequent decrease over time and the sample, with a 3:4 rice-to-water ratio was given the lowest PH value. Coagulation occurred significantly within 1 hour, with proper coagulation achieved in all samples within 2–3 hours, comparable to the control. After 18 hours, milling began, and all samples coagulated properly, with no milky serum or abnormal color/texture, matching the

control. However, the samples showed lower hardness and higher spreading during milling compared to the control. There were no significant differences in color or appearance of the RSS after drying with the control. The collected serum showed no visible differences in appearance or pH compared to the control. However, it exhibited higher COD and TSS with no difference in nitrogen content. Analysis of raw rubber properties—P0 (plasticity), PRI (Plasticity Retention Index), Mooney viscosity, ash, and volatile matter—revealed no significant differences between the samples and the control. The RSS, however, showed higher nitrogen content than the control, though this did not significantly impact the overall rubber quality. Therefore, it can be concluded that there is a potential to use the waste-cooked rice extract solution as an alternative coagulant for natural rubber latex (K Adhikari, W H C Nuwanthika, R D Illeperuma, and N Sandamali)

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.

Research Students

Ms K K P M Kulathilake, a student of Faculty of Agriculture, University of Ruhuna carried out her research project on 'Effect of climate on growth and canopy performance of immature rubber: a case study of wet and dry zones in Sri Lanka' under the supervision of Dr (Mrs) E S Munasinghe.

Seminars/Training/Workshops/Exhibitions conducted

Officer/s	Subject/Theme	Beneficiary/Client
ES Munasinghe	Training Programme on Rubber Cultivation in Non-traditional Areas and Carbon Trading	Rubber Development Officers
ES Munasinghe	Awareness Programme on Dry Zone Rubber Cultivation	Farmers in Anuradapura District
ES Munasinghe	Awareness Programme on Carbon Trading Benefits	Rubber farmers in Nontraditional Areas
ES Munasinghe	Training Programme on Entrepreneurial Development	Z-Generation Rubber Entrepreneurs of Ampara District
ES Munasinghe	Seminar on Exploring the Opportunities of Carbon Trading	Rubber Stakeholders

Seminars/Training/Workshops/Meetings/Conferences attended

Officer/s	Subject/Theme	Organization
ES Munasinghe	Training of Trainers on Net-zero Carbon	Ministry of Environment

ES Munasinghe	Committee Meeting of Agriculture Sector Carbon Net Zero – Road Map and Strategic Plan	Ministry of Environment
ES Munasinghe	Committee Meetings of Preparation of Greenhouse Gas Inventory of Sri Lanka	Ministry of Environment
ES Munasinghe	Technical Working Committee for Enhanced Transparency Framework for Agriculture, Forestry and Other Land use (AFOLU) Sector	Ministry of Environment
ES Munasinghe	Committee Meeting on Policy Formulating in Reaching Carbon Market for Sustainable Development in Rubber Sector	Ministry of Plantation Industries
ES Munasinghe	Workshop on BICOST – Agriculture Sector	Ministry of Agriculture
ES Munasinghe	National Steering Committee Meeting	STaRR Project
ES Munasinghe	Meeting on KPI development	Ministry of Plantation Industries
ES Munasinghe	IRRDB Workshop on Carbon Trading	IRRDB
ES Munasinghe	Workshop on GAP	Ministry of Plantation Industries
ES Munasinghe	Workshop on Data Interoperability	Ministry of Plantation Industries
ES Munasinghe	Workshop on Sustainability Horizons	Ministry of Plantation Industries
ES Munasinghe	Committee Meeting of European Union Deforestation Regulations and Green Deal	Ministry of Plantation Industries
ES Munasinghe	Workshop on Completion Mission of STaRR Project	STaRR Project
ES Munasinghe	CEO Forum	RRISL
ES Munasinghe & BMDC Balasooriya	Scientific Committe Meetings	RRISL
ES Munasinghe & BMDC Balasooriya	Research Meetings	RRISL

Field visits

Experimental - 80
Advisory - 04
Other - 04

FIELD INVESTIGATIONS

Expansion of rubber cultivation to non-traditional areas (ARU/01)

Improving the protocols available to cultivate rubber in the Dry Zone

To improve suitable protocols to cultivate rubber in the Dry Zone, farmer participatory adaptive research trials were maintained in the Northern and North Central Provinces of the country.

The growth performance (in terms of girth and height) of immature rubber plants of sites in Kilinochchi, Mullaithivu and Anuradhapura was assessed (Table 1).

Table 1. *Details of rubber planting sites in the Dry zone*

Sites	Year of planting	Site code	Land extent (Ac)	Clone	% Tree density	Mean girth at 120 cm (cm)	Mean height (cm)
Kilinochchi	2017	2017/K2	½	RRISL 203	66	29.1±0.48	Not taken
Mullativu	2017	2017/M2	½	RRIC 121	75	35.7±1.01	Not taken
Anuradhapura	2017	2017/A1	2	RRISL 203	82	43.9±0.32	Not taken
			2	RRIC 121	81	42.3±0.22	Not taken
	2019	2019/A2	½	RRIC 121	98	23.1±0.59	Not taken
			½	RRISL 203	92	15.8±0.54	Not taken
			½	RRISL 2001	97	20.9±0.57	Not taken
	2019	2019/A3	¾	RRIC 121	92	23.2±0.43	Not taken
	2019	2019/A4	1	RRIC 121	93	21.8±0.41	Not taken
	2019	2019/A5	1	RRIC 121	92	26.8±2.37	Not taken
			½	RRISL203	86	25.2±0.48	Not taken
			½	RRISL 2001	88	24.2±0.58	Not taken
	2021	2021/A6	1	RRIC 121	99	9.9± 1.05	Not taken
	2022	2022/A8	1	RRIC 121	100	5.60± 0.15	143.7±6.07
	2022	2022/A9	1	RRIC 121	95	5.02± 0.10	164.1±2.38
	2022	2022/A10	1	RRIC 121	100	6.96± 0.18	178.0±3.17

The farmer participatory adaptive research plot established in 2021 under the site code 2021/A7, has been discontinued this year onwards due to improper management by the farmer, resulting in an unsuccessful field.

Two new farmer participatory adaptive research trials were established in Ipalogama and Nuwaragam Palatha East Divisional Secretaries Divisions of Anuradhapura district.

In order to assess the yield potential and seasonal variation of rubber production at the smallholder level in the Northern Province, daily yield records were maintained throughout the year in the two mature smallholder fields located in the Vavunia and Mullaithivu districts, which were the only ones in the tapping stage in the province.

As depicted in Table 02, smallholder field in Vavuniya remained untapped for four months, while the Mullaithivu field experienced seven months without tapping due to issues with skilled tappers. Among the tapped months in Vavuniya field, a wide variation of yields was observed where Januray reported the highest yield, *i.e* 49 grams/tree/tapping, whilst December reported the lowest of 10. During the five months that tapped in Mullaithivu, the yield ranged between 31 to 35 grams/tree/tapping. The average annual yield for the Vavunia district was 927 kg/ha with 77 tapping days, whereas the average annual yield was 768 kg/ha with 65 tapping days in the Mallaithivu district.

Table 2. *Seasonal yield variation under smallholder conditions at Northern province*

Month of 2023	Yield (gram/tree/tapping)	
	Smallholder field Vavuniya district	**Smallholder field Mullaithivua district**
January	49	Not tapped
February	48	35
March	Not tapped	33
April	Not tapped	Not tapped
May	Not tapped	Not tapped
June	Not tapped	Not tapped
July	23	33
August	22	35
September	18	31
October	24	Not tapped
November	16	Not tapped
December	10	Not tapped

(E S Munasinghe, P M M Jayathilake and N M Piyasena)

Water requirement of young rubber plants in the Dry zone

This was a continuation of the experiment conducted to assess the water requirement of young rubber plants in the Dry Zone of the country at Thalawa,

Anuradhapura. The results of the previous trial indicated that the application of 4 litres of water weekly was sufficient for young rubber in this region. Accordingly, this experiment was laid out in a farmer participatory adaptive research trial established in 2021 at Nachchaduwa, Anuradhapura under redused amounts of water. The new experiment was arranged with 2, 4 and 6 litres of water per plant at watering intervals of 5, 6 and 7 days. Randomized Complete Block Design was applied with four blocks (replicates) with each block having all nine combinations of watering intervals and amounts. Each treatment plot contained 6 trees of RRIC 121 clone. The watering schedule as follows;

T1 - 2 l in 5-day interval
T2 - 2 l in 6-day interval
T3 - 2 l in 7-day interval
T4 - 4 l in 5-day interval
T5 - 4 l in 6-day interval
T6 - 4 l in 7-day interval
T7 - 6 l in 5-day interval
T8 - 6 l in 6-day interval
T9 - 6 l in 7-day interval

The growth of rubber plants was monitored in terms of girth at 120 cm height. Within the period, no significant difference in mean girth increment rates among treatments was observed (Table 3).

Table 3. *Mean grith increment rates of rubber plants under different watering systems*

Watering system	**Mean grith increment cm per Month**
T1 - 2 l in 5-day interval	0.157
T2 - 2 l in 6-day interval	0.050
T3 - 2 l in 7-day interval	0.050
T4 - 4 l in 5-day interval	0.125
T5 - 4 l in 6-day interval	0.175
T6 - 4 l in 7-day interval	0.129
T7 - 6 l in 5-day interval	0.160
T8 - 6 l in 6-day interval	0.170
T9 - 6 l in 7 day interval	0.182

Accordingly, the application of 2 l weekly seems sufficient to cultivate rubber at the age of two years in this region. During the latter part of the dry period, physiological measurements such as stomatal conductance and relative water content of rubber leaves were taken.

No significant difference in stomatal conductance was found among treatments in the morning and evening of the day (Table 4).

Watering system	Stomatal conductance ($\mu molm^{-2}s^{-1}$)	
	Morning	Evening
T1 - 2 l in 5-day interval	0.262	0.040
T2 - 2 l in 6-day interval	0.122	0.039
T3 - 2 l in 7-day interval	0.341	0.182
T4 - 4 l in 5-day interval	0.172	0.041
T5 - 4 l in 6-day interval	0.163	0.045
T6 - 4 l in 7-day interval	0.243	0.097
T7 - 6 l in 5-day interval	0.113	0.016
T8 - 6 l in 6-day interval	0.096	0.030
T9 - 6 l in 7-day interval	0.045	0.011

Further, there was no significant difference observed in the relative water content (%) of rubber leaves among the treatments (Table 5).

Table 5. *The relative water content of rubber leaves under different watering systems*

Watering system	Relative water content (%)
T1 - 2 l in 5-day interval	89.16
T2 - 2 l in 6-day interval	89.40
T3 - 2 l in 7-day interval	89.10
T4 - 4 l in 5-day interval	88.70
T5 - 4 l in 6-day interval	88.46
T6 - 4 l in 7-day interval	88.43
T7 - 6 l in 5-day interval	99.01
T8 - 6 l in 6-day interval	88.93
T9 - 6 l in 7-day interval	90.19

The soil moisture contents (%) within the watering cycle were measured (VWC) and no significant difference was observed among the treatments (Table 6).

Table 6. *The moisture contents of the soil under different watering systems*

Watering system	Soil moisture (%)
T1 - 2 l in 5-day interval	1.45
T2 - 2 l in 6-day interval	1.50
T3 - 2 l in 7-day interval	1.60
T4 - 4 l in 5-day interval	1.50
T5 - 4 l in 6 day interval	1.38
T6 - 4 l in 7 day interval	1.53
T7 - 6 l in 5 day interval	1.55

T8 - 6 l in 6 day interval	1.40
T9 - 6 l in 7 day interval	1.55

The above mentioned physiological parameters further confirmed the sufficiency of applying 2 l of water weekly to maintain rubber cultivation at the age of two years during dry periods. (E S Munasinghe, P M M Jayathilake and N M Piyasena)

Establishment of rubber-based farming models in the Anuradhapura district

Area-specific rubber-based farming models were established in Thalawa and Nachchaduwa Divisional Secretaries Divisions of the Anuradhapura district in order to facilitate the demonstration purpose (Fig. 1).

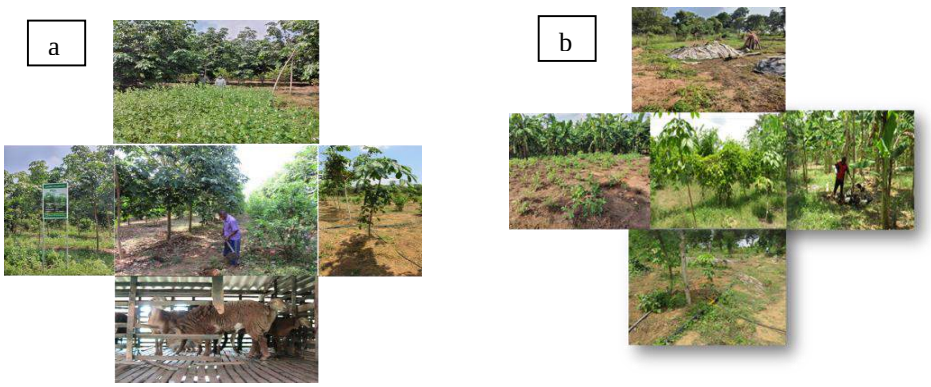


Fig. 1. (a) Farming Model 1-Thalawa (Rubber/Guava/Sesame/Sheep with drip irrigation)
(b) Farming Model 2-Nachchaduwa (Rubber/Banana/Passion/Cowpea Poultry with drip irrigation and compost)

An assessment on technological and socioeconomic conditions of new rubber cultivations established in Moneragala and Ampara districts

A pilot study was conducted to review the status quo of the new rubber cultivation in the Moneragala and Ampara districts. Data collection was done using a structured questionnaire among randomly selected 54 smallholders to evaluate the adoption of key agronomic practices at the immature phase and assess the attitudes and motivational factors of smallholders.

The findings revealed that the cultivation practices of rubber have followed the pattern of Nort-East monsoon rains. A considerable percentage (65%) of farmers have adopted proper land selection, land preparation and plant establishment in parallel to the monsoons. However, the receipt of two whorl budded plants at the onset of the rains was not at a satisfactory level (28%). Further, the majority of farmers (81%) stressed of non receipt of additional plants for filling vacancies.

Being the most crucial factor for establishing rubber in the Dry and Intermediate zones of Sri Lanka, the adoption of recommended agronomic practices related to moisture conservation was assessed. As such, practicing mulching and cover crops were at a favorable level with values of 65% and 56%, respectively. However, being flat terrains available in the area, the practice of contour planting, and preparation of drains and terraces remained at a low level (Fig. 2).

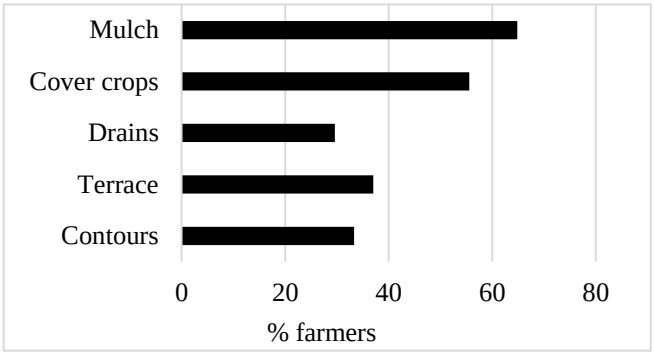


Fig. 2. Moisture conservation practices

Further, intercropping during the immature phase has been recommended as one of the best options to be practiced to obtain multiple benefits, it was observed 69% of the smallholders have adopted intercropping during the first three years of rubber cultivation.

Management of weeds was adopted only by 56%, however, 26% practiced alternative methods such as circle weeding and weeding at fertilizing (Fig. 3).

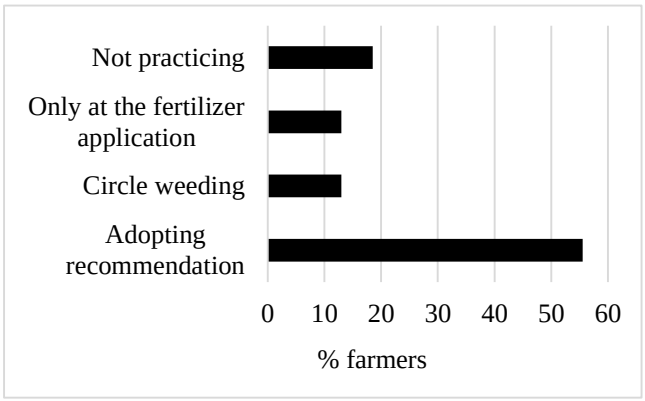


Fig. 3. Weed management

As per the recommendation given to nontraditional areas, fertilizer R/SA 7:9:9:3 with three applications per year was endorsed. However, the adoption of the recommendation was observed only from 37% of smallholders whilst the rest were practising irregular systems or nonapplications (Fig. 4).

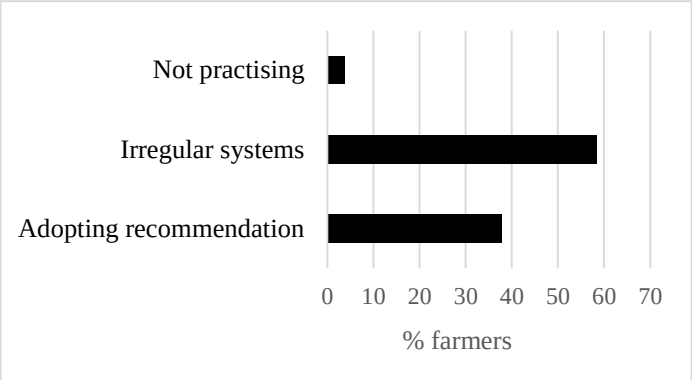


Fig. 4. Fertilizer application

Being a newly introduced crop to the area, it is important to assess the farmer's motivational factors for rubber cultivation. The major causal factor that farmers drove to rubber cultivation was identified as government intervention (61%). Intimated by friends and relatives and personal networks had led 18% of the farmers to rubber cultivation and importantly, 15% of the group was identified as self-driven. The rest have joined rubber cultivation in favour of the benefits received from the subsidy scheme (Fig. 5).

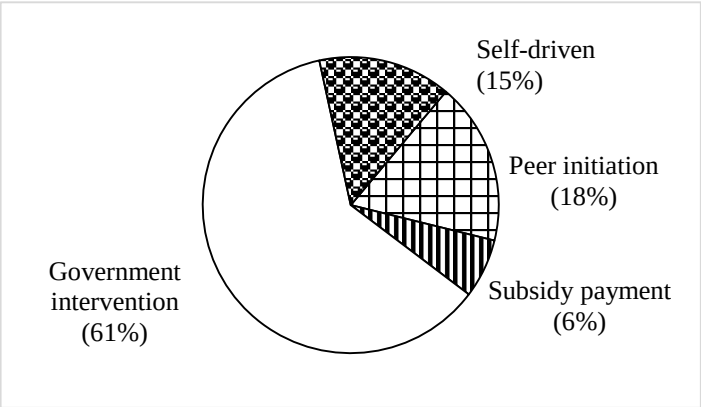


Fig. 5. Causal factor for rubber cultivation

The attitudes and knowledge of farmers on rubber cultivation were assessed and observed their consensus of the receipt of environmental benefits (87%) and effective utilization of resources (72%). Amongst, 69% of the smallholdings had the knowledge of low pollution as a consequence of cultivation practices. The majority of smallholders (69%) were aware of the receipt of high income through rubber cultivation. However, farmers' attitudes and knowledge of the contribution of food security remained at a low level (44%) (Fig. 6).

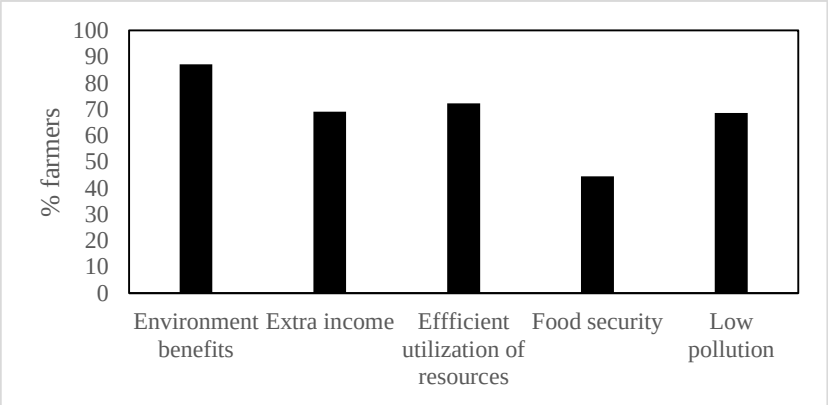


Fig. 6. Farmer attitudes and knowledge on rubber cultivation

(S P Withanage, E S Munasinghe, T U K Silva, J K S Sankalpa, P G N Ishani and S D Rathnayaka)

Development of entrepreneurial skills among young rubber farmers in the Ampara district

A training and capacity-building programme was conducted for a group of young rubber smallholders of Padiyathalawa of Ampara district, where the first rubber planting was established in the Eastern province of Sri Lanka. The programme covered both technical and practical aspects of sustainable farming and production practices, financial management, and market access strategies. Further, farmers were encouraged in value addition in the processing and manufacturing of rubber products having the objective of developing the entrepreneurial skills of the farmers to revitalize the rubber smallholder sector (E S Munasinghe, B M D C Balasooriya and P M M Jayathilake in collaboration with all Departments/Units/Sections).

Increase land productivity through technology adoption (ARU/02)

Adoption of harvesting techniques in the rubber smallholders of the Kegalle district

The study was conducted to assess the adoption of harvesting techniques in the rubber smallholder sector in the Kegalle district. Sixty smallholdings were assessed through field evaluations and smallholder interviews. Though panel marking at the opening of harvesting was done in 82% of the fields, annual marking has been practiced in none of the fields. The tapping height, i.e. 120 cm from the bud union was correct in 76% of the fields, however, 3% commenced tapping at a lower position whereas the other 21% at a higher position over the recommended. Though some farmers started tapping at the correct height in virgin bark and shifted to 150 cm height in the renewed bark. The tapping direction was correct in almost all the rubber smallholders. Issues with tapping angle were observed in 45% of the smallholdings.

(B M D C Balasooriya and N M Piyasena)

Adoption of RRISL recommendations in the Kalutara district

A pilot study was conducted to identify the rate of adoption of the RRISL recommendations among rubber growers in the Kalutara district. The survey covered 203 rubber smallholder fields (<10 Ac), 25 fields of 20 medium-scale estates (11-50 Ac), and 28 fields of 4 Regional Plantation Companies (>50 Ac) situated in the Kalutara district. The findings of the study revealed that the rate of adoption of the recommendations of the smallholders, medium-scale estates, and Regional Plantation Companies remained at 55%, 60%, and 73%, respectively (Table 7).

Table 7. *Adoption levels for the RRISL recommendations in the smallholder sector, medium-scale estate sector, and Reginal Plantation Companies*
(a) Land preparation, field establishment, and immature upkeep
(b) Nutrient management and plant protection
(c) Latex harvesting

(a)

Recommendations on land preparation, field establishment and immature upkeep	Smallholder [Adoption %]				Medium-scale [Adoption %]				RPCs [Adoption %]		
	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Not adopted
Avoiding lands with > 50% rockiness	96			04	92			08	92		08
Avoiding water-logged areas	91			09	96			04	100		

Correct spacing and density	94			06	92			08	93			07

Recommendations on land preparation, field establishment and immature upkeep	**Smallholder [Adoption %]**				**Medium-scale [Adoption %]**				**RPCs [Adoption %]**			
	Fully adopted	**Moderately adopted**	**Less adopted**	**Not adopted**	**Fully adopted**	**Moderately adopted**	**Less adopted**	**Not adopted**	**Fully adopted**	**Moderately adopted**		**Not adopted**
Correct size of the planting hole	92			08	92			08	93			07
Demarcation of White Root Disease patches*	60			40	63			37	65			35
Removing roots up to pencil thickness roots*	63			37	63			37	76			24
Quality planting material	89	05	02	04	96	04			89	11		
Correct planting time	99			01	100				100			
Adopting proper planting techniques	89			11	72			28	93			07
Maintaining extra plants for infilling	65			35	88			12	92			08
Infilling during first three years	78	11	02	09	88			12	96			04
Branch induction**	82			18	72			28	96			04
Intercropping during immature phase	19	01	09	71	17			83				100
Soil and moisture conservation practices	63	21	08	08	60	28	12		70	26		04

(*If previous field affected with White Root Disease, ** In the absence of natural branching)

(b)

Recommendations on land preparation, field establishment and immature upkeep	Smallholder [Adoption %]				Medium-scale [Adoption %]				RPCs [Adoption %]			
	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted
Application of the organic manure to the planting hole	09			91	12			88	23			77

Recommendations on land preparation, field establishment and immature upkeep	Smallholder [Adoption %]				Medium-scale [Adoption %]				RPCs [Adoption %]			
	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted
Application of organic manure during immature phase	17			83	20			80	14			86
Application of inorganic fertilizer during immature phase	74	12	05	09	72	20	08		62	19	08	11
Application of inorganic fertilizer during mature phase	11	02	04	83	42	05	05	48	64	16	16	04
Weed management	68	22	05	05	52	36	12		89	11		
Management of pest attacks*	46	08	08	38	80	20			92		08	
Management of root diseases*	36	08	08	48	47	13	07	33	88		06	06
Management of leaf diseases*	16		02	82	39	06		55	56			44

(*If diagnosed)

(c)

Recommendations on land preparation, field establishment and immature upkeep	Smallholder [Adoption %]				Medium-scale [Adoption %]				RPCs [Adoption %]			
	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted
Tapping commenced when 70% of the trees have reached to 50cm girth at the height of 120cm	75			25	84			16	82			18
Tapping opening during dry spell after NE monsoon	97			03	100				100			

Recommendations on land preparation, field establishment and immature upkeep	Smallholder [Adoption %]				Medium-scale [Adoption %]				RPCs [Adoption %]			
	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted	Fully adopted	Moderately adopted	Less adopted	Not adopted
Marking tapping panel by dividing the trunk into two equal halves	81	02	03	14	92	4	4		95	05		
Starting tapping at correct height	78	01	01	20	84	05		11	90	05		05
Starting tapping at Poi kanu	75			25	79			21	68			32
Stop tapping at Neththi kanu	72			28	79			21	86			14
Annual panel marking	23			77	42			58	81			19
Correct tapping angle	42	10	10	38	37	42	05	16	82	10	04	04
Correct depth of the tapping cut	52	10	06	32	37	42	05	16	45	23	09	23
Inward tapping cut	45	08	14	33	37	32	10	21	73	14	09	04

Correct thickness of the shaving	50	06	14	30	32	21	32	15	36	32	05	27
Use of new tapping knife	08			92	05			95	09			91
Correct placement of cups and spouts	18			82	11			89	59			41
Tapping rubber trees in early morning (before 6.00 am)	61			39	63			37	82			18
Annual rain guard application	07			93	16			84	67			33
Tapping system	65			35	79			21	91			09

(Fully adopted - more than 80%, Moderately adopted - 50% - 80%, Less adopted - 20% - 50%, Not adopted - less than 20%)

Not being aware of the RRISL recommendations, No clear understanding of the impact of adopting recommendations and the financial constraints involved in adopting were identified as the major reasons for the low rate of adoption.
(E S Munasinghe, B M D C Balasooriya, P M M Jayathilake in collaboration with Advisory Services Department and Biometry Unit).

Socioeconomic improvement in plantation workers (ARU/03)

Psychosocioeconomic status of the rubber plantation workforce in the Kalutara district

This study was commenced to identify the psychosocioeconomic status of the rubber plantation workforce. A semi-structured questionnaire survey was conducted to collect data on gender issues, child protection and education systems among plantation workers in seven Rubber Esatates of Kalutara district.

The distribution of worker age was depicted in Figure 7 and observed majority (70%) of workers are within the range 40-60 years. Additionally, 6% are aged above 60, exceeding the normal age range of 18 to 60 years. The estate management has decided to retain this group on a contractual basis due to the shortage of skilled workers.

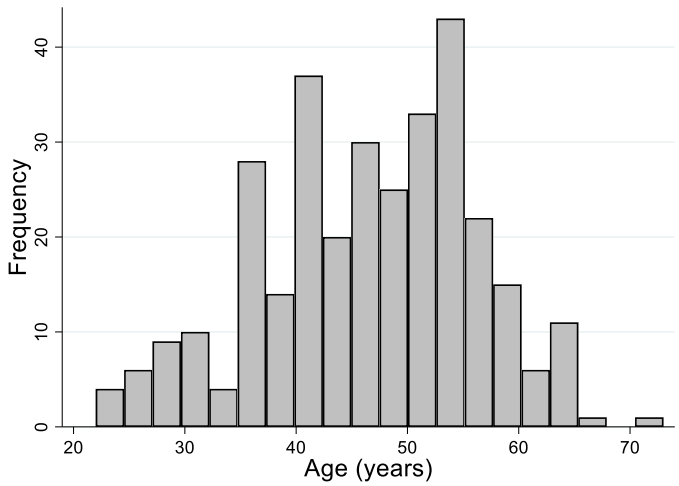


Fig. 7. Distribution of the age of the plantation workers

The demographic features of the sample are given in Table 8. Accordingly, 36% of the workers are male, while the majority, comprising 64%, are female. Considering the civil status, 86% of the workers are married, with only 4% being unmarried. Additionally, 3% are widowed, and 7% are divorced. The community consists of both Sinhala and Tamil workers, with 47% being Sinhala and 53% being Tamil. Religious affiliations of the sample showed that 47% were Buddhists, 47% were Hindu, and the other 6% were Catholic.

Table 8. *Demographic features of the plantation workers*

	Variable	**Percentage**
Gender	Male	36
	Female	64
Civil Status	Married	86
	Unmarried	04
	Divorced	03
	Widowed	07
Nationality	Sinhala	47
	Tamil	53
Religion	Buddhism	47

	Hindu	47
	Catholic	06
Years in schooling	No schooling	07
	1-5 years	38
	6-10 years	40
	Above 11years	15
Marital age	< 18 years	09
	18 – 20 years	30
	21 – 25 years	32
	26 – 30 years	21
	31 – 35 years	06
	> 35 year	02

Of the workers, the majority (54%) reside permanently within the estate premises, with a small percentage (1%) being temporary residents. A proportion of 45% of the sample live outside the estate. The types of their houses, as well as access to water and sanitary facilities, are depicted in Table 9. Accordingly, out of the sample, 44% own their own houses, 4% reside in quarters, and the remaining 52% live in line houses. The majority (72%) have access to water through a separate tap, while a smaller percentage utilize common taps (4%) or separate wells (6%). Additionally, 18% of individuals rely on common wells for their water supply. In terms of sanitary facilities, a significant proportion (92%) have access to separate toilets, while a minority rely on common toilets shared between two houses (1%) or line houses (7%).

Table 9. *Facilities available in houses*

Variable	**Category**	**Percentage**
Residence	Estate (permanent)	54
	Estate (temporary)	01
	Outside	45
Type of house	Own house	44
	Quarters	04
	Line house	52
Access to water	Separate tap	72
	Common tap	04
	Separate well	06
	Common well	18
Sanitary facilities	Common toilet for two houses	01
	Common toilet for line houses	07
	Separate toilet	92

The Household Decision Making Index was calculated using the guidelines provided by the Indikit (a smart indicator for gender equality), and the value given was

0.9 indicating high female participation in decision making activities. Further, 86% of the females in the sample has participated in any kind of society which was functioning in the area.

When considering the education level of the workers, 76% faced fincancial constraints during their schooling, while 4% experienced family issues. Financial assistance was provided by parents for 97% of the sample, while the remaining 3% received support from other relatives. Guidance provided by the family for education was deemed sufficient by 48% of the sample.

Of the sample, 94% of workers who have children below 18 years old live with both parents. Only 3% live with their mothers, while the catogeries of living with farther, living with grand parents and livng with other relatives each account for 1%. Incidences of household verbal and physical violence towords children were minimal and each reported 3% in the sample. Verbal and physical violence from society were reported as 2% and 1%, respectively. (B M D C Balasooriya, E S Munasinghe and N M Piyasena).

Developing a project to approach the voluntary carbon market with the rubber cultivation in Eastern and Uva Provinces for the sustainable rubber industry

The project was initiated with the objective of developing a carbon trading project to obtain Verified Carbon Standards (VCS) for 3,000 ha of new rubber cultivations in the Uva and Eastern Provinces. The project registration was requested from international accredited VCS registry; Verra with the submission of Final Validation Report (FVR).

As the financial situation is not favourable for carrying out future project activities, proposals were called for a partnership/joint venture/service/assistance for the continuation of the project (E S Munasinghe).

BIOMETRY

Dilhan Ratnayaka

DETAILED REVIEW

Staff

Mr Dilhan Rathnayaka, Research Officer, and the Experimental Officer, Mr Vidura Abeywardene were on duty throughout the reporting year.

Research students

Mr Dilhan Rathnayaka conducted the following training programmes organized by RRISL. Mr Vidura Abeywardene assisted in practical sessions on meteorological data recording.

Seminars/Training/Workshops addressed/conducted

Subject/Theme	Beneficiary/Client
Climatic conditions and rainfall distribution in rubber growing areas	Participants of the Advanced Certificate Course in Plantation Management
Climatic conditions and rainfall distribution in rubber growing areas	Officers of Rubber Development Department

Seminars/Conferences/Meetings/Workshops attended

Officer	Subject/Theme	Organization
Dilhan Rathnayaka	Experiences during the 2021/22 North East monsoon season	Department of Meteorology
Dilhan Rathnayaka	Experiences during the 2022 South West monsoon season	Department of Meteorology
Dilhan Rathanayaka	ArcGIS Pro Training program	GIS Solution (Pvt) Ltd
Dilhan Rathnayaka Vidura Abeywardena	Workshop on Circular leaf sport disease	RRISL and IRRDB
Vidura Abeywardena	Annual Training Workshop on INFOR	SLCARP

Seminars/Conferences/Workshops/Meetings/Training sessions addressed

Officer	Subject/Theme	Organization
Dilhan Rathnayaka	Experiences during the 2021/22 North East monsoon season	Department of Meteorology
Dilhan Rathnayaka	Experiences during the 2022 South West monsoon season	Department of Meteorology

RESEARCH AND DEVELOPMENT

The Biometry section focuses its activities on two different programmes; *viz.* improving the reliability of interpretations through appropriate statistical methods (BM 01) and Improving the knowledge base on climate, climate change & variability for better decision making in rubber growing areas (BM 02).

Improving the reliability of interpretations through appropriate statistical methods (BM 01)

Statistical consultancy (BM/01/a)

Statistical consultancy is provided on designing experiments and questionnaires, statistical analyses, designing and developing databases and interpretation of experimental results to the fellow scientists at RRISL and industry stakeholders on request. (Dilhan Rathnayaka).

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 the proper use of these methods.

Application of pairwise ranking matrix to order the problems facing farmers in nontraditional areas

Pair-wise ranking can be used to prioritize different reasons responsible for a particular problem one wishes to study. In order to identify and prioritize the issues they are encountering, this study conducted farmer group discussion in nontraditional areas. The participants are requested to list out the reasons responsible for an identified specific problem. These listed reasons are then arranged in a matrix in rows and columns. In the next step, they are requested to consider two of the reasons at once, and select the most important reason and to fill in the elements of the matrix with its number (identity). Once they finish all possible combinations, the number of occurrences is counted for each reason. The resulting matrix is presented in Table 1. Finally, the ranking is done based on the number of occurrences, as indicated in column ‘Rank’ in Table 1. This matrix provides only an idea about the priority order of identified problem.

Table 01. *The pair-wise ranking matrix prepared by the participants*

Factors	Factors 1	2	3	4	5	6	7	8	9	Total	Rank
1.Bad weather		1*	3	1	1	1	7	8	9	4+	4
2.Poor Extension service			3	4	5	2	7	8	9	1	7
3.High cost of inputs (fertilizers)				4	5	3	7	8	9	3	5
4.Subsidy					4	4	7	8	9	4	4
5.Loan and Credit availability						5	7	8	9	3	5
6.Animal damage and disease							6	6	9	2	6
7.Low selling price								7	9	6	2
8.Market access and sales opportunities									9	5	3
9.No income during immature period										8	1

* The value indicates the 'most important factor' when the 'row' factor and the 'column' factor were considered

\+ The number of times the 'row factor' being preferred over the other factors

The table has two columns labeled "Factors" and two rows labeled "Factors". The factors are numbered from 1 to 9, and each cell in the table represents the number of times the factor in the row was ranked higher than the factor in the column. For example, the cell in row 1 and column 2 shows that the factor "Poor Extension service" was ranked higher than the factor "Bad weather" three times.

Number of times a certain factor being preferred over another is given as the 'Total' in Table 1. This situation can be regarded as binary outcomes where we can assign '1' for 'being preferred over another' and '0' for 'not being preferred over another' for further analysis. This will create a data set as given in Table 2, where the illustration has 9 factors to compare among them, and therefore there are 8 binary outcomes.

Table 2. *Dataset generated from the pair-wise ranking exercise in Ampara*

Factors	**Binary scores**							
1.Bad weather	1	1	1	1	0	0	0	0
2.Poor Extension service	1	0	0	0	0	0	0	0
3.High cost of inputs (fertilizers)	1	1	1	0	0	0	0	0
4.Subsidy	1	1	1	1	0	0	0	0
5.Loan and Credit availability	1	1	1	0	0	0	0	0
6.Animal damage and disease	1	1	0	0	0	0	0	0
7.Low selling price	1	1	1	1	1	1	0	0
8.Market access and sales opportunities	1	1	1	1	1	0	0	0

9.No income during immature period	1	1	1	1	1	1	1	1

The data in Table 2 can be analyzed by the Kruskal-Wallis (K-W) test (Table 3), which is applicable for testing the differences among several treatments (in this case 'factors'). The analysis was done using SAS software.

Table 03. *Results of Kruskal-Wallis (K-W) Test in Ampara*

Chi-Square	DF	Pr > ChiSq
17.75	8	0.0232

The K-W test signified that at least 2 median values are significantly different ($\chi 2$ = 17.75, P< 0.05). Consequently, hierarchical cluster analysis (Fig. 1) was performed to further categorize the factors according to their importance.

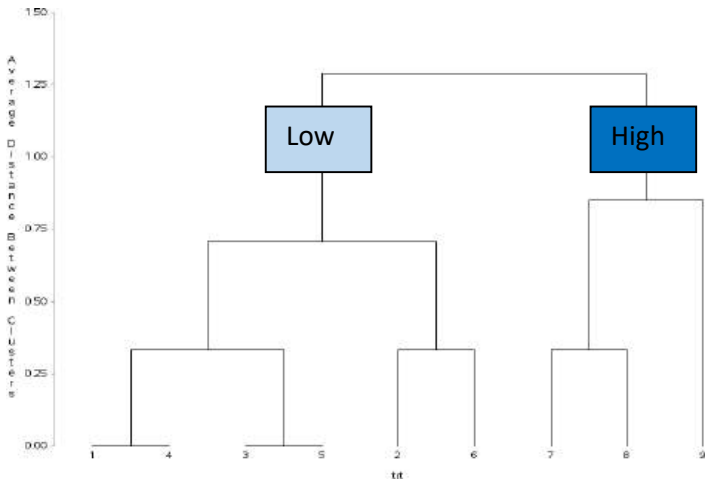


Fig. 01. Dendrogram indicating the importance and the categories of importance High and Low

According to the ranking, top of the list is "No income during immature period" followed by "Low selling price" and "Market access and sales opportunities". "Subsidy" and “Bad weather” came next, while "High cost of inputs (fertilizers)", "Loan and Credit availability" and "Animal damage and disease" followed suit. Finally, "Poor Extension service" was ranked lowest among the considered factors

Application of parametric and nonparametric techniques to determine the turning moment in the global natural rubber production.

Change point detection is a widely studied area in statistics, with applications across various disciplines. This study utilized data from natural rubber production spanning the years 1950 to 2022 to detect any change points present in the time series. Both parametric and nonparametric methods were employed in this analysis. While the literature on change point detection was extensive, many existing methods were parametric. A common parametric approach involved modeling the data within a segment, using the negative maximum of the resulting log-likelihood to define a segment's cost, and then defining the cost of a segmentation as the sum of the costs for each of its segments.

Among nonparametric methods, the Pruned Exact Linear Time (PELT) method is the most commonly used for detecting multiple change points in a time series. Additionally, this study employed the sequential Mann-Kendall method to identify a single change point within the time series. Fig. 2 illustrated the change points detected by different methods.

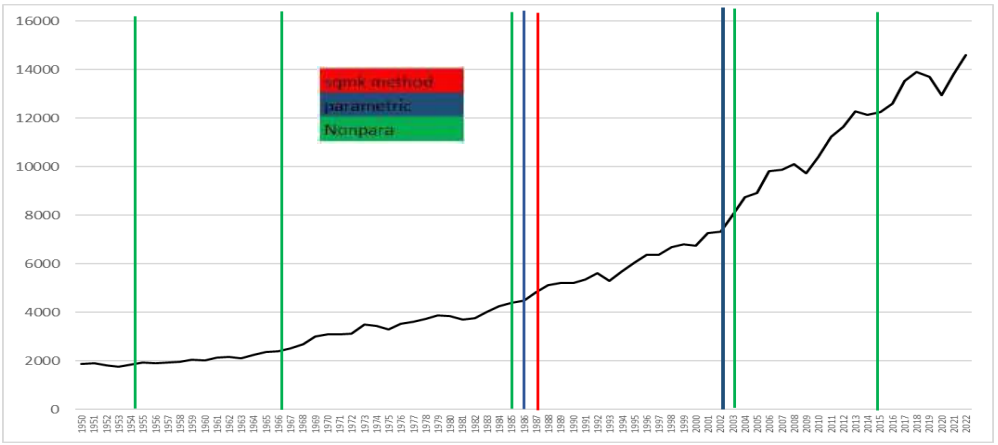


Fig. 2. Change points exist in the time series

In Fig. 2, the vertical lines of different colors indicated the detected change points by various methods. The results show that the period from 1985 to 1987 contained breakpoints identified by all methods, whereas the period from 2002 to 2003 showed breakpoints detected only by the parametric and nonparametric (PELT) methods.

Improving the knowledge base on climate, climate change and variability for better decision making in rubber growing areas (BM 02)

Maintenance and establishment of meteorological and agro-meteorological stations (BM/02/a)

Maintenance and data recording is being done in the meteorological stations owned by RRISL by visiting and inspecting these sites and by providing instruments when necessary. These include the AGROMET station at Dartonfield and rainfall stations in Moneragala, Kuruwita, Nivitigalakele, Polgahawela, Galewatta and Nivitigalakele. The data and information pertaining to these stations are explained in the Meteorological Summary of this report (D Rathnayaka and O V Abeywardene).

Maintenance of databases on meteorological data in rubber growing areas (BM/02/b)

The database with daily meteorological data collected at Dartonfield meteorological station was 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 are given in Table 4 (D Rathnayaka and V Abeywardene).

Table 4. *Monthly rainfall in rubber growing areas in 2023*

	Location										
Month	**Hanwella**	**Rathnapura**	**Agalawatta**	**Galle**	**Kekanadura**	**Pasyala**	**Kurunegala**	**Monaragala**	**Uhana**	**Matale**	**Badulla**
	WL 1a	**WL 1a**	**WL 1a**	**WL 2a**	**IL 1a**	**WL3**	**IL 1a**	**IL 1c**	**DL 2a**	**WM 3b**	**IM 1a**
January	134.4	75.2	180.9	91.1	24.0	47.4	19.3	35.2	132.7	48.0	92.8
February	89.2	163.9	232.7	277.6	174.0	117.4	23.6	299.8	206.9	85.9	129.4
March	172.1	350.4	444.9	230.3	15.5	190.4	99.6	135.7	61	179.0	71.7
April	366.4	313.9	356.7	134.2	145.0	327.4	365.4	328.9	29.7	162.3	132.3
May	352.5	434.3	467.0	320.6	318.0	270.9	143.6	168.3	86.7	109.6	213.3
June	289.2	618.5	818.5	240.6	325	170.5	93.6	45.1	98.3	20.3	22.9
July	150.4	237.5	223.9	129.4	135	81.5	64.8	38.3	22.5	60.6	17.8
August	211.3	207.7	215.7	187.0	200	90	46.5	72.0	66.4	20.6	125.3
September	877.7	799.0	1015.4	695.2	702	734.5	310.8	69.2	248.6	158.3	165.9
October	829.2	681.5	771.9	833.7	946.0	682.3	489.1	457.8	326.8	351.0	370.3
November	553.5	535.2	535.1	394.3	234.0	940.8	538.4	500.2	379.4	316.1	359.6
December	370.2	364.0	688.9	408.2	403.0	NA	205.4	361.6	543.6	520.6	451.7
Total Rainfall (mm)	**4396.1**	**4781.1**	**5951.6**	**3942.2**	**3621.5**		**2400.1**	**2512.1**	**2202.6**	**2032.3**	**2153.0**
No. of Rainy days*	**196**	**244**	**257**	**226**	**160**		**167**	**157**	**111**	**132**	**180**

** Wet days is a day with a greater than or equal 0*

AGRICULTURAL ECONOMICS

J K S Sankalpa

DETAILED REVIEW

Staff

Mr J K S Sankalpa, Senior Research Officer and Mrs P G N Ishani, Research Officer, were in duties throughout the year.

Seminars/Conferences/Meetings/Workshops attended

Mr J K S Sankalpa attended the following during the year under review.

Activity	Organisation
Scientific committee meetings	Organized by the Rubber Research Institute of Sri Lanka
Committee meetings for Sustainable rubber price	Association for Natural Rubber Producing Countries (ANRPC)
Committee meetings	International Rubber Study Group (IRSG)
Formulation of Thailand Sri Lanka Free Trade Agreement	Department of Trade and Investment, Sri Lanka
Stakeholder workshop for rubber new planting under Smallholder Tea and Rubber Revitalization Project (STARR) Project	International Fund for Agricultural Development (IFAD) and Ministry of Plantation Sri Lanka
ArcGIS Pro Advanced Functionalities Course Online Series	Organized by GIS SOLUTIONS (PVT) LTD
Sri Lanka ArcGIS User Conference (SLAUC 2023)	Organized by GIS SOLUTIONS (PVT) LTD

P G N Ishani attended the following during the year under review.

Activity	Organisation
Scientific committee meeting	Organized by the Rubber Research Institute of Sri Lanka
Stakeholder workshop for rubber new planting under Smallholder Tea and Rubber Revitalization Project (STARR) Project	International Fund for Agricultural Development (IFAD) and Ministry of Plantation Sri Lanka
Workshop on Interoperability and GAP Awareness	Jointly organized by the Food and Agriculture Organization & Ministry of Plantation Industries
Activity	**Organisation**
Workshop on Good Manufacturing Services	Organized by Agriculture Organization & Ministry of Plantation Industries
Member of the judging panel	21st Agricultural Research Symposium of Wayamba University of Sri Lanka
Sri Lanka ArcGIS User Conference (SLAUC 2023)	Organized by GIS Solutions (PVT) Ltd.
ArcGIS Pro Advanced Functionalities Course Online Series	Organized by GIS Solutions (PVT) Ltd.
International Workshop on Circular Leaf Spot Disease (Pestalotiopsis) of Rubber	Jointly organized by RRISL & IRRDB
Workshop on IP Management, Technology Transfer & Commercialization	Ministry of Plantation Industries & National Innovation Agency Sri Lanka

Services

Research support

Various cost-benefit and economic analyses were carried out at the request of other researchers.

Database management

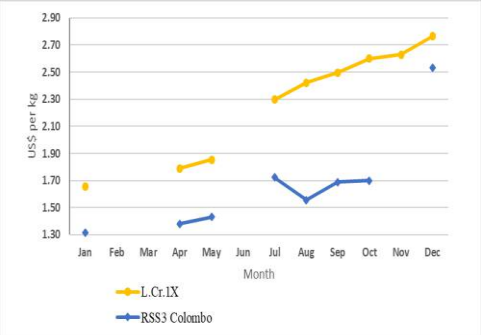
A database on auction prices in Sri Lanka and International rubber prices was updated throughout the year. The Agricultural Economics Unit analysed the rubber price and rubber products export performance quarterly and presented the information to both the industry and the plantation sector.

Rubber Marketing in Sri Lanka

The Colombo auction is the main mode of disposal of rubber manufactured in factories. During this year, the Ceylon Chamber of Commerce under the Colombo Rubber Traders' Association (CRTA) conducted 50 auctions, all of which were updated

and recorded in a database. Table 1 gives the monthly average prices of major raw rubber categories.

Sri Lanka enjoyed a fairly reasonable price for both RSS and Crepe rubber during the second half of the year 2023. The average price of RSS category 3 was US $ 2.53 per kg in December 2023 while it was as low as US $ 1.5 per kg at the beginning of the year. The price of Latex Crepe rubber went up to US $ 2.76 per kg during December 2023, which was as low as US $ 1.70 at the beginning of the year. (Fig. 1). Global prices have shown a gradual recovery in the year 2023. Initially, the price of RSS3 was lower than Thailand's RSS3 prices until June of this year. However, starting in November, it saw an increase, reaching US$ 1.76, which surpassed the Bangkok price (Fig.2). The average RSS4 price of the Kottayam market, India, has increased starting from March 2023 and decreased slightly up to $ 1.83 per kg of RSS4 rubber at the end of December.



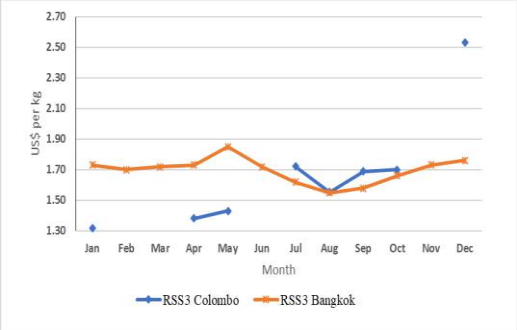


Fig. 1. RSS1 and Cr.1X prices Colombo Auction Fig. 2: RSS 3 price of Colombo and Bangkok market

Regarding the Colombo Crepe price, Cr.1X was close to US$ 2.76 at the end of December 2023. The price of rubber began to rise in April 2023 and it is currently experiencing positive growth (Fig. 3).

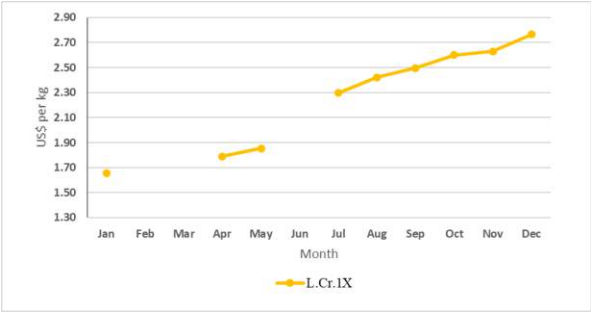


Fig. 3. Crepe1X price in the Colombo Auction

Table 1. *The monthly Auction Prices of Rubber (Latex Crepe, Sheet, and Scrap) in the year 2023*

Month	RSS (LKR/kg)					Latex Crepe (LKR/kg)					Scrap Crepe (LKR/kg)				Flat Bark (LKR/kg)
	RSS1	RSS2	RSS3	RSS4	RSS5	LC-1X	LC-1	LC-2	LC-3	LC-4	1Xbr	2Xbr	3Xbr	4Xbr	.
Jan	473	483	477	457	450	600	572	466	439	422	398	389	392	395	358
Feb	515	485	.	.	.	625	615	563	483	479	455	428	437	423	.
Mar	480	.	.	.	.	.	.	400	378	374	363	.	365	355	.
Apr	464	447	444	426	418	575	570	517	481	463	440	418	440	429	.
May	485	.	.	.	.	637	637	613	580	516	485	.	470	457	.
Jun	580	.	.	.	.	668	660	551	492	456	436	.	439	435	400
Jul	600	.	550	.	.	733	732	603	514	474	456	454	444	435	.
Aug	518	510	500	480	470	779	754	542	456	441	420	403	400	391	383
Sep	566	.	545	.	.	806	785	570	502	470	443	410	413	409	.
Oct	610	.	.	.	.	845	812	539	513	499	480	461	460	438	.
Nov	682	.	.	.	.	851	835	554	540	537	518	513	496	473	458
Dec	784	773	0	752	0	898	865	746	654	645	610	565	593	586	0
2023 Average	563	300	280	264	167	729	712	555	503	481	459	404	446	435	200

RESEARCH

Sustainability Analysis of Rubber-Based Farming System (AE/03)

Financial feasibility analysis of rubber-based farming was conducted as the last part of this research project. Accordingly, the study collected primary data relevant to input and labour costs for different rubber-based farming systems. These estimations were based on recommended agronomic practices by the Rubber Research Institute assisted with the data published by the other agricultural research institutes in Sri Lanka. Commercial harvesting yield and prices of intercrops were also assessed with the market information as of the end of 2023. Table 2 gives a summary of the profitability indicators of different rubber-based farming practices.

Updating databases on the rubber industry, analysis of rubber end products manufacturing sector & other economic evaluations (AE/05)

Rubber Production and Consumption in Sri Lanka

The total quantity of raw natural rubber production is estimated as 64,443 tons in Sri Lanka at the end of year 2023, reporting a 9% annual growth reduction compared to the same period of the previous year. This quantity doesn't include country production of TSR. However, it was a challenging year for the local rubber industry where extremely high rainfall was registered in major rubber growing areas, reporting over 3,000 to 5,000 mm rainfall reducing the number of tapping days dramatically. Apart from the adverse rainfall, continued spared of leaf disease known by the name Pestaloliopsis or Circular Spot Leaf Diseases, and lowering the demand for natural rubber, particularly in Sri Lanka also affected a yield decrease of at least 10% an estimated figure. These two factors suggest moving the rubber plantations from traditional rubber growing areas to non-traditional areas where more dry weather prevails to ensure economically viable natural rubber plantations. (Fig 1).

The total NR consumption, which was 117,288 tons during the year 2022, has significantly declined in the year 2023 (91,866 tons), contributing about a 22% reduction against the previous year (Fig 2).

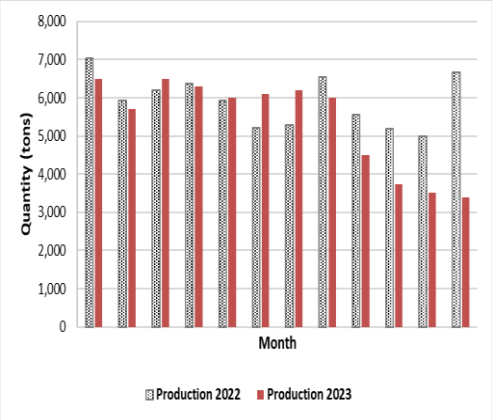


Fig. 1. Monthly NR production in 2022 & 2023

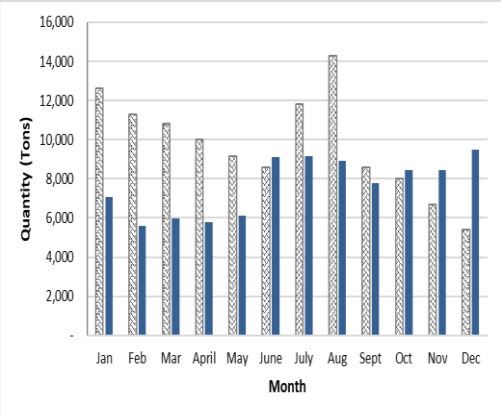


Fig. 2. Monthly NR consumption in 2022 & 2023

Table 2. *Profitability Indicators of Rubber-Based Farming Systems*

Type	Intercrop	Unit Price (LKR)	Intercropping period in years	Intercrop yield begins	Initial Investment	Income (LKR/ha/ month)	Seasonal Crops (LKR/ha/ season)	NPV (LKR)	BCR	IRR (%)	Payback Period (Year)
Monocrop		540/kg			2,069,118	63,837		334,658	1.07	11.6	10
Annual	Maize	100/kg	first 4		74,912		112,404	465,388	1.09	12	7
	Groundnut	405/kg	first 4		94,607		423,014	2,323,534	1.55	29	7
	Cowpea	370/kg	first 4		71,400		186,436	1,705,899	1.43	19	7
Semi Perennial	Pineapple	185/kg	first 4	2nd year	765,889	155,622		3,654,827	1.64	32	7
	Banana	160/kg	first 4	2nd year	942,659	41,481		1,259,131	1.18	17	7
	Passionfruit	200/kg	first 4	1st year	537,098	58,453		4,937,713	1.86	29	7
Perennial	Cinnamon	3351/kg	first 7	3rd year	890,196	54,113		1,206,249	1.2	14	5
	Cocoa	337/kg	30	3rd year	225,250	17,491		314,124	1.06	11	12
	Pepper	1638/kg	first 7	3rd year	657,353	77,559		1,298,237	1.66	27	9

Note: Financial analysis was done for 30 years as the rubber has a 30-year life span. Costs and benefits were discounted at a 10 % discount rate

Raw Rubber Exports and Imports of Sri Lanka

As it has been in the previous years, Sri Lanka has exported NR in two forms namely Crepe rubber and RSS. RSS and Crepe rubber contributed to 15% and 74% of the total exports, respectively while the balance was miscellaneous types such as TSR and compounded rubber. The total exports of NR from the country were recorded as 12,672 tonnes in 2023 against 15,138 tonnes of NR exports made in 2022 indicating a decline in exports (Fig. 3). The continuous decline of the natural raw rubber production in the country may have been attributed this reduction.

Sri Lanka imported around 37,295 tonnes of NR in 2023, mainly in the forms of TSR (20%), RSS (51%), centrifuged NR latex & other latex (29%), and compounded rubber (0.3%). This records a 42% decrease in imports in 2023 compared with the figure for the year 2022.

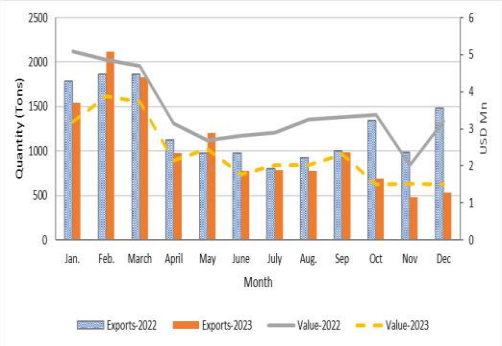


Fig. 3. Raw rubber exports and values in Sri Lanka

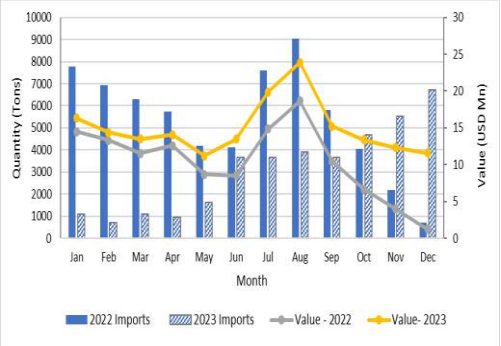


Fig. 4. Raw rubber imports and values in Sri Lanka

Use of GIS in rubber plantation management (AE/06)

A study looked at how the ways land is used and what it's covered with change over time in Sri Lanka's Kegalle District. Since there isn't always updated data available, this study used satellite images and computer programs to compare different ways of figuring out what the land looks like. The study found that one method, called Random Forest, was consistently the most accurate. The study also discovered that certain factors, like what features are considered and how they're chosen, make a big difference in how well the computer programs work. Looking at changes from 2001 to 2013 and then from 2013 to 2022, some significant shifts were noticed. like more areas being built on or turning into barren land. GridSearch CV hyperparameter optimisation approach was used to identify the best parameters of classification algorithms. The findings of this study indicate that the Random Forest (RF) classifier consistently surpasses Support Vector Machine (SVM) and Classification and Regression Tree

(CART) in accuracy, underscoring its reliability in Land Use Land Cover (LULC) classification. Figure 5 presents LULC maps of the Kegalle District generated using the RF, SVM, and CART classifiers, respectively.

The research recommends using detailed satellite images, advanced methods for selecting important features, and integrating various types of data. By improving our understanding of how land use and cover change over time, this study can help shape future research and inform better land management practices, especially in developing countries where agriculture plays a crucial role.

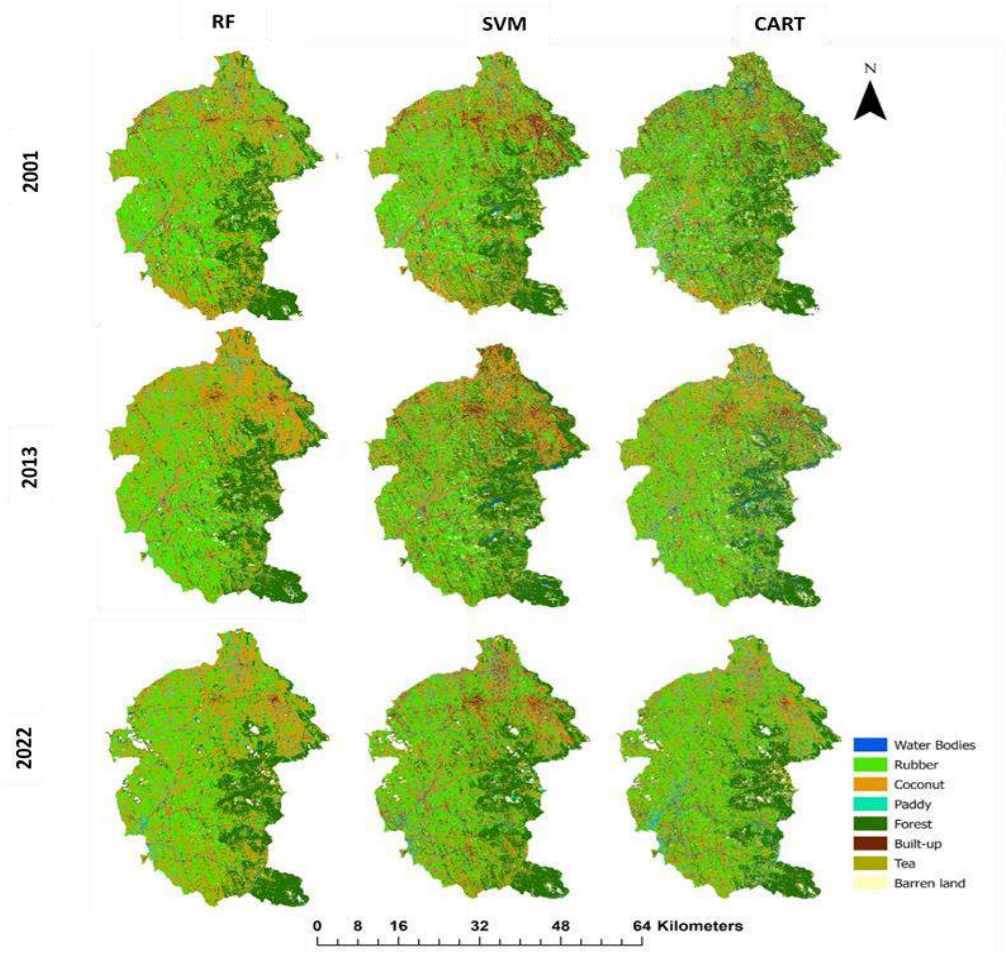


Fig. 5. LULC maps of Kegalle District classified using RF, SVM, and CART for the years 2001, 2013, and 2022 using all features

Analysis of smallholder rubber farmers' resilience and adaptation to climate change (AE/07)

Export Competitiveness Analysis of the Rubber Products (AE/08)

This study was conducted to measure the export competitiveness of rubber products during the past two decades. This study utilized Revealed Symmetric Comparative Advantage (RSCA) as the primary measure for assessing export competitiveness, emphasizing its widespread adoption in the past literature. The selection was driven by the method's simplicity and the ease of interpreting its results. Concerning this index, if the value is positive, then that particular product is competitive in the market and vice versa. Five rubber products that account for more than 80% of the total rubber products export earnings of Sri Lanka from the year 2005 to 2022 period were selected for the analysis. We opted for Ribbed Smoked Sheet (HS 400121) and Crape (HS 400129) as raw rubber categories and New Pneumatic Tyres (HS 4011), Retreated and Solid Tyres (HS 4012) and Gloves of Vulcanized, Unhardened Rubber (HS 4015) as finished rubber products. Secondary data was collected from the Export and Import data bank of the Ministry of Plantation Industries of Sri Lanka, World Integrated Trade Solutions (WITS) and Trade Map (International Trade Centre's trade statistics for international business development).

Based on the RSCA values all five rubber products selected for the analysis exhibited comparative advantage consistently throughout the 18 years. Of the two Raw Rubber categories, Crape products are more competitive compared to RSS products, as witnessed by the RSCA values (Fig. 6).

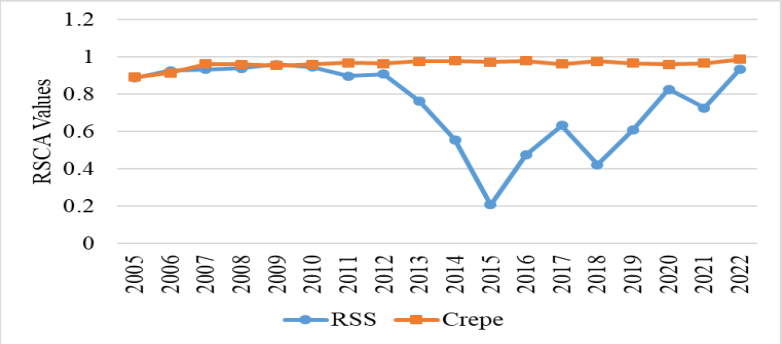


Fig. 6. RSCA - raw materials

Regarding the three finished rubber products, the highest comparative advantage is shown by Solid Tyre followed by Glove exports which have closer comparative values to Solid Tyre competitiveness values. Despite, having a comparative advantage, pneumatic tyres are less competitive than the other two products (Fig. 7).

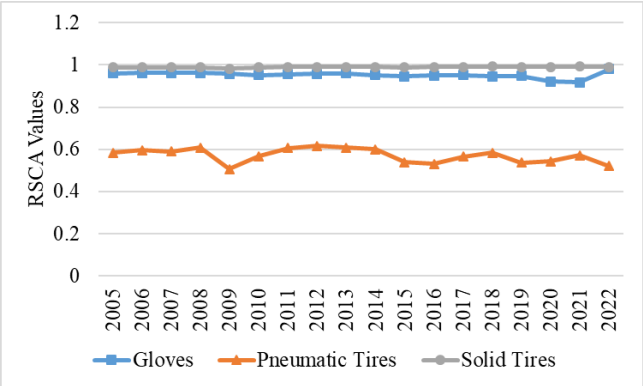


Fig. 7. RSCA - Finished Rubber Products

Economic Viability of Natural Rubber Cultivation (AE/01)

Cost of production Natural Rubber (LKR. /kg)

The cost of production (COP) is a key factor which determines the economic viability of a particular firm. Understanding and managing COP is crucial for farmers and agribusinesses to optimize profitability and sustainability. This study aims to investigate the variation in COP from 2021 to 2023.

Table 3.*Cost of production Natural Rubber (LKR. /kg)*

Item	2021	2022	2023
Fertilizer	13.51	47.50	46
Chemicals	2.18	3.00	3
Other cultivation Costs (Maintenance etc.)	23.65	35.00	44
Labour (Family Labor & Hired Labor)	175.29	175.29	175.29
Material cost (When age less than one year)	2.00	21.00	25
Other materials (Knife, Stencils, Collection buckets)	5.10	12.00	15
Total	221.73	293.79	308.29

Table 3 depicts the COP to produce one kg of natural rubber. Major components of the total cost of cultivation of rubber have been categorized as, fertilizer, chemicals, labour, material and other cultivation cost. In 2022, COP surged by a notable 32.5% compared to 2021, largely due to the sharp rise in market prices of inputs. However, in 2023, there was only a modest 5% improvement in COP compared to the preceding year. Fertilizer costs experienced a substantial increase from 2021 to 2022, indicating a 252% rise, followed by a slight decrease in 2023. Similarly, other cultivation costs showed an 86% increase from 2021 to 2022 and further escalated by 26% in 2023. While Labor costs remained constant, material costs for young plants and other materials exhibited significant percentage improvements (Table 3).

Cost of Replanting & New Planting

It's important for rubber plantation owners and investors to carefully estimate and manage replanting and new planting costs to ensure the economic viability of rubber cultivation. By carefully assessing and managing these factors, rubber plantation owners and investors can make informed decisions to optimize the cost-effectiveness and sustainability of replanting and new planting projects. This study aims to investigate the variation in replanting and new planting costs of rubber plantations in the immature phase based on one hectare of land.

In 2022, the cost of new planting increased significantly compared to 2021, while the cost of replanting also saw an increase but to a lesser extent. However, in 2023, the cost of both replanting and new planting decreased compared to 2022, except for the first year. These variations in expenditure per hectare for new planting and replanting highlight the changing financial requirements associated with establishing and maintaining natural rubber plantations over the three years. The following two tables show the variation in new and replanting rubber cultivations per hectare of land from 2021 to 2023 (Tables 4 & 5).

Table 4. *Cost of New Planting by Year (LKR./ha)*

Year	2021	2022	2023
1	655,261.00	821,291.8	808,637
2	132,226.00	200,791.8	185,743
3	108,961.00	209,569.8	184,304
4	99,786.00	198,085.0	173,353
5	107,836.00	225,425.0	189,425
6	107,547.00	427,200.0	310,100
7	91,692.00	368,046.4	309,006

Table 5. *Cost of Replanting by Year (LKR./ha)*

Year	2021	2022	2023
1	532,132.10	556,271.8	614,297
2	132,226.00	200,791.8	185,743
3	108,961.00	209,569.8	184,304
4	99,786.00	198,085.0	173,353
5	107,836.00	225,425.0	189,425
6	107,547.00	427,200.0	310,100
7	91,692.00	368,046.4	309,006

LIBRARY AND PUBLICATION

N C D Wijesekara

DETAILED REVIEW

Staff

Mrs N C D Wijesekara, Librarian & Publication Officer and two Library Attendant were on duty throughout the year. Mrs R M Amaratunga, Library Assistant & Assistant Publication Officer, who served the Rubber Research Institute for 40 years retired on 22nd August 2023.

Publications

Institutional publications, namely Bulletin 60(2023), Rubber Puwath Vol. 35(2023), Annual Review 2022 and Annual Report 2022 were prepared during the year. All publications were uploaded to the institute's website (www.rrisl.gov.lk).

List of books purchased and donated during the year

No	Title	Publisher	Year of Publication
01	Different stimulations method to obtain economic Yields from puncture tapping	-	1996
02	Ecophysiological effects of simulated acid rain on Seedling *Hevea Brasilliensis Muell.Arg.* and on Glycine Max(L) Merr.	-	1996
03	Deproteinization of *Hevea* latex using papain	-	1994
04	Biological control of pollution in Rubber effluents Using water hyacinth (eichhornia crassipes) (Mart) Soins-Lau Bach)	-	1989
05	The proteolytic Action of enzymes on *Hevea* Latex Protein.	-	1981
06	A Study on the influence of some Agro climatic factors on disease Incidence of White Root Disease (WRD) of *Hevea Brasilliensis* in Sri Lanka	-	1991
07	A study of Phospholipids and their significance in *hevea brasillensis* latex	-	1986
08	Effectiveness of Coconut fiber media in biological waste water treatment for rubber factory effluent	-	2004
09	Evaluation of Organic Materials for the Improvement of Soil fertility in rubber cultivation	-	2002

No	Title	Publisher	Year of Publication
10	Possibility of using Coconut fiber pieces as stationary media in high rate anaerobic treatment of rubber factory waste	-	2000
11	Adenosine Triphosphates Activity in Hevea Latex with special reference to brown bast	-	1983
12	Use of Rubber Factory Effluents as a Source of N. P and K for Rubber and paddy plants	-	1991
13	Influence of crop Profitability, Market, Labor and Land on Smallholder Cropping Systems in Rubber Growing Areas of Sri Lanka	-	2002
14	Report on the study on factory effluents in rubber plantations in Sri Lanka its Disposal /utilization and control of pollution	-	1983
15	Biochemical and Physiological effects of buds and leaves on Adventitious root initiation in pear stem cuttings.	-	1966
16	Effect of different treatments for rooting of cuttings from seedings and clone of *Hevea brasiliensis* (A. Juss.) (*Muell. Arg.)*	-	2009
17	Comparison of yields between bud grafted clonal and seeding trees in *Hevea brasiliensis* (Muell. Arg.)	-	2013
18	Possible causes for the gap between potential and commercial yields of recommended (*Hevea brasiliensis* Muell. Arg.) clones.	-	2010
19	අගලවත්ත රබර් පර්යේෂණායතනයේ රබර් වගාවේ බද්ධ කිරීම සඳහා භාවිතා කරන ලද බද්ධ පොතු පිළිබඳ සිදු කරන ලද අධ්‍යයනයක්.	-	2000
20	A study on Basic Practical Aspects of Plantation Management and the Inspection Report of Immature Clearings on Dartonfield Group.	-	2004
21	Effectiveness of low intensity tapping suitable for rubber (*Hevea*) grown in the low country wet zone of Sri Lanka.	-	2013
22	Biofilm Bio fertilizer for improved Plant Growth and Soil Health of Rubber Nurseries and Plantations.	-	2016
23	අගලවත්ත රබර් පර්යේෂණායතනයේ වැඩි දියුණු කරන ලද රබර් ක්ලෝන සහ බද්ධ අතු තවාන් ආශ්‍රිතව සිදුකරන ලද අධ්‍යයනයක්.	-	1999
24	The effect of spacing and thinning out of seedlings in the nursery on growth of *Hevea brasiliensis*	-	1997
25	The effect of clone and the position of bud on grafting success and scion growth of *Hevea brasiliensis*	-	2010

No	Title	Publisher	Year of Publication
26	Verification of Genetic Orgin of Twin Rubber Plants by RAPD Analysis.	-	2010
27	Possible Reasons for yield variation in RRIC 102 Clearings of *Hevea brasiliensis* (Muell. Arg.)	-	2010
28	Optimizing the culture medium for axillary shoot growth of nature Hevea and acclimatization of jurenile plantlets of *Hevea brasiliensis* (Muell. Arg.)	-	1999
29	The Effectiveness of Plant Quality Monitoring Program on the Condition of the Rubber Clearings	-	2012
30	Time-caused variation in latex yield parameters of *Hevea brasiliensis* (Muell. Arg.) in the Eastern Province of Sri Lanka	-	2012
31	Study on the Implemented Management Strategies in Dartonfield Group and Maximizing profit in Rubber Plantation by fixing Rainguards	-	2004
32	Evaluation of variation in dry rubber content in different rubber (*Hevea Brasiliensis*) genotypes and bulk latex	-	
33	අගලවත්ත රබර් පර්යේෂණායතනයේ පටක රෝපණ අංශය ආශ්‍රයෙන් පොලෝනියා (*Paulownia spp)* ශාකයේ පටක රෝපණය	-	2003
34	Socio- economic Factors Determining the adoption of Rubber/Tea intercropping in Kalutara District at Smallholder Level	-	2002
35	රබර් වගාවේ නියුතුවුවන්ගේ ආර්ථික හා සමාජීය ප්‍රතිලාභවල කාලින විචලනය (කළුතර දිස්ත්‍රික්කය ඇසුරින්)	-	2016

DARTONFIELD GROUP

P A Lukshaman

DETAILED REVIEW

Mr P A Lukshaman, Senior Estate Manager, Mr Dinesh Achinda, Mr M N S Pavinda, Management Assistants, Mr T D Harsha, Acting Factory Officer Mr B M Siriwardena, Field Officer & Mr K A Sarath Kumara, Mr Jagath Nakandala, and Mr Lasantha Sampath, Acting 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	04
Total	**12**

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	17.47	119.28	33.76	170.51
Immature area	13.66	38.61	9.56	61.83
Cinnamon under power line	1.08	2.95	0.93	4.96
Tea area	0.25	1.50	-	1.75
Cemetery	0.60	-	-	0.60
Compost unit	0.25	-	-	0.25
State land take in	0.27	-	-	0.27
Nurseries	7.01	2.61	2.00	11.62
Dunukeyya Trial	-	-	0.50	0.50
Paddy/Deniya land	0.75	1.22	0.72	2.69
Waste land	0.19	0.18	-	0.37
Earth slipped area	4.43	1.26	-	5.69
Jungle	0.80	0.50	1.03	2.33
Rocky areas	2.14	5.29	2.76	10.19
Roads	2.92	5.57	0.36	8.85
Building	18.07	3.93	6.94	28.94
Play ground	1.00	-	-	1.00
Abandoned area	2.75	-	12.51	15.26

Proposed Cinnamon Ns.	0.20	1.10	-	1.30
Streams	0.45	0.35	2.17	2.97
Grand total	**74.29**	**184.35**	**73.24**	**331.88**

Rainfall

The annual rainfall recorded for the year was 5,951.6 mm with 175 wet days. Annual rainfall and wet days of the group for the past five years are given in Table 2.

Table 2. *Annual rainfall and wet days of the group for the past five years*

	2019	**2020**	**2021**	**2022**	**2023**
Rainfall (mm)	4389.7	3376.8	5,049.1	4,287.5	5,951.6
Wet days	204	177	176	159	175

* From 2020, a day having more than 5mm rainfall was considered as a rainy day which was 1mm before 2020.

Crop

A total crop of 84235.5kg has been harvested against the estimated crop of 125042 kg (67.36%) showing a difference of 40806.5 kg. The crop and YPH (kg) of the Dartonfield group from 2019 to 2023 are given in Table 3. Low crop were harvested due to the experience of continues unexpected rainfall and due to the Circular Leaf Spot Disease.

Table 3. *The crop and YPH (kg) of the Dartonfield group from 2019 to 2023*

Hect.	**2019**		**2020**		**2021**		**2022**		**2023**	
	178.02		**181.97**		**166.71**		**169.26**		**170.51**	
Division	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**	**Crop**	**YPH**
Dartonfield	15,683	677	17774	767	10387	681	8898	574	6,234	357
Gallewatte	104,699	865	116501	932	79771	672	70470	587	61,481	515
N'kele	30,034	890	31696	939	21595	640	20620	611	16,520.5	489
Group total	150,416	845	165971	912	111752	666	99988	591	84,235.5	494
Group estimate	197,295	1,108	197393	1,085	184571	1,107	171649	1,014	125,042	733

Tappers productivity

The average IPT during the last five years is given in Table 4.

Table 4. *The average IPT (kg) of the Dartonfield group from 2019 to 2023*

	2019	**2020**	**2021**	**2022**	**2023**
Dartonfield	6.7	6.8	5.1	5.1	4.4
Gallewatte	7.1	8.0	6.4	5.4	5.5
Nivitigala kale	7.8	9.2	7.0	6.6	6.1

Group average	**7.2**	**8.0**	**6.4**	**5.6**	**5.5**

Continued unexpected rainfall also resulted in more No tapping days and also month of May to December had only 30% - 50% canopies due to Pestolotiopsis disease.

Tapping days

Annual breakdown 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*

	2019	**2020**	**2021**	**2022**	**2023**
Normal tapping	201	217	171	200	178
Late tapping	19	11	35	14	24
Cash/double tapping	(21)	(18)	(03)	-	-
No tapping	80	52	76	73	80
Rain guard tapping	65	85	82	77	83
Slight rain	-	-	01	01	-
Total no of tapping days	285	313	289	292	285

Rain guards

Total area of 157.61 hectares were rainguarded during the year and an additional crop of 13,644kg was harvested which amounts to 16.2% of the total crop harvested. Additional tapping days done with rain guards during the year were 85, 59 and 105 for Dartonfield, Galewaththa and Nivithigalakele respectively. Profit generated due to rain guarding was Rs. 559,152.97 and profit per hectare was Rs. 3,547.70.

Table 6. *Additional income generated by fixing of rain guards (Rs/kg)*

	Dartonfield Division	**Gallewatta Division**	**Nivithigala kale Division**	**Total**
Hectares	8.22	119.27	30.12	157.61
No. of rain guards fitted	2,050	15,055	7,893	24998
Additional crop	1,512	7,231	4,901	13644
Rain guard cost per kg.	185.43	284.75	220.26	250.58
Tapping cost per kg.	245.84	245.84	245.84	245.84
C.O.M. Rs/kg	67.22	67.22	67.22	67.22
Total cost Rs/kg	498.49	597.81	533.32	563.64
N.S.A. Rs./kg	604.62	604.62	604.62	604.62
Additional profit Rs./kg	106.13	6.81	71.3	40.98
Additional profit from Rain guards	160,468.56	49,243.11	349,441.30	559152.97
Additional profit per hectare	19,521.72	412.87	11,601.64	3,547.70

Total Loss/profit & profitability per hectare

The total loss and loss per hectare were Rs. 8,711,911.33 and Rs. 51,093.26 for the year under review. In 2019, the Estate showed a loss due to very low NSA as explained below Table 8.

Table 7. *Comparative statement of the revenue profit per kg and profit per hectare for the past five years*

	Years				
	2019	**2020**	**2021**	**2022**	**2023**
Mature area (ha)	178.02	181.97	166.71	169.26	170.51
Total profit (loss) (Rs)	(8,226,251.04)	5,448827.93	6,966,796.71	10,030,643.59	(8,711,911.33)
Profit (Loss) per ha. (Rs)	(46,209.70)	29,943.55	41,789.91	59,261.75	(51,093.26)

Cost of production and productivity

Table 8. *Labour rates and break down of cost of production from 2019 to 2023 (Rs /Kg)*

	2019	**2020**	**2021**	**2022**	**2023**
1. Labour wages	805.00 up to Jan. and 855.00 from Feb.	855.00	855.00 up to Mar. and 1150.00 from Mar.	1150.00	1150.00
2. Cost of production	330.91	300.90	502.49	617.70	708.04
2.1 Tapping	139.94	138.17	204.01	239.79	245.84
2.2 Manufacture	35.35	38.94	49.56	64.39	67.22
2.3 General charges	124.18	94.87	113.03	125.23	139.93
2.4 Mature/area upkeep	31.44	28.92	38.65	71.90	114.24
2.5 Administrative	-	-	97.23	116.40	123.34
3. N.S.A.	276.22	333.73	564.83	718.02	604.62
4. Profit/(Loss) per kg	(54.69)	32.83	62.34	100.32	(103.42)

Manufacture

Out of the latex crop of 74549.5 kg harvested, 62769 kg has been graded as Pale Crepe No. 01 which is 85%. Details are given in Table 9.

Table 9. *Summary of grades manufactured during the year*

Grade	**Quantity (Kg.)**	**Percentage %**
Latex crepe No.1	62769	85
Latex crepe No.2	200	-
Latex crepe No.3	1025	02
Latex crepe No.4	10555.5	13
Total	**74549.5**	**100**

Grade	Quantity (Kg.)	Percentage %
RSS No.01	-	-
RSS No.02	-	-
RSS No.03	-	-
RSS No.04/05	-	-
Total	**-**	**-**
Scrap crepe No.1	9202	95
Scrap crepe No.2	291	03
Scrap crepe No.3/4	193	02
Total	**9686**	**100**
Grand Total	**84235.5**	**-**

Different types of rubber manufactured, percentage of grades received for pale crepe, RSS and Scrap Crepe are shown in figures 1(a), (b) and (c).

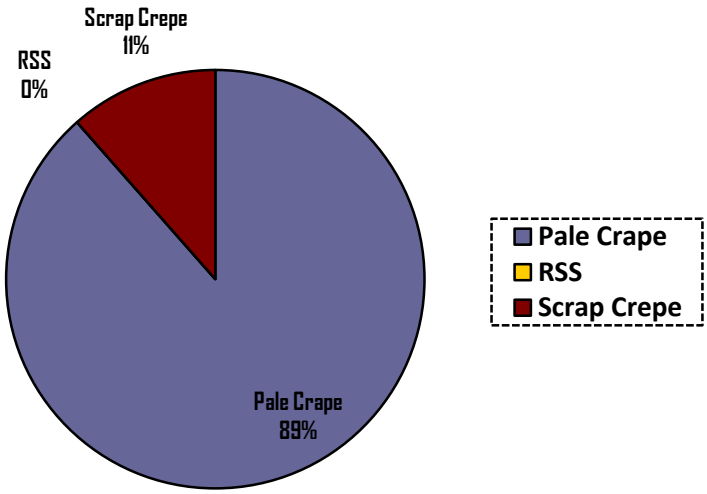


Fig. 1(a). Grade percentages of different types of rubber manufactured Pale Crepe.

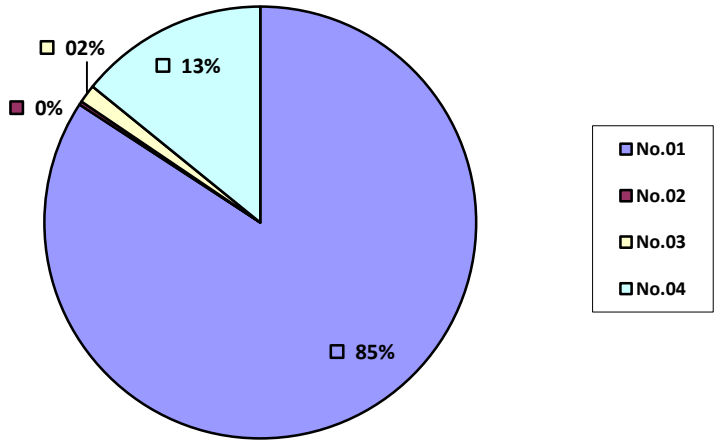


Fig.1(b). Percentage of grades of Pale Crepe manufacture

KURUWITA - SUB STATION

P A Lukshaman

DETAILED REVIEW

Staff

Mr P A Lukshman, Senior Manager (Estate) attended to the duties of the Manager (Estate), Mr D S Jayasinghe, Management Assistant Mrs E P S L Errawwala General worker, Mr D D A Jayathunga, Field Officer (resigned with effect from 25.12.2023), K K S Dinesh General worker was on duty throughout the year. The estate cadre stood as follows at the end of the year.

Intermediate Staff - 01
Assistant Staff - 02
Minor Staff - 02

Hactarage

A summary of the hectarage is given in Table 01.

Table 1. *Land distribution (ha.) in Kuruwita sub station*

Land type	Extent (ha.)
Mature area	74.66
Nurseries	2.25
Immature - rubber	7.30
Tea area	3.49
Paddy	1.00
Buildings, Gardens and Road	10.23
Water Tank	0.01
Unsuitable for planting	1.06
Total	**100.00**

Crop

A total crop of 40595 kg was harvested during the year, recording a decrease of 5225 kg compared to the previous year's crop.

The actual yield per hectare (YPH) was 543.7 kg which is a decrease of 46.3 kg compared with the previous year.

The yield per hectare (YPH) for the past five years are given in the Table 02. The yield per hectare recorded (kg) for each month during the year is given in Table 03.

Table 2. *Yield per hectare for the past five years*

YPH (Kg)	Year				
	2019	**2020**	**2021**	**2022**	**2023**
Estimated	1,271	1,238.6	1219.6	1119.7	787.7
Actual	911.1	1,001.2	786.8	590.01	543.7

Table 3. *Actual yield per hectare (kg) recorded for each month during the year*

Month	YPH (Kg)/month
January	80.9
February	48.8
March	47.8
April	29.5
May	41.8
June	39.7
July	47.0
August	46.1
September	19.1
October	32.7
November	54.4
December	55.9

Tapper Productivity

The average intake per tapper at the end of the year was 4.6 kg. The average IPT during the last five years are given in table 04.

Table 4. *The average intake per tapper (IPT) (kg) for the last five years*

IPT (Kg.)	Year				
	2019	**2020**	**2021**	**2022**	**2023**
Intake per tapper	7.3	7.4	6.1	4.8	4.6

Rainfall

The annual rainfall recorded during the year was 5141.2 mm with 158 wet days (Table 5).

Table 5. *Annual rainfall figures & the number of wet days of the estate for the past 5 years*

	Year				
	2019	**2020**	**2021**	**2022**	**2023**
Rainfall (mm)	3,976.8	3428.3	5396.8	4762.10	5141.2
Wet days	226	138	177	134	158

Tapping Days

There were 334 tapping days recorded during the year (Table 06). This was possible due to the use of rain guards. When compared with the last year there was a decrease in normal tapping days from 221 to 210 during the year 2023.

Table 6. *The Average number of tapping days of the Kuruwita Sub Station for the past five year*

	Year				
	2019	**2020**	**2021**	**2022**	**2023**
01.Total tapping days	323	337	316	316	334
1.1 Normal	250	241	189	221	210
1.2 Late	11	-	17	-	-
1.3 Rain Interference	-	-	-	-	-
1.4 Rain guarded Tapping	62	96	110	95	124
02 Recovery Tapping	-	-	-	-	-
03.No tapping	42	29	48	49	31

Rain guard

Due to the use of rain guards an additional 124 tapping days were recorded during the year 2023. This contributed to 31% of the total crop, yielding an additional profit of Rs. 3,380,206.18. An analysis of the use of rain guards for the years 2019, 2020, 2021, 2022 & 2023 are given in table 07.

Table 7. *An analysis of the use of rainguards (Rs/kg)*

	Year			
	2020	**2021**	**2022**	**2023**
Hectare (ha.)	79.36	67.15	53.70	57.45
No. of rain guards fixed	23150	18480	14802	15432
Additional tapping days	96	110	95	124
No. of kilos harvested	19558	25667	11761	12659
Rain guard cost per (kg)	26.75	21.37	62.78	76.93
Tapping cost (Rs./ kg)	127.79	192.91	255.76	255.16
Total cost (Rs./ kg)	154.54	214.28	318.54	332.09

N.S.A. (Rs./ kg)	311.69	523.82	653.25	599.11
Additional Profit (Rs./ kg)	157.15	309.54	334.71	267.02
Additional profit from rain guards (Rs.)	3,073,539	7,944,963	3,936,524.31	3,380,206.18
Additional profit per hectare (Rs.)	38,729.07	118,316.65	73,305.85	58837.35

Total profit and profitability per hectare

The total loss and loss per hectare were Rs. 1,124,887.45 and Rs. 14484.77 respectively for 2023. Table 08 compares 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				
	2019	**2020**	**2021**	**2022**	**2023**
Mature extent (ha.)	79.36	79.36	79.36	77.66	74.66
Total profit (Rs.)	(5,363,084.36)	1,535,903.81	5076072.76	3,448,413.20	(1,124,887.45)
Profit per hectare (Rs.)	(67,579.19)	19,353.63	63962.61	44403.98	(14484.77)

Cost of production and profitability

The cost of production has increased by Rs. 28.73 per kg comparing with the previous year (Table 09). Labour rate and the breakdown of the cost of production (Rs/kg) for the past five years are given in Table 09.

Table 9. *Labour rate (Rs.) and the breakdown of the cost of production from 2019 to 2023(Rs./kg.)*

	Year				
	2019	**2020**	**2021**	**2022**	**2023**
Labour rate up to Jan. from Feb.	805.00 855.00	855.00	855.00	1150.00	1150.00
Cost of production	337.71	292.36	442.53	499.89	528.62
Tapping cost	134.74	137.41	205.40	272.89	272.56
Manufacturing	33.11	37.12	45.41	71.91	102.24
General chargers	135.40	89.49	157.64	81.62	88.15
Field & cultivation cost	34.47	28.35	34.08	73.47	65.67
N.S.A	263.54	311.69	523.82	653.25	599.11
Profit per kg.	(74.17)	19.33	81.29	75.26	(27.71)

POLGAHAWELA SUBSTATION

P A Lukshaman

DETAILED REVIEW

Mr. P A Lukshaman, Senior Estate Manager overlooked the activities of the Substation and Mr. D P Nuwan Dissanayaka, Management Assistant was on duty throughout the year.

Hectarage summary

	Hectarage
Mature	17.75
Immature	1.50
Cashew	0.25
Rocks	23.60
Total	43.10

Crop

Total crop of 18849 kg have been harvested against the estimated crop of 20739 kg which is a decrease of 1890 kg. The total crop, YPH and IPT for 2019, 2020, 2021, 2022 and 2023 are given in Table 1.

Table 1. *Total crop (kg), YPH (kg) and IPT (kg) for the years 2019 - 2023*

Year	Hectare	Crop (kg)	YPH (kg)	IPT (kg)
2019	17.75	15678	883	9.4
2020	17.75	17080	962	8.8
2021	17.75	16828	948	8.0
2022	17.75	12507	704	7.0
2023	17.75	18849	1061	8.7

Rainfall

The annual rainfall recorded for the year was 2782.3mm with 122 wet days. From 2020, a day having more than 5mm rainfall was considered as a rainy day which was 1mm before 2020.

Table 2. *Annual rainfall and wet days of the estate for last five years*

	2019	**2020**	**2021**	**2022**	**2023**
Rainfall	2170.5	2385.5	3485.4	2350.6	2782.3
Wet days	139	118	128	94	122

Tapping days

The annual breakdown of tapping days and no tapping days are given in table 3.

Table 3. *Annual Tapping days and No tapping days of the estate for last five years*

	2019	**2020**	**2021**	**2022**	**2023**
Tapping days	310	301	313	327	335
No tapping days	55	65	52	38	30

Meteorological Summary

Dartonfield Station

Dilhan Rathnayaka

The AGROMET station at Dartonfield, Agalawatta is maintained by the Biometry Section of the Rubber Research Institute of Sri Lanka. This station located in the Agro-Ecological Region $WL_{1a,}$ recorded an average annual rainfall of 4259 mm during the last 20 years. Out of the 24 years since 2000, a total rainfall of less than 3000 mm has been recorded only once during 2016 which was 2966 mm (Fig. 1). The rainfall recorded in 2023 was 5952 mm, which accounted for a increase of 39%, compared to the previous year and highest recorded in last 20 years. The long term average rainfall is marked as a horizontal line in Fig. 1.

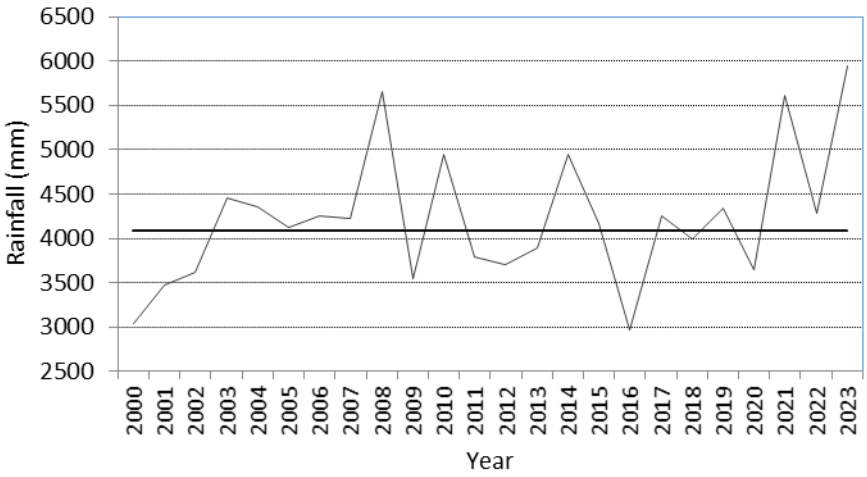


Fig. 1. Variation in annual rainfall at Dartonfield from 2000 to 2023

As indicated in Fig. 2, the rainfall distribution at Dartonfield during this year departed from the usual bimodal rainfall pattern. Remarkably high above-average monthly rainfall values were observed in June (819 mm-106%), September (1015 mm-133%) and December (688 mm- 159%). Above average rainfall values were also observed in January (181 mm-16%), February (233 mm-104%), March (445 mm-100%), October (771.9 mm-50%) and November (535 mm-38%) while below average rainfall value were observed in the rest of the months. The minimum monthly rainfall of 181 mm was recorded in January whilst the maximum monthly rainfall of 1015 mm was recorded in September.

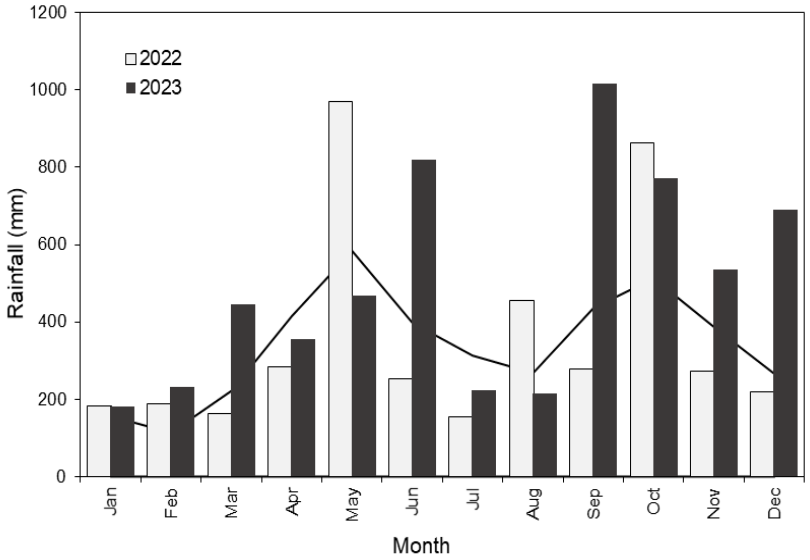


Fig. 2. Distribution of monthly rainfall in 2022 and 2023 at Dartonfield (The line graph indicates the long-term average)

The distribution of rainfall in different seasons at Dartonfield is given in Fig. 3. Rains during the South West season (May – September) carried most of the rains (2741 mm compared to the long-term average 1564 mm) during 2023. This rainfall amount contributed 50% to the total rainfall, which is slightly higher than the long-term average contribution (48%). Rainfall during IM2 (October & November) in 2023 brought 1307 mm whilst IM1 (March & April) recorded 802 mm of rainfall. During the North East season (December 2022 to February 2023), 632 mm of rain was recorded, which is lower (11%) than the long-term average contribution (15%) of this season.

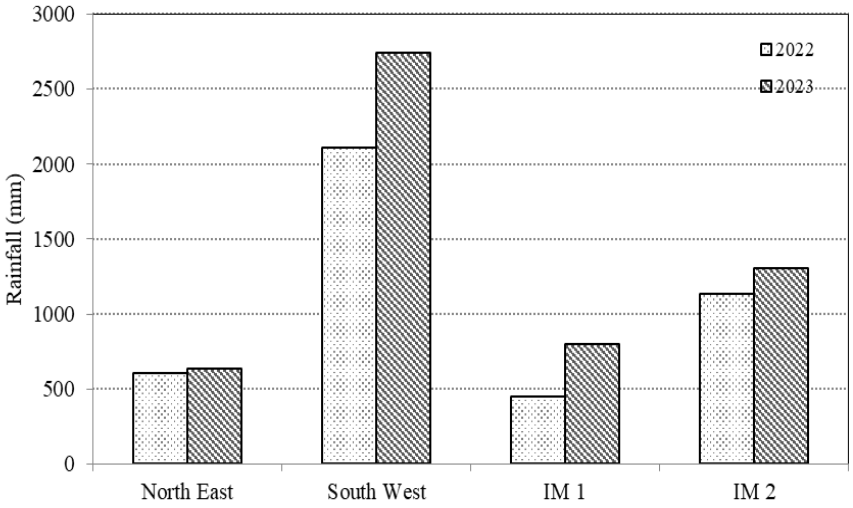


Fig. 3. Seasonal distribution of rainfall at Dartonfield in 2022 and 2023

The distribution of weekly rainfall is depicted in Fig. 4. four dry weeks (weeks having a total rainfall less than 10 mm) were observed during this year. The highest weekly rainfall of 343 mm was observed in the 50th standard week (10th - 16th December).

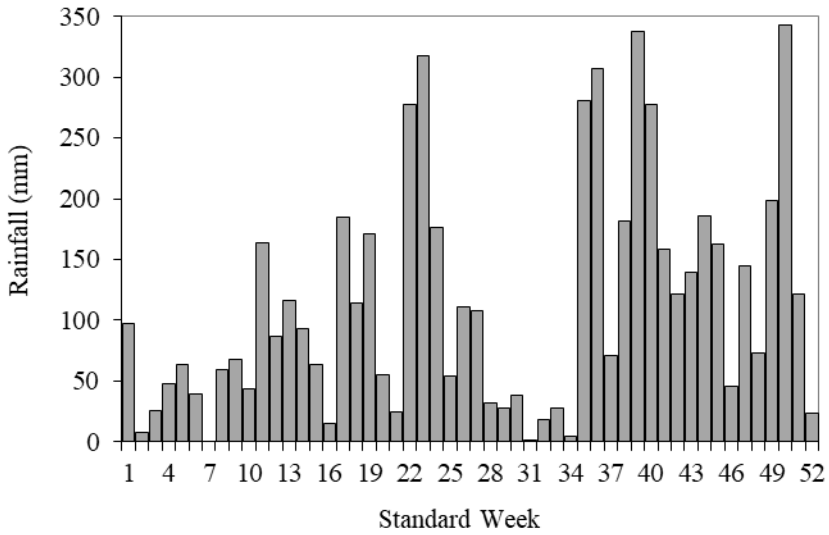


Fig. 4. Weekly variation in rainfall in 2023

Three rainfall events exceeded the hazardous limits for landslides (100 mm of rainfall during a day) reported during the year under review. A dry spell lasting over a month or more can adversely impact rubber plantations. There were only 2 dry spells greater than or equal to 7 days (Table 1).

Table 1. *Details of dry spells at Dartonfield in 2023*

Dry spell No.	Period	No. of days
1	11th - 21st February	11
2	27th July - 3rd August	8

The amount of rainfall and the number of rainy days under low, moderate and high rainfall categories are listed in Table 2. The observed total number of rainy days of the year was 256, which is higher than the long-term average of 220 days.

Table 2. *Monthly variation of rainfall and rainy days in 2023 at Dartonfield, Agalawatta*

Month	Total rainfall (mm)	Average** (mm)	No of rainy days *	Avg.** Days	No. of days under each category			Evaporation (mm)
					0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)	
January	180.9	(156)	13	(11)	3	9	1	2.79
February	232.7	(114)	12	(09)	5	6	1	3.36
March	444.9	(222)	20	(13)	4	13	3	3.90
April	356.7	(415)	16	(18)	3	10	3	3.81
May	467.0	(584)	24	(24)	4	17	3	2.92
June	818.5	(398)	30	(23)	3	22	5	2.80
July	223.9	(313)	20	(22)	3	17	0	3.00
August	215.7	(268)	18	(20)	7	10	1	3.50
September	1015.4	(436)	27	(22)	1	18	8	3.30
October	771.9	(513)	27	(23)	3	18	6	2.80
November	535.1	(387)	26	(20)	4	18	4	3.34
December	688.9	(266)	23	(15)	4	15	4	2.70
Total	5951.6	(4072.0)	256	(220)	44	173	39	38.22

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm

** Average values for 1980-2005 are shown in parentheses

Rainfall at RRISL substations

RRISL maintains substations in Kuruwita (WL_{1a}), Narampola (IL_{1a} bordering WL_{2b}), Moneragala (IL_{1c}), Galewatta (WL_{1a}) and Nivithigala Kele (WL_{1a}). The annual rainfall totals of 4962 mm, 2782 mm, 2224 mm, 5769 mm and 4730 mm were recorded, respectively, in Kuruwita, Narampola, Moneragala, Galewatta and Nivithigala Kele stations during 2023. The details of rainfall in these stations are given in Tables 3 to 7.

Table 3. *Monthly variation of rainfall and rainy days in 2023 – 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	104.9	11	4	7	0
February	179.2	13	2	10	1
March	342.8	18	4	13	1
April	427.6	23	4	16	3
May	293.3	22	6	16	0
June	658.4	30	7	19	4
July	203.8	17	3	13	1
August	209.7	12	5	5	2
September	884.6	27	3	18	6
October	846.5	29	1	22	6
November	511.2	20	6	10	4
December	299.99	21	5	16	0
Total	4961.99	243	50	165	28

* A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 4. *Monthly variation of rainfall and rainy days in 2023- Gallewatta*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	199.6	11	2	8	1
February	311.1	10	2	5	3
March	341.5	15	2	10	3
April	272.4	13	1	12	0
May	557.7	18	0	15	3
June	789.7	26	1	20	4
July	164.3	12	0	12	0
August	253.2	8	2	4	2
September	1044.4	27	1	17	9
October	804.2	26	0	18	8
November	532.1	20	0	16	4
December	526	19	1	14	4
Total	5796.2	205	12	151	41

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 5. *Monthly variation of rainfall and rainy days in 2023 –Nivithigalakele*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	128.4	9	1	7	1
February	222.7	8	0	8	0
March	321.5	16	2	13	1
April	263.8	13	2	11	0
May	397.8	19	2	16	1
June	593.8	24	3	17	3
July	135.4	15	2	13	0
August	215.8	10	2	7	1
September	902.6	26	1	19	6
October	626.4	24	1	17	6
November	453.4	23	2	18	3
December	468.5	16	1	12	3
Total	4730.1	203	19	158	25

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 6. *Monthly variation of rainfall and rainy days in 2023 –Moneragala*

Month	Total rainfall (mm)	No of rainy days *	No. of days under each category		
			0.3-2.5 (mm)	2.6-50 (mm)	>50 (mm)
January	23.2	4	0	4	0
February	274.4	8	0	6	2
March	113.4	8	1	7	0
April	241.3	14	2	11	1
May	174.7	10	1	9	0
June	34.3	4	1	3	0
July	34.2	2	0	2	0
August	66.2	3	0	3	0
September	68.1	6	0	6	0
October	445.6	15	2	9	4
November	432	18	1	15	2
December	316.4	14	0	12	2
Total	2223.8	106	8	87	11

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Table 7. *Monthly variation of rainfall and rainy days in 2023 – 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	32.5	4	0	4	0
February	29	4	1	3	0
March	175.3	8	1	6	1
April	246.5	16	1	15	0
May	185	10	0	9	1
June	118.1	8	0	7	0
July	103.2	8	2	6	0
August	75	2	0	1	1
September	416.9	23	2	20	1
October	482.4	24	2	9	4
November	659.8	24	2	19	3
December	258.6	18	1	16	1
Total	2782.3	149	12	115	12

*A rainy day is defined as a day with a rainfall ≥ 0.3 mm

Other meteorological parameters

Table 8 depicts the monthly values of important meteorological observations and averages from 1980 to 2005 at Dartonfield. Daily fluctuations of the minimum and maximum temperatures at Dartonfield are illustrated in Fig.5. During the year under review, the minimum temperature dropped below 20 ^{0}C in January, April, May, August, September and December. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.6 ^{0}C, which could be a favorable condition for rubber plantations. The lowest mean monthly minimum temperature of 17.6 ^{0}C was observed in September while the highest monthly mean maximum temperature of 35 ^{0}C was observed in April. However, any signs of adverse conditions concerning the temperature regime at Dartonfield were not reported during the year.

A total of 1647 bright sunshine hours was received at an average rate of 4.6 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 34% of the days, while in 41% of the days, it was below 4 hours.

High morning Relative Humidity (RH) is favourable for high latex yields. Daily morning RH at Dartonfield in 2023 was observed in the range, 63 % to 98 %. The mean RH values recorded at 08:30 and 15:30 were 85% and 74%, respectively.

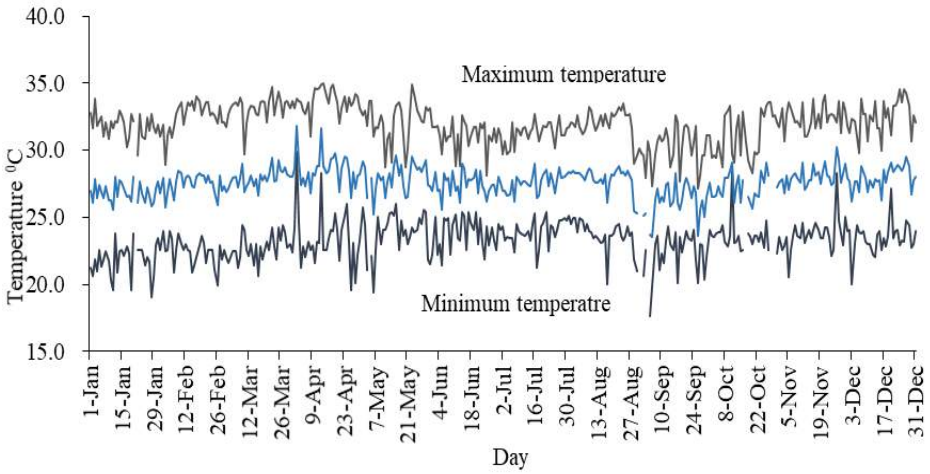


Fig.5. *Daily minimum, maximum and average temperature distributions in 2023*

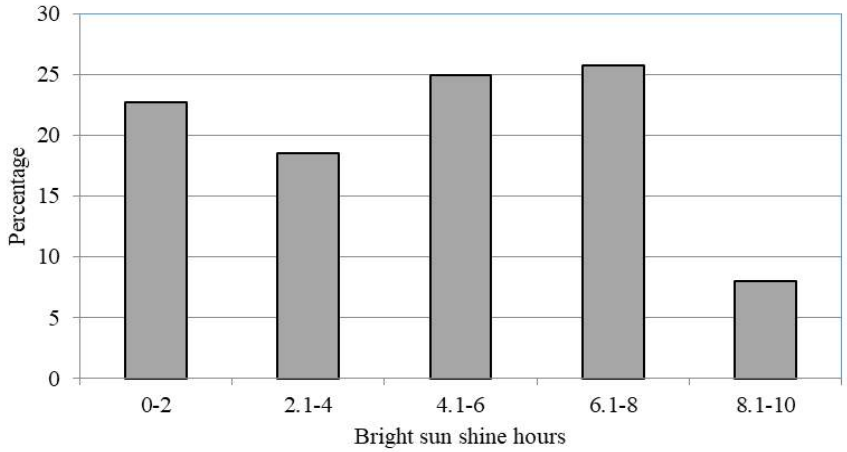


Fig. 6. *Distribution of bright sunshine hours in 2023*

Table 8. *Variation of observed meteorological factors at Dartonfield – 2023*

Month	*(Latitude 60°32'; Longitude 80.09 E; Altitude 65.50mm)*								
	Temperature (^{0}C)					Relative Humidity (%)			Mean Wind Speed (km/hour)
	Mean Max	Mean Min	Mean	No of Days Min Temp<20	Sun shine hours	8.30 am	No of Days 8.30am >90%	3.30 pm	
January	31.7	21.7	26.7 (26.7)	3	5.5	85 (88)	9	67 (68)	0.15
February	32.5	22.5	27.5 (27.6)	1	6.3	85 (86)	6	71 (65)	0.25
March	33.0	22.7	27.8 (27.6)	0	5.8	82 (85)	3	68 (68)	0.24
April	33.7	23.5	28.6 (27.8)	1	5.2	81 (85)	2	75 (75)	0.20
May	32.2	23.8	28.0 (27.6)	1	3.7	86 (88)	7	73 (77)	0.32
June	31.1	23.8	27.4 (26.9)	0	3.5	90 (89)	13	78 (77)	0.41
July	31.3	23.9	27.6 (26.7)	0	5.0	86 (89)	7	71 (75)	0.63
August	32.0	23.7	27.8 (26.6)	0	6.4	84 (88)	2	66 (74)	0.45
September	30.1	22.0	26.0 (26.7)	3	2.6	87 (88)	9	77 (75)	0.33
October	31.0	22.9	26.9 (26.6)	3	2.8	86 (86)	7	82 (77)	0.13
November	32.5	23.7	28.1 (26.6)	0	4.1	81 (85)	2	81 (77)	0.15
December	32.5	23.5	28.0 26.7	0	4.0	83 (85)	6	77 (73)	0.14

** Average values for 1980-2005 are shown in parenth

List of Publications

Scientific Journals
(Bold type - Employees of Rubber Research Institute of Sri Lanka)

Gunarathne, P.K.K.S., Tennakoon, T.M.S.P.K., Edirisinghe, J.C., and Jayasundara, K.I. (2023). Impact of Rubber Farming on the Socio-Economic Status of Households of Smallholders: A Descriptive Analysis. Vidyodaya Journal of Humanities and Social Sciences: Vol. **8** (02): 13-25. DOI: http://doi.org/10.31357/fhss/vjhss.v08i02.02

Sankalpa, J.K.S., Gunarathne, P.K.K.S., Wijesuriya, Wasana., Ishani, P.G.N. and Rathnayaka, A.M.R.W.S.D. (2023). The determinants of job satisfaction of rubber latex harvesters: a case from smallholder rubber lands in Sri Lanka. *Journal of Rubber Research* (IF 1.208). DOI:10.1007/s42464-023-00191-w.

Attanayake, A.M.U.K., **Munasinghe, E.S., Wijesuriya, B.W**. and Nissanka, S.P. (2023). Rubber in non-traditional areas: factors influencing the adoption of cultivation by smallholders in Ampara district of Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka*. **103**, Pp. 23-43.

Munasinghe, E.S and Hapugoda, J.C. (2023). A study on intention to retain staff grade employees in the Rubber Research Institute of Sri Lanka. *Journal of the Rubber Research Institute of Sri Lanka.* **103**, Pp. 1-21.

Sankalpa, J.K.S., Rathnayaka, A.M.R.W.S.D. and Ishani, P.G.N. *et al.*(2024). Fusion of spectral and topographic features for land use mapping using a machine learning framework for a regional scale application. Environ Monit Assess 196, 1030 https://doi.org/10.1007/s10661-024-13178-w.

Ishani, P.G.N., Sankalpa, J.K.S. and Rathnayaka, A.M.R.W.S.D. (2024). 'Comparative advantage and export performance of the Sri Lankan rubber sector', Plastics and Rubber - Sri Lanka, 22. Available at: https://www.prisrilanka.com/journal/

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Sankalpa, J.K.S., Gunarathne, P.K.K.S., Wijesuriya, Wasana., P.G.N. Ishani and Rathnayaka, A.M.R.W.S.D. (2023). The determinants of job satisfaction of Rubber Latex Harvesters: A case from Smallholder Rubber lands in Sri Lanka, *Journal of Rubber Research,* **26**(1), Pp. 71–80. doi:10.1007/s42464-023-00191-w.

Sampath, W.D.M., Fernando, C.A.N. and **Edirisinghe, D.G.** (2023). Synthesis of copper-grafted graphite and its effect on properties of natural rubber composites. Journal of Elastomers & Plastics, **0**(0) Pp.1–18 **(**Expanded Science Citation Index).

Wijewardane, **D.S.**, Senevirathna**,** M.A.S.R., **Siriwardena, S**., **Edirisinghe**, **D.G. and Sudusingha, Y.C.Y.** (2023). Preparation of skim natural rubber and polypropylene blends via melt blending: A study on physico-mechanical properties" – Journal of Elastomers and Plastics, **55**(4), Pp.559-582 **(**Expanded Science Citation Index).

Weerasinghe, U.A., Edirisinghe, D.G., Sampath, W.D.M., and **Nanayakkara, N.** (2023). Evaluation of suitability of lemongrass powder as an allernative antioxidant for dry rubber composites – *Journal of the Plastics and Rubber Institute of Sri Lanka*, **21**, Pp.56-60.

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Gunarathne, P.K.K.S., Ranasinghe P.H.U. and **Jayasundara K.K.I.** (2023). The physical wellbeing of elderly latex harvesters: a case study in Kegalle District in Sri Lanka, *Bulletin of Rubber Research Institute of Sri Lanka,* **60**, Pp. 53-55.

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Gunarathne, P.K.K.S., (2023**).** Potential for smallholder rubber farming based agro-tourism development: evidence from Moneragala District in Sri Lanka, *Bulletin of Rubber Research Institute of Sri Lanka,* **60,** Pp. 61-70.

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GENETICS AND PLANT BREEDING

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

The girth performance of the foreign clones established at Galewatta Estate, Dartonfield Group and Neuchattle estate under the multilateral clone exchange programme were evaluated. The highest girth was recorded in the clones RRIT 3904, RRII 429, and ARCPC 2/4 from Thailand, India, and Myanmar, respectively. Two genotypes from 2017 HP progeny, i.e. 2017HP-59 and 2017HP-60, showing higher latex yields were tested using the Ref gene expression, and it was proven that Ref gene expression and yields were significantly higher in 2017HP-11 than the control clone.

To study the drought tolerance of clones, the relative quantification of the expression of eight genes under water-stressed conditions was compared in RRIC 100, RRIC 102, RRISL Centennial 3, RRISL Centennial 4, RRISL 2003, PB 260, with drought-tolerant clone RRIM 600. The clones PB 260, RRISL Centennial 4, and RRISL Centennial 3 exhibited comparatively higher tolerance to drought conditions than the RRIM 600. When both physiological and molecular data were considered, PB 260 exhibited greater drought tolerance than the RRISL Centennial 4 and RRISL Centennial 3 clones.

PLANT SCIENCE

In order to strengthen the clonal balance in the rubber cultivated areas, a total of 6,277 rubber plants were distributed as authentic bud-wood plants during the year. Also, the monitoring rubber nurseries under Rubber Development Department, Regional Plantation Companies and Private nurseries was done frequently. Discarding of weak plants in the nurseries was done with the support of the Nursery Managers. The rapid and juvenile bud grafting techniques also continued during this year. Testing of root trainers for young budding nurseries has been continued. By promoting healthy root development and improving morphological characteristics, they contributed to the quality and resilience of plants. In order to study the impact of stock-scion interaction on the growth performance of young rubber nursery plants under Wet and Dry climates two nursery experiments were established at the Dartonfield and Moneragala Sub Station in January, 2023. The clonal variation of stock-scion interaction according to morphological and physiological attributes under nursery conditions in different climatic zones was assessed.

Optimizing the bark of rubber plantations through possible tapping systems has been assessed in Sirikandura Estate, Mathugama. Out of the six treatments, T6 and T5 were recorded with higher g/t/t values than the other treatments due to the lower tapping intensity. The T2 and T3 recorded the lowest value due to the effects of both higher frequency and shorter cut length

Growth, yield and physiological data of different intercropping trials were assessed in Wet and Intermediate Zones. The growth, yield and physiological data of rubber and fruit crops have been assessed and the performance of inter-crops was much better in the wider spatial arrangements of rubber, i.e., 2.5 m x 12.0 m. The growth and yield performance of three paired rows of pineapple under rubber were assessed in Salawa estate with the collaboration of Pussellawa Plantations. Tree girth of rubber was higher with pineapple than that with rubber mono cropping. 236 inspection visits were made to the rubber nurseries for the nursery inspection and plant certification. During the year, 25 advisory visits were made and 10 training programmes conducted on nursery management, bud-grafting and tapping.

PLANT PATHOLOGY AND MICROBIOLOGY

Incidence of the secondary leaf fall diseases, Powdery mildew and Colletotrichum leaf disease was mild to moderate during the refoliation period except for a few disease-vulnerable sites. The Circular Leaf Spot Disease primary causative agents were published as four new Colletotrichum species namely; Colletotrichum siamense, C. fructicola, C. gigasporum and C. tropicale. And secondarily attacked by three Pestalotioides genus: Pestalotiopsis spp. Neopestalotiopsis spp. and Pseudopestalotiopsis spp. which have been regarded as opportunistic weak parasites. During the year 2023, CLSD reported lower severity compared in the year 2022. The studies on the biology and epidemiology of the pathogen isolates were in progress and till the studies will be completed, a revised interim recommendation was continued. Two systemic fungicides carbendazim (10g per liter) and hexaconazole (10 ml per liter) were recommended to be used alternatively. The Indian oil based copper oxychloride was tested for phyto toxicity. Immature leaves showed toxic effects while mature leaves tolerated the conc. 8kg /ha. A range of concentrations and timings were tested in chemical controlling trials. Three Hevea clones: RRIC 100, RRISL 2006 and CEN 4 tolerated CLSD to a considerable extent. Screening of clones against Corynespora showed a very mild disease level and no new clones were reported. A national plan was forwarded with short term, medium term and long term strategies for CLSD jointly with the Rubber Development Department for funding. Incidence of Phytophthora disease was also observed on the clone RRISL 203 and growers mis-identified as CLSD. White root disease had become destructive and played an important role in reducing the tree stand in rubber plantations. Affected field was rehabilitated using Cassava cultivations to detect the disease patches while securing a reasonable income. One Trichoderma harzianum based biopesticide was forwarded to the Registrar of Pesticides, Department of Agriculture for the registration of the products. The national level culture collection maintained at the department was generally checked for the viability. An international Conference was conducted in Sri Lanka funded by the IRRDB on the CLSD.

SOILS AND PLANT NUTRITION

Research activities on improving soil fertility, enhancing fertilizer use efficiency, promoting sustainable fertilizer application, and managing diseases through fertilizer practices continued throughout the year. The special capital project on "Establishing environmental friendly, economically viable, slow-release fertilizer techniques to enhance crop performance and the creation of an accredited laboratory to serve the industry" progressed steadily. The National Research Council (NRC)-funded project on "Enhancing soil fertility in degraded rubber lands through combined agro-management practices such as inorganic fertilizers, biofertilizers, cover cropping, and mulching with organic matter" continued. An experiment at the Kuruwita substation, evaluating the combined use of inorganic fertilizers with compost, partially burnt paddy husk, biochar, and commercially available effective microorganisms (EM) demonstrated growth performance comparable to conventional fertilizer applications in immature rubber. The study on the impact of different fertilizer treatments on the severity of the circular leaf spot disease was in progress. Promising growth performance under the application of slow-release fertilizers in immature rubber plantations were reported on par with the conventional fertilizer treatments. A new trial was also initiated at the Waga division of the Halpe estate to evaluate the effectiveness of different fertilizer treatments on the circular leaf spot disease in mature rubber plantations. At the Kuruwita substation, a project focusing on the establishment of management zones in mature rubber plantations using geospatial and geo-statistical approaches showed promising results. Spatial variability of soil organic carbon, pH, total nitrogen, and the carbon-to-nitrogen ratio is providing key insights for identifying management zones. Trials on the efficacy of 4th-generation fertilizers in immature rubber plantations were initiated under both traditional and non-traditional rubber-growing areas, with ongoing experiments at four sites in each region. The site-specific fertilizer recommendation program generated 28 reports covering 4,136.73 hectares of mature rubber plantations across the country. Additionally, the department's laboratory provided analytical services, issuing 60 reports based on the analysis of 241 soil, leaf, fertilizer, and compost samples. Two training programs on slow-release fertilizer application and laboratory soil analysis were conducted for the estate sector personnel and Laboratory Technicians. Dr (Mrs) R P Hettiarachchi, a highly respected scientist known for her pioneering work on slow-release fertilizers and biofilm biofertilizers (BFBF) for rubber cultivation in Sri Lanka, retired on December 15th, 2023.

BIOCHEMISTRY AND PHYSIOLOGY

Technology transfer programmes were conducted to rubber smallholders, Officers and workers of RPCs, and extension personals to improve the knowledge on stimulation based low intensity harvesting systems. Investigations were carried out to identify opportunities and drawbacks in adopting S/2 d4 LIH system in commercial rubber plantations.

Experimental fields established to identify the best clones for the sub-optimal climatic conditions in non-traditional rubber growing areas have been monitored and investigations have been carried during 2023. Plant physiological and growth data of different Hevea genotypes were collected from experimental fields established at Kandakadu, Padiyathalawa, Vauniya, Hambegamuwa and Meerigama to investigate the performance of clones under suboptimal climatic conditions in nontraditional rubber growing areas.

To strengthen the screening process of newly introducing Hevea genotypes, assessment of biochemical and physiological properties of latex of twenty Hevea HP progenies developed in 2014 has been carried on request of Department of Genetics & Plant Breeding. Latex physiological parameters of established clones have been investigated in order to develop a physiological index to support the clonal screening. Plant physiological assesments were carriedout to identify clones with a better defence mechanism against biotic and abiotic stresses.

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

ADVISORY SERVICES

The extension strategy focusing the farmer participatory development of selected rubber smallholdings was continued in each REO range in traditional rubber growing areas and 45 immature sub-standard rubber smallholdings, 57 mature sub-standard rubber smallholdings were developed according to the RRISL recommendations. Construction of 6 new one-day RSS processing centers and rehabilitation of 15 substandard centers were achieved. Ten smallholdings were fixed with rain guards as demonstrations. Five smallholdings were established with different intercrops as models. Two hundred and ninety two technical advisory visits were carried out to solve problems in technology adoption on the requests made by rubber smallholders. Seven hundred and sixteen pre-planned technical advisory visits were conducted by REOs to solve technology adoption problems in the rehabilitation holdings, introduction of intercropping systems, rainguarding, construction of new RSS centers and rehabilitation of substandard RSS centers. Twenty six awareness training programmes were conducted educating 313 rubber smallholders and 131 estate staff (Field Officers and Estate Workers) on general cultivation practices, rain guard fixation and processing aspects of rubber. As a solution to the tapper shortage in rubber growing areas, 02 Mobile Tapper Training programmes were conducted with the collaboration of Thurusaviya fund, in Kegalle district covering both practical and theoretical aspects. To upgrade the knowledge and skill levels of semi-skilled rubber harvesting assistants, 10 skill development training programmes were conducted for 359 semi skilled rubber harvesting assistants' in order to improve the quality of tapping in the estate sector. Nine skill development training programmes were conducted for 159 semi skilled rubber harvesting assistants in order to improve the quality of tapping in the smallholder rubber sector. Under the project of "Livelihood development for Sustainable Rural Economy" Rubber based value addition product development training programme was conducted to educate 40 participants with the collaboration with Rubber Technology and Development Department. A special pilot project, "Introducing the Rubber Farming Service Providers" was conducted to introduce seven special multi skilled work groups to facilitate rubber industry. Practical workshop on contour lining and planting practical workshop was introduced to improve the contour lining knowledge and skills of field practitioners in the estate sector especially focused Field Officers and Managers. Dr P K K S Gunarathne, C P K Senanayake, H G M B Jayasinghe, D S Dissanayake, G R Tennakoon, P V S Madhubhashana, E W S R Kumara, J A S Chandrasiri and M N P De. Silva were appointed as Registered Contingency based Assessors to assess the Rubber Harvesting Assistants (NVQ 3) by TVEC.

RUBBER TECHNOLOGY AND DEVELOPMENT

Natural rubber (NR) composites with good mechanical properties were produced using reduced graphene oxide nanosheets synthesized in the laboratory. Polyethylene glycol (PEG) grafted as well as copper (Cu) grafted reduced graphene oxide were also synthesized and NR composites were produced incorporating the same. Electrical conductivity of 1 phr Cu grafted reduced graphene oxide incorporated NR composite was at a maximum level. Cellulosic fibers of corn husk (CHF) were extracted from corn husk leaf waste and chemical treatment was conducted. The treated CHF even at a low loading (2.5 phr) in NR composites showed its potential to reinforce NR in the presence of a coupling agent. Also, green composites with acceptable physico-machanical and ageing properties were produced with treated pineapple fibre. NR based eraser with the lettering "Dartonfield" was produced using the crepe rubber manufactured at the Rubber Research Institute of Sri Lanka (RRISL) crepe rubber factory, Dartonfield, Agalawatta. A dry rubber based cellular rubber compound for a marine engineering application, deproteinized natural rubber (DPNR) based reusable hygiene product, NR latex based glue to bond recycled carpet material to NR latex based as well as fabric materials, crepe rubber based compound to produce a medical item and a mechano-chemical reclaiming process for nitrile rubber (NBR) glove waste were developed at the request of industries/ universities. Further, 122 entrepreneurs / rubber small holders were trained on rubber based product manufacture. 146 crepe rubber, 830 rubber compound, 99 rubber product and 10 polythene sample tests were conducted and reports were issued at the request of the rubber industry and state universities. Furthermore, the staff was actively involved in arranging the RRISL/ Ministry of Plantation Industries stall at various industrial/educational exhibitions.

POLYMER CHEMISTRY

Laboratory trials on synthesizing Epoxidized Natural Rubber and Cyclized Natural Rubber using natural rubber latex were successful.

A hybrid filler system for tyre tread compounds was studied using combination of carbon black and waste mica with the aim of minimizing the use of carbon black and its detrimental effects on the environment and human health.

A unique gravimetric analysis approach to determine the sodium salt of thiol mercaptan bleaching agent use in the crepe rubber industry was introduced. The gravimetric methodology tested is effective and yields findings comparable to those of conventional approaches. Main benefit of this gravimetric approach is it improves accessibility and worker safety environment with significant involvement of unpleasant odor of conventional approaches. In adddtion, it benefits users with less analytical experience and on-site applications in manufacturing environments.

More than a thousand samples of polymeric materials and compounding ingredients received from industry and academia were analyzed using advanced instrumentation including, Fourier transform infrared spectrophotometer (FTIR) and Thermo-gravimetric Analyzer (TGA).

RAW RUBBER AND CHEMICAL ANALYSIS

The Raw Rubber & Chemical Analysis Department (RR & CA) specializes in essential analytical services to maintain the quality of dry rubber, latex, and rubber processing chemicals, adhering strictly to ISO standard procedures. We offer a wide range of testing and inspection services that are facilitated by modern equipment and technical expertise in analytical testing. The department offers testing, analytical, and certification services to all sectors of the rubber industry for raw natural rubber and rubber chemicals. These services were also extended to rubber traders, researchers from fellow departments of the institute, and various local institutions, such as universities, other research institutes, and individuals, including postgraduate students, consultants, and inventors. A total of 789 samples of natural rubber latex, dry rubber, and processing chemicals were tested for their quality throughout the year. This included 1718 dry rubber tests, 564 latex tests, and 52 rubber processing chemicals. 364 no: of test certificates issued on requests from the respective parties for their quality assessment and marketing purposes. In addition, the department conducted miscellaneous analytical tests, troubleshooting activities, and two major research projects during the year. Two research projects were conducted on the effect of heavy metal ions on latex quality parameters: the effect of different zinc concentration levels on latex film properties and the identification of an alternative natural product to replace the bleaching agent used in the crepe rubber industry in collaboration with Uva Wellassa University. Project on identification of an alternative carbon black source from waste wood ash were conducted in collaboration with C W Mackie PLC and University of Sri Jayewardenapura. The department staff provided five training programs on raw rubber and natural rubber latex testing for university undergraduates and one special training program for TSR and tire manufacturers in Sri Lanka. During the year, two factories were visited for troubleshooting activities. Completed the MPI-funded special project for the development of laboratory according to the accreditation status and laboratory procedures were established as per ISO 17025 requirements. The laboratory participated for the proficiency testing program conducted by Malaysian Rubber Board and demonstrated outstanding performance among 15 international latex testing laboratories.

RAW RUBBER PROCESS DEVELOPMENT AND CHEMICAL ENGINEERING

Two major research projects were conducted during the year 2023 while providing services to the rubber industry, such as troubleshooting activities, advisory services by visiting selected factories, issuing test reports for wastewater and other samples, etc. Undergraduate and postgraduate students from different universities were guided and facilitated for their research projects during the year.

Extending last year's project of finding alternative acid sources to formic acid successfully studied the potential of using extracted acids from fermented waste rice to coagulate natural rubber latex in the RSS processing. Since rice waste is the starting material of this process it can be considered as a cost-effective, user-friendly coagulant for RSS manufacturing.

Another study was conducted on the manufacture of low-nitrogen RSS using pineapple extract to produce deproteinized natural rubber. Here, RSS was produced by varying the volume of pineapple extract added into natural rubber latex as 5 ml, 10 ml, 15 ml, 20 ml, 25 ml, and 30 ml and adding 1% formic acid for the control sample. It was found that pineapple extract is suitable to reduce the nitrogen content.

ADAPTIVE RESEARCH

Awareness programmes on Dry Zone rubber cultivation were conducted to educate farmers in the Anuradhapura district of the North /Central Province. Feasibility assessments were conducted and thereafter, farmer participatory adaptive research trials were established in Ipalogama and Nuwaragam Palatha-East Divisional Secretaries Divisions of the Anuradhapura district. The findings of the study conducted to assess the water requirement of young rubber plants in the Anuradhapura district revealed that, applying 2 litre of water weekly was sufficient to maintain rubber cultivation during dry periods. Two area-specific rubber-based farming models were established in Thalawa and Nachchaduwa Divisional Secretaries Divisions of the Anuradhapura district in order to facilitate the demonstration purpose. The findings of a pilot study conducted in the Kalutara district revealed that the rate of adoption of the RRISL recommendations among smallholders, medium-scale estates and Regional Plantation Companies as 55%, 60% and 73%, respectively. A training and capacity building programme was conducted to develop the entrepreneurial skills of young rubber farmers in Padiyathalawa of Ampara district. The psychosocioeconomic status of the rubber plantation workforce in the Kalutara district was identified in terms of education systems, gender equality and child protection.

BIOMETRY

The Biometry section has been involved in research, focusing on Biometrical aspects especially on development, modification and application of statistical methodologies related to the needs of the rubber sector. Statistical methods, research support and studies on climatology are the three major research and development focuses of the Biometry section. During the year review, the research studies were mainly focused on uses of pairwise ranking matrix to order the problems facing farmers in nontraditional areas and application of parametric and nonparametric techniques to determine the turning moment in the global natural rubber production.

Research support extended to other departments included assisting the design of experiments, data analysis, design and analysis of surveys, interpretation of results and database management. Databases on meteorological data collected in the stations at Dartonfield, Moneragala and Kuruwita and rainfall data collected in stations at Nivitigalakele, Galewatta and Polgahawela were updated and provided the data for scientific purposes on request. The database on rainfall in rubber growing areas was updated for the reporting year. Moreover, the officers of the Biometry section have been involved with multi-disciplinary studies with different departments of RRISL, Universities and other crop research institutions.

AGRICULTURAL ECONOMICS

The Agricultural Economics Unit (AEU) has conducted analyses on the global rubber industry and international rubber prices by leveraging extensive world trade statistics. It highlighted some remarkable changes in the industry in terms of local and international rubber trade. The AEU has studied the profitability of rubber and rubber-based farming practices and presented the profitability indicators. Additionally, the AEU is currently engaged in an ongoing review to assess the impact of climate change on rubber harvesting and its socioeconomic impact on smallholder rubber farming. Furthermore, The AEU has recently updated the cost of rubber planting and processing with a comprehensive review of the changes to the cost structure. AEU also has contributed to the use of Geographic Information System (GIS) and Remote Sensing (RS) techniques in rubber plantation management. Furthermore, the AEU has explored the trade statistics and provided guidelines for formulating bilateral free trade agreements during this year.

LIBRARY AND PUBLICATION

The Library and Publication Unit continued with its regular services in collecting and disseminating information on natural rubber and related subject areas and also processing and publishing its periodicals. The Library and Publication Unit supported the staff of the institute by providing primary as well as secondary sources, maintaining permanent collections, and providing access to all necessary materials. The services provided by the Library include lending facilities for books & other printed materials, tracing references, facilitating inter-library loan, photocopying, indexing service for publications, circulating content pages of latest periodicals among researchers, current awareness service on updating the users on new arrivals of book and selective dissemination of information (SDI) service on demand.

Nineteen books were added to the reference section of the library bringing the total collection up to 6268. Twenty journals were received on an exchange basis.

DARTONFIELD GROUP

A total crop of 84235.5kg has been harvested during the year under review 67.36% of the estimated crop. When compared with the previous year, crop records a decrease of 15.75%. The crop harvested on wet days due to the rain guards was 13644kg which amounts to 16.2% of the total harvested crop. The average Yield per Hectare (YPH) for the year was 494kg showing a decrease of 97kg from the previous year.

The average intake per tapper recorded during the year was 5.5kg from a tapping task of 195trees. The highest intake per tapper of 6.6kg was recorded from the 4.69ha (RRIC 121/102 PB260, PB 217 clones) planted in the year 2007 and tapped at S/2 d4 low frequency systems with ethereal stimulation (tapping task of 259 trees). The total number of normal, late, rain guard & no tapping days recorded during the year were 178,24, 83 & 80days, respectively.

Total rainfall recorded for the year was 5951.6mm with 175 wet days showing 1664.1mm over rainfall and 16 wet days than the values recorded in the previous year. The Cost of Production (COP) and Net Sale Average (NSA) recorded for the year were Rs.708.04 and Rs.604.62 respectively, giving a loss of Rs.103.42per kg and a total loss of Rs.8.7Million. Loss per hectare recorded for the year was Rs.51093.26. The average percentage of Pale Crepe grade No. 01 was 84% during the year.

KURUWITA SUB - STATION

The mature extent of the Kuruwita Sub Station was 74.66 hectares during the year.

A total crop of 40595 kg was harvested during the year recording decrease of 5225kg on previous year's crop.

The actual yield per hectare (YPH) was 543.7 kg. The average intake tapper (IPT) of the estate was 4.6 kg and this is a decrease of 0.2 kg when compared with the previous year.

The total number of Normal, Rainguard, and No tapping days recorded during the year were 210,124 and 31 respectively.

The annual rain fall recorded during the year was 5141.2 mm with 158 wet days as against 4762.1 with 134 wet days during the previous year.

The cost of production (C.O.P) and the net sale Average (N.S.A) for the year were Rs.626.82 and Rs.599.11 per kg respectively. The loss made for the year was Rs.1.1 million and the loss per hectare recorded for the year was Rs.14484.77.

POLGAHAWELA SUB - STATION

A total crop of 18849kgs has been harvested during the year and it was 90.88% of the estimated crop. However, there was a 48.17% increase from the value recorded for the previous year. The crop harvested on wet days due to the rain guards was 5567kg which amounts to 29.5% of the total harvested crop. (There was a labour dispute in 2022 and fixing of rainguard was also started in 2023.)

The YPH for the year was 1061kg. This showed an increase of 357kg (50.71%) over the last year value. The average intake per tapper during the year was 8.7kg. The highest intake per tapper of 10.0kg was recorded from the 2008 field with a tapping task of 269 trees of clone RRIC121 tapped on S/2 d3 systems.

The total numbers of Normal, Slight Rain, Rainguard and No Tapping Days during the year were 238, 06, 91 & 12 respectively.

Total rainfall recorded for the year was 2782.3mm with 122wet days showing 431.7mm over rainfall and 28wet days than the values recorded in the previous year.

The Cost of Production (COP) and Net Sale Average (NSA) recorded for the year were Rs.449.92 and Rs.529.87 respectively, giving a profit of Rs.79.95per kg and a total profit of Rs.1.5Million. Profit per hectare recorded for the year was Rs.130864.72. Out of the total manufactured RSS, the share of No.01 grade was 73%.

METEOROLOGICAL REPORT

The total annual rainfall at Dartonfield during this year was 5952 mm, which accounted for a 39% increase compared to the previous year. Remarkably high above-average monthly rainfall values were observed in June (819 mm-106%), September (1015 mm-133%) and December (688 mm- 159%). Above average rainfall values were also observed in January (181 mm-16%), February (233 mm-104%), March (445 mm-100%), October (771.9 mm-50%) and November (535 mm-38%) while below average rainfall values were observed in the rest of the months. The minimum monthly rainfall of 181 mm was recorded in January whilst the maximum monthly rainfall of 1015 mm was recorded in September.

Rains during the South West season carried most of the rains (2741 mm compared to the long-term average of 1564 mm) during 2023. This rainfall amount contributed 50% to the total rainfall. During the North East season (December 2022 to February 2023), 632 mm of rain was recorded, which is slightly lower (11%) than the long-term average contribution (15%) of this season.

Three rainfall events exceeded the hazardous limits for landslides (100 mm of rainfall during a day) reported during the year under review. A dry spell lasting over a month or more can adversely impact rubber plantations. There were only 2 dry spells greater than or equal to 7 days

The minimum temperature dropped below 20 0C in January, April, May, August, September and December. The daily average temperature pattern was fairly steady with a mean annual temperature of 27.6 0C. The lowest mean monthly minimum temperature of 17.6 0C was observed in September while the highest monthly mean maximum temperature of 35 0C was observed in April. A total of 1647 bright sunshine hours was received at an average rate of 4.6 hours/day which was comparatively lower than the respective figures observed during the last year. Daily morning RH at Dartonfield in 2023 was observed in the range, 63% to 98%. The mean RH values recorded at 08:30 and 15:30 were 85% and 74%, respectively.

The annual rainfall totals of 4962 mm, 2782 mm, 2224 mm, 5769 mm and 4730 mm were recorded, respectively, in Kuruwita, Narampola, Moneragala, Galewatta and Nivithigala Kele stations maintained by RRISL during 2023. The respective rainy days for these stations were 243, 149, 106, 205 and 203.